Stakeholder Perceived Barriers to the Use of Solar Energy in Thailand’s Buildings

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Abstract

Energy efficiency and use of renewable energy is currently a key topic given rising fuel prices and concerns regarding future energy security. Governments around the world are looking for ways to reduce the demand for energy from unsustainable sources either through improving energy efficiency or through generating energy using renewable sources.

The building industry is one industry where it is considered that energy demand can be reduced. Studies have shown that green building practices, such as the use of solar energy, can substantially reduce the energy demand of residential and commercial buildings. However for green building practices such as solar energy to be incorporated into a building design, industry stakeholders must understand the benefits.

Despite Thailand having a tropical climate there is little adoption of either passive solar design strategies or solar energy technologies. In this study 30 interviews were conducted with stakeholders in the Thai building industry and analysed using grounded theory methodology to determine what stakeholders perceive as the barriers to using solar energy in buildings in Thailand. As well as analysis of the interview transcripts, research participants also completed a 20 question Likert scale survey designed to gauge opinions towards known barriers to the use of solar energy in buildings.

The research identifies 25 barriers that stakeholders in the building industry perceive to be barriers to the use of solar energy in buildings in Thailand. The core concept of the research is that stakeholders perceive a difference between the concepts of awareness and knowledge and a lack of awareness and a lack of knowledge is the primary reason solar energy is not used more often. Increasing both awareness and knowledge of solar energy is the primary way to encourage consideration of solar energy in Thailand's building projects.

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- Experientia docet -

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“We need to develop energy resources for greater self-reliance in order to increase energy stability and to sufficiently meet the demand at both domestic and international level.”

Abhisit Vejjajiva
Thailand Prime Minister
December 2008

From *Thailand’s Renewable Energy and its Energy Future* (Sutabutr, 2009)

1. Introduction

While individuals often take the availability of energy for granted, governments are acutely aware of being reliant on energy to further economic growth (Yergin and Gross, 2012). Given the finite supply of fossil fuels, the environmental impacts of energy use and energy security issues for countries that do not have their own fossil fuel reserves, governments are devoting considerable resources to reducing their energy needs and secure future energy supply (Yergin and Gross, 2012). In fact many already believe it is possible to meet global energy demands without using fossil fuels but it depends on when societies are ready to establish a sustainable energy supply and the infrastructure required to support it (Quaschning, 2005).

There are various ways in which the energy consumption of a country can be made more sustainable. One option is to manage energy demand through tariff structures that discourage peak energy use, promotion of energy efficient appliances and changing consumer behaviour to reduce individual energy use (Koeppel and Urge-Vorsatz, 2007). Another option is to create energy from renewable primary energy sources such as the sun, wind and biomass.

For government programs to be efficient, they must concentrate on areas where the biggest energy efficiency gains can be made. There is a considerable amount of energy, primarily in the form of electricity, used in buildings (World Business Council for Sustainable Development, 2009) and as a result programs designed to reduce building energy use have the potential to significantly impact the country's total energy consumption. According to the World Business Council for Sustainable Development (2009) buildings account for 40 percent of global energy use and significantly contribute to the carbon footprint from electricity generation. Effective use of solar energy in building design can substantially reduce both the overall energy consumption of a building and the environmental impact of the energy that is used (Reardon, Milne, McGee and Downtoh, 2010).

These factors provide strong drivers to reduce energy consumption in buildings through the use of green building practices. One green building practice is to reduce reliance on the national grid through either reducing the energy required to operate the building or through the building generating its own electricity using renewable sources. However neither of these practices is standard within the building industry in Thailand. While research has been undertaken in some parts of the world, gaps still exist in the body of knowledge regarding the decisions being made daily that impact building energy use.

Despite Thailand's tropical climate and growing construction industry (Asia Development Bank, 2011), it seems the Thailand construction industry gives little consideration to the use of solar energy in buildings through either passive solar design strategies or the use of solar technologies. With Thailand's tropical climate building energy efficiency could be improved through greater use of passive solar design strategies such as improved glazing, greater shading and insulation or the use of solar technology to heat water or provide electricity. However in Thailand solar energy is hardly ever incorporated into current construction projects indicating that day to day decisions made in the building industry do not take into account energy efficiency or renewable energy. Understanding the decisions made by building industry stakeholders in relation to energy is a vital component of transferring a new innovation (Painuly, 2001) and making buildings more sustainable.

This research aims to explain what building industry stakeholders in Thailand perceive to be the barriers to using solar energy in buildings when considering either passive solar design strategies or the use of solar energy technologies.

1.1 Problem Statement

In spite of the tropical climate in Thailand, there seems to be minimal consideration to the use of solar energy in buildings either through passive solar design strategies or the use of solar energy technologies. Although construction is a growth industry in Thailand, there is little currently known about what stakeholders in the Thai building industry perceive to be the barriers to using solar energy in buildings and the impact these perceptions have on the use of solar energy in Thailand's buildings.

1.2 Research Aims

This research aims to identify stakeholder perceived barriers to using either passive solar design strategies or solar energy technologies in buildings in Thailand.

1.2.1 Research Objectives

Specifically the objectives of the research are to:

1. Explain what building industry stakeholders in Thailand perceive to be the barriers to the use of passive solar design strategies and solar energy technologies in buildings in Thailand;
2. Identify how current perceptions of building industry stakeholders influence the use of solar energy;
3. Determine necessary future changes for stakeholders to support the use of solar energy within Thailand's buildings.

1.3 Importance of Research

Through identifying how building industry stakeholders in Thailand perceive the use of solar energy, there can be greater understanding as to why passive solar design strategies and solar energy technologies are not used to a great degree in Thailand. Creating more energy efficient buildings reduces the amount of energy required from the national grid for building operation which subsequently has the potential to reduce both Thailand's total energy demand and greenhouse gas emissions.

By focusing on the perception of building industry stakeholders it is hoped to identify barriers that prevent the use of solar energy during building design and construction. Painuly (2001) highlights that through interacting with stakeholders and understanding their perspective, it is possible to identify the policy gaps that are most relevant to stakeholders and create suitable measures to overcome these.

1.4 Research Approach

The research adopts a mixed method approach using both individual interviews which were recorded, transcribed and analysed using grounded theory methodology and a survey using a Likert response format which was completed by participants at the end of each interview. The sample was not large enough for the survey results to be statistically significant however the results are robust enough to identify stakeholder attitudes toward specific barriers to using solar energy.

Participants were selected using theoretical sampling following the grounded theory methodology. As such not all of the participants were selected at the start of the research but rather participant selection was guided by the data analysis (Goulding, 1996) which happened concurrently with data selection. Goulding (1996) highlights that initially a researcher will go to the most obvious sources for information and include additional individuals, situations and places as concepts are identified and theory develops. In this research, the initial participants were known to the researcher and additional participants were included to widen the geographical area of the research and determine if the identified concepts applied to other occupational groups in the building industry.

1.5 Limitations of this Research

Participants in the research mostly have experience in the high end residential sector aimed at expatriate buyers and therefore the research is predominantly limited to the construction of high end villas. While this limitation was not intended, participants with knowledge of solar energy are most likely involved with projects at the top end of the market where budgets are sufficient to at least consider solar energy.

The research was also limited by the time involved in undertaking and transcribing individual interviews. Confidence in the results could have been increased if the survey was distributed to a larger sample outside of those being interviewed.

1.6 Organisation of Thesis

Following this introduction, the thesis is organised into the following sections:

- Chapter 2: Reviews the literature related to stakeholder perceptions and the use of solar energy.
- Chapter 3: Describes the methodology used for data collection, analysis and presentation.
- Chapter 4: Shows the demographics of participants and outlines the research findings from both the individual interviews and survey.
- Chapter 5: Discusses the findings in relation to the research objectives and theorises as to why solar energy is not used to a greater extent in buildings in Thailand.
- Chapter 6: Concludes the thesis and provides suggestions on areas for further research.
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2. Literature Review

Today there is greater awareness that the current methods of generating and using energy are unsustainable long term due to limited fossil fuel resources and the environmental impacts of using these. This has resulted in a global desire to decrease the consumption of energy produced through traditional and unsustainable methods (Omer, 2009) and the overall reliance on fossil fuels (Owen, 2006). Efforts to achieve this objective can be focused in two directions. Firstly, the demand for energy can be reduced by educating the end user and encouraging the use of more energy efficient technologies and secondly, by generating energy through the use of renewable sources.

From the available options each country must decide the best alternatives to ensure the ongoing availability of energy at an affordable price. Aside from reducing environmental impacts and reliance on fossil fuels, reducing overall energy requirements reduces demand on national power supply infrastructure and the need to develop additional generation and distribution capacity (Sawangphol and Pharino, 2011). This can be a huge cost saving for national budgets. The Intergovernmental Panel on Climate Change (IPCC) has stated that it is more cost effective to develop programmes to support the efficient use of energy than it is to continually build power plants to keep up with rising demand (Laurenzi, 2007).

Incorporating solar energy into buildings is one way to reduce national energy demand through reducing both the building's electricity demand and generating electricity sustainably outside of the national grid. Buildings that incorporate passive solar design strategies can substantially reduce the energy required for heating and cooling (Reardon et al., 2010) while the use of solar energy technologies to allow the sun to heat water or generate electricity further reduces the building's energy demand. However despite the tropical climate of Thailand, solar energy is not often utilised in buildings. This research focuses on the reasons for this through investigating what stakeholders perceive to be the barriers to using solar energy.

The topic of solar energy in buildings crosses a range of subjects including green building, renewable energy, sustainable construction, energy efficiency and energy policy. As a result there is a broad scope of literature that is applicable, at least to some degree, to this research. From the sources reviewed, there are five key areas in the literature which are relevant to this research:

- Drivers for alternative energy sources;
- Thailand energy industry;
- Building energy consumption;
- Barriers to renewable energy;
- Transfer of renewable energy technologies.

Each of these topics is discussed in the following sections.

2.1 Drivers for Alternative Energy Sources

The availability of energy is an important component of economic development (Yergin and Gross, 2012). While some Asian economies began considering energy efficiency in the late 1970s, most countries were focused solely on growth and development and did not seriously consider energy efficiency until the 1990s (Laurenzi, 2007). This has changed, particularly over the last decade, and Asia energy policies have moved from concentrating solely on the supply side of energy generation to taking measures to address demand recognising that it is more economically efficient to reduce demand first (Laurenzi, 2007).

The Asia Development Bank considers affordable access to energy a prerequisite to economic development and poverty reduction (Tayman and Galvez, 2006). Omer (2009) also maintains that *"energy security, economic growth and environment protection are the national energy policy drivers for any country in the world" (*p.3). The need to secure energy supply while managing adverse environmental impacts is made more difficult by the increased energy demand of growing populations. Along with security and environmental protection, the ability to meet the growing demand for energy is a key objective for government energy policy.

Energy Security

Fossil fuels, including coal, oil and natural gas, provide more than 85 percent of global primary energy (Quaschning, 2005). The International Energy Agency (2009) reports there were 180 trillion cubic metres of proven natural gas reserves in 2008 with over half of these reserves in Russia, Iran and Qatar. There is also an estimated 850 trillion cubic metres of natural gas that may be recoverable in the long term (International Energy Agency, 2009). However as the more accessible fossil fuel reserves have already been exploited, future extraction is likely to be more difficult and expensive than it is today (Quaschning, 2005). Many Asian countries do not have sufficient energy resources of their own and have to import energy to meet the growing energy demand, creating concern that rising energy prices or disruptions to supply may cause energy shortfalls for countries that rely on importing to meet their energy needs (Laurenzi, 2007).

Increasing demand for electricity

Globally it is projected that there will be a growth in electricity demand of 2.5 percent annually to 2030 (International Energy Agency, 2009). More substantial demand increases are expected in developing countries as they start to catch up economically with more developed countries (Quaschning, 2005). Not only does the economic growth of developing countries increase energy demand, the predicted growth in population in these countries will also increase energy needs (Quaschning, 2005). The countries that make up the Association of South East Asian Nations (ASEAN) are experiencing both rapid economic and population growth and the resulting increase in energy demand (International Energy Agency, 2009; Tayman and Galvez, 2006). As these countries have little in the way of fossil fuel reserves, they are heavily reliant on importing to meet their energy needs (International Energy Agency, 2009).

Environmental impacts

Increasingly Asian economies recognise the impact energy consumption has on green house gas emissions and global warming and this issue is being addressed in energy policies (Laurenzi, 2007). Electricity generation is a main source of carbon dioxide emissions accounting for 75 percent of total emissions (Quaschning, 2005). The combustion of fossil fuels increases the level of carbon dioxide in the atmosphere and many believe that the current level of greenhouse gases produced from energy consumption is unsustainable, let alone the levels that will be produced due to greater consumption of fossil fuels resulting from increased energy demand (Tayman and Galvez, 2006). Sawangpho and Pharino (2011) consider the amount of electricity generated by a country and how it is generated is an important element of climate change policy. In addition to the global warming effects of greenhouse gases, the heavy air pollution occurring in Asia has also raised awareness of environmental issues as the consumption of energy is the largest contributor to air pollution (Laurenzi, 2007). Environmental events in recent years such as the Deepwater Horizon oil spill in 2010 and problems with the Fukushima nuclear power plant after the Japan tsunami in 2011 have further highlighted the environmental impacts of energy generation.

There is a range of policy options governments can choose to help guarantee future energy supply and each government will have to take measures to ensure these policies are adopted nationally. The International Energy Agency (2009) highlights that while it will be up to households and businesses to invest in low carbon options, their willingness to make these investments will depend on both national and international government policy.

Although governments understand the drivers for reducing energy consumption, there are conflicting views as to whether this need is understood in the general population. While Bradford (2006) considers that the majority of people recognise the current world energy system is not sustainable, Sovacool (2009) suggests that renewable energy may face opposition as people do not understand why it is needed. The perception of the general population as to whether there is a need to reduce energy consumption seems to differ throughout the world depending on the level of environmental awareness.

2.2 Thailand Energy Industry

The Kingdom of Thailand is a country in South East Asia with a population of about 66 million people. The country has a tropical climate with annual average temperature ranges between 26°C to 28°C, however during the dry season from October to April temperatures between 31°C and 34°C are normal (Thai Meteorological Department, n.d.). The climate makes Thailand a popular tourist destination and the tourism industry accounts for about six percent of Thailand's gross domestic product (GDP) (New Zealand Trade and Enterprise [NZTE], 2011). However more than half of the country's GDP comes from exports mainly in motor vehicles, electronic components, textiles and furniture (NZTE, 2011).

In 2011 Thailand's commercial primary energy consumption was 61,247 thousand tonnes of crude oil equivalent (KTOE) of which 50,477 KTOE (55%) was imported (Energy Policy and Planning Office [EPPO], 2012). Approximately 22 percent of final energy consumption is in the form of electricity (EPPO, 2012). Part of the demand for electricity is the year round requirement for space cooling due to the tropical climate. Figure 1 shows that electricity generation in Thailand relies predominantly upon natural gas which accounts for 70 percent of power generation, while other fuels make up the remaining 30 percent (Asia-Pacific Economic Cooperation, 2010).

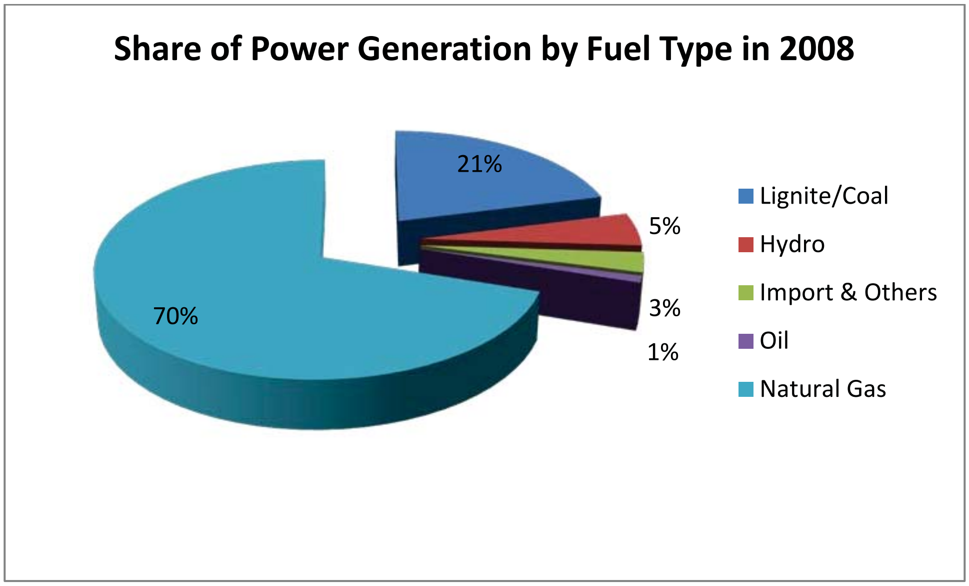

Figure 1: Electricity generated in Thailand by type of fuel in 2008 (from Asia-Pacific Economic Cooperation, 2010)

The heavy reliance on one form of fuel raises concern about energy security and it is possible that Thailand may face natural gas shortages as demand for energy grows (Sawangphol and Pharino, 2011).

To understand Thailand's energy situation in relation to other countries, statistics from the World Bank data bank (www.databank.worldbank.org) are provided in table 1, rows one to eight. The data shown is from 2009 and covers Thailand, its immediate neighbors and three countries classified as high income countries by the World Bank. The high income countries are shown to provide a comparison against the lower income countries of Thailand and its immediate neighbours and statistics are shown from New Zealand, United Kingdom and United States as eight of the research participants are from these countries.

It is assumed that the entire population of the high income companies has access to electricity while access to electricity in the low income countries of Myanmar and Cambodia is 13 and 24 percent of the population respectively. Electricity prices also vary between the eight countries with Myanmar having the lowest cost per kilowatt hour (kWh) at US 0.03 cents and the United Kingdom having the highest cost per kWh at US 0.21 cents. Thailand, Malaysia, Lao PDR and the United States have similar electricity prices ranging between US 0.09 cents and US 0.12 cents per kWh.

Table 1: Comparison Thailand energy supply with neighbouring and high income countries.

			Neighbouring Countries of Thailand				High Income Countries		
		Thailand	**Malaysia**	**Myanmar**	**Lao PDR**	**Cambodia**	**New Zealand**	**United Kingdom**	**United States**
1	**Total Population**	68,706,122	27,949,395	47,601,374	6,112,143	13,977,903	4,315,800	61,811,027	306,771,529
2	**GNI per capita, PPP (current int. $)**	7,610	13,550	1,770	2,340	1,980	28,100	34,960	45,440
3	**Income Category**	Upper middle	Upper Middle	Low	Lower Middle	Low	High	High	High
4	**Energy use (kt of oil equivalent)**	103,315.94	66,826.20	15,062.16		5,182.29	17,402.76	196,762.48	2,162,915.15
5	**Energy use (kg of oil equivalent per capita)**	1,503.74	2,390.97	316.42		370.75	4,032.34	3,183.29	7,050.57
6	**Energy imports, net (% of energy use)**	40.28%	-34.22%	-48.43%		29.22%	12.57%	19.24%	22.03%
7	**Fossil fuel energy consumption (% of total)**	79.39%	94.68%	27.70%		27.82%	63.70%	87.32%	84.13%
8	**Access to electricity (% of population)**	99.3%	99.4%	13%	55%	24%			
9	**Electricity Cost Per kWh [1,2,3]**	2.78 THB[4] 0.09 USD	0.36 MYR[4] 0.12 USD	25.00 Kyat[4] 0.03 USD	773 LAK[4] 0.10 USD	720 Riels[4] 0.18 USD	0.24 NZD[5] 0.18 USD	0.13 GBP[6] 0.21 USD	0.12 USD[7]

1. *Price based on residential use of 400 kWh per month. Tariffs for some countries vary depending on the total electricity used.*
2. *Conversions to USD approximate only.*
3. *Electricity unit prices rounded to the nearest cent.*
4. *Asian electricity prices sourced from Suryadi (2011) and are 2011.*
5. *Recent national average prices for New Zealand are unavailable. This price was sourced from Consumer.Powerswitch (n.d) and is calculated from an annual cost for 8096 kWh in Auckland from Contact Energy (the retailer with the largest market share in New Zealand) in 2011.*
6. *UK average price per kWh in 2010 sourced from Department of Energy and Climate Change (n.d).*
7. *US average price per kWh in 2011 sourced from U.S Energy Information and Administration (2012).*

2.2.1 Thailand Energy Policies

As the demand for energy escalates so does the need for an efficient energy sector to manage the generation and distribution of electricity. The Government of Thailand has outlined five principles for the energy sector (Sutabutr, 2009):
These principles are:

- Develop domestic energy resources to increase energy stability;
- Expedite and promote alternative energy;
- Monitor energy prices and ensure appropriate levels;
- Effectively save energy and promote energy efficiency;
- Support energy development while simultaneously protecting the environment.

Thailand has implemented legislation and policies to promote these principles. In 1992 Thailand had a relatively unregulated energy industry and introduced the Energy Conservation Promotion Act 2535 (Department of Alternative Energy Development and Efficiency and Danish Ministry of Foreign Affairs, 2006) aimed at conserving energy in commercial buildings. There were minor amendments to this Act in 1995 and 1997 with more major changes being made in 2007 with the Energy Conservation Promotion Act (No. 2) 2550.

Also in 2007 the Energy Industry Act 2550 came into force. The Act provided for the creation of the Energy Regulatory Commission which was established in 2008. The Energy Regulatory Commission (ERC) approves tariffs and issues licenses, and was established to separate the policy making and regulatory functions in the electricity and natural gas sectors (Wisuttisak, 2010).

Within the legislative framework there are a number of energy efficiency policies. In 2010 Thailand created the Power Development Plan which outlines the country's aim to reduce its reliance on natural gas and increase its use of renewable energy generation (Sawangphol and Pharino, 2011). Recognition that fossil fuel resources are finite and air pollution is growing also led the government to implement a number of programs to reduce energy consumption (Tanatvanit, Limmeechokchai, and Chungpaibulpatana, 2003). The majority of these have concentrated on reducing demand for energy through reducing consumption of residential and commercial users (Tanatvanit et al., 2003). Thailand is also recognised as a leader amongst the Association of Southeast Asian Nations (ASEAN) countries for polices on electricity demand side management which include appliance energy labelling, building energy efficiency and consumer education (Laurenzi, 2007).

2.2.2 Thailand Electricity Sector

There are number of government agencies involved in managing the energy policies of Thailand as shown in figure *2.*

The National Energy Policy Council (NEPC) reports directly to the Office of the Prime Minster and is responsible for managing Thailand's energy sector including issuing energy pricing regulations and granting operating licences. Under the National Energy Policy Council are the Ministry of Energy, Energy Conservation Promotion Fund Committee and the Committee on Energy Policy Administration.

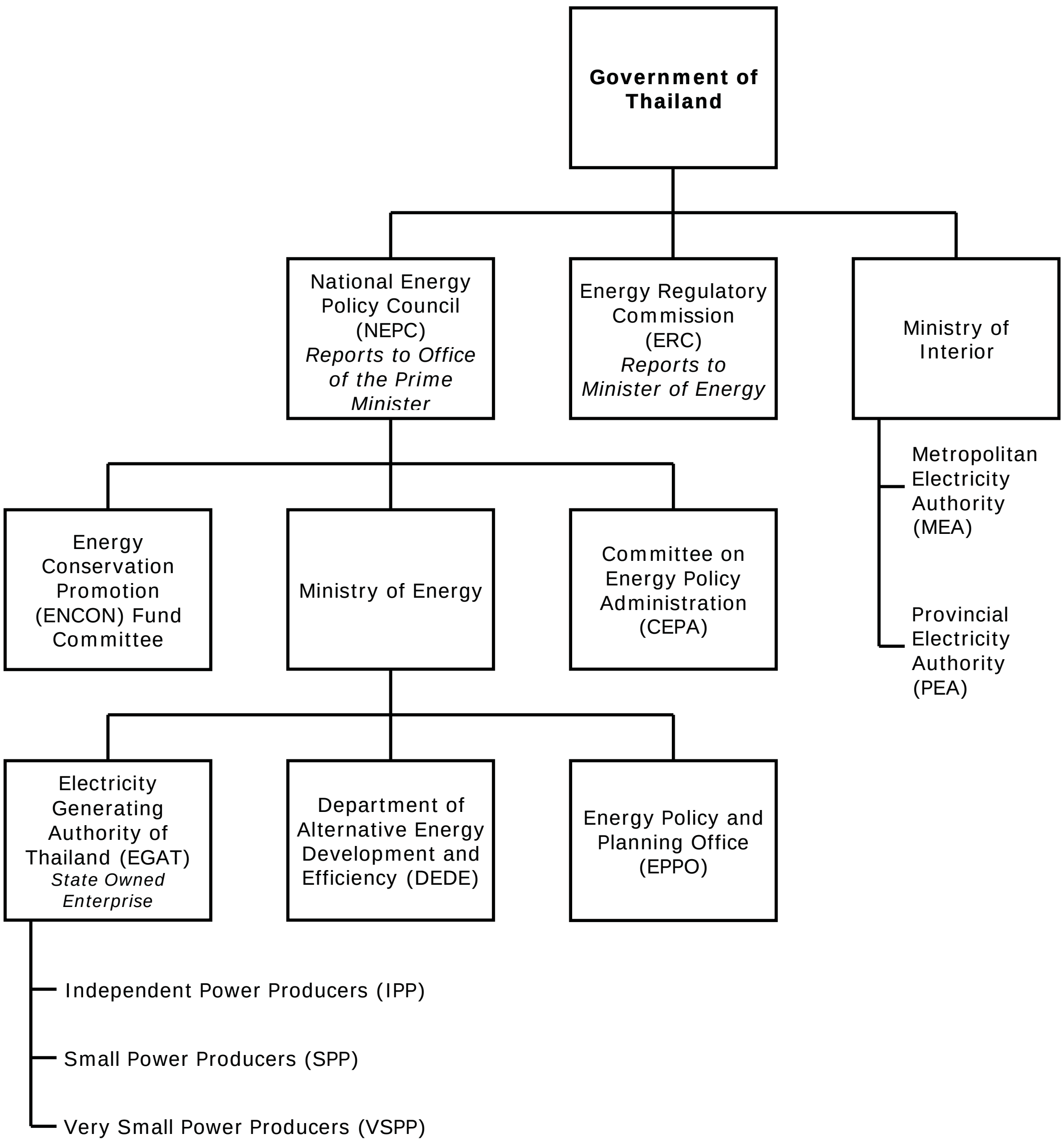

Figure 2: Agencies in the Thailand electricity sector

The Ministry of Energy is also responsible for the state owned enterprise the Electricity Generating Authority of Thailand (EGAT) which provides about 53 percent of Thailand's electricity (Sawangphol and Pharino, 2011).

The electricity generated by EGAT is sold to two state owned electricity distribution utilities: the Metropolitan Electricity Authority (MEA) who is responsible for selling electricity in Bangkok and surrounding areas and the Provincial Electricity Authority (PEA) who is responsible for selling electricity to the rest of the country (Sawangphol and Pharino, 2011). The Ministry of the Interior is responsible for the MEA and PEA (Department of Alternative Energy Development and Efficiency and Danish Ministry of Foreign Affairs, 2006). Additional electricity is provided by private power producers who sell to the electricity utilities or nearby local users (Sawangphol and Pharino, 2011).

Private power producers in Thailand are divided into three categories (Department of Alternative Energy Development and Efficiency and Danish Ministry of Foreign Affairs, 2006):

1. Independent Power Producers (IPP) are power producers that are large in scale and normally use natural gas or coal.
2. Small Power Producers (SPP) that normally use natural gas, oil, coal, biomass, wind, solar or hydro to a capacity of less than 60 Megawatt.
3. Very Small Power Producers (VSPP) with capacity of less than 1 megawatt based on renewable energy.

With the range of government organisations involved in the electricity sector, there can be difficulty coordinating overlapping policies and duties between the lead agencies (Uddin, Taplin and Yu, 2010).

2.2.3 Building Codes and Regulations

The adoption of building energy codes is considered an important element in reducing energy consumption (Chirarattananon, Chaiwiwatworakul, Hein, Rakkwamsuk and Kubaha, 2009). While interest in energy efficiency for commercial buildings in Thailand started during the oil price rises and oil shortages of the 1970s and early 1980s (Chirarattananon et al., 2009), the Thailand Energy Conservation Promotion Act 2535 was not promulgated until 1992 and further amended in 2007. The Act applies to designated buildings defined as facilities with an installed capacity of 1 MW or greater and an annual consumption of 20 million MJ or greater that use steam power or other non-renewable energy sources (Brulez and Rauch, n.d.).

In 2009 a Ministerial Regulation (known as the 2009 Building Energy Code) was issued which redefined designated buildings and further defined building energy efficiency requirements. The 2009 Ministerial Regulation applies to hospitals, educational facilities, department stores, offices, hotels, condominiums, theatrical and entertainment service buildings and buildings designed for congregations with a total area of 2,000 square metres or more. The 2009 Building Energy Code is now the primary piece of legislation governing building energy efficiency in Thailand.

Building energy code requirements in Thailand are formulated by the Department of Alternative Energy Development and Efficiency (DEDE) while the Department of Public Works and Town and Country Planning under the Ministry of Interior are responsible for enforcing the building energy code (Laurenzi, 2007).

2.2.4 Renewable Energy in Thailand

Renewable energy strategies in Thailand focus on using renewable energy technologies for large scale power generation and providing electricity to rural areas where it would not otherwise be available (Department of Alternative Energy Development and Efficiency and Danish Ministry of Foreign Affairs, 2006). In 2006 the Department of Alternative Energy Development and Efficiency published an action plan for the promotion of renewable energy technologies to be used for electricity generation (Department of Alternative Energy Development and Efficiency and Danish Ministry of Foreign Affairs, 2006).

In 2006 the National Energy Policy Council approved EGAT to purchase power from small power producers and regulations were introduced in 2007 to allow this (Chandler and Thong-ek Ltd, 2011). In 2009 and 2010 payment rates for electricity sold to utility companies (known as adder rates) were established to encourage the use of renewable energy. Early in 2010 an adder rate of 8 baht per kilowatt for solar energy was prescribed. Interest in the program was greater than expected and applications have been submitted for 3,500 megawatts of solar power generation from small and very small power producers (Greacen, 2011). Given the number of applications and concerns that the total power generated from solar exceeded Thailand’s targets for solar energy, the government reduced the solar adder rate for existing applications from 8 baht a kilowatt to 6.5 baht a kilowatt in July 2010 (Greacen, 2011). The government also announced that new solar applications would not be accepted. As at October 2010 only 55 projects totalling 16 megawatts were operating and selling to Thailand utility companies (Greacen, 2011).

It is recognised that renewable energy has great potential in Thailand and despite the interest that would seem to exist from the number of applications to sell power to utility companies, the current electricity generation from renewable technologies is comparatively small (Uddin et al., 2010). The annual average intensity of daily total solar radiation in Thailand is about 17 MJ/m2-day, which is considered relatively good (Wibulswas, 2003) and highlights the potential of solar energy technologies. Sawangphol and Pharino (2011) outline that most areas in Thailand are exposed to high sunlight intensity and therefore there is a high potential for the utilisation of solar energy.

2.3 Building Energy Consumption

It is well recognised globally that the energy consumed in buildings is a substantial component of a country's overall energy footprint. The European Union considers that buildings account for 40 percent of energy use in Europe and have implemented a number of directives aimed at reducing building energy consumption (Flamos, Van der Gaast, Doukas and Deng, 2008). Laurenzi (2007) outlines that buildings are responsible for about a third of total energy consumption in Asia and a similar proportion of greenhouse gas emissions and the United Nations Environment Programme estimates that globally 30 to 40 percent of primary energy is used in buildings (United Nations Environment Programme, 2007). This is supported by the World Business Council for Sustainable Development (2009) which estimates buildings account for 40 percent of global energy consumption.

The energy use of a building is dependent on the type of building and the climate in which it is located (United Nations Environment Programme, 2007). While energy is consumed in the construction, operation and decommissioning of a building, most of the energy consumed in a buildings lifecycle is used during the operational phase (United Nations Environment Programme, 2007).

Studies in architecture and building technologies have shown that the energy consumption of buildings can be drastically reduced through energy saving measures and energy efficient building design (Cheung, Fuller, and Luther, 2004;

Omer, 2009; Australian Sustainable Built Environment Council [ASBEC], 2008). More and more governments are placing priority on reducing the energy consumed by buildings and generating the energy that is used in a more sustainable manner (Laurenzi, 2007). Using renewable energy technologies to generate electricity at a building level reduces both the energy used and greenhouse gas emissions created by the building (ASBEC, 2008). Also savings made on each individual building can combine to significant national savings through limiting investment required in additional energy generation (Chirarattananon et al., 2009; Laurenzi, 2007; ASBEC, 2008). The use of renewable energy in buildings can produce electricity at peak times which reduces overall peak demand (ASBEC, 2008). Reducing the energy consumption of buildings is considered a key area where environmental gains can be realised (Laurenzi, 2007) which means the decisions made by building designers and owners as to what energy efficiency measures are implemented substantially alters environmental impact of a building.

2.3.1 Solar Energy in Buildings

Due to the earlier failed promises of solar energy, there is a perception that using solar energy is expensive however at the same time it is also questioned whether solar energy is really as expensive as perception suggests. Bradford (2006) suggests there is an assumption that solar photovoltaic cells will not play a great role in energy reforms as they are too expensive and lagging behind in market penetration. Yet there is also a prediction that the barrier of cost will be mostly eliminated as technological breakthroughs occur and the manufacture of solar energy technologies becomes cheaper (Castro-Lacouture and Roper, 2009).

Omer (2009) considers that the adoption of renewable energy technologies for buildings is an important aspect in reducing green house gas emissions and that the key elements in realising the potential of building renewable energy technologies are 1) ensuring building design professionals have suitable skills and attitudes and 2) that they are given the opportunity to utilise this knowledge.

2.3.2 Passive Solar Design Strategies

Passive solar design strategies involve optimising the building’s orientation, materials, structure and glazing to make use of the available solar energy (Pitts, 1994).

By designing a building with consideration to climatic factors such as temperature and humidity, it is possible to maximise natural cooling and heating and reduce the required energy consumption of the building (Reardon et al., 2010). The comfort of occupants can also be improved through controlling temperature by maximising natural cooling and air flow (Reardon et al., 2010). This in turn reduces the level of mechanical cooling required and saves electricity during building operation. Other passive design strategies such as maximising the use of natural light also improves the comfort of building occupants and reduces the need for artificial light which consumes electricity and may generate heat depending on the lighting used (Reardon et al., 2010).

Recognition of the benefits of passive solar design in buildings is increasing globally with a number of countries now incorporating elements of passive design, such as required insulation levels, into building codes. For example, the building code of New Zealand specifies minimum insulation levels but there can often be further energy savings through installing insulation above the minimum levels (Energy Efficiency and Conservation Authority, n.d.). The Building Code of Australia also specifies minimum insulation levels (Reardon et al., 2010).

While some passive solar design strategies such as using optimal forms of glazing may cost significant amounts of money to implement, other strategies such as consideration of the building orientation and maximising natural shading can be implemented relatively cheaply.

Research into passive solar design in tropical climates has been undertaken (Salmon, 1999; Garde, Mara, Lauret, Boyer and Celaire, 2001) and from this research are recommendations of the most appropriate passive solar design strategies depending on specific climate factors. However, it passive solar design strategies are not often considered by the construction industry in Thailand despite potential advantages of improved occupant comfort and reduced energy use.

Pitts (1994) identified that there is little public awareness of passive solar design which translates into a lack of demand. Sustainable Sources (n.d) considers that while finance is not a barrier to the implementation of passive solar design, public acceptance is a limiting factor particularly regarding the use of passive solar design for cooling which is less understood than passive solar design for heating. So although passive solar design is considered a key element in creating energy efficient buildings (Laurenzi, 2007); implementing these strategies does require a certain level of public acceptance. Knowledge of passive solar design strategies may be another factor in the limited use of these strategies as designers in particular need to have a good understanding of passive solar design for it to be implemented (Ministry for the Environment, 2008).

The reason passive solar design strategies are not utilised more in Thailand is unknown however a lack of knowledge in project teams and a lack of public acceptance may be contributing factors.

2.3.3 Solar Energy Technologies

While passive solar design strategies rely on the building's design to effectively manage solar energy coming into contact with the building, solar energy technologies such as those used to heat water and generate electricity require additional equipment. Solar panels are the most recognised solar technology but depending on the system design and requirements, other electrical equipment such as fans, pumps or inverters could be required. Generally solar hot water seems to be the most common application of solar energy technology with photovoltaic solar panels used only when a low level of electricity is required such as in landscape lighting and electric street signs.

2.4 Barriers to Renewable Energy

Research into energy efficiency, green building and renewable energy technologies has highlighted a range of barriers to using renewable energy and implementing energy efficiency and green building practices in general. While these studies address green building or renewable energy as a whole, many of the barriers identified are applicable when specifically considering the use of solar energy in buildings.

The following three studies identify a diverse range of barriers that affect the use of renewable energy technologies and/or green building practices. These studies are particularly highlighted as they each consider the perspectives of stakeholders:

- Painuly (2001) identifies 40 barriers grouped in seven categories to using renewable energy technologies in developing countries.
- Cooke, Cripps, Irwin and Kolokotroni (2007) conducted 41 interviews with building industry stakeholders in the United Kingdom identifying 9 drivers and 15 barriers to the use of renewable energy technologies. The research determined that the six main barriers to the use of renewable energy technologies are 1) high capital costs and long payback times, 2) ignorance and a lack of understanding, 3) a perception of risk, 4) an unsuitable site, 5)

perception that renewable energy technologies are unproven and 6) incoherent policy and planning constraints.

- Chan, Qian, and Lam (2009) surveyed building designers in Hong Kong and Singapore seeking opinions on the drivers for and barriers against green building practices in Asia.

Models for understanding barriers can be useful for increasing awareness of the elements that influence stakeholder decisions however models of barriers are orientated toward emphasising actions that can be taken to overcome barriers and may fail to recognise solutions that require stopping a particular action or activity. The definition of barrier used by the Intergovernmental Panel on Climate Change (2007) outlines that a barrier is "*Any obstacle to reaching a goal, adaptation or mitigation potential that can be overcome or attenuated by a policy, programme, or measure*" (p.810). This definition also supports the idea that a barrier is an obstacle and reinforces that action is required to overcome a barrier, in this case as a policy, programme or measure. While this is not to say that barrier models are not useful, it is important to recognise this limitation and that the existence of a barrier does not necessarily justify action to overcome it. On the other hand an advantage of using a barrier model is that it brings together the usual focus on technical processes while also taking into account the social context of human behaviour, institutions and markets (Weber, 1997).

To further understanding of different barriers that influence the use of renewable energy, researchers have characterised barriers into a number of different categories. Although there is not one definitive list of barrier categories there are similarities in the work of different researchers. For the purposes of this research barriers are divided into the following six categories: financial and economic, institutional and regulatory, technical, market, awareness and information and behavioural. The categories and descriptions have been adapted from the work of Painuly who has undertaken substantial research into barriers to renewable energy (Painuly, 2001; Reddy and Painuly, 2004; Painuly, n.d). The six barrier categories are described in table 2.

While categorising barriers aids understanding it is important to recognise that successful implementation of renewable energy is dependent on the entire chain from first introductions, to development of legislation, through to market availability and finally to the end user (Flamos et al., 2008). The development of a market for renewable energy is often impaired by a range of both non-technical and technical barriers that are specific to the country or region (Flamos et al., 2008).

Table 2: Categories of barrier to the use of renewable energy

Barrier Category	Example
Financial and Economic	Inadequate financing arrangements, unfavourable costs, long payback periods, taxes, subsidies and energy prices.
Institutional and Regulatory	Limitations in institutional capacity such as research and development and implementation, limited or no regulations supporting implementation, lack of professional institutions.
Technical	Limited access to technology, inadequate availability of maintenance, poor quality product, lack of codes and standards.
Market	Small market size, limited private sector involvement, trade barriers such as import duties, missing market infrastructure.
Awareness and Information	Lack of awareness, little or no available information, limited training availability.
Behavioural	Lack of social acceptance, attitudes of stakeholders, consumer preferences such as aesthetics.

Painuly (2001) also states that specific barriers may only be applicable to a particular technology or geographical region. Cooke et al. (2007) outlines that barriers to renewable energy in buildings is site and situation specific and that *"this variation is due to a number of key factors such as project location, contract type, building type, the client type, client motivations, planning requirements and the technologies being considered" (*p.2324).

2.4.1 Financial and Economic Barriers

Financial barriers relate to initial costs, long payback periods and inadequate financing arrangements. These barriers are a reoccurring theme in studies relating to renewable energy with the initial cost of implementing technology often cited as a key barrier (Cooke et al., 2007). It is acknowledged that using renewable energy technologies in building projects will increase the initial cost of the project during both the construction and design phases which in turn increases the time it will take to see a return on investment.

Cooke et al (2007) outlines that cost is often the primary assessment tool used to determine whether renewable energy technologies are viable. Higher capital costs and long payback periods were identified as one of the primary barriers in their research (Cook et al., 2007). However it is also acknowledged that the cost of these technologies, particularly solar technologies, is coming down. Significant cost reductions for solar photovoltaic have been noted mainly due to economies of scale and technological advances. The initial high costs of solar energy technologies is due largely to a lack of market experience both in regards to the learning curve of suppliers and experience of the end user (Shum and Watanabe, 2009).

The degree to which cost implications are a barrier to renewable energy is influenced by any government financial incentives available to the project. These financial incentives improve the financial viability of using renewable energy technologies and therefore increase market diffusion (Taleb and Pitts, 2009).

The financial and economic barriers impacting the use of solar energy can be compounded by other types of barrier. Subsidies on the production of conventional energy are identified as a barrier as they directly impact the payback period of renewable energy technology and make it more difficult for these technologies to compete on cost. A perceived low cost of energy by the end consumer does not take into account the externalities of energy production such as environmental costs which are often not factored into the cost of electricity production (Flamos et al., 2008; Shum and Watanabe, 2009).

2.4.2 Institutional and Regulatory Barriers

Institutional and regulatory barriers relate to regulatory and policy instruments, building industry practices, rating and labelling standards and the role of professional bodies. Inconsistent policies are considered a barrier to the use of renewable energy (Cooke et al., 2007) and frequently the large number of government organisations involved in developing and regulating renewable energy creates a barrier due to a lack of coordination between various agencies (Flamos et al., 2008). This lack of coordination is often blamed for difficulties in obtaining permits and the long lead times required for projects (Flamos et al., 2008). Industry and professional bodies have a key role to play in encouraging the use of green building practices and renewable energy technologies.

2.4.3 Technical Barriers

There are a range of technical barriers associated with the performance of renewable energy technologies. Lack of experience in installing these technologies and the fact there is little information about performance over the long term makes the industry reluctant to incorporate renewable energy. There is also a perception that these technologies have variable output which is another barrier to their utilisation (Cooke et al., 2007). Project specific factors may also affect what can be used on a project and unsuitable project sites have also been identified as a barrier (Cooke et al., 2007). Climate is also a factor. A study into the potential of renewable energy in Ireland considered that the country is best suited to using solar for low temperature applications such as water and space heating as the generation of electricity requires direct sunlight which is intermittent and unpredictable in Ireland (Rouke, Boyle and Reynolds, 2009).

2.4.4 Market Barriers

Market barriers are those which create an impediment to renewable energy in the free market. Taxes on renewable energy technologies which reduce their competitiveness in the market place is one such barrier (Rouke et al., 2009). Grid connections and access not being fairly provided has also been identified as a barrier (Rouke et al., 2009). Owen (2006) points out that a small market for renewable energy in a particular location can create a barrier as economies of scale cannot be recognised. Additionally the market can be hampered by other forces such as established companies that impeding the use of renewable energy to protect their market position.

2.4.5 Awareness and Information Barriers

Previous studies have highlighted a lack of knowledge as a common barrier to the use of renewable energy (Cooke et al., 2007; Chan et al., 2009). This lack of knowledge includes both a lack of general awareness as well as a lack of formal education on utilising solar energy. The education of building design professionals is a required element for implementing renewable energy technology on a larger scale (Pitts, 1994).

Along with this general lack of knowledge, a further barrier is a lack of research and case studies on how renewable energy technologies perform under certain conditions (Chan et al., 2009). Flamos et al. (2008) mentions that many potential end users have no experience with these technologies and it can be difficult to obtain information on the success and failures of other projects. Past experience has shown that research has a considerable role to play in reducing the cost of renewable energy (Flamos et al., 2008).

A study by Taleb and Pitts (2009) into the use of building integrated photovoltaics in Gulf Cooperation Council countries shows that awareness varies between different stakeholder groups. The study found that home owners had little knowledge of environmental concerns and this lack of knowledge affects the potential of widespread diffusion of photovoltaic technologies in buildings. On the other hand, while the architects surveyed had a good knowledge of photovoltaics, most had not considered how the use of these would affect their architectural designs. Taleb and Pitts (2009) also found that academics who participated in the research did not consider cost or technical performance to be genuine barriers to the diffusion of photovoltaic technology but that public awareness and acceptance is the main barrier to diffusion.

2.4.6 Behavioural Barriers

The category of behavioural barriers includes barriers related to the social acceptance of renewable energy, attitudes of stakeholders and consumer preferences which influence demand.

The building industry in general perceives renewable energy technologies as high risk and unproven (Cook et al., 2007) and this perception, whether correct or not, is a barrier to the use of renewable energy. The concern that the use of renewable energy technologies will increase the complexity of the project is also a barrier (Voss, 2000; Cooke et al., 2007)

Previous studies have identified a lack of demand for renewable energy technologies from investors and consumers as a barrier as clients are the key stakeholders in decision making (Chan et al., 2009; United Nations Environment Programme, 2007). In Cooke et al. (2007) 35 of the 41 participants mentioned the importance of the client and their background with the implication that it is the client who makes the decision whether to use renewable energy. The lack of demand for renewable energy may be due to a general lack of education and awareness about renewable energy technologies or a lack of acceptance of renewable energy products.

Shove (1998) considers stakeholder perceptions and the characteristics of the project influence the choice of technology for a building development as choosing technology is a social and highly contextual process. To identify any gaps between existing policies and stakeholder perceptions, effective participatory processes are required to determine stakeholder views (Painuly, 2001).

2.4.7 Known Barriers to Renewable Energy in Thailand

As mentioned, barriers to the use of renewable energy are situation specific. In considering the situation in Thailand researchers note the influence of a number of barrier categories. Uddin et al. (2010) identified lack of policy mechanisms, institutional development and financing as major barriers to renewable energy in Thailand.

Technical barriers in Thailand relate to an absence of skilled manpower and efficient renewable energy technologies, while financial and economic barriers include the high cost per unit of electricity generated using renewable sources (Sawangphol and Pharino, 2011). Sawangphol and Pharino (2011) consider the government needs to support Thailand's solar industry and expand research and development.

Awareness and information barriers in Thailand include dissemination of knowledge on Thailand's renewable energy programs. It is considered that knowledge dissemination is lacking as it requires coordination from the many different government agencies involved in energy policies (Uddin et al., 2010).

2.4.8 Importance of Stakeholders in Identifying Barriers

The important role of stakeholders both in defining barriers to the diffusion of a new technology and in developing ways to overcome these barriers has been well noted in previous research (Cook et al., 2007; Shove, 1998; Painuly and Reddy, 2004). Stakeholders can be defined as "*individuals, groups, institutions and companies that have something at stake."* (Boldt, Nygaard, Hansen and Trærup, 2012, p.42) and the importance of their perspectives is well recognised with research being undertaken into how specific compositions of stakeholders influence technology transfer. Shove (1998) considers that innovation depends on the actions of individuals while Morsink, Hofman and Lovett (2011) concentrate on the influence of multi-stakeholder partnerships where groups of stakeholders work in collaboration.

Boldt et al. (2011) also consider that stakeholders have roles both as individuals and as group members commenting that *"stakeholders have an interest in a particular decision, either as individuals or as representatives of a group. This includes those who influence a decision, or can influence it, as well as those affected by it."* (p.42). Given the influence stakeholders have in the diffusion process, stakeholders themselves have been identified as a barrier to the diffusion of new technology (Boldt et al., 2012) and to the diffusion of renewable energy technologies in particular (Cooke et al., 2007). While innovation theory recognizes that the characteristics of individuals directly influences how quickly they will adopt a new innovation (Rogers, 2003).

The perspectives of stakeholders are not static, however, and will develop as they gain further information (Collantes, 2007). For this reason it is recommended that stakeholder analysis is not just conducted in the initial stages of technology transfer but reviewed as necessary throughout the process (Boldt et al., 2012).

The importance of stakeholder views in identifying both barriers and policy measures that can be used to overcome them; as well as in daily decision making around the diffusion of a new technology means that stakeholder perspectives are a vital component of understanding the adoption of a new technology.

2.5 Diffusion of Renewable Energy Technology

For new technology to move away from where it is developed and be adopted on a wider scale, there needs to be a transfer of not only the technology but also the knowledge needed to successfully implement the technology.

The concept of technology transfer refers to the transfer of skills, knowledge and equipment from individuals and organisations within a region or from one region to another (Wilkins, 2002). Research has been undertaken into how the process of technology transfer occurs and the most well known theory on technology transfer is the diffusion of innovation theory developed by Everett Rogers. Rogers (2003) considered that the greater our understanding of technology transfer, the greater our ability to influence change in whether a technology is used.

Rogers (2003) defined diffusion as "*the process by which an innovation is communicated through certain channels over time among the members of a social system" (*p.5), with four main factors affecting diffusion: the innovation, time, communication channels and social system. In order for technology transfer to be successful it must also include shared knowledge and the ability to adapt technology for local conditions (van Alphen, Hekkert and van Sark, 2008).

The time aspect of innovation theory considers the process each individual has to work through in order to consider whether to adopt an innovation. Rogers (2003) outlines the following five stage process:

1. Knowledge: person becomes aware of an innovation and has some idea of how it functions;
2. Persuasion: person forms a favourable or unfavourable attitude toward the innovation;

3. Decision: Person engages in activities that lead to a choice to adopt or reject the innovation;
4. Implementation: person puts an innovation into use;
5. Confirmation: person evaluates the results of an innovation decision already made.

The social system in which the technology is being introduced will also influence how quickly the technology is adopted. Carlson (2007) points out that the ideology of a culture will determine how a technology is adopted and whether the technology will be used to pursue material abundance, social order or cultural meaning. While Western cultures generally emphasise using technology to develop material abundance, other cultures may have different priorities as to whether the primary goal of adopting a new technology is meaning, order or abundance (Carlson, 2007). Carlson (2007) also points out that many people like to own technological devices, not just for the convenience they add to daily life but also for the image they portray about the person who owns them.

While the diffusion of innovation theory outlines key factors in the technology transfer process, the actual process undertaken for any technology will be individual to the precise situation including any linguistic and cultural differences that exist (Coppola, 2007). Cross cultural factors are significant in technology transfer (Scheraga, Tellis and Tucker, 2000) and influences both the social system and the effectiveness of communication channels.

Studies into technology transfer show a range of barriers that impact on the transfer of technology (Painuly, 2001; Coppola, 2007). These studies generally consider that barriers can be technical, regulatory or human in nature which is similar to the barrier categories discussed in the previous section.

2.6 Innovation in a Project Orientated Environment

Jones and Alony (2011) comment that it is recognised that the fragmented nature of project based activities, such as film making or construction, makes it more difficult to successfully transfer knowledge, however, they also note that relatively little research into knowledge transfer in project based environments has been undertaken.

The building industry is unique in that a construction project relies on the input of other firms and often subcontractors have less understanding of innovations in the industry (Aouad, Ozorhon and Abbott, 2010). The majority of innovation in construction takes place on a project level and may not be easily recognisable (Aouad et al., 2010).

The one off nature of construction projects causes discontinuities of knowledge (Blayse and Manley, 2004) as changes in personnel and information occur from project to project. Aside from the project by project nature of construction, the difficulty of knowledge transfer is further increased through the division of different professional occupations each with its own knowledge base and language (Bresnen, Edelman, Newell, Scarbrough and Swan, 2003).

3. Methodology

3.1 Introduction

To reiterate briefly, this research examines stakeholder perceptions to the use of solar energy in buildings in Thailand. In particular the research endeavours to explain what stakeholders perceive to be the barriers to using solar energy in buildings and how these perceptions influence stakeholder decisions.

As research areas, the fields of renewable energy and green building practices are growing and a range of research has already been undertaken into various aspects. However much of the previous research has focused on the technical and financial elements of using renewable energy with less research being undertaken on the social and cultural elements such as the perceptions of stakeholders. Prior research that has been undertaken focuses on other geographical areas and there is little information available regarding the perceptions of stakeholders to renewable energy in Thailand. Therefore the degree to which barriers identified in other research are applicable to Thailand is unknown.

For this research the challenge was to choose a methodology which would allow investigation in an area not previously researched while still determining whether barriers to renewable energy identified in green building and renewable energy research are applicable to Thailand.

3.2 Research Methods

A number of factors influence the choice of research methodology, primarily the research topic and the specific research objectives (Remenyi, Williams, Money and Swartz, 1998). Each research methodology, whether it is quantitative or qualitative, has advantages and disadvantages. In qualitative research the complexity of data collection and analysis is often mentioned as a disadvantage while quantitative research is considered to allow large data collection at reasonable cost (Amaratunga, Baldry, Sarshar and Newton, 2002). However qualitative research can be used to make sense of the meanings people place on the process and structures of their lives (Amaratunga et al., 2002) which is not possible using quantitative research methods.

There are differing opinions on whether qualitative and quantitative research can be successfully combined. Some consider that combining two methodologies provides for stronger research as it provides different ways to view elements of the same phenomenon, while others argue that research should be limited to a single methodology due to the need to limit the scope of the research (Johnson and Onwuegbuzie, 2004). Although practical limitations of time constraints and cost of data collection do influence the choice of methodology, the definitive factor is whether the research methodology selected is the most appropriate to answer the research question. Researchers that are not purely orientated toward either the qualitative or quantitative research paradigm have the option of mixing components of the research design in such a way as to provide the best chance of answering the research question (Johnson and Onwuegbuzie, 2004).

This research used a mixed methodology approach as it was the most effective way to uncover a broad range of participant viewpoints within a short timeframe. The qualitative methodology of grounded theory was used as the primary methodology as it enabled research participants to have input into the direction of the interview which was a vital component of identifying the key issues for stakeholders. However in order to find out if other commonly identified barriers to the use of renewable energy was important to Thailand stakeholders, a survey using a Likert scale response format was given to each research participant at the end of the interview. The survey asked participants to agree or disagree with twenty statements regarding barriers to solar energy whether these topics had been discussed during the interview or not.

One advantage of using mixed research methods is increasing validity through triangulation which involves collaborating participant's perceptions regarding the same topic using the quantitative and qualitative research methodologies (Rocco, Bliss, Gallagher and Perez-Prado, 2003). The idea is that by combining two methodologies to study the same phenomenon the weaknesses of each methodology can be overcome (Amaratunga et al., 2002). In this research, some topics were covered in both the interview and survey making it possible to compare participant views between the two methods.

3.2.1 Grounded Theory

Grounded theory is a qualitative research methodology with the primary aim of generating theory (Strauss and Corbin, 1990) that is grounded in the words, actions and behaviour of those being studied (Goulding, 1999). The methodology was initially created in 1967 by Barney Glaser and Anheim Strauss as a path between the quantitative research studies at one end of the spectrum and qualitative research at the other (Dey, 1999). However in time Glaser and Strauss developed different ideas on how grounded theory research should be conducted and they each individually expanded on the original model of grounded theory taking the methodology in different directions.

Glaser's' work emphasises induction in grounded theory research where empirical generalisation is developed out of the data and the researcher works to limit the impact of literature and prior knowledge (Heath and Cowley, 2004) to avoid preconceived ideas that are not grounded in the data from entering the research. In contrast, the approach by Strauss and Corbin uses both induction and deduction where the data is interrogated in an inductive approach as emphasised by Glaser but also deductive questions are asked of the data using a paradigm model (Heath and Cowley, 2004). However Stauss and Corbin (1990) still emphasise that ideas obtained through deductive reasoning have to be verified against the data. This difference in the coding paradigm is one of the major differences between the two versions of grounded theory (Ng and Hase, 2008).

Grounded theory was created within the discipline of sociology which influenced how the methodology developed, however it has now been utilised in a broad range of disciplines such as education, nursing, psychology, information technology and management (Goulding, 2002). The use of grounded theory in a wider range of disciplines has required variations to the methodology to relate it to the specifics of the area under study (Goulding, 2002) which are not always harmonious with the original principals of grounded theory (Goulding, 1999). Strauss and Corbin (1990) consider that this does not mean altering the central elements of the methodology but rather that additional ideas and concepts are being introduced analytically into grounded theory studies.

While different schools of thought vary in the components of a grounded theory study, the overall premise of grounded theory methodology to let theory emerge from the data rather than forcing the data into preconceived ideas is the same (Ng and Hase, 2008). The need for the researcher to avoid introducing preconceived ideas into the research has led many to think that the researcher must start the research with limited prior knowledge (Goulding, 2002) however both Glaser and Strauss recognise that prior knowledge is important for sensitising the researcher to the significance of emerging concepts (Goulding, 1999).

Generally in qualitative research the literature is used to provide an overview of the research area. By reviewing the literature it is possible to determine the gaps in existing knowledge and use this to guide the research focus (Strauss and Corbin, 1990). In grounded theory however, there are opposing views on the role of literature and little agreement on the extent and depth of any literature review (Ng and Hase, 2008). On one hand it is acknowledged that the researcher must have some prior knowledge of the area being studied in order to give meaning to the data through the creation of theoretical codes (Strauss and Corbin, 1990). However Strauss and Corbin (1990) also outline that being too immersed in literature can create preconceived ideas in the researcher and constrain their ability to view all aspects of the data. Given this, some theorists advocate delaying the literature review until after data collection to avoid imposing preconceived ideas on the research (Charmaz, 2006).

The influence of the researcher on the research project must be accepted. Charmaz (2006) considers that the influence of the researcher's prior knowledge and experience should be openly acknowledged. The theoretical sensitivity of a researcher describes the researcher's insight into their own research approach, the topic being studied and the theories they are familiar with (Birks and Mills, 2011).

Grounded theory methodology was chosen for this research as the topic of stakeholder perceived barriers to the use of solar energy has not been fully explored in Thailand. The use of grounded theory allowed an exploratory view of the topic where the views of the research participants could take precedence without being constrained by existing theories. An initial review of the literature was conducted before data collection. This was partially due to the requirements of the research proposal required by Massey University and the need to justify the importance of the research before starting. The preliminary literature review also played a role in choosing grounded theory methodology. While existing literature outlines incentives and barriers to green building practices and use of renewable technologies, there is a gap in understanding the attitudes of building industry stakeholders who are making business decisions regarding the use of solar energy in buildings. The initial literature review determined that the existing conceptual framework was not sufficient to understand the attitudes of those implementing the technologies.

3.2.2 Likert Scale Survey

Likert scale response surveys where respondents rate themselves on a rating scale is a commonly used methodology for measuring the attitudes of research participants (Jamieson, 2004). In this research a Likert scale survey was used in conjunction with the qualitative data collected through interviews as it ensured the researcher could gather opinions on commonly identified barriers to renewable energy that may or may not be discussed during the interviews. The survey instrument is shown in appendix two.

The Likert scale was chosen due to its familiar format and the likelihood it would be recognisable to the different nationalities participating in the research. However Painuly (2001) considers some precautions are necessary when using questionnaires to elicit stakeholder opinions on measures to overcome barriers to renewable energy. These precautions are (Painuly, 2001):

- Designing suitable questions for each category of stakeholders;
- Enabling stakeholders to provide additional barriers and measures to overcome them;
- Have a provision for gathering stakeholder opinions beyond the structured questions.

While in this research the questionnaire design was not changed for each stakeholder group, more scope was available in the individual interviews undertaken before participants were given the survey. During the interview, research participants had the opportunity to provide additional information and opinions on solar energy without being influenced by the questionnaire.

The questions in the survey were formulated from barriers identified during the literature review and from informal discussions with people in the Thailand building industry. Each of the 20 questions focused on a different barrier to the use of solar energy. The questionnaire was written in both English and Thai so both languages were available for all participants regardless of nationality.

The Likert scale survey used a seven point scale from completely agree to completely disagree with a neutral midpoint. According to Johns (2010) research shows that Likert scales are less accurate if the number of points on the scale goes above seven or drops below five but that the studies do not provide any reason for preferring either a five or seven point scale. The neural midpoint on the survey means participants did not have to choose a position of agreement or disagreement if they did not feel strongly either way (Johns, 2010).

3.3 Data Collection

The use of two methodologies meant there were two distinct activities that participants undertook. The primary form of data collection was through interviews with the participants. Twenty six interviews were undertaken one on one between the researcher and participant and a further two interviews involved two participants being interviewed in pairs. Twenty nine of the research participants were interviewed face to face while one participant was interviewed via a telephone conversation on Skype. At the end of each interview the participants were asked to complete a twenty question survey asking them to agree or disagree with statements regarding specific barriers to the use of solar energy.

Data collection is a vital component of any research project as the quality of the research is directly dependent on the data collected (Mavetera and Kroeze, 2009). Interviews are a common data collection method in qualitative research as it is an extremely flexible method that can generate a great depth of data (King, 1994). King (1994) outlines that interviews are particularly appropriate when the research focuses on the meanings participants attach to a particular phenomenon. Interviewing is particularly suited to grounded theory as it is both open ended and directed (Charmaz, 2006) with the researcher determining how strictly the interview follows predefined questions. Goulding (1999) considers that researchers should not be too strict with their data collection methods and that the use of a predetermined set of questions defeats the objective of obtaining data from the participant's point of view. However as research participants often want some indication of what the interview will entail and unstructured interviews can quickly become unwieldy, a balance needs to be found between keeping the interview focused while still enabling participants to share their experiences and point of view (Goulding, 1999).

To ensure common themes were addressed by research participants, the interviews were semi structured with a core set of questions being asked of all participants. However the interview questions were open ended which made it possible for participants to introduce their own issues during the interview. The grounded theory methodology allowed variations in interview questions to follow up on particular key points.

3.3.1 Sampling Procedure

Grounded theory methodology differs from conventional research in that data collection and analysis is undertaken concurrently and as a result sample selection in grounded theory differs from representational sampling commonly used in qualitative research. Dey (1999) states that the criterion for sample selection in grounded theory are determined by the concepts being investigated. This theoretical sampling means further empirical enquiry is made after some data has been collected and initial ideas about that data are formed (Charmaz, 2006). These enquiries continue until theoretical saturation occurs which is when no new properties, categories or relationships emerge from the data (Dey, 1999).

For this research the initial research participants were identified by the researcher's prior knowledge of the building industry. The six initial interviews were undertaken in Phuket and included two Thai and four expatriate participants who, aside from completing the interview and survey, also provided feedback on the research questions and process. Once these interviews were completed it was necessary to determine if the information showing in the data analysis was the same in other locations in Thailand and a further seven interviews were conducted in Bangkok. At this stage five occupational groups had been interviewed. The next ten interviews sought to broaden the range of stakeholders and included two Developers and an Environmental Consultant, which were occupational groups that had not previously been included in the research. By now clear themes were emerging in the data and the last seven interviews aimed to extend the range of participants including a further two occupational groups not previously included. As no new themes were emerging, data collection was stopped after thirty interviews.

Research participants were initially approached by email with an information sheet that outlined the purpose of the research and explaining that the interview could be conducted in English or Thai. Once the person had indicated they were willing to participate, interview times were arranged by email or telephone. At the time of the interview each participant completed a consent form and was asked if the interview could be recorded to which twenty seven of the thirty participants agreed. None of the participants requested an interpreter and all interviews were conducted in English. The information sheet, consent form and survey form were written in both Thai and English.

3.4 Data Analysis

The research data consisted of interview recordings and notes as well as a completed survey form for each of the 30 participants. Of the 30 interviews, 27 were recorded and fully transcribed. In some cases notes were also taken if conversation relevant to the research was made when the recorder was not on. Three interviews were not recorded at the request of the participants and handwritten notes were taken and analysed.

The analysis of data in grounded theory adopts a constant comparative approach where data items are continually compared against each other for similarities and differences (Ng and Hase, 2008). This comparison occurs until the emergence of a core concept that explains most of the variations in the data (Ng and Hase, 2008). In order to obtain this core concept data is coded through a number of stages. Differences in the Glaser and Strauss schools of thought are evident in the coding of data with Glaser arguing that the theory should only relate to the phenomena under study while Strauss advocates the use of coding matrixes to conceptualise the researcher beyond what is immediately being studied (Goulding, 1999). This research follows the approach of Strauss and Corbin (1990) where the second stage of coding follows a paradigm model and consideration was given to the coding matrix. This approach was chosen as the greater level of structure helped guide the researcher to review the data systematically.

Stages of Coding

The first stage of coding, called open coding, involves the initial identification of concepts in the data. At this stage the notes and transcripts from the interviews were analysed sentence by sentence to determine the concepts that could describe each piece of data. Goulding (1999) defines this stage of the process as *"breaking down the data, most commonly interviews and, or, observations, into distinct units of meaning which are labelled to generate concepts"* (p.17).

The second stage of coding is axial coding where connections are made between concepts and categories in the data start to emerge. Also in this stage relationships between the concepts are identified and categories are related to subcategories. In following the methodology of Strauss and Corbin (1990), axial coding followed the paradigm model to ensure all elements of the data were considered.

The third stage of coding is called selective coding where the core category from the research emerges (Dey, 1999). It is in this stage that categories are integrated into the emerging theory. As the core concept emerged, selective coding was undertaken to review the data for any additional instances of the core concept that may have been coded under different categories in the previous stages of coding.

The coding of data was made easier by the use of computer assisted qualitative data analysis software which in this case was QSR*NVIVO version 8. The software was used to mark codes on the interview transcripts and keep track of concepts as they were discovered, however the decision to assign a particular concept to particular data was a manual decision made by the researcher and not a task automatically undertaken by computer.

Memo Writing

Memo writing is a key concept in grounded theory methodology. As categories are discovered through the coding process, memos are used to record details about categories and the properties that relate to the category (Charmaz, 2006). This is the intermediate stage between coding the data and the writing the theoretical analysis. In this research memos were used to track concepts as they emerged from the data and trace relationships between concepts as they developed.

Likert Survey

Each of the 30 participants completed the survey at the end of the interview. While in itself the sample size is too small to generate statistical results with a meaningful confidence level, the survey fulfilled its purpose by addressing barriers not covered in the interview and in some cases providing comparison with statements made during the interviews.

There are differing points of view as to whether a Likert response format can be considered to produce ordinal or interval data (Jamieson, 2004) however for this research the data is considered ordinal as with different cultures completing the survey it is difficult to determine whether the elements on the scale of slightly, mostly and completely represent equal intervals. Given the small sample, analysis of the survey results has been limited to descriptive statistics created using Microsoft Excel. The data generated from the survey was also compared to the participant’s interview responses.

As the use of solar energy in the building industry is not just a theoretical concept but requires practical application in the real world the aim of the data analysis and subsequent results is to provide information that can be used in real business decisions. The value of any conceptual framework is in how it can aid our understanding of the real world (Maylor and Blackmon, 2005).

3.5 Methodological Limitations

Validity and reliability are principal concerns of any research design. The validity of a study considers how well the research answer fits the question being asked (Amaratunga et al., 2002). Internal validity refers to whether the research has identified the correct cause and effect relationships and external validity considers whether the research findings can be generalised beyond the sample or setting in which the research took place (Amaratunga et al., 2002). The concept of reliability refers to whether the same test or procedures will produce similar results as to what was produced by the research (Amaratunga et al., 2002). Essentially reliability asks whether the procedures used minimised errors and bias to a sufficient degree that another researcher could repeat the research and obtain similar results.

There are number of ways in which bias can influence the outcome of research which will affect both the validity and reliability of the research. Central tendency bias where interview respondents avoid extreme response categories, acquiescence bias where respondents are likely to agree with a statement and social desirability bias where respondents choose answers to show themselves more favourably are all known to occur with Likert scales (Johns, 2010).

The collection of data through interviews and the participant's responses to a Likert scale survey were heavily dependent on language. The interviews were conducted in English although participants were given the option of having a translator present when the interview was arranged. The survey instrument was presented in both English and Thai. Cultural conditions determine how language is used and different cultures use words and explanations differently according to the understanding within that cultural group (Goulding, 2002). As a number of different cultures where involved in this research it is possible subtle differences in word use and interpretation have influenced the findings of the research and possibly affected future repeatability of the research.

3.6 Logistical Issues

This research project was undertaken by a single researcher which meant there were limited time and resources available to complete the research. In particular the following two logistical issues impacted on the research:

Geographical limitations: Research interviews were conducted face to face with participants in Phuket and Bangkok and one interview was conducted by Skype with a participant from Chiang Mai. The research would have benefited in having participants from a greater geographical area within Thailand.

Recording and Transcribing: Due to the need to find a mutually convenient meeting point, a number of interviews were conducted in public places such as cafes which influenced the quality of the audio recording. Also the time needed to transcribe all the interviews limited the number of interviews that could be undertaken in the timeframe available.

3.7 Research Ethics

Massey University requires all research to be assessed for potential risks to the researcher, general public or the University. This research project was deemed low risk as any harm would be minimal and no more than encountered in daily life and the appropriate low risk notification was given by the Massey University Research Ethics Committee.

The information sheet sent to individuals when they were asked to participate in the research outlined participant rights and Ethics Committee approval in the format recommended by Massey University. This information was provided in both Thai and English. All information pertaining to research has been treated confidentially.

4. Findings

The findings from analysis of the interview transcripts and survey are presented in this chapter. The chapter outlines the demographics of research participants and explains the key themes that arose from analysis of the interview transcripts. It then shows the findings from the survey conducted at the end of each interview.

The five sections are:

- Demographics, awareness and experience: The demographics of the research participants and their prior experience of solar energy.
- Barriers: The barriers to the use of solar energy in buildings in Thailand as perceived by building industry stakeholders.
- Roles: The various stakeholder groups in the building industry identified by participants and how they are perceived as influencing the use of solar energy.
- Drivers and future outlook: The drivers for considering solar energy and what research participants consider is the future outlook for solar energy in buildings in Thailand.
- Survey results: An overview of the results of the twenty question Likert scale survey.

4.1 Demographics

A total of 30 people involved in the building industry in Thailand were interviewed and completed a Likert scale survey on barriers to solar energy (see appendix one for participant list). The people interviewed are from nine different stakeholder groups related to the building industry. Eleven of those interviewed are Thai nationals while 19 are expatriates. Figure 3 shows the stakeholder groups of those interviewed.

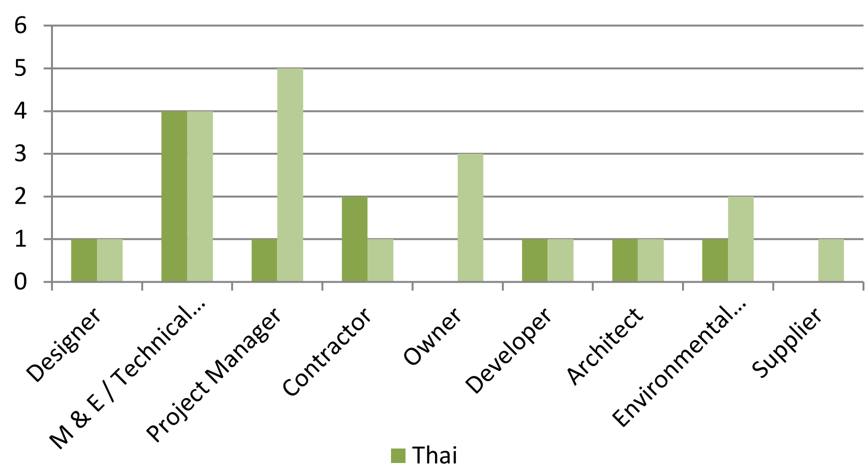

Figure 3: Research participants by stakeholder group

The 30 participants have been involved in the building industry for different lengths of time. The majority of participants (36.7%) have been involved in the industry for between 5 and 14 years. A further 33.3 percent of participants have been involved in the industry for 25 years or more. The duration each participant has been involved with the building industry is shown in table 3.

Table 3: Participants length of time in building industry by stakeholder group

	Less than 5 Years	5 to 14 Years	15 to 25 Years	25 Years or More
M & E / Technical Consultant		4	3	1
Designer		1		
Project Manager		1	1	4
Contractor			1	2
Owner		2		1
Developer		1		1
Architect		1		1
Environmental Consultant	2	1		
Supplier	1			
Total	**3**	**11**	**5**	**10**

N.B. n=29. Length of time in industry is unknown for one participant.

Not all of the participants have had direct experience of either passive solar design strategies or solar energy technologies. Many of the participants required an explanation of what was meant by passive solar design. While 56.7 percent of the participants were aware of some passive solar design strategies, most did not consider elements such as glazing, orientation and thermal mass as elements of passive solar design. Once participants understood what is considered passive use of solar energy, 33.3 percent realised they had considered or implemented passive solar energy strategies such as window films and glazing options.

Participants were more familiar with the use of solar energy technologies with 90 percent of participants stating they are aware of these. Thirty percent of participants have had experience with solar hot water systems; however none of the people interviewed have experience with photovoltaic cells. Figure 4 shows a comparison of the number of participants with awareness and experience of either passive solar design strategies or solar energy technologies.

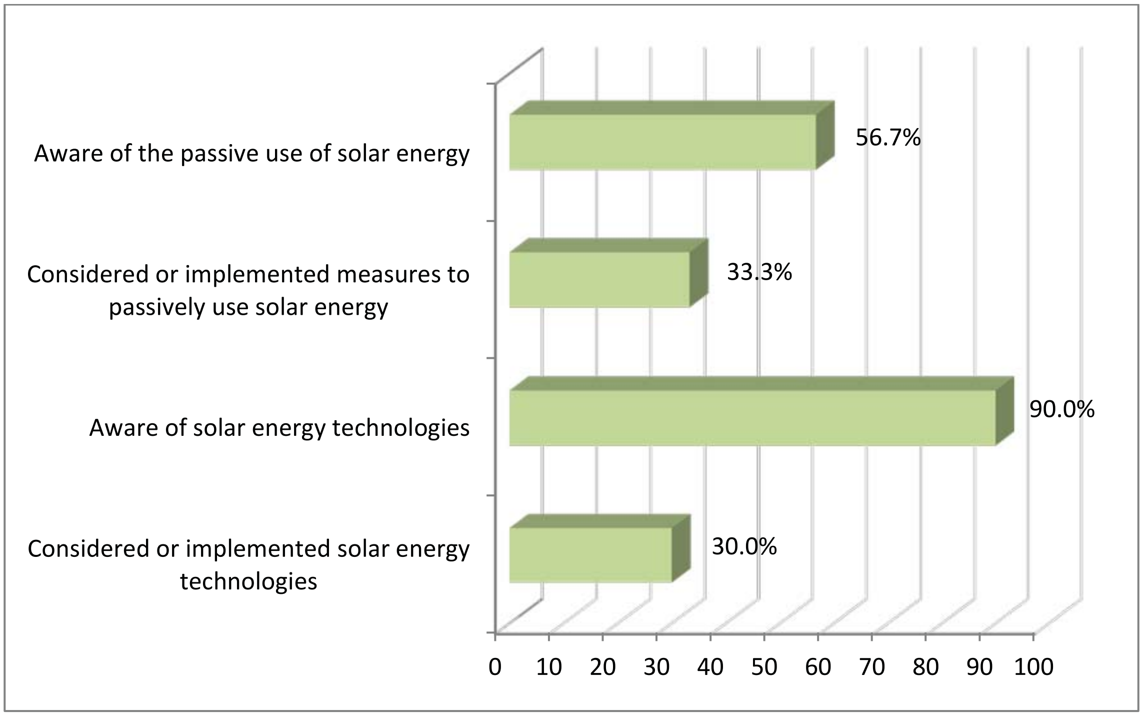

Figure 4: Number of participants with awareness and/or experience of passive solar design strategies or solar energy technologies

4.2 Key Themes from the Interviews

This section explains the key themes that arose during analysis of the interview transcripts. Each transcript was analysed line by line and coded in the three stages of open, axial and selected coding. In the initial stage of open coding, hundreds of concepts were identified in the data. This was followed by axial coding where connections between the concepts were identified. During this stage the key themes from the interviews were identified as the barriers to solar energy, the role of building industry stakeholders in relation to solar energy and the drivers and future outlook for solar energy in buildings in Thailand. Also during the second stage of coding it was discovered that the barriers identified by participants could be classified under the barrier categories described in chapter 2. These barrier categories have been used to divide the research results to aid understanding.

4.2.1 Barriers to the Use of Solar Energy in Buildings

During the interviews participants identified a range of barriers that building industry stakeholders in Thailand are aware of and which influence project decisions.

Financial and Economic Barriers

Financial and economic barriers include any barrier that increases the cost of using solar energy and therefore making the use of solar energy financially unfavourable. The interview participants outlined a number of ways in which cost influences the use of solar energy in buildings. The four financial and economic barriers identified in the interviews are:

- Cost of solar energy in buildings;
- Payback periods and return on investment;
- Responsibility for ongoing cost;
- Availability of financial instruments.

The percentage of participants who identified each barrier is shown in figure 5.

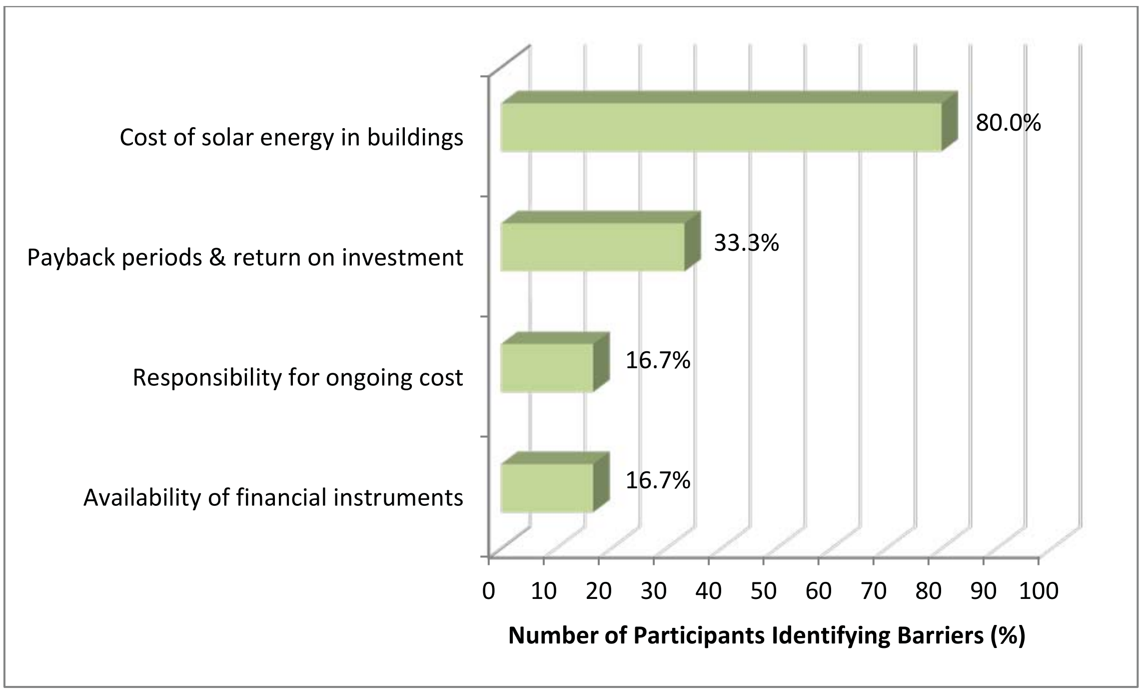

Figure 5: Percentage of participants identifying financial and economic barriers

<u>Cost of Solar Energy</u>

The barrier cost of solar energy includes statements participants made about the initial cost of solar energy as well as general comments about cost. Twenty four of the 30 participants (80%) made general comments about either the cost of solar energy or the initial costs of solar energy which are coded in this category, such as:

> *"Again most, I tend to think of the cost as being the big issue. All these things are great ideas but they all cost money unfortunately to implement it at the outset."* – Owner #1

> *"Upfront costs is the only barrier"* – Environmental Consultant #3

As well as mentioning cost as a barrier, some participants went on to explain why it is a barrier. Two of the participants noted that developers are looking to sell their developments as quickly as possible and the increased cost of installing solar energy would make the project less competitive. They consider that in the current economic climate, people are focusing on the lower end of the market and the use of solar energy would add to the cost of the development:

> *"They, what you call the development, they need is low cost otherwise they have other competitors, if they feel everything in the cost will be high then the cost higher than other competitors, they cannot sell it."* – Project Manager #5

Three participants mentioned that the cost of solar energy compared with traditional electricity generation is another consideration and people are not willing to pay more unless there is a clear advantage.

> *"If you've got a product A and a product B that look the same, do the same, sing the same songs and one is cheaper than the other, 99% will go to that product, that's just a fact of the world…"* – Owner #1.

On the other hand three participants considered that the initial cost of solar energy will come down as technology improves:

> *"I can see the price come down because more, you know, new technologies going to be introduced and things like that, and I can see it becoming a much more affordable if you like to the average household in maybe another 10 years or something like that."* – Project Manager #2

> *"But what's happened recently in the last few years is that the cost of the technologies has come down and the information implantation of them has been more accessible, there's more products on the market for competition, photovoltaics is cheaper."* – Environmental Consultant #1

Payback Periods and Return on Investment

Ten participants (33.3%) specifically made reference to the amount of time it takes for any initial outlay on solar energy to be recouped. They consider that return on investment is a barrier and that payback periods are too long:

> *"The property we have, we rent it out as well so anything that's invested into the property has got to be worthwhile and add value to the property."* – Owner #1

> *"… you make that up on savings on energy costs in the long run but when you tell a developer it costs that much up front but takes another*

five or eight years to recover that initial cost, they're not too keen on it right" – M&E / Technical Consultant #1

One participant commented that the payback periods on the initial cost of solar energy need to be guaranteed however the supplier who was interviewed highlighted that payback periods cannot be guaranteed as nobody knows what the price of electricity will be in Thailand in the next 20 to 25 years or what the weather will be, which affects the efficiency of the system:

> *"Mainly every time I talk with the customer truly in all the world nobody know when because for two main matter. First is nobody know in the next 20 – 25 years what about the price of the energy. So how can I say to you okay today in Thailand we pay 4 baht per unit but in the next 10, 20, 25 years this timeline of one solar system, how much the Thai government will charge for one unit. So we cannot, we don't know. The second reason is how we know about the weather in the next 20 – 25 years. Will it be more cloudy, more sunny, this make the efficiency of the system completely different, the system can work at 10, 20, 30 percent higher efficiency or 10, 20, 30, 50 percent lower efficiency so how can calculate now."* – Supplier #1

Six participants (20%) indicated that a payback period between four to six years is acceptable. One participant considered seven to eight years acceptable and another thought five to ten years was an acceptable payback period:

> *"So the payback period maybe around 10 to 15 years in future but still long. Somebody the private sector they look for maybe 5 years payback period so 10 to 15 is too long."* – M&E / Technical Consultant #3

> *"You probably want a payback period of 7-8 years, if you're in a hotel for example, you're in theory going to gut the interior and redo all the interior and upgrade the hotel after 7 years, theoretical norm. So if it is going to pay back over 15 years what's the point."* – Project Manager #1

One participant commented that many villas in Thailand are holiday homes and that if payback periods of solar energy are calculated on the time the villa is occupied, it will not be cost effective:

> *"If you're only using the villa part time during the year, the returns on, are much much less than full occupation so the numbers get a bit skewed by, depending on how they're done. If you assume that the villas were occupied and do your calculations that way, your payback period will be you know moderately reasonable. If you were to try and work out on the basis of real occupation it wouldn't, probably wouldn't even stack up."* – Project Manager #6

Responsibility for Ongoing Costs

The responsibility for ongoing costs was also considered to be a barrier to solar energy; however participants perceive different ways in which ongoing costs are a barrier:

- People don't fully understand how ongoing costs will be reduced by installing solar energy;
- Many developments are built to be sold immediately and therefore the developer does not get the benefit of reduced running costs and is unlikely to recoup the additional cost of solar energy in the sale price;
- Potential future maintenance costs are a barrier to using solar energy.

Availability of Financial Instruments

Five participants (16.7%) mentioned a need for financial instruments to encourage the use of solar energy. Three participants were concerned about the adder rates for buying back solar energy being reduced:

> *"Number 1 is the whole craziness that was just done with the adder rates, where the adder rates were reduced for solar and basically eliminated for wind and every other sort of renewable energy, it needs to be really looked at long and hard by the Government."* – Environmental Consultant #3

Institutional and Regulatory Barriers

Institutional and regulatory barriers are those that affect the ability of institutions or organisations to implement solar energy. This includes limitations in research and development, limitations in implementation, limited or no regulations and a lack of professional institutions.

The participants mentioned two areas where institutional and regulatory barriers affect the use of solar energy in Thailand. These barriers are limitations of the building design process and a lack of standards and laws applicable throughout the country. As shown in figure 6, 40 percent of participants commented that limitations in the building design process are a barrier but only 6.7 percent of participants identified a lack of standards and laws as a barrier.

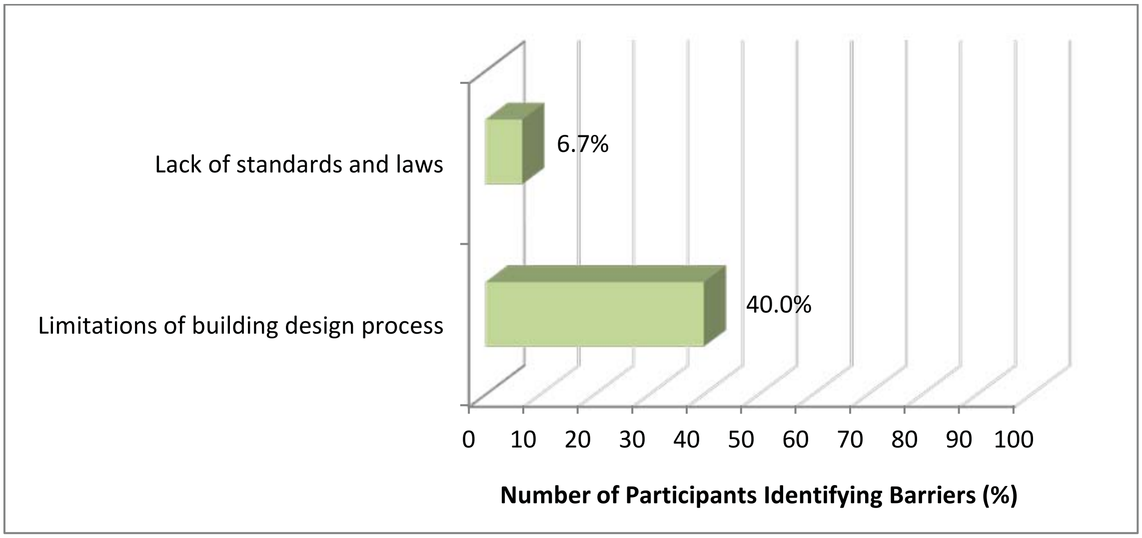

Figure 6: Percentage of participants identifying institutional and regulatory barriers

Participants identified the following eight elements as components of these two barriers:

<u>Limitations of the building design process:</u>

- Solar energy needs to be considered in the initial stages of a project and early consideration should mean that it does not make the project more complex;
- A more detailed design process would save costs later on;
- Foreign architects cannot sign off on a design in Thailand. A Thai architect has to give the final sign off;
- Opinions of mechanical and electrical professionals are not given as much weight as those of the architect and developer;
- Mechanical and electrical professionals need to be brought onboard in the initial design stages and often this does not happen;
- Building modelling is not a common practice partially due the rush to get to construction and partially due to cost.

<u>Lack of standards and laws:</u>

- Standards and regulations in Thailand are old school and more work needs to be done in this area;
- Laws are not applied consistently in all circumstances.

Participants believe that for solar energy to be incorporated in a project it has to be considered in the initial stages with comments made by 23.3 percent of participants indicating that how early in the project energy efficiency is considered influences the likelihood of energy efficiency measures being incorporated into a project:

> *"Yeah, they need to be saying at that particular point way back in the very beginning I want to take into account solar hot water, photovoltaics, low e glass, make it as environmentally friendly and maximise the use of the environment as much as possible."* – Project Manager #1

The stage of the project where energy efficiency is considered is also influenced by the sale price of the development as pointed out here:

> *"The trouble is that when you sell something already, you have already a certain price and thereby you have a certain cost that you have to work to, you don't have the freedom to say ok now will change this factor cause its better for the energy consumption."* – Developer #2.

One participant commented about the detail in the design process and that more detailed design makes construction easier. Another two participants commented that the design process is made more difficult by foreign architects not being able to sign off on drawings in Thailand.

> *"Yeah. If you're an engineer you're allowed to be a member of the Engineers Association of Siam and if your foreigner you're still not allowed to join the Siamese Association of Architects but I am an architect in Australia."* - Architect #1

Five participants commented that mechanical and electrical professionals need to be brought into the project as early as possible with two participants stating they need to be brought in earlier. Three of the participants commented that they have mechanical and electrical people involved in the design process from the very beginning.

The building codes in Thailand and discrepancies in how laws are implemented throughout the country were identified as barriers. One participant commented that the building standards in Thailand are very poor:

> *"Standards they build to are very 1980's, old school, I mean there's not, the building codes in Thailand are very poor and they're more adopted from other countries and they've just never been updated."* - Environmental Consultant #1

And that more work on standards is required in Thailand:

> *"There needs to be more work done by either the professional engineers or the government on policies, regulations, rules, codes to implement this stuff."* - Environmental Consultant #1

The fact that laws can be implemented differently throughout Thailand was also highlighted:

"...also that is the problem of Thailand, is don't have just one law for all the country" – Supplier #1

Technical Barriers

The technical barriers to solar energy include poor quality products and inadequate access to technology or maintenance. The interview participants identified a range of technical barriers during the interviews. These are:

- Increased complexity;
- Performance of solar;
- Required maintenance;
- Availability in Thailand.

The number of participants who identified each barrier is shown in figure 7.

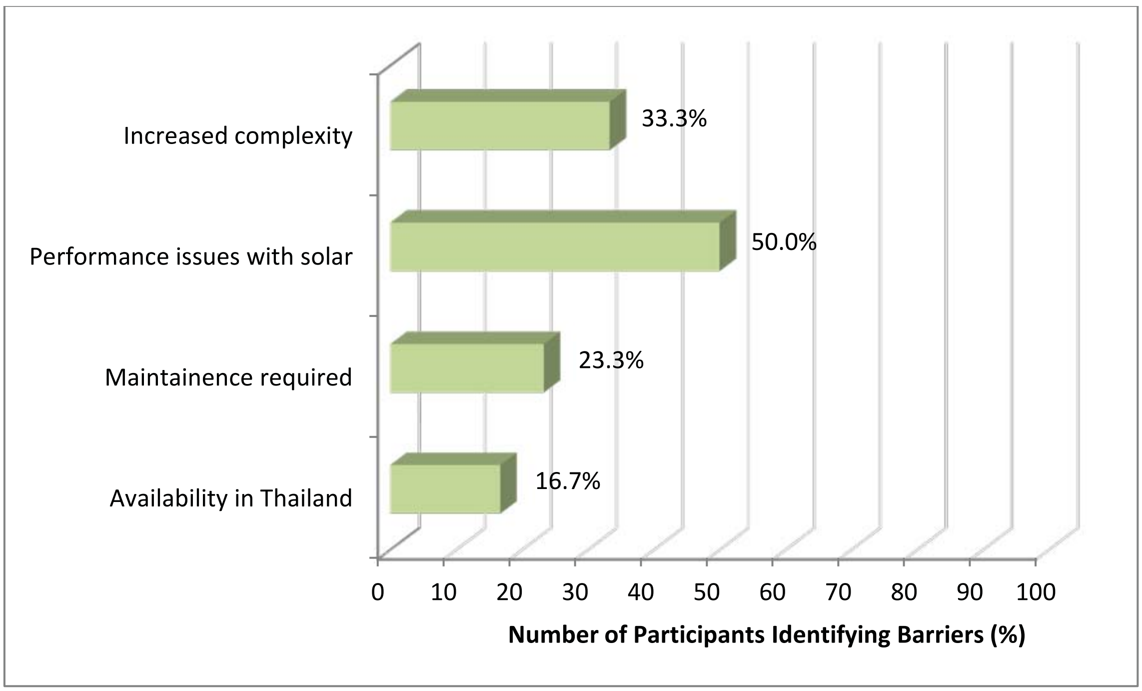

Figure 7: Percentage of participants identifying technical barriers

<u>Increased Complexity</u>

Whether the use of solar energy makes a project more complex was one of the issues raised during the interviews with 22.2 percent of participants considering that the use of solar energy increases the complexity of a project:

"To certain degree yes, yeah. I think again that's a part of the fact that there's not enough general knowledge known about, has it got huge maintenance issue, what happens if something goes wrong, what

happens if the people that they want, there're no experts, aren't available until next week." – Architect #1

"Definitely because with Thai contractors it can be difficult anyway getting a design installed as it's actually designed, they tend to take shortcuts, and when you make a design more complicated then you're going need a lot more site attendants, more construction managers and you've also then got a limited amount of companies you can approach to do the work." – M&E / Technical Consultant #2

On the other hand, a further nine participants (30%) did not consider that the use of solar energy increases the complexity of a project:

"No not at all, it just comes back, if it was incorporated in the initial discussions and design, I can't see why it should be. If it was an afterthought yes but you know it depends on what you're talking about, are you talking hot water and lighting or other areas as well." – Contractor #3

One participant commented that as there is very little history of solar energy in Thailand, it is impossible to know whether the use of solar energy increases complexity. It was also noted that the view of whether solar energy increases complexity depends on who is looking it. While engineers may consider that complexity is increased, owners do not necessarily see it that way.

<u>Performance Issues with Solar</u>

The participants indicated there are a range of areas where the performance of solar influences whether it is incorporated in a project. Half of the participants commented that performance issues are a barrier to the use of solar energy. In particular the following performance issues were highlighted:

- Poor performance of solar in cloud cover (10 percent of participants);

"The barriers are probably a mixture of the hot and the rainy season here so the rainy season is basically six months of the year where it is overcast most of the time, sure the cloud breaks up but really probably that's one of the barriers there's a lot of cloud cover, solar panels can work still with cloud cover but there not as efficient right." – Architect #1

- Solar panels require a lot of space for installation (23.3 percent of participants);

"I mean here for example, if I would like to add solar powers, where can I add them here. Our roof is, what we can put on our roof is little cause we have cooling towers sitting on our roof, we have machine roofs for the lifts sitting up on top, they're many M&E issues, mechanical electrical

machinery sitting on the roof top of a hotel…" – M&E / Technical Consultant #1

- Issues with batteries and storage of electricity (13.3 percent of participants);

> *"Then you've got the problem of batteries and storage, most of the time and batteries aren't very efficient, they don't have as long a life as the panel's themselves may and they degrade over time."* – M&E / Technical Consultant #7

- Problems with equipment not installed correctly (6.7 percent of participants);
- Solar panels not being efficient (16.7 percent of participants);

> *"The solar panel, the efficiency around not more than 6%. If they save energy from solar 100% but produce energy only 6% as maximum. If in the future they can raise up the efficiency of the solar panel like 10%, 20%, 30% then you bring down the cost and it will be possible that residential can use it."* – M&E / Technical Consultant #3

- Need to install two systems as cannot rely on solar system (13.3 percent of participants);

> *"If you've got a tall building its supplying such a minimal amount of the overall hot water heater that you've got to still supplement it anyway with an active system so when it comes to actually installing you've got all the additional installation, it doesn't seem cost effective to them."* – M&E / Technical Consultant #2

- Cheaper products are selected but are not of good quality (6.7 percent of participants).

<u>Maintenance Required</u>

One of the technical barriers identified by participants is the requirement for maintenance, or at least the concern that maintenance will be required, with 23.3 percent of participants considering that maintenance is a barrier to solar energy. This includes the cost or potential cost of maintenance as well as the potential difficulty in getting someone who has the required skills to maintain the equipment:

> *"Yes normal like that, rate of return, operation cost, and maintenance cost because our normal Thai investor afraid mostly maintenance cost. If they buy or invest in the new product, the new material, new technology or something after 2, 3 year or 1 year something have time to maintenance but sometime very difficult to call back supplier or local technical, cannot modify something. Throw away."* – Contractor #2

Availability in Thailand

Of the 30 percent of participants who discussed the availability of solar energy technologies in Thailand, 16.7 percent considered that the limited availability is a barrier to the use of solar energy. However 6.7 percent of participants consider the availability of technology is not a barrier:

> *"It's difficult. When I made enquires about the current two villas I'm working on. I could only find one guy who supply, I think chromosell and they were being imported from Spain. No information on any Thai products, nothing. I still to this day don't know of any Thai companies that sell solar, I never get leaflets from Thai companies."* – Project Manager #4

> *"Obviously it's not cost effective here at the moment but I think what the industry, in respect measures like photovoltaics, active measures like that, they need to provide greater subsidies to international companies to actually start manufacturing the technology here."* - M&E / Technical Consultant #2

One participant commented that the availability of solar energy technologies in Thailand has improved over the past decade. Another participant mentioned that there is a lack of competition in commercial products as most products have to be imported.

> *"…not enough competition in the commercial products, most commercial products are imported and Thailand has very high import duties so it's just cheaper if I buy everything overseas and smuggle it in."* – Environmental Consultant #1

Market Barriers

Market barriers are those that limit the market or act as an impediment to trade within the market. The participants identified five market barriers that are an impediment to the use of solar energy in buildings in Thailand. These barriers, shown in figure 8, are:

- Economic climate encouraging more low end developments;
- Low cost of electricity in Thailand;
- Electricity generating companies not wanting to support the use of solar due to the potential loss of profit;
- High import duties;
- Corruption in standards and regulations not being applied consistently and costs being increased for high end developments.

Three participants (10%) mentioned that the use of solar energy depends on whether a development is aimed at the high or low end of the market and consideration of solar energy or energy efficiency only occurs at the high end. One participant considered that the recent economic climate has created a driver to accommodate budget travellers resulting in a greater number of low end developments.

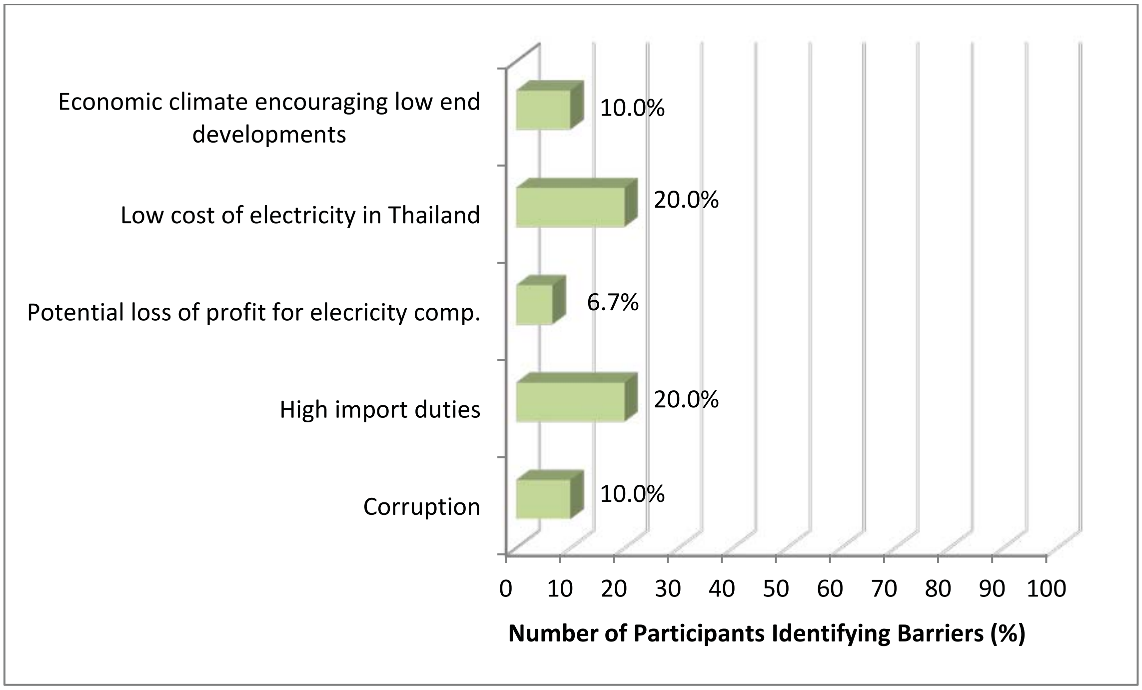

Figure 8: Percentage of participants identifying market barriers

One of the market barriers mentioned by participants is how solar energy is viewed by the electricity company. The two aspects of this is how the cost of electricity influences the overall payback period of solar technology and how the installation of solar energy is supported or not by the electricity companies.

There were a range of opinions on the cost of electricity in Thailand. Twenty percent of participants considered that electricity is cheap in Thailand and this reduces the likelihood that people will spend money to reduce electricity costs:

> *"The main thing I'd really say is probably cost, electricity here is pretty cheap overall, a lot cheaper than the UK for example and it depends on what exactly the client wants to implement when it comes to say photovoltaics, it's still not cost effective, especially in Thailand."* - M&E / Technical Consultant #2

This is a different opinion than what was given by three expatriate participants who considered that electricity is expensive in Thailand:

> *"What I've found is electricity charges in both here and in St Lucia are ridiculously expensive. We're used to a reasonable rate, electricity is not really considered to be a major expense in the UK."* – Owner #2

One developer when asked if he had seen any demand from clients responded:

> *"No. Never. Even though they come from sophisticated countries where solar energy is probably a no brainer and you know electric is expensive here so it makes all the more sense to have any method of saving money here on your electric bill."* – Developer #2

During the interviews two participants suggested that the Electricity Generating Authority of Thailand (EGAT) is driven by profit which may be reduced if there is a greater uptake of renewable energy:

> *"I think in Thailand most about political problems cause most of the wealthy people they own what do you call it, energy like energy generator company, they have some kind of asset or involvement with the revenue from the electricity, mainly from petroleum or from natural gas so they don't want to stop using this kind of energy. This kind of fuels cause otherwise if everyone use solar energy so they will lost their revenue."* – Environmental Consultant #2

Six participants (20%) mentioned the impact of import duties on the cost of solar energy. These people indicated that the import duties in Thailand affect the payback period:

> *"Even though for someone in the US the payback period even without any subsidies can be 10 years but when you bring to a country that has no subsidies, high taxes to bring in these items because its international manufacture, as well as other import taxes it can then double that and it just doesn't become cost effective."* - M&E / Technical Consultant #2

> *"Anything imported here, I know they're starting to make them here now but in the past anything imported has a whole added import tax which makes it even pricier."* – M&E / Technical Consultant #7

Three of the interview participants mentioned corruption as a barrier in Thailand. This included the opinion that standards and regulations were not applied consistently and that prices for materials and building permits were increased for high end developments.

> *"I think there needs to be a greater level of transparency and whatever rules are there, and standards, regulations they need to be consistently enforced across the board to you know some developers can, I won't say break the law, rules can be bent for certain people if they have the right connections and that's where developers lose confidence in the industry."* – M&E / Technical Consultant #2

Awareness and Information Barriers

Awareness and information barriers are those that relate to a lack of knowledge or awareness as well as the availability of information and training. A lack of awareness, knowledge, understanding or experience was a common theme raised by interview participants as a barrier to the use of solar energy in buildings in Thailand. The way participants use different terms during the interviews indicate that they perceive a difference in awareness, knowledge, understanding and experience. Table 4 shows the number of times words relating to knowledge were used in regards to being a barrier.

Table 4: Words relating to knowledge concepts used in interviews (by frequency)

Word	No. of Occurrences
Aware / Awareness	56
Know / Knowledge	126
Experience	23
Perception	15
Understand / Understanding	42

While the research did not set out to identify the meanings participants placed on these words or whether there is consistency among the meanings attributed by each participant, the way the words were used in the interviews indicates different meanings. From this the categories of lack of knowledge, lack of awareness, lack of experience and limited understanding were identified in the interview transcripts.

In addition to these categories, an additional three awareness and information barriers were identified by participants:

- Lack of desire to increase knowledge;
- Limited people with knowledge;
- Language of information.

The number of participants that identified each barrier is shown in figure 9.

Lack of Awareness

Participants used the term awareness most often in the context of general familiarity with the topic rather than full in depth knowledge. Of the 46.7 percent of participants who identified lack of awareness as a barrier, some considered there was a general lack of awareness of solar energy while others considered there is a lack of awareness as to the benefits of solar energy.

> *"You have to raise awareness of the end user. If your clients demand it, developer, architect will have to serve the clients, that's first thing, second thing is bottom line, the cost."* – Developer #1

> *"I think once people become more aware and it probably comes back to making people more aware of the product and the long term benefits of it"* – Contractor #3

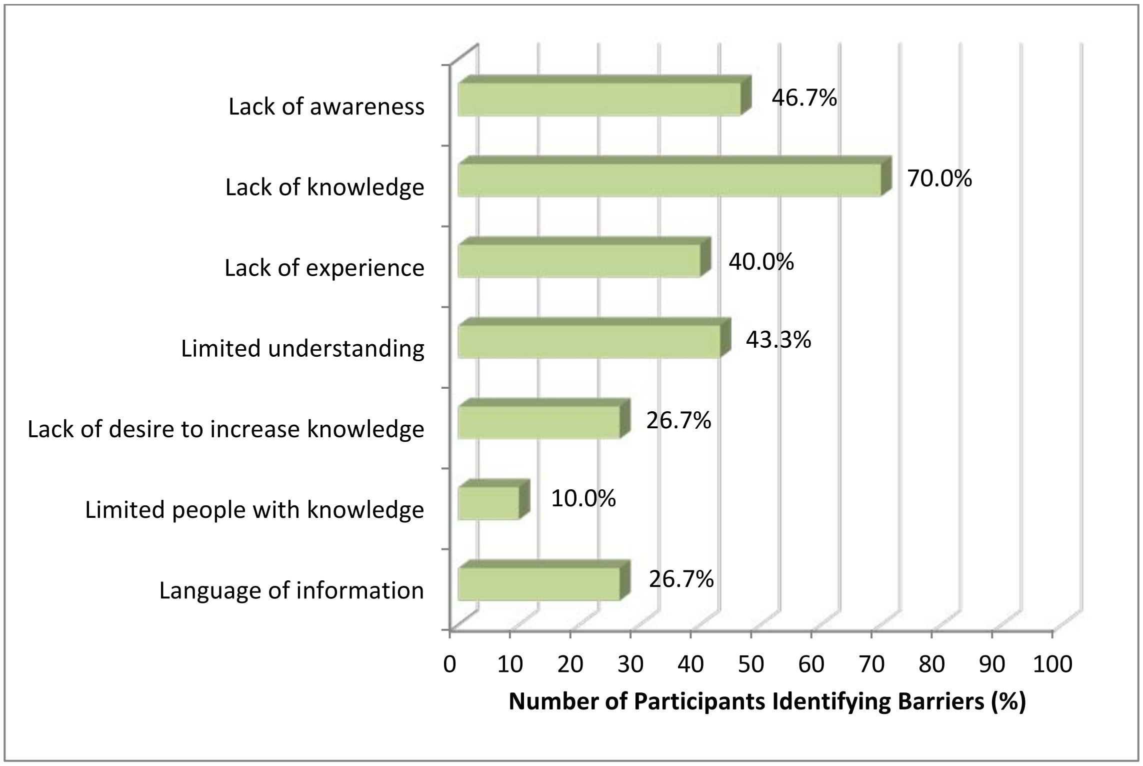

Figure 9: Percentage of participants identifying awareness and information barriers

Further, two of the participants consider that those with limited awareness of environmental issues think there is less need to use solar energy.

> *"I think it's wishful thinking rather than reality yet, but I don't think there's enough awareness of the state the world's in, people are not thinking that way enough yet"* - Project Manager #6

> *"Having said that I honestly think it is down to the awareness if you like or the opinions of the developer in the first place, whether they are aware, whether they do in their own opinion feel that efforts should be made any where we possibly can to save these emissions"* – Project Manager #2

<u>Lack of Knowledge</u>

A broader scope was shown in the use of the term knowledge. While some participants use knowledge as a general concept, the term knowledge was more often used in relation to professional roles and the particular knowledge that a role may be expected to have.

Knowledge seems to be placed at a higher level than awareness and often in the context of a person having a full comprehension as would be required to implement solar energy. Twenty one participants (70%) identified lack of knowledge as a barrier to the use of solar energy:

> *"I think we discussed it earlier, the vast majority of pubic don't know what options are available to them, some of them may be interested in it. If it's worthwhile, if they can see a benefit for it but if you're not supplied with that information in the first place you don't know about it."* – Owner #1

> *"No one really knows, even people who are selling the equipment don't really seem to understand how they can do economical and sensible proposals for particular situations. Everyone needs more education about the issues and about what's coming, what's changing than is being done."* – Project Manager #6

Knowledge was the term used by participants when discussing particular roles with comments indicating a lack of knowledge in particular professions as a barrier to solar energy:

- Lack of knowledge in designers (10 percent of participants);

> *"I think one of the biggest ones to begin with from a designer point of view is lack of knowledge."* – Project Manager #1

- Lack of knowledge in contractors (6.7 percent of participants);

> *"…there seen as people whose supposed to have the knowledge for installing MEP and renewable energy systems but the reality is not many contractors have experience with renewable energy and implementing PV into buildings for example."* – M&E / Technical Consultant #2

- Lack of knowledge in developers (3.3 percent of participants);

> *"I've always recommended it to the developer that he look at solar power but they've always, to date actually thought about it but decided to go the conventional way because they don't know enough about it…"* – Project Manager #4

- Lack of knowledge in suppliers (3.3 percent of participants);

> *"…and the other side, company like me, trading or installation company often they don't have the right knowledge too."* – Supplier #1

<u>Lack of Experience</u>

Twelve participants (40%) mentioned lack of experience as a barrier to the use of solar energy in buildings. This lack of experience referred to experience in the building industry, experience of owners previously owning property and participants themselves stating they did not have enough experience:

> *"You've got a limited amount of distributors for you know relatively small installations. There's not very much project experience when it comes to installing on buildings."* - M&E / Technical Consultant #2

> *"...I suppose because the developers, the people with the money who are paying for it, they just lack the experience, they're not professional developers, usually bankers who have stepped in to develop."* – Environmental Consultant #1

<u>Limited Understanding</u>

As used by participants the term understanding can overlap with either the concepts of lack of awareness or lack of knowledge, however as 43.3 percent of participants specifically referred to understanding, it was coded as a separate concept. The following quotes show how participants used understanding in a general context:

> *"I think it's probably cause of the fact not many people really understand it, and I'm one of them, to be honest with you. I've never really looked into the system, to its advantages and everything else. You know having said that I think that is probably one of the main reasons why it hasn't been introduced here too much is the fact that people don't really understand it."* – Project Manager #2

> *"You got to get to the designers, people who come up with the concept and see if you can sell a much better understanding of what's available and how to use things passively, if beyond that, how to use systems and things appropriately for that project."* – Project Manager #6

> *"...have to ensure that there is not only miscomprehension because of language but also because of knowledge and I think it's not only a language barrier, I think there is also a understanding barrier of what is this technology about."* – Developer #2

In contrast 13.3 percent of participants do not consider that lack of understanding is a barrier. They consider that professionals in the building industry do understand solar energy but are not prepared to implement it for other reasons. One of the participants commented that developers and contractors understand but do not want to implement due to cost. He stated that people in general have to be given more knowledge so they understand solar energy.

Ten percent of participant's related understanding to language and that people will keep away from something they do not understand.

<u>Limited Desire to Increase Knowledge</u>

Eight participants (26.7%) mentioned that those in the building industry have little desire to increase their knowledge, while twelve participants (40%) hold the opposite view. One comment is that only those working on high end projects are interested in increasing their knowledge of solar energy:

> *"A lot of Thais do actually look forward a bit but I would say not that many to be honest, not as many as I'd like to see, they kind of go with the flow and they need, their education system is not particularly good."* – Project Manager #4

> *"People tend, you know they don't actively go out looking for additional information; you just struggle on with what you know."* – Project Manager #6

Limited People with Current Knowledge

Ten percent of participants commented that there are limited people with current knowledge and one mentioned that on a previous project, they had to get specialists in from outside of the project to ensure solar energy technologies were working:

> *"Yea and they're not updated you know, especially in Phuket, one you're talking about all this system we call it heat pump to use the energy, use the heat from air con to make the hot water. We have to tell them how it works, that is the problem. Being designer you have to be engineer also, that's something sad."* – Designer #1

Language of Information

The language that information is in is considered a barrier by 26.7 percent of participants. This included product specification sheets and conferences and seminars only being in Thai which make them less useful for expatriates in the building industry:

> *"You'll find some product spec sheets that you get are only in Thai, if you can't read Thai or understand Thai you're out of luck as a farang* you can't say this is good bad or whatever, you've then got to rely on someone else to translate it, if they've got no knowledge on the subject, you're wasting your time. Particularly if they've got no technical knowledge they'll miss translate it."* – Project Manager #1

> *"I did go a renewable energies seminar last year briefly, all the information was in Thai and I spoke to a few people, I can look at pictures in any language. It was still a barrier to me but there seems to be generally Thai engineers, very few of them are interested when it comes to that side of technology. You know at the same level things like LEED the exams in English..."* – M&E / Technical Consultant #2

The language of information was also considered a barrier when it comes to dealing with clients. It was highlighted by 6.7 percent of participants that a developer who

** N.B. Farang is a Thai word to describe a foreigner of European complexion.*

wants to target foreign clients had to be able to communicate in English and another participant commented that some Thai developers only market to Thai people and have their contracts written only in the Thai language.

Behavioural Barriers

Behavioural barriers (shown in figure 10) includes barriers related to stakeholder attitudes, social acceptance and consumer preferences. The interview participants raised three barriers that are classified as behavioural barriers. These barriers are:

- Aesthetics;
- Mindset;
- Language as a communication barrier.

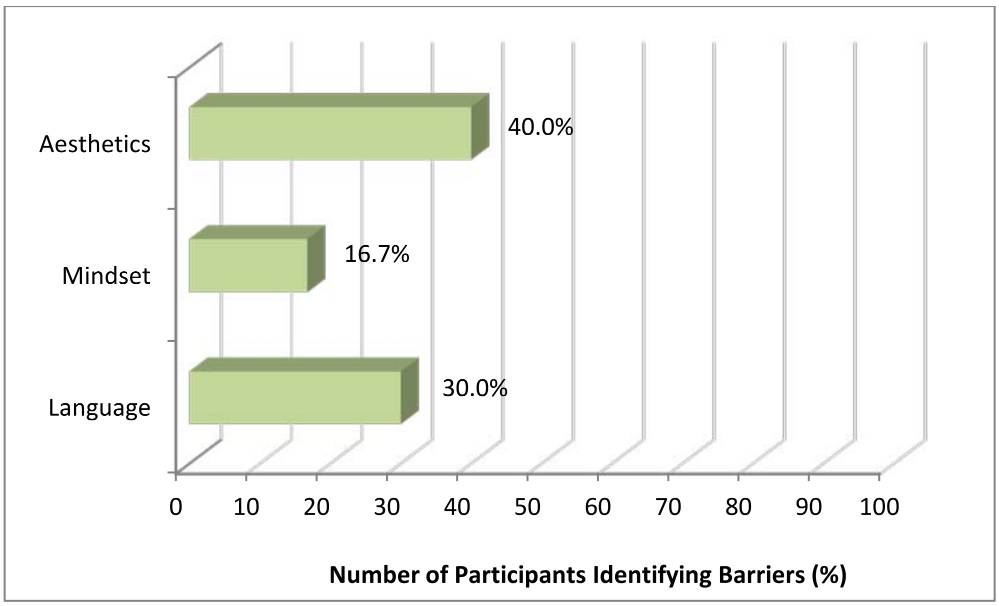

Figure 10: Percentage of participants identifying behavioural barriers

<u>Aesthetics</u>

The aesthetics, or look of solar energy, is considered to be a barrier by 40 percent of participants:

> *"...you have resistance from architects, they don't like it in their overall design, the look of the design and then if the architect doesn't like it, purely based on aesthetics and he's hired by the owner, he is in a much better position to convince a owner than me."* – M&E / Technical Consultant #1

> *"Oh yea who wants to look at an awful solar panel, which is going to look bad after a year."* – Developer #2

However 20 percent of participants thought that the use of solar energy is part of the overall design of a project and can be incorporated in an aesthetically pleasing way:

> *"...if you consider this system, solar panel so to make it work and to make part of your design that is your job to do it. That is more challenge for me, it's not something I don't want this thing stuck on my roof, it's not like that and now the design of the solar panel depends on what type you're going to select."* – Designer #1

<u>Mindset</u>

A person's mindset towards solar energy is also a barrier with 16.7 percent of participants raising issues related to how people regard solar energy. The issues coded under this category are having a bad previous experience with solar energy which has influenced current attitudes and a desire to stick with technologies and designs that are already known to them:

> *"Everyone uses a designer somewhere along the line, M & E whatever, to do their design and if they don't know about, they are hesitant to change to something they are not aware of or have little knowledge of, they prefer to stick to something they have used many a time before because then they can't be blamed if something goes wrong".* – Project Manager #1

> *"In my house I have hot water, solar hot water, doesn't work. It doesn't work."* – Developer #1

> *"It's a misunderstanding barrier between what foreigners think they can do here and what the locals say can work. And that's very often a problem, so sometimes you're better off just doing the same old thing where you don't rock the boat, you don't try something new because you're going to get in trouble maintaining it."* – Developer #2

<u>Communication as a Language Barrier</u>

The concept of whether the use of two languages, Thai and English, posed a barrier to solar energy was discussed in 66.7 percent of interviews. There are opposing views as to whether language creates a barrier with 40 percent of participants considering that the use of two languages does not pose a barrier.

> *"No. I believe now language barrier is no such thing anymore because now even internet, you can search through Thai language on the net."* – Contractor #1

> *"No I don't know because I think English and it is being promoted in education circles anyway, that English is going to be the number two language in Thailand, obviously Thai remains number one."* – Architect #1

> *"I don't think so. I don't think so, I never heard that the language is a barrier using solar energy."* – M&E / Technical Consultant #3

However 30 percent of participants do consider that language is a barrier to solar energy:

> *"Yes to a certain extent, I mean language barriers are always, is your biggest problem, communication here in the building industry, as far as I'm concerned is the communication. To achieve and get a nice job at the end of the day takes a hell of a lot of communication and coordination and the whatever."* – Project Manager #2

> *"Well I mean that is always something that you have to take into consideration. If you take reasonably advanced technology and you have a local company installing that you have to ensure that there is not only miscomprehension because of language but also because of knowledge…."* – Developer #2

4.2.2 Roles in the Building Industry

Throughout the interviews participants spoke about the roles of specific stakeholder groups in the building industry and the role they have in determining whether solar energy would be used on a project. Each of the eight stakeholder groups (shown in figure 11) identified in the interview transcripts influences the use of solar energy in different ways.

The interview transcripts were analysed to determine how participants perceive each stakeholder group. From this it was determined that participant comments referred to whether each stakeholder group acted as a driver, barrier or decision maker in relation to solar energy in buildings. The following sections outline the role of each stakeholder group.

Architect

The term architect and designer were both used by participants. The responses that were coded under this category either specifically referred to architects or design of the entire project concept (as opposed to specific design of mechanical and electrical or interiors which is discussed later). The role of the architect was discussed by 63.3 percent of participants and is considered to be one of the key roles in deciding whether solar energy is incorporated in a project.

The research participants mentioned the architect is responsible for the overall design of the project and as such can be a driver, barrier and decision maker in relation to solar energy. The architect is considered to have a key role in decision making as they work closely with the owner to provide what the owner wants:

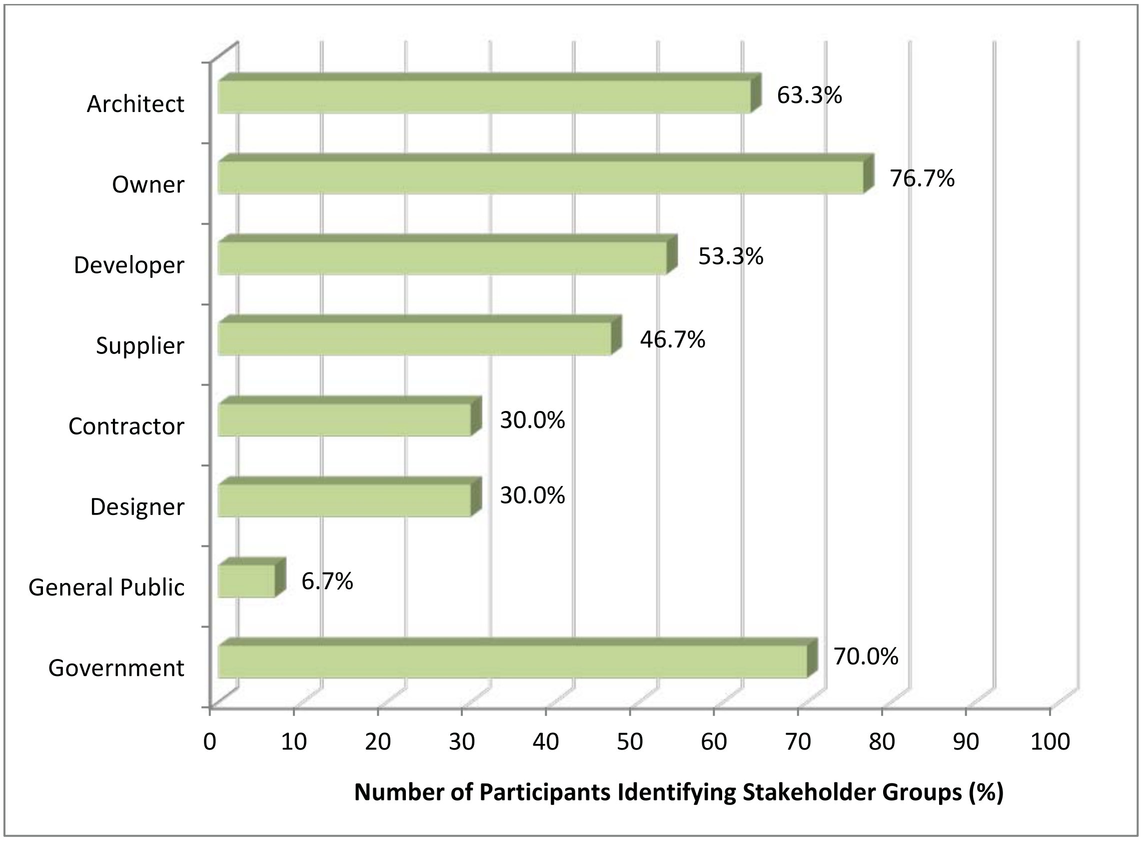

Figure 11: Percentage of participants who identified particular stakeholder groups

> *"What I've learned in my very short years of construction is that the architect and the owners always have a close relationship because it's about needs, no about wants, the owner says I want this, I want that, so the architect applies it."* – Project Manager #3

Two participants commented that the architect has control of everything and is the only person involved who has an overview of the whole project:

> *"I've found that certainly in the design process it's a bit old school, usually it's the architects normally involved and sort of control everything and yes they're more concerned about making a monument to mankind, something really beautiful."* – Environmental Consultant #1

The key role of the architect shows that they can also be either a driver or a barrier to the use of solar energy depending on their knowledge and attitude. As a driver the architect is regarded as the best person to convince an owner or developer of what needs to be included in a project with one participant commenting that it is:

> *"...about the skill of the architect and how the architect presents it to basically convince, seduce the developer that this is really worthwhile doing."* – Architect #1

This is further highlighted by the perception of one of the developers:

> *"It needs to come from the architect, you know, if the architect is somebody whose aware of it and he suggests it, then you can say ok is this appealing, is it something I can work out in the cost, will it translate into a higher value because the cost will go up. Will the customer be prepared to pay more because the higher cost. But it has to start with the architect."* – Developer #2

The architect is also recognised as a barrier to solar energy if they do not have the knowledge to introduce it into their designs with 26.7 percent of participants commenting that an architect's lack of knowledge, or desire to stick to what they know, is a barrier to the use of solar energy.

Owner

The owner or investor is also a key stakeholder in deciding if solar energy, or energy efficiency, will be incorporated in a project. Of the thirty participants interviewed, 76.7 percent made reference to the role of the owner or investor.

The owner's role in relation to solar energy can be proposing the initial concept to the designers or making a decision once the concept has been proposed. Seven participants commented that the owner needs to drive consideration of solar energy such as:

> *"They generally don't look at the long term but now we're finding buyers are asking questions, are you using renewable resources and they're having to think more about it. To satisfy the clients, the green image, clients are looking for a green image."* – Project Manager #4

While a further three participants discussed projects they had worked on previously where the owner was the driver. Participants defined the role of the owner as a decision maker primarily as making a decision on whether to spend additional money on energy efficiency or solar energy:

> *"Ultimately it is the owner, the person who is paying for it. You've got to ask them, you've got to front up and say right if we do it this way it is going to cost this, the traditional way for lack of a better term."* – Project Manager #1

> *"There's always a new client and that's the variable that makes a big difference …, makes a huge difference to the success of a project, they need to make decisions and they need to make payments and that's really their role."* – Project Manager #6.

It is in this decision making process where the owner can become a barrier. Participants identified four key elements that influence whether owners will be willing to use solar energy.

Willingness to spend: Participants considered that some owners are willing to spend additional money on energy efficiency or solar energy while others commented that in their experience the owner has a budget to stick to and generally wants things as cheap as possible.

> *"Yes we have some client that ask us about alternative energy like wind turbine or solar panel and we consult with them about the efficiency and the price and normally when we give them the consultation, the result is always to cancel the solar energy cause the price still high*." – M&E / Technical Consultant #3

Absentee owners: Many of the villas brought by foreigners in Thailand are for holiday homes and are not occupied all year round. As the owners are only using the property for part of the year, they get less benefit from the money they invest and are less likely to spend additional money on solar energy.

No experience buying in Thailand: Five participants mentioned that once people have experience buying in Thailand they are more likely to consider solar energy as electricity costs are not considered by owners until the property is complete:

> *"…a lot of times once the client has sort of owned the house for a couple of years, and as you said its only used on a very small part time basis, one of the questions that they do ask is how do we reduce running costs when we're not here, that is asked a lot"* - Contractor #3

Lack of knowledge: Participants highlighted that often owners do not understand the benefits of solar energy or the heat impact of tropical conditions that may influence their decision.

> *"We usually have the, as I explained we're quite specialised in west coast Phuket which has extremely harsh conditions late in the afternoon and most designers and even clients don't appreciate how difficult that can be, they're all in love with the sunset view and that sort of thing, the reality is it's the last thing you want to see"* - Project Manager #6

Developer

Developers are the stakeholders who initiate a construction project and see it through to completion with the aim of making a profit. Often the developer is an investor in the project so there is an overlap of roles, however there may also be other investors who are not directly involved in the development. The role of the developer was mentioned by 16 participants (53.3%) with 15 participants outlining that developers are a barrier to the use of solar energy. Twelve participants specifically mentioned that cost is a barrier for developers.

> *"…you know developers now days Amanda, from what I've found in reality there in it just to make the quick money and get out and anything else like that, yes their more than happy to discuss it, talk about it, agree to it but if it costs them anything it's only a discussion and that's where it stops…"* – Project Manager #2

Five participants commented on the lack of knowledge or experience of developers being a barrier to solar energy. This includes the idea that developers need to be made more aware of the benefits and be given a greater understanding that green building practices can reduce building cost. One participant commented that developers have an out of date perception:

> *"I think their perception is based on 10 – 20 years ago when there was not a drive from the consumer to have renewable energy as part of their residence, they start to push toward zero energy homes and that all exists, people are thinking in that direction now, developers have to catch up."* – Environmental Consultant #3

Four participants considered that developers may drive solar energy if they already have an awareness of environmental issues and see an advantage in marketing themselves as environmentally friendly. The role of developers as a decision maker was only mentioned by two participants who commented that developers make the decision on whether to have energy building modelling done for their projects. However developers seem to be regarded less of a decision maker than architects and owners.

Supplier

The role of suppliers and manufacturers was highlighted by 46.7 percent of participants. Suppliers are considered to be both a driver and a barrier to the use of solar energy. Participants considered suppliers a barrier in regards to guaranteeing workmanship, the ease of calling a supplier back for maintenance and the limited number of suppliers for certain products.

> *"If they buy or invest in the new product, the new material, new technology or something after 2,3 year or 1 year something have time to maintenance but sometime very difficult to call back supplier or local technical, cannot modify something. Throw away."* – Contractor #2

Suppliers are also seen as having a role in driving solar energy through promoting themselves and their product and that more competition should drive prices down. The knowledge of suppliers and the information they provide is considered to be both a driver and a barrier with participants commenting that suppliers do not always have the right knowledge and that they need to provide more accurate information. One participant noted that they had previously had difficulty getting glass specifications from suppliers.

Contractor

The contractor is the stakeholder who builds the project and their role was discussed by 30 percent of participants. Contractors are not deemed to have any role as a decision maker when it comes to solar energy; rather their role is to follow designs that have already been created as highlighted in this comment:

> *"We are the builder so we just follow the drawing and the design from the engineer so if the engineer give us sufficient information I think we can follow their design."* – Contractor #1

Possibly because they have no role as a decision maker, contractors were not considered by participants to be a driver for solar energy. Although four participants considered that contractors can be a barrier to the use of solar energy. Three participants commented that contractors have a lack of knowledge in relation to renewable energy and solar energy.

> *"Whether it's something that Thai contractors and businesses can actually get a proper handle on and understand it properly that is something I'm not too sure about as well."* – Project Manager #2

There were also comments made about the difficulty of getting a design built the way it has been drawn with an example of a mechanical and electrical design firm who started doing their own installation for this reason.

Designer

The stakeholder group of designers includes comments made about any designer other than the architect. In this context participants most commonly used the word designer to refer to mechanical and electrical designers though some participants did not specify mechanical and electrical specifically. However if the participant referred to a designer in a context that did not include the overall design of the project (as done by the architect), their comments were coded to this category of general design. The role of designers was mentioned by 30 percent of participants who mainly considered that designers (particularly mechanical and electrical designers) are a barrier to using solar energy referring to the need to change the mindset of designers and that designers are a barrier if they have no knowledge of solar energy. The need to have mechanical and electrical designers onboard early in a project was reflected by participants through comments that mechanical and electrical designers are not brought in early enough and it is too late once the architect has already designed the project. Two participants commented that they bring in the mechanical and electrical designers early on their projects:

> *"...early in the piece when the architectural concepts are shaping up we also bring in the MEP consultants and have them run options for types of air conditioning and glazing so that they can pick up the solar load differences and provide for it."* – Project Manager #6

General Public

The role of the general public was the least discussed stakeholder group with only 6.7 percent of participants highlighting the role of the public. The participants that did discuss the public considered that while the general public as a whole does not have a role as a decision maker, they do have a role as a driver of solar energy. The participant's comments highlighted that the public has a responsibility to drive the use of solar energy and to put more demand on the building industry:

> *"General public's got responsibility to drive it but general public can only take things on board if they are supplied with that information. 99% of the public I dare say don't know too much about solar energy and it's not a sort of thing that the vast majority of people go home and read about at night, or use their spare time to look on the internet, they've got other priorities."* – Owner #1

Participants also considered that if the public is to take on this role, they need to be educated more and provided with more information as without this they would not take solar energy on board. One participant suggested that people's interest in solar energy will wane if it is not continually driven.

Thai Government

The Thai Government is considered to be a major stakeholder in solar energy with 70 percent of participants mentioning the role of the government. Those interviewed are of the opinion that the government has a role to drive the use of solar energy through disseminating information, providing financial incentives and using legislation to force energy efficiency.

> *"I think the government should be really pushing it. Yeah I think the government should be really pushing it. I think it's their responsibility to promote it for this, what do you call it these days, saving the planet, environmental friendly products."* – M&E/Technical Consultant #8

Two participants commented that the government has more basic problems so renewable energy is not a particular priority. It was also mentioned that the driver for the government to take action will come from the people pushing for it:

> *"I think the thing is you have to raise the awareness of the people first, if people still don't care, if what happened, if people don't care the government will not care too."* – Developer #1

The government's lack of clear rules and policies on areas such as selling electricity back to the grid was also mentioned as a barrier to solar energy.

4.2.3 Drivers and Future Outlook

The opposite side of barriers to solar energy are the elements that drive the use of solar energy in buildings.

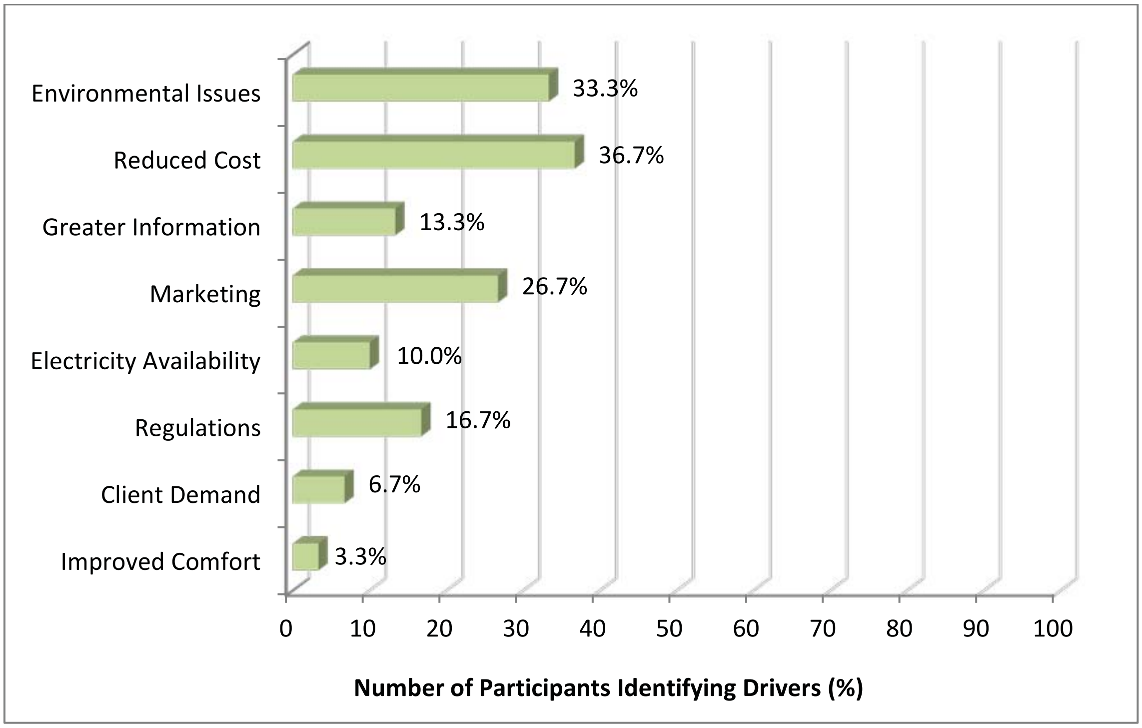

Figure 12: Percentage of participants identifying drivers for solar energy

There are eight elements participants mentioned as driving the use of solar energy as shown in figure 12. The drivers discussed by participants range from those that have already influenced projects in the past or are currently influencing projects, while others are considered to be potential drivers that may influence projects in future. Statements by participants were only coded to these categories if they specifically discussed the element as a driver to using solar energy.

<u>Environmental Issues as a Driver</u>

Environmental issues are considered to be both a current and future driver for solar energy with ten participants (33.3%) mentioning environmental issues. This includes the opinion that more people are aware of emissions and global warming and there is a general understanding of the need to take care of the environment. In regards to the environment as a future driver, participants commented that solar energy will be used more when payback periods are reduced due to the cost of pollution treatment, the cost of carbon credits and the price of oil rising due to declining oil reserves. Two participants commented that while there is awareness of environmental issues, it still needs to be driven further.

Reduced Cost as a Driver

Eleven participants (36.7%) discussed elements of how reduced cost could be a driver to use solar energy. In regards to current drivers of solar energy, two participants mentioned a desire to reduce running costs and one participant talked about offsetting costs by selling electricity back to the grid. In terms of future drivers, eight participants (26.7%) consider that the cost of solar energy will have to be reduced to encourage people to use it with seven of those participants specifically mentioning the need for subsidies or tax incentives.

Greater Information as a Driver

The supply of information is considered to be both a current and future driver. Three participants (10%) commented on the need for more information with one discussing a previous project where the driver for using solar hot water was information provided by a supplier.

Marketing as a Driver

Eight participants (26.7%) suggested that marketing a green image is a current and future driver for solar energy. One participant regards the international move toward green buildings a driver.

Electricity Availability as a Driver

Three participants (10%) commented that solar energy is only used in areas where electricity is not available and as a backup during power cuts. One participant discussed a project which used solar energy as the estate had been under provided with power.

Regulations as a Driver

Five participants (16.7%) mentioned that for energy efficiency to be increased in future the government needs to make it compulsory through regulations or building codes.

Client Demand as a Driver

Two participants (6.7%) commented that client demand is becoming a driver; however this has not translated into greater spending as yet.

Improved Comfort as a Driver

One participant (3.3%) commented that additional comfort from energy efficient buildings is a current driver.

Future Outlook

The participants also discussed the future outlook of solar energy in buildings in Thailand during the interviews. Twelve participants (40%) deemed that attitudes toward solar energy in Thailand have changed over the past five years while eight (26.7%) participants considered there has been no change at all. In general the view is that solar energy is very much in the infancy stage in Thailand, however as time progresses there is likely to be faster advancement.

4.3 Results of the Survey

At the end of each interview, participants were asked to complete a Likert scale survey. This was done to gauge participant views on barriers that were identified in the literature in case they were not brought up during the interview as well as to check for differences between information provided in the interviews and opinions given on the survey. The 20 questions in the survey covered the barrier categories defined in chapter two and the findings are discussed in the context of these categories. An overview of the survey results is given in table 5.

For each survey question the median, mode, range and inter-quartile range is provided. Separate statistics are shown for the two participant groups, Thai (n=11) and expatriates involved in the building industry in Thailand (n=19). In each of the 20 survey questions participants were asked to rate whether they agreed or disagreed with a statement about barriers to solar energy. The survey responses were coded with the following numerical values:

1 = Complete Agree
2 = Mostly Agree
3 = Slightly Agree
4 = Neither Agree or Disagree
5 = Slightly Disagree
6 = Mostly Disagree
7 = Completely Disagree

The average range of responses from expatriate participants was 4.1 which is slightly greater than the average range in the responses from Thai participants at 3.25. In 12 of the survey questions, answers by expatriate participants were skewed toward the agree side of the rating scale. For Thai participants this increased with the results of 16 questions skewed toward the agree side of the scale.

Table 5: Overview of survey responses for expatriate and Thai participants

	Median		Mode		Range		Inter-quartile Range	
	Expat	Thai	Expat	Thai	Expat	Thai	Expat	Thai
1. The building industry sees higher capital costs as a barrier to using solar energy.	2	2	2	2	4	2	1	1
2. Solar energy would be used more in buildings if payback periods were shorter.	1	1	1	1	2	5	1	2
3. Cost is the only factor considered when deciding to use solar energy in a building.	3	2	2*	2	6	5	2	2
4. The subsidy of electricity costs in Thailand reduces the need to use solar energy.	4	2	4	2	6	6	3	4
5. Perceived risk reduces the use of solar energy in buildings.	5	3	6	3	5	6	3	1
6. The use of solar energy in buildings is affected by English not being the common business language in Thailand.	5	4	6	2*	5	5	3	3
7. Whether project staff has studied solar energy as part of their formal education affects the use of solar energy in buildings.	2	2	2	2	4	2	1	1
8. Lack of awareness is the reason passive use of solar energy through building orientation, selecting appropriate glazing & thermal mass of materials is often not considered.	2	2	2	2	4	3	1	2
9. More research and case studies specific to buildings in Thailand would increase the use of solar energy.	1	2	1	2	2	2	1	2
10. Use of solar energy is not limited by availability of solar energy technologies in Thailand.	5	6	6	6*	5	3	2	2
11. Lack of Knowledge about operation and ongoing maintenance limits the use of solar energy technology.	2	2	1*	2	3	2	2	1
12. Lack of demand from investors/buyers reduces the likelihood of solar energy being used.	2	2	2	1*	5	2	1	1
13. Industry experience in installing solar energy technologies affects whether solar energy is included in the building.	3	2	3	2	5	2	1	1

	Median		Mode		Range		Inter-quartile Range	
	Expat	Thai	Expat	Thai	Expat	Thai	Expat	Thai
14. The perception of solar energy technologies being unreliable or having variable output is a barrier to the use of solar energy in buildings.	4	2	6	2	5	3	3	1
15. Lack of an integrated approach to building design impacts the use of solar energy.	2	2	2	2	5	2	2	1
16. Cost competitiveness in the building industry influences whether solar energy is incorporated in the building.	2	2	2	2	3	3	1	1
17. Industry bodies encouraging the use of solar energy in buildings would increase the use of solar energy.	2	2	2	2	2	2	1	1
18. The building industry considers that using solar energy in a building increases the complexity of the project	3	3	3	2*	5	4	2	2
19. Energy efficiency regulations in Thailand would increase the use of solar energy.	2	2	2	1	2	2	1	1
20. A lack of consistent energy and green building rating tools and standards impacts the use of solar energy in buildings.	2	2	2	2	4	4	0	1

** = 2 modes apply. Smallest mode has been used in table.*

Survey Results: Financial and Economic Barriers

Four of the survey questions relate to financial and economic barriers. For all four questions, more than two thirds of participants either slightly, mostly or completely agreed with each of the statements (figure 13).

In relation to capital costs being a barrier the results for both Thai and expatriate participants were skewed on the agree side of the scale with 87.7 percent of participants answering that they slightly, mostly or completely agree. The mode for both Thai and expatriate participants was two meaning that the most common response was mostly agree. The responses from both participant groups had an inter-quartile range of one showing responses are consistently close to each other.

One of the survey questions asked whether "solar energy would be used more in buildings if payback periods were shorter" and 96.7 percent of participants agreed to some extent that solar energy would be used more if payback periods were shorter. The mode for both Thai and expatriate participants is one illustrating that completely agree was the most common answer however the inter-quartile range for expatriate participants is one as opposed to the inter-quartile range for Thai participants at two showing a greater range of responses for Thai participants.

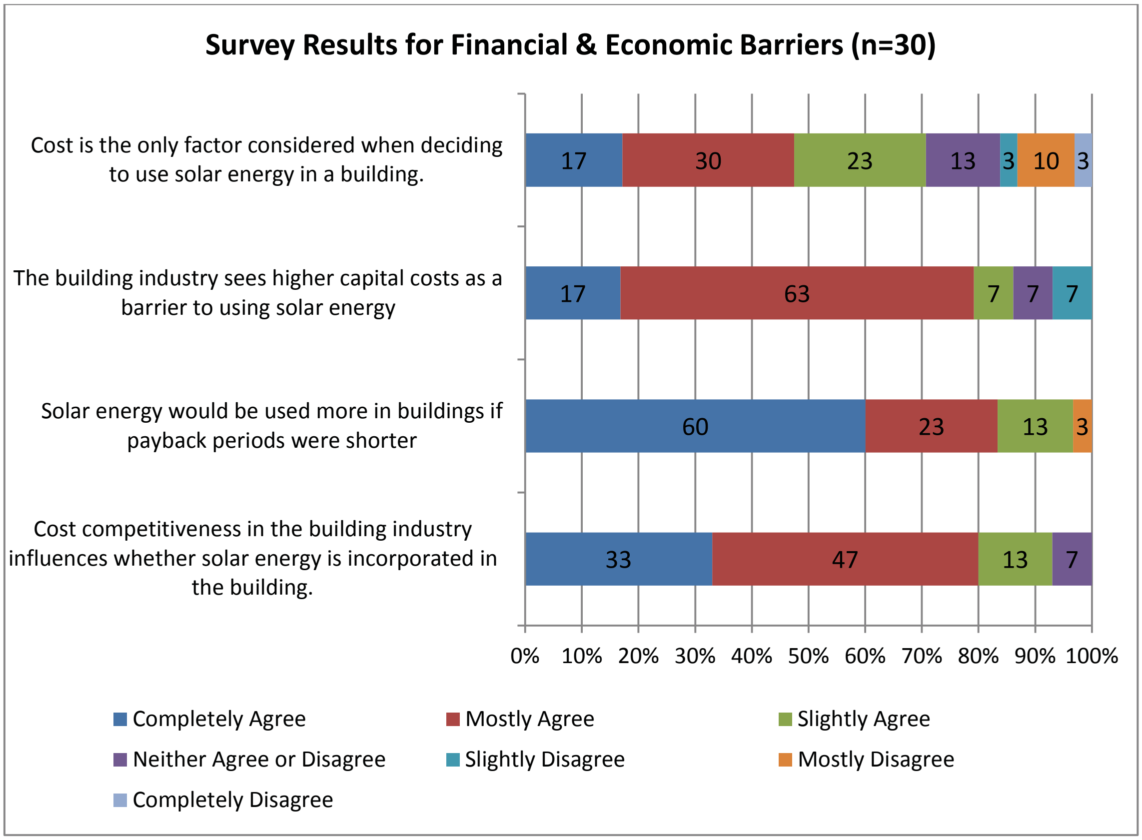

Figure 13: Survey results for financial and economic barriers

However some respondents did not agree with the statements. In regards to higher capital costs, seven percent of respondents neither agreed nor disagreed that capital costs were a barrier to the use of solar energy and a further seven percent slightly disagreed with the statement. There was less disagreement in relation to payback periods with only three percent of participants saying they mostly disagree that solar energy would be used more if payback periods were shorter.

There was a high level of agreement that cost competitiveness in the building industry influences whether solar energy will be used with 93.3 percent of participants answering on the agree side of the scale. None of the participants answered on the disagree side of the scale and 6.7 percent neither agreed nor disagreed.

More disagreement was seen in the statement "cost is the only factor considered when deciding to use solar energy in a building" with 16.7 percent of participants disagreeing with the statement. There were a greater range of responses to this question from both Thai and expatriate participants than for other questions relating to financial and economic barriers.

Table 6 shows the median, mode and range of participant responses by occupational group. In relation to capital costs being a barrier the median and mode is consistent across the occupational groups indicating that most participants either completely or mostly agree with the statement. The exception is the supplier who with a mode of four neither agreed nor disagreed. There is a greater range of responses from M&E / technical consultants and contractors. There is more than one mode for the contractor and architect groups and the range of four in the contractor group indicates that there are differing opinions within this group.

Table 6: Responses to financial and economic barriers by occupational group

		M&E / Technical Consultant	Designer	Project Manager	Contractor	Owner	Developer	Architect	Environmental Consultant	Supplier
		n=9	n=2	n=5	n=3	n=3	n=2	n=2	n=3	n=1
The building industry sees higher capital costs as a barrier to using solar energy.	Median	2	2	2	2	2	2	2.5	1	4
	Mode	2	2	2	1*	2	2	2*	1	4
	Range	4	0	1	4	2	0	1	1	0
Solar energy would be used more in buildings if payback periods were shorter.	Median	1	1	1	2	2	3.5	1	1	2
	Mode	1	1	1	1*	2	1*	1	1	2
	Range	2	0	2	2	0	5	0	0	0
Cost is the only factor considered when deciding to use solar energy in a building.	Median	3	2.5	2	3	2	2	4.5	3	3
	Mode	2	1*	2	1*	1*	2	3*	2*	3
	Range	4	3	3	5	6	0	3	4	0
Cost competitiveness in the building industry influences whether solar energy is incorporated in the building.	Median	2	2	2	1	2	2	3.5	2	4
	Mode	2	2	2	1	2	1*	3*	2	4
	Range	2	0	1	1	1	2	1	1	0

** = 2 modes apply. Smallest mode has been used in table.*

Responses are also generally consistent in relation to solar energy being used if payback periods were shorter except for developers where multiple modes and a range of five indicates the two developers interviewed have different opinions. However the developers were more in agreement on cost being the only factor considered when deciding to use solar energy. The range of zero and mode of two shows both developers interviewed mostly agreed with this statement. There is a greater range of opinions in the other occupational groups with five of the groups having more than 1 mode. These five groups have ranges between three and six indicating a wide range of responses to this statement within each occupational group.

The responses to cost competitiveness in the building industry being a barrier were consistently on the agree side of the scale across the occupational groups except for the supplier who neither agreed nor disagreed.

Survey Results: Institutional and Regulatory Barriers

Four of the survey questions relate to institutional and regulatory barriers. In all of the questions the mode is two showing that mostly agree was the most common response, except for Thai participants commenting on whether energy efficiency regulations would increase the use of solar energy, where the mode is one or completely agree. Figure 14 shows that all 30 participants were on the agree side of the scale on the fact that industry bodies encouraging the use of solar energy would increase the use of solar energy and that energy efficiency regulation in Thailand would increase the use of solar energy.

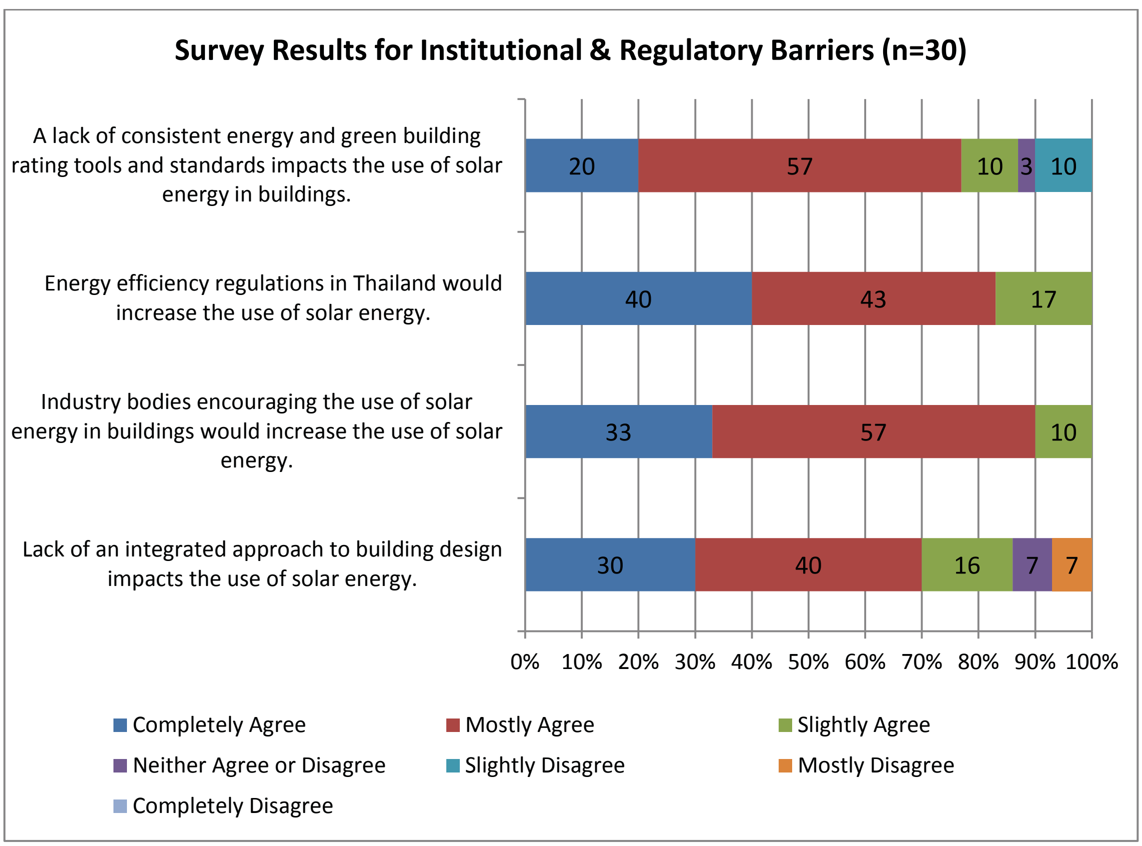

Figure 14: Survey results for institutional and regulatory barriers

However in relation to whether consistent green building rating tools and standards impacts the use of solar energy, 3.3 percent of participants neither agreed nor disagreed with the statement and 10 percent of respondents slightly disagreed. In regards to whether a lack of an integrated approach to building design impacts the use of solar energy, 6.7 percent of participants neither agreed nor disagreed and 6.7 percent mostly disagreed. Nonetheless 86.7 percent of participants agreed with the statement to some extent and this seems to be the view expressed during interviews.

Participant responses to institutional and regulatory barriers by occupational group are shown in table 7. A consistent mode of one or two across the occupational groups shows that the majority of participants either completely or mostly agreed that green building rating tools impact the use of solar energy. The supplier was the exception with a response of neither agrees nor disagrees. There is a greater range of responses for project managers and owners indicating that not everyone in these groups agrees with the statement.

Table 7: Responses to institutional and regulatory barriers by occupational group

		M&E / Technical Consultant	Designer	Project Manager	Contractor	Owner	Developer	Architect	Environmental Consultant	Supplier
		n=9	n=2	n=5	n=3	n=3	n=2	n=2	n=3	n=1
A lack of consistent energy and green building rating tools and standards impacts the use of solar energy in buildings.	Median	2	2	2	1	2	2	2.5	2	4
	Mode	2	2	2	1	2	2	2*	1*	4
	Range	2	0	4	1	3	0	1	1	0
Energy efficiency regulations in Thailand would increase the use of solar energy.	Median	2	2	2	1	2	1	2.5	1	3
	Mode	2	2	1*	1	2	1	2*	1	3
	Range	2	0	2	1	0	0	1	0	0
Industry bodies encouraging the use of solar energy in buildings would increase the use of solar energy.	Median	2	2	2	1	2	2	1.5	1	3
	Mode	2	2	2	1	2	2	1*	1	3
	Range	2	0	1	0	1	0	1	1	0
Lack of an integrated approach to building design impacts the use of solar energy.	Median	2	3	2	1	2	2.5	3.5	1	4
	Mode	2	2*	1*	1	2	2*	1*	1	4
	Range	5	2	2	0	1	1	1	2	0

** = 2 modes apply. Smallest mode has been used in table.*

In regards to energy efficiency regulations and energy bodies increasing the use of solar energy, the responses across the different occupational groups is consistent at completely or mostly agree except for the supplier who only slightly agreed with both these statements.

All but one of the occupational groups had a mode of one, two, or three indicating agreement that integrated approach to building design impacts the use of solar energy. While multiple modes apply to four of the occupational groups the small range in responses shows that most participants responded on the agree side of the scale except for the supplier who neither agreed nor disagreed. M&E / technical consultants have a range of five in their responses indicating that not everybody in this group agrees with the statement.

Survey Results: Technical Barriers

Shown in figure 15 are the three survey questions which relate to technical barriers. The majority of participants consider that the use of solar energy increases the complexity of a project with 67 percent of participants agreeing with this statement to some extent.

A further 17 percent of participants either slightly or mostly disagreed with the statement while another 17 percent neither agreed nor disagreed.

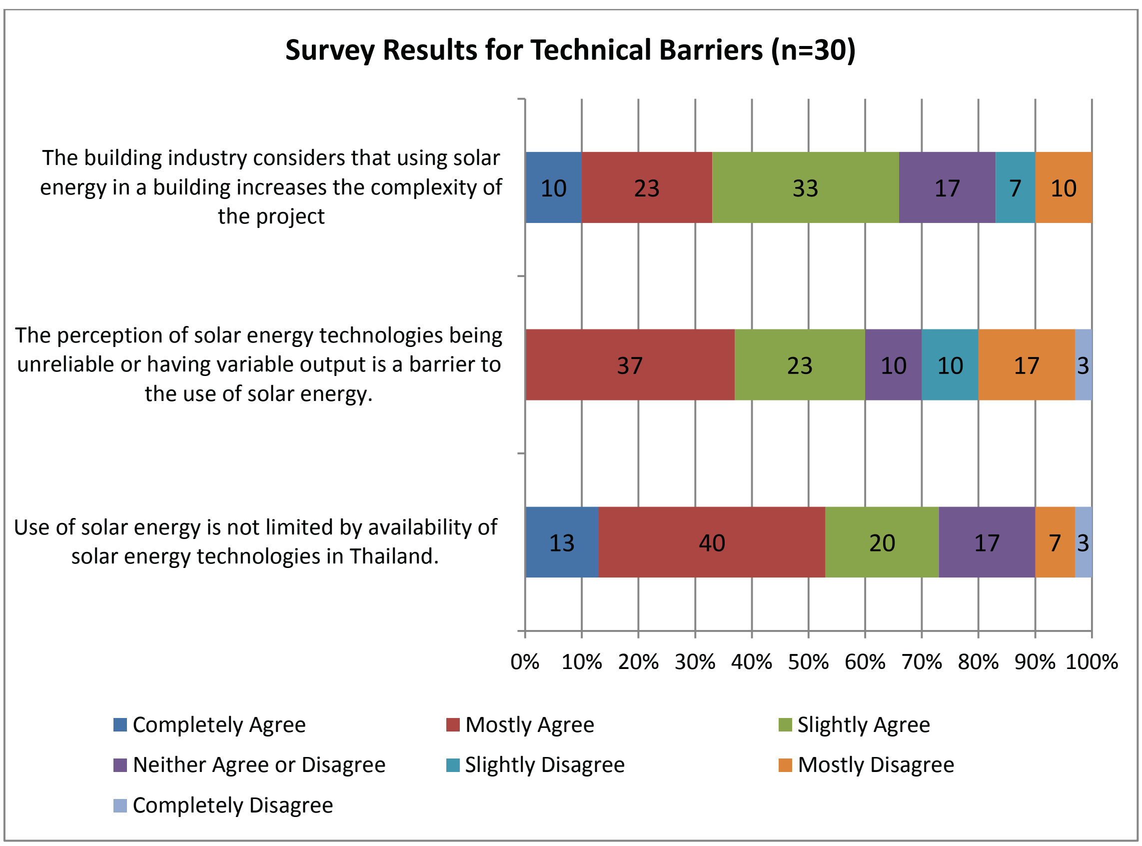

Figure 15: Survey results for technical barriers

There was less agreement from participants as to whether the perception of solar energy technologies being unreliable affects the use of solar energy. Only 60 percent of participants slightly, mostly or completely agreed with this statement while 30 percent slightly, mostly or completely disagreed. Ten percent of participants neither agreed nor disagreed. There is more disagreement from expatriate participants with a mode of six being mostly disagree as opposed to Thai participants with a mode of 2 or mostly agree. The answers from Thai participants were also more consistent with an inter-quartile range of one as opposed to an inter-quartile range of three for expatriate participants.

The question “solar Energy is not limited by availability of solar energy technologies in Thailand” was purposely worded in reverse which may have affected participant responses. With the reverse phrasing 73 percent of participants either slightly, mostly or completely agreed with this statement indicating that the availability of solar energy technologies in Thailand is not a barrier. The neural position was chosen by 17 percent of participants while only 10 percent either mostly or completely agreed.

Table 8 shows participant response to technical barriers by occupational group. There are a wide range of opinions on technical barriers both between and within the different occupational groups. The mode and range indicates M&E / technical consultants, project managers and architects answered on the agree side of the scale. While the range of responses from designers, contractors, owners and environmental consultants indicates there were differing opinions within these groups.

All but two of the groups have a range of responses to the statement that there is a perception that solar energy technologies are unreliable. Both developers interviewed slightly agreed with this statement while the supplier interviewed neither agreed nor disagreed. The other six occupational groups have a range between three and five indicating a wide range of responses within the group.

Table 8: Responses to technical barriers by occupational group

		M&E / Technical Consultant	Designer	Project Manager	Contractor	Owner	Developer	Architect	Environmental Consultant	Supplier
		n=9	n=2	n=5	n=3	n=3	n=2	n=2	n=3	n=1
The building industry considers that using solar energy in a building increases the complexity of the project	Median	3	4	2	3	5	3.5	2.5	2	3
	Mode	3	2*	2	1*	3*	3*	2*	1*	3
	Range	3	4	2	5	3	1	1	4	0
The perception of solar energy technologies being unreliable or having variable output is a barrier to the use of solar energy in buildings.	Median	3	3.5	3	4	5	3	4	2	4
	Mode	2	2*	3	2*	2*	3	2*	2	4
	Range	4	3	5	3	4	0	4	4	0
Use of solar energy is not limited by availability of solar energy technologies in Thailand..	Median	6	5	6	7	4	4.5	6	5	5
	Mode	6	4*	6	7	4	4*	5*	2*	5
	Range	4	2	6	1	2	1	2	4	0

** = 2 modes apply. Smallest mode has been used in table.*

Survey Results: Market Barriers

One of the survey questions relates to the market barrier of electricity subsidies. Figure 16 shows there are a wide range of views on whether the subsidy of electricity costs in Thailand reduces the need for solar energy. While 46.7 percent of participants were on the agree side of the survey scale, 16.7 percent neither agreed nor disagreed with the statement and 36.7 percent disagreed to varying extents. The broad range of responses is reflected in the inter-quartile range of three for expatriate participants and four for Thai participants.

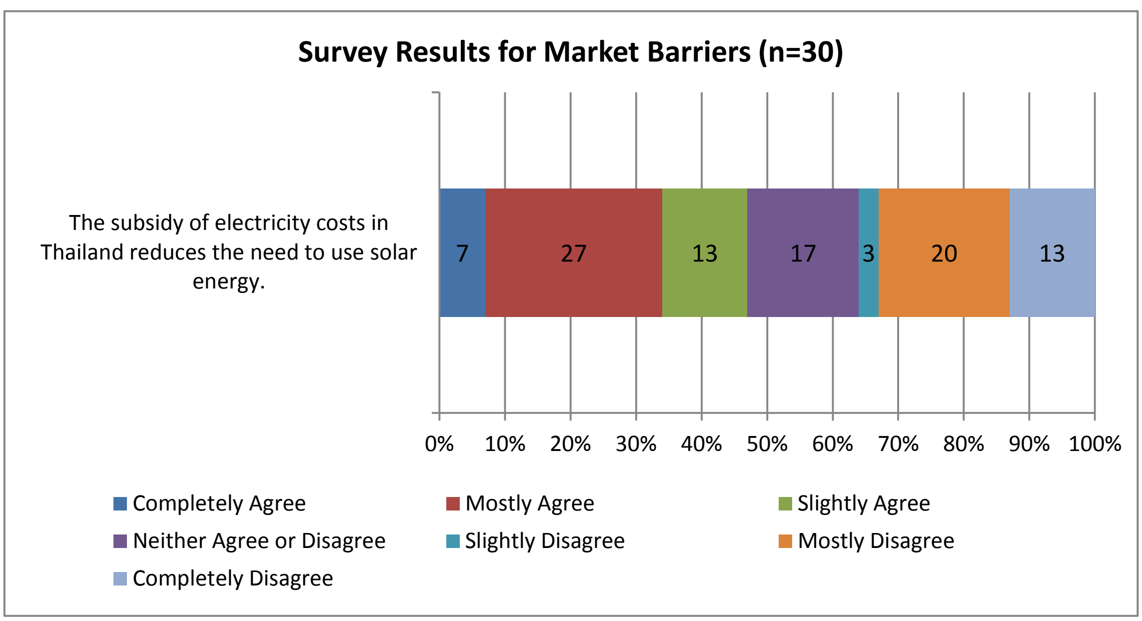

Figure 16: Survey results for market barriers

Table 9 shows participant responses by occupational group. Architects were the only group with a consistent opinion of mostly disagree shown by the mode of six and range zero. The supplier (n=1) neither agreed nor disagreed with the statement. The other six occupational groups have a range of between three and five indicating a wide range of responses within each group and multiple modes apply to four of the occupational groups. The occupational groups where only one mode applies still have a wide range; however these modes indicate that environmental consultants mostly disagree, M&E / technical consultants neither agree nor disagree and project managers mostly agree that the subsidy of electricity reduces the need to use solar energy.

Table 9: Responses to market barriers by occupational group

		M&E / Technical Consultant	Designer	Project Manager	Contractor	Owner	Developer	Architect	Environmental Consultant	Supplier
		n=9	n=2	n=5	n=3	n=3	n=2	n=2	n=3	n=1
The subsidy of electricity costs in Thailand reduces the need to use solar energy.	Median	3	4.5	2	6	4	3.5	6	6	4
	Mode	4	2*	2	2*	2*	2*	6	6	4
	Range	5	5	6	5	5	3	0	3	0

** = 2 modes apply. Smallest mode has been used in table.*

Survey Results: Awareness and Information Barriers

As shown in figure 17, five of the survey questions relate to awareness and information barriers. The statement that lack of industry experience installing solar energy affects whether solar energy will be used on a project gained the most disagreement. While 86.7 percent of participants agreed with the statement, 6.7 percent neither agreed nor disagreed, 3.3 percent slightly disagreed and 3.3 percent of participants mostly disagreed. The median of responses for expatriate participants is three or slightly agree; however for Thai participants the median response was two or mostly agree. Only 40 percent of participants expressed lack of experience as a barrier to solar energy in buildings during the interviews; however the survey response indicates that lack of experience may be a larger barrier than what was expressed in the interviews.

There were also high levels of agreement on the other four questions. In regards to lack of awareness being the reason passive solar design strategies are not often considered, 86.7 percent of participants answered on the agree side of the scale.

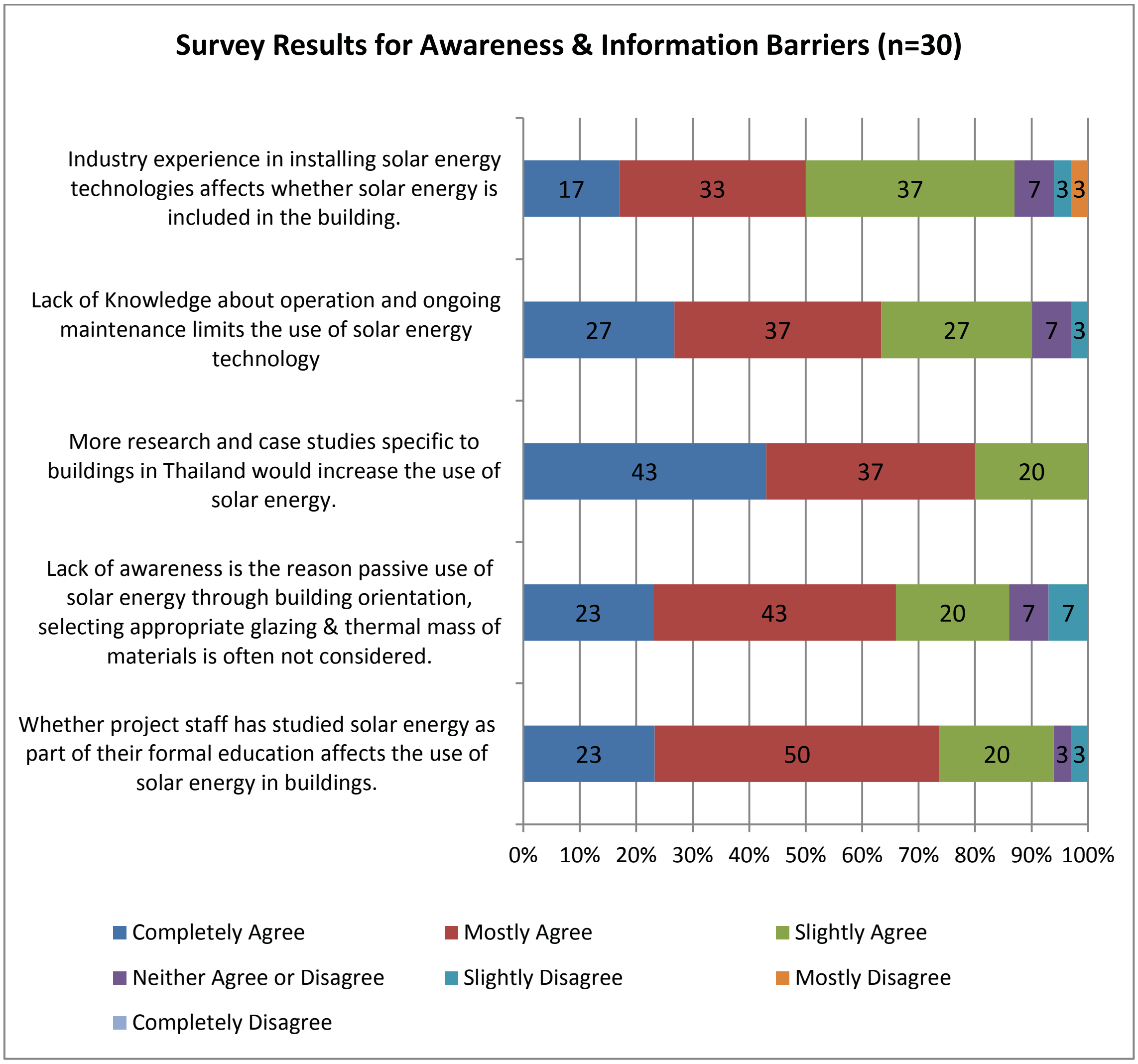

Figure 17: Survey results for awareness and information barriers

Also 93.3 percent of participants agreed to some extent with the statement that the use of solar energy is affected by project staff having a formal education that includes solar energy with 50 percent of participants mostly agreeing. Ninety percent of participants either completely, mostly or slightly agreed that lack of knowledge about operation and ongoing maintenance limits the use of solar energy technology. The statement "more research and case studies specific to buildings in Thailand would increase the use of solar energy" had the most agreement from participants, with 100 percent of participants selecting an answer on the agree side of the scale with 43.3 percent of participants completely agreeing with the statement.

Table 10 shows participant responses to awareness and information barriers by occupational group. Six of the occupational groups have a mode of two or mostly agree to the question "Industry experience in installing solar energy technologies affects whether solar energy is included in the building." although multiple modes apply to five of these groups. Architects were the most consistent in their responses with both of the architects interviewed stating they slightly agree with the statement.

Table 10: Responses to awareness and information barriers by occupational group

		M&E / Technical Consultant	Designer	Project Manager	Contractor	Owner	Developer	Architect	Environmental Consultant	Supplier
		n=9	**n=2**	**n=5**	**n=3**	**n=3**	**n=2**	**n=2**	**n=3**	**n=1**
Industry experience in installing solar energy technologies affects whether solar energy is included in the building.	Median	2	4	2	3	3	2.5	3	1	4
	Mode	2	2*	2*	2*	2*	2*	3	1	4
	Range	2	4	2	3	2	1	0	2	0
Lack of Knowledge about operation and ongoing maintenance limits the use of solar energy technology.	Median	2	2	1	1	2	3	3	3	3
	Mode	2	2	1	1	2	3	3	1*	3
	Range	3	0	1	1	0	0	0	4	0
More research and case studies specific to buildings in Thailand would increase the use of solar energy.	Median	2	2.5	1	1	2	1.5	1.5	1	3
	Mode	2	2*	1	1	2	1*	1*	1	3
	Range	2	1	2	0	1	1	1	1	0
Lack of awareness is the reason passive use of solar energy through building orientation, selecting appropriate glazing & thermal mass of materials is often not considered.	Median	2	1.5	2	1	2	3	2.5	5	3
	Mode	2*	1*	1*	1	2	2*	2*	5	3
	Range	3	1	2	1	0	2	1	3	0
Whether project staff has studied solar energy as part of their formal education affects the use of solar energy in buildings.	Median	2	3.5	2	1	2	2	2.5	2	3
	Mode	2	2*	2	1	2	1*	2*	2	3
	Range	3	3	1	2	1	2	1	1	0

** = 2 modes apply. Smallest mode has been used in table.*

All nine occupational groups answered on the agree side of the scale to the statements that a lack of knowledge of operation and maintenance affects the use of solar energy, that more research and case studies would increase the use of solar energy and that whether project staff have studied solar energy as part of their formal studies affects the use of solar energy.

In regards to lack of awareness being the reason passive solar design is not often considered, eight of the nine occupational groups answered on the agree side of the scale with a mode of one, two or three. While multiple modes apply to five of the groups, the small range for each group indicates that most participants agree with this statement. The exception is the environmental consultants who have a mode of five which indicates that most participants in this group slightly disagree with the statement.

Survey Results: Behavioural Barriers

Three of the survey questions relate to behavioural barriers as shown in figure 18. In relation to solar energy being affected by English not being the common business language in Thailand, there was more disagreement from expatriate participants than from Thai participants. Thai participants have a mode of two so the most common response was mostly agree as opposed to a mode of six for expatriate participants who gave mostly degree as the most common response. Overall 40 percent of the participants agreed with the statement to some extent while 50 percent disagreed. Ten percent of participants neither agreed nor disagreed that language is a barrier to the use of solar energy.

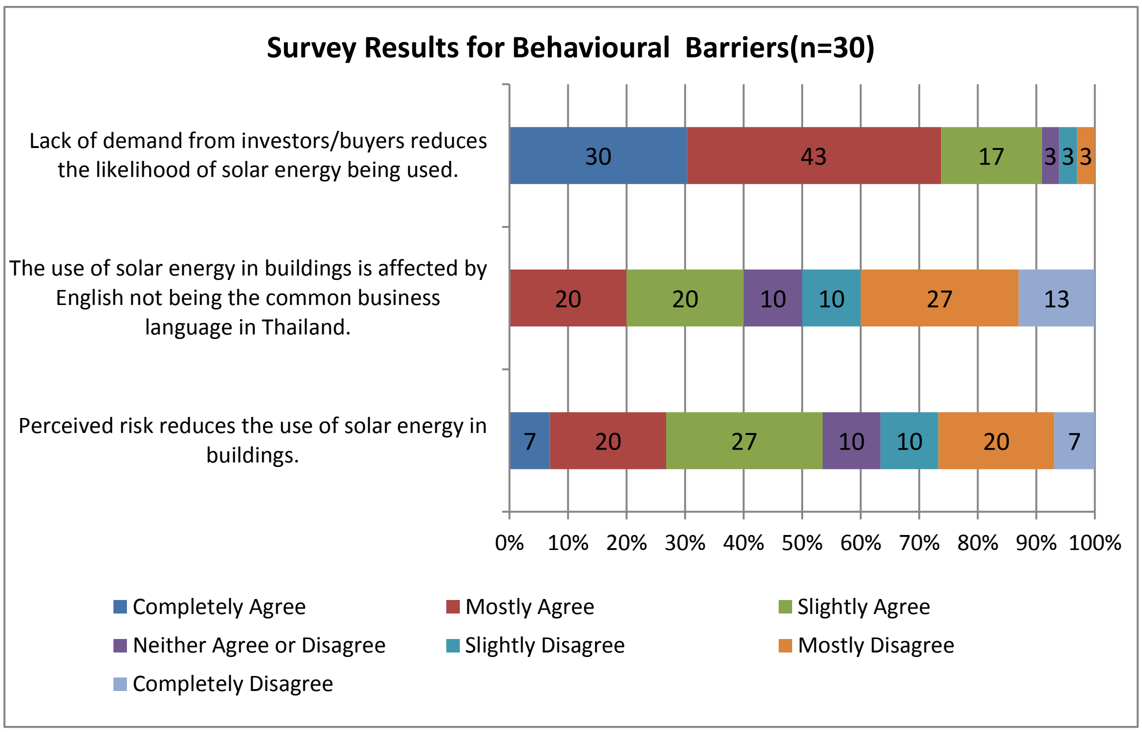

Figure 18: Survey results for behavioural barriers

Whether perceived risk affects the use of solar energy also showed a broad range of views with 54 percent of participants either slightly, mostly or completely agreeing that perceived risk reduces the use of solar energy while 37 percent answered on the disagree side of the scale. Ten percent of participants neither agreed nor disagreed with the statement. Again there were differences in the most common response between Thai participants who had a mode of three or slightly agree as opposed to expatriate participants who had a mode of six or mostly disagree.

There was more agreement on whether lack of demand from investors/buyers reduces the likelihood of solar energy being used with 90 percent of participants answering on the agree side of the scale.

Participant responses by occupational group are shown in table 11. Eight of the occupational groups answered on the agree side of the scale in relation to lack of demand reducing the likelihood of solar energy being used, the exception is the supplier who had a mode of five or slightly disagree.

Table 11: Responses to behavioural barriers by occupational group

		M&E / Technical Consultant	Designer	Project Manager	Contractor	Owner	Developer	Architect	Environmental Consultant	Supplier
		n=9	n=2	n=5	n=3	n=3	n=2	n=2	n=3	n=1
Lack of demand from investors/buyers reduces the likelihood of solar energy being used.	Median	2	3	2	1	2	2	2	2	5
	Mode	2	3	1*	1	2	1*	1*	2	5
	Range	2	0	3	0	4	2	2	1	0
The use of solar energy in buildings is affected by English not being the common business language in Thailand.	Median	5	4	2	4	6	6	4.5	3	5
	Mode	6	2*	2	2*	3*	6	3*	2*	5
	Range	4	4	5	5	4	0	3	3	0
Perceived risk reduces the use of solar energy in buildings.	Median	3	3.5	2	4	6	4.5	4	3	5
	Mode	3	1*	2	1*	4*	3*	2*	2*	5
	Range	3	5	1	6	3	3	4	4	0

** = 2 modes apply. Smallest mode has been used in table.*

There are a greater range of responses to the question of whether English not being the common business language in Thailand affects the use of solar energy. Six of the occupational groups have a mode that indicates the most common answer was on the agree side of the scale while the mode of the other three groups is on the disagree side of the scale. However multiple modes apply to five of the occupational groups and seven occupational groups have a range between three and five indicating there is a wide range of opinions within the group. Developers were the most consistent in their answers with both participants answering they mostly disagree with the statement while the supplier interviewed slightly disagrees with the statement.

A wide range of responses is also seen in relation to perceived risk being a barrier to solar energy with multiple modes applying to six of the occupational groups and seven of the groups having a range between three to six indicating varied responses within the group.

5. Discussion

The goal of this research is to outline how stakeholders in the building industry in Thailand perceive the use of solar energy in buildings with a view to understanding why passive solar design strategies and solar energy technologies have limited use in Thailand. The previous section provided an overview of the research findings and showed the barriers to solar energy identified by participants.

The aim of grounded theory methodology is to discover a core concept that emerges from the data. While participants outlined a range of barriers that influence the use of solar energy, the reoccurring theme of the research is that the low adoption of solar energy in Thailand's buildings is primarily due to a lack of knowledge. All but three of the research participants raised issues related to knowledge, awareness, experience or understanding. Given the frequency and scope with which the concept of knowledge is mentioned throughout the interviews, this is regarded as the core concept of the research.

In this section the barriers perceived by stakeholders are examined to determine key areas where changes would influence the use of solar energy in Thailand's buildings. This is followed by a discussion of the key theme of the importance of knowledge in regards to solar energy and outlining how this concept can be combined with an innovation perspective to influence the use of solar energy in buildings in Thailand.

5.1 Key Areas to Increase Consideration of Solar Energy

The research identifies a range of barriers that stakeholders perceive as influencing the use of solar energy in Thailand's buildings. These are classified into six different categories as shown in figure 19. Each barrier shown on the diagram has a number which indicates the number of participants who identified that particular barrier.

In considering the 25 barriers highlighted in the interview transcripts, there are key areas where changes would encourage greater use of solar energy. These are:

- Reducing the cost of solar energy;
- Improving the performance of solar energy technologies;
- Increasing support from government and institutions;
- Incorporating solar energy earlier in the building process;
- Increasing the availability of technology and expertise in Thailand;
- Encouraging greater awareness and knowledge of solar energy.

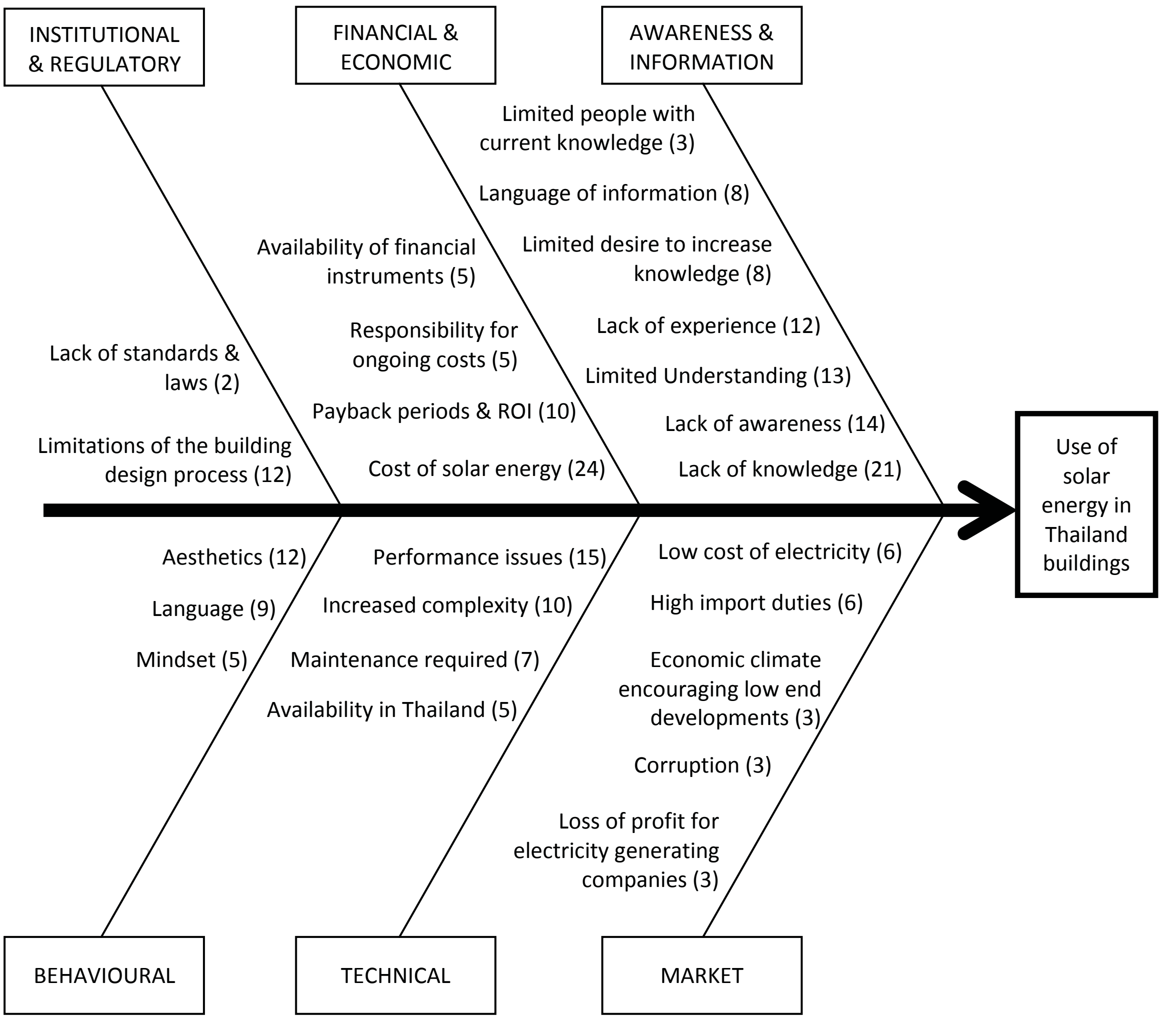

Figure 19: Barriers identified by participants during interviews

The first five key areas are discussed here while greater awareness and knowledge is discussed in the following section as the core concept of this research.

5.1.1 Reducing the Cost of Solar Energy

Eighty percent of participants made comment about the cost of solar energy which makes this the most commonly identified barrier. Aside from the initial cost of solar energy, participants also discussed the length of payback periods, the responsibility for ongoing costs and the availability of financial instruments such as adder rates for selling energy back to the grid. Other barriers mentioned by participants also influence the cost of solar energy such as the requirement for maintenance and high import duties. Looking at the broader environment the desire to spend additional money is reduced by an economic climate encouraging low end developments and the low cost of electricity (although there is disagreement amongst participants as to whether electricity in Thailand is cheap).

Reducing the cost of using solar energy, whether it is alternative types of glazing for passive design strategies or solar energy technologies is a vital component of creating greater acceptance and is recognised by 36.7 percent of participants as a future driver. Suggested ways of reducing the cost of solar energy include reducing import duties and creating subsidies to support the use of solar energy.

Some participants consider that the cost of solar energy is already coming down due to technological development:

> *"I think the price is a lot cheaper now than it used to be. Probably purely because of technology and better ways of, actually in the manufacturing process and materials."* – Contractor #3

Participants also consider that the cost of solar energy will seem cheaper as traditional fuel prices increase:

> *"You know cost of oil and other fuels natural fuels is becoming a fairly contentious issue in the global environment that the more we look any kind of renewable energy like solar or wind, the better it's going to be for a developer or nation as a whole."* – Project Manager #4

This indicates that not only is the actual cost of solar energy an issue but also how people perceive the cost in relation to other factors. How participants perceive barriers to solar energy is discussed in the next section.

There was a high level of agreement in the survey questions stating capital costs and payback periods are a barrier indicating that this is a common belief among participants. However the survey results indicate that payback periods are slightly more of an issue for stakeholders than capital costs suggesting that it is not so much the upfront cost that is a barrier but the time in which there will be a return on investment.

The cost of solar energy as a barrier is a common theme in research relating to renewable energy. Research by Cooke et al (2007) found that capital cost is a major barrier and the principal factor in decision making while a study by Painuly and Reddy (2004) showed that cost is the biggest barrier to solar water heaters for residential owners. Chan et al. (2009) also found that perceived higher upfront costs is an obstacle to green building practices. There are a number of ways in which the cost of solar energy can be reduced for end users. As market demand increases and technology develops it is believed the cost of solar energy will come down. Governments can also use financial instruments such as tax reductions to encourage the use of solar energy. Changes to energy pricing due to scarcity or demand for fossil fuels will encourage a greater use of solar energy. Owen (2006) suggests that removing subsidies on fossil fuel power generation and pricing electricity to reflect the cost of environmental damage would encourage the development of renewable energy and speed up transition.

5.1.2 Improving the Performance of Solar Energy

Fifty participants outlined a range of performance issues with solar energy such as the efficiency of solar panels, the space required to install solar panels and the ability to store energy generated from panels.

As technology develops these barriers will be less of an issue. However there is also an issue in how the performance of solar energy technologies is perceived and the need for accurate information. Participant statements about the efficiency of solar panels indicate there are differing opinions in this area and as new technology is developed, knowledge of these will need to be disseminated to stakeholders. One participant commented that:

> *"We also need to learn the efficiency of the system."* – Supplier #1

The efficiency of renewable energy technologies is often very site specific which is considered a disadvantage over fossil fuels which are generally priced consistently due to international trading (Owen, 2006).

Another issue related to the performance of solar energy is the issue of required maintenance. This has previously been discussed in relation to cost but also the degree of maintenance required influences whether equipment will be maintained to perform adequately. The survey showed participants have differing opinions as to whether the perception that solar energy technologies are unreliable or have variable outputs is a barrier to the use of solar energy.

5.1.3 Increasing Support from Government and Institutions

Government and institutions such as industry bodies, educational institutions and environmental organisations can play a greater role in promoting solar energy. Seventy percent of participants recognised the Thai Government as a stakeholder in the use of solar energy. The government is seen as having a responsibility to drive solar energy through implementing regulations and providing financial support though financial instruments.

In a wider context three participants suggested that corruption is a barrier to solar energy which is an area that needs to be addressed by government. It was also suggested that those who profit from electricity generation do not want greater use of renewable energy.

Painuly (2001) outlines that government intervention is required when there are unfavourable financial, institutional and regulatory environments combined with imperfections in the market place. However support from government alone is not likely to be sufficient to promote widespread use of solar energy. Reddy and Painuly (2004) point out that even after efforts by government to promote renewable energy; they have not become significant competitors to traditional energy generation.

Other institutions such as industry bodies and educational institutions have a role to play in promoting solar energy. The survey showed 100 percent agreement that industry bodies promoting solar energy would increase its use. There was also a high level of agreement (93%) that whether project staff has studied solar energy as part of their formal education affects the use of solar energy in buildings.

5.1.4 Incorporating Solar Energy Earlier in the Building Process

The participants indicated that the building design process influences whether solar energy will be used. In particular it was mentioned that solar energy needs to be considered at the very initial stages of the project including bringing mechanical and electrical people into the project earlier.

> *"...once you pull the trigger on construction and you tender, the better your drawings are and the more thought out your design, the cheaper it is, it might take a little bit longer to do that design and do all that coordination at the beginning but when you're actually going to build it, when you've actually got monthly payments, your investor has to keep paying monthly to the contractor, it goes a lot smoother if you have a really excellent drawing set, everything's been considered. Typically what you find in Thailand is that they don't, they sort of do it on the fly, do coordination on the fly."* – Environmental Consultant #1

Other research also shows that a less fragmented and more integrated design approach is import to the success of renewable energy technologies (Cooke et al., 2007).

5.1.5 Increasing the Availability of Technology and Expertise in Thailand

The participants have different opinions as to whether the availability of solar energy technologies is a barrier however there is a degree of perception that solar energy technologies and expertise are not readily available in Thailand. There is also a perception that while items may be available in Bangkok, it is more difficult to source technology and expertise in other parts of Thailand:

> *"I'm sure in Bangkok or something or you ring up a big supplier and say I need 10 fitted on a project, he would send a team down from Bangkok, I'm sure that would be much better because the local ones here in Phuket, its very very small businesses if you know what I mean and unless you get the boss doing actually the work, you can't really guarantee the workmanship..."* – Contractor #3

This also creates concern about whether technologies can be maintained outside of Bangkok:

> *"I mean if we do the system in the house, in his house, maybe one year later or two year they need to maintenance that equipment or that system, that is the problem, very difficult for him to do, he cannot call the local technical to come and maintain it, he have to request through the company"* – Contractor #2

Making technologies and expertise more readily available is one component of increasing the use of solar energy.

5.2 The Importance of Knowledge

Increasing the awareness, knowledge and experience of solar energy in Thailand is the key area which will influence the use of solar energy. As well as increasing knowledge for its own sake, greater knowledge has the ability to influence the other key areas affecting solar energy such as:

- Changing the perception of cost as a barrier to solar energy as the perception of cost, whether accurate or not, can sway solar energy decisions.
- Ensuring greater knowledge of solar energy technologies to ensure they are installed and maintained correctly which will likely improve perceptions of efficiency.
- Greater knowledge is required to change negative attitudes and mindset toward solar energy.

Knowledge is a vital component of implementing new technologies. As far back as 1994 (Pitts, 1994) it was recognised that the potential of renewable energy technologies would only be reached when those commissioning buildings have a greater understanding of what renewable technologies could achieve and the resources required. The level of knowledge of stakeholders involved in solar energy decisions impacts all aspects of using solar energy in buildings. This includes how and what stakeholders perceive to be the barriers to solar energy, whether they translate this into action in the current environment and subsequently whether there will be greater utilisation of passive solar design strategies or solar energy technologies in buildings in Thailand.

The importance of knowledge is reflected in the remarks made by 90 percent of participants who mentioned lack of awareness, knowledge, experience and limited understanding as barriers to the use of solar energy in buildings. The references participants made to these concepts shows that knowledge influences the perception stakeholders have toward other barriers to solar energy. There are five key themes in the research findings which contribute to the concept of knowledge in this research. These themes are:

- Definition of knowledge: How stakeholders perceive and describe knowledge.
- How knowledge influences stakeholder perceptions: How stakeholders hold a number of perceptions in relation to solar energy, some of which are inconsistent with known facts about solar energy.
- Importance of individual knowledge: How the knowledge of different professions in the building industry influences the use of solar energy.
- Drivers to increase knowledge: Whether there is a desire to learn about solar energy in the building industry.
- Influence of language and culture: How language and culture affects the pursuit of knowledge.

5.2.1 Awareness, Knowledge and Experience

The findings show that a lack of knowledge is the biggest barrier to the use of solar energy in Thailand. The research considered both passive solar design strategies and the use of solar technologies. While 56.7 percent of participants were aware of passive solar design strategies and 90 percent of solar technologies, this does not translate to experience with only 50 percent of participants having experience in considering or implementing solar energy in one form or another.

This lack of knowledge is reflected in the statements by participants which shows there is generally little knowledge of the use of solar energy in buildings. A number of participants commented that while they were aware of solar energy, their knowledge or understanding was very limited.

> *"Minimal, absolutely minimal, I have to admit I'm very naive and not up to date with the benefits apart from the obvious things that you see in newspapers and television but apart from that very little."* – Owner #1

Previous research that involves defining the concept of knowledge shows there is not one precise definition of knowledge as variations occur between different disciplines. However, knowledge is generally considered a broad encompassing construct which includes the concepts of awareness and experience (Biggam, 2001). However the building industry in particular is considered to lack a working definition of knowledge (Graham and Thomas, 2008).

The comments made by participants indicate perception of different levels of knowledge. The terms used by participants to describe knowledge differed depending on the particular area being discussed and the way these various terms are used reflects the different meanings applied to each term. Although this research did not specifically look at how participants define knowledge or whether they apply the same meanings, the common use of words by participants was in line with dictionary definitions:

<u>Awareness:</u> knowing that something (such as a situation, condition, or problem) exists.
<u>Perception:</u> the way you think about or understand someone or something.
<u>Knowledge:</u> information, understanding, or skill that you get from experience or education.
<u>Understanding:</u> the knowledge and ability to judge a particular situation or subject.
<u>Experience:</u> skill or knowledge that you get by doing something.

When participants were discussing general knowledge, such as the level of knowledge of the public, the term awareness was most often used. However when discussing the role of a particular profession, the word knowledge was used more often. This indicates that participants perceive knowledge as a different concept to awareness. Rather than considering knowledge as a broad concept, participants used the term knowledge to represent one point in a continuum that moves from awareness through knowledge and then to experience. For example one of the Project Managers commented *"they are hesitant to change to something they are not aware of or have little knowledge of",* which indicates that awareness and knowledge are perceived differently.

The finding that awareness, knowledge and experience represent different concepts to the participants supports the diffusion of innovation theory that there are different stages in the decision process. As discussed in chapter two, Rogers (2003) considers there are five stages of the innovation-decision process. The findings of this research tentatively support the existence of the first three stages of the innovation decision process shown below:

1. Knowledge: person becomes aware of an innovation and has some idea of how it functions;
2. Persuasion: person forms a favourable or unfavourable attitude toward the innovation;
3. Decision: person engages in activities that lead to a choice to adopt or reject the innovation;

Most likely due to the lack of experience, there is less information from the interviews relating to stages four and five of the innovation decision process which involve implementation and confirmation.

Lack of education and experience with renewable energy technologies has been highlighted as an issue in other research. Research by Cooke et al., (2007) highlighted a lack of experience in installing renewable technologies in buildings, while Chan et al. (2009) highlighted both a lack of education and lack of awareness as barriers to green building practices. Taleb and Pitts (2009) noted a lack of public awareness and understanding as a barrier to building photovoltaics in Gulf Cooperation Council countries.

5.2.2 Influence of Stakeholder Perceptions

While the definition of knowledge discussed in the previous section does not include feelings as knowledge, these also play a role in influencing how building industry stakeholders perceive solar energy.

Not only is lack of knowledge a barrier to the use of solar energy in buildings, the level of knowledge a person has affects whether they perceive solar energy as beneficial and how they perceive other barriers to solar energy. Research participants have conflicting opinions on a number of topics discussed in the interviews such as whether electricity in Thailand is expensive and whether solar energy technologies are manufactured in Thailand. There were a number of areas where stakeholders did not seem to have clear information which likely influences what they see as the barriers to solar energy. Cost in particular was recognised as an area where perception influences decision making, particularly the perception that solar energy is expensive, whether the perception is accurate or not:

> *"Whether it's real or just perceived cost is the biggest one, everyone thinks that it is expensive and tied up with that, the reason why it's like*

that is I think there's not enough understanding of the issues." – Project Manager #6

In researching green building practices in Singapore and Hong Kong, Chan et al. (2009) mentions that *"perception of higher upfront cost might be exaggerated due to the lack of real knowledge of the cost of GB"* (p.3068).

Comments by participants show there are different perceptions as to what is an acceptable payback period. Different participants mentioned that somewhere between three to eight years is an acceptable payback period and the idea that these payback periods are not possible prevents solar energy being considered as a possibility for a project.

The perception a person has influences the speed in which an innovation will be adopted. Rogers (2003) diffusion of innovation theory outlines that the rate of adoption of an innovation will be affected by an individual's perception of the following five attributes of the innovation:

- Relative advantage: the extent to which an innovation is perceived as being an improvement over the method it supersedes.
- Compatibility: the degree to which an innovation is seen as compatible with the values, needs and experience of potential adopters.
- Complexity: how complex an innovation is to understand and use.
- Trialability: whether the innovation can be experimented with on a trial or limited basis.
- Observability: how observable the results of an innovation are to others.

In the barriers mentioned by participants during the interviews, three of these attributes were discussed. This included the low cost of electricity which reduces the relative advantage of solar energy, the perception that project complexity is increased if solar energy is used and that the use of solar energy increases the cost of a development which makes the project less compatible price wise with other developments on the market. A lack of experience with solar energy may also reduce the degree to which it is seen as compatible with the needs of building industry stakeholders in Thailand.

It is recognised that stakeholder perceptions, whether accurate or not, directly impacts whether users will accept an innovation. Research by Miller, Radcliffe and Isokangas (2009) showed that negative perceptions of a new technology will negatively impact its implementation. This indicates that to increase the use of solar energy in buildings in Thailand not only is increasing the level of knowledge important, it is also vital to consider the best way to communicate knowledge in a way that influences stakeholder perceptions.

5.2.3 Importance of Individual Knowledge

As each construction project includes personnel in a number of different professions, the knowledge of these individuals has a substantial impact on whether solar energy will be used on a project. The participants in this research identified eight stakeholder groups in the building industry which influence whether solar energy will be used in a project. The participants outlined that each group has a different degree of influence on a project. This is supported by other research with Aouad et al. (2010) noting that each stakeholder in a construction project has a different role and responsibility in implementing an innovation.

Research participants particularly recognised the client or investor, as well as the architect, as being instrumental in decisions involving the use of solar energy. Participants hold a general opinion that if solar energy is not driven by the client or architect, it will not be incorporated in a project.

The importance of individual knowledge is increased by the project nature of the building industry with many professionals moving from project to project rather than contributing to the ongoing knowledge base of a particular company. One of the participants mentioned a desire to work with the same consultants which further limits the availability of additional knowledge to the project:

> *"We try and put the team together, we work often with the same consultants cause sort of the familiarity and the understanding of each other's ways of working which makes running the whole thing a lot easier."* – Project Manager #6

Another aspect is the desire for people to stick with what they know rather than trying something new which was highlighted in the interviews. This is also supported by Hong, Chaing, Shapiro and Clifford (2007) when they state *"Designers must meet developers' needs in the most reasonable and time efficient manner and with short development time frames; this reality often means off the shelf design with only aesthetic changes".* Aouad et al. (2010) also mentions that innovation can be threatening in the building industry as it is not easy to change normal ways of working and a return on investment is not guaranteed.

The knowledge of individuals in the building industry may also influence the performance of solar energy technology as indicated by this participant:

"...in our design we put in solar hot water heaters and they installed them from a reputable company but they didn't install them correctly and as a result instead of it being 70% efficient, it's only 40% efficient" - M&E / Technical Consultant #2

A lack of professional knowledge in this case is likely to add to negative perceptions regarding the performance of solar energy technologies.

Individuals involved in a construction project have a vast range of backgrounds from unskilled labour to professional and managerial positions (Pathirage, Amaratunga and Haigh, 2007) which can make communication more complex and lead to disparate efforts which hamper innovation. Blayse and Manley (2004) point out difficulties in communication often arise as each firm or individual generally only controls one part of the overall design process. This also relates to the need to incorporate solar energy at the early stages of a building project. By bringing people (such as mechanical and electrical professionals) into the project earlier they have a greater chance of using their knowledge to make the project more energy efficient.

5.2.4 Drivers for Increasing Knowledge

The majority of interview participants have been in the workforce for sometime so have not studied energy efficiency or solar energy in their formal education. Only three participants mentioned covering these areas in their studies. As a result the knowledge the majority of interview participants have about solar energy has come from sources other than formal education.

For people to learn about solar energy, the information has to be provided in an easily accessible way with one participant commenting that people will not make an effort to go and seek the information themselves.

One factor that influences whether a person will make an effort to learn new information is based on how important they deem that information to be. This is where drivers such as regulations created by government or a demand by clients can create an impetus to learn new information. Research by Cooke et al. (2007) highlighted the importance of the client in their past experience with renewable energy technologies and whether they choose to pursue it while also noting that clients were often disappointed by the project teams understanding of renewable energy.

As previously mentioned the knowledge of individuals in the building industry is important for solar energy. The knowledge of each individual contributes to some degree to the knowledge of the whole project, with individuals promoting their own awareness and attitudes. When it comes to understanding how people learn, knowledge can be considered either explicit or tacit. Explicit knowledge can be articulated as words or numbers and is easily communicated where tacit knowledge relies on intangible factors such as personal beliefs, experiences and values. Therefore tacit knowledge is more difficult to communicate.

Sexton and Barrett (2004) outline that the success with which a technology can be absorbed by small construction firms depends on two factors: whether the knowledge embodied in the technology is explicit or tacit and complexity. They consider that whether the knowledge involved is explicit or tacit, some technologies are more complex than others and therefore more difficult to absorb for the small construction firm.

Solar energy, whether it is using passive design strategies or solar technologies, requires technical or explicit knowledge while attitudes towards the benefits and usefulness of solar energy is tied to the tacit knowledge of individuals. So while more formal channels of knowledge transfer such as books and seminars are primarily useful for increasing the explicit knowledge held by an individual, the transfer of tacit knowledge relies more on relationships and the social transfer of knowledge. Due to the nature of tacit knowledge, the transfer of personnel is one method of encouraging tacit knowledge transfer (Gorman, 2002). Gorman (2002) says this kind of tacit knowledge that can only be transferred by *"a person-to-person sharing of technical and managerial experience, attitudes, and viewpoints"* (p.220).

5.2.5 Language

During the research two separate aspects of language were discussed. One was that the language of information is a barrier to solar energy and other is that the use of different languages (Thai and English) creates a communication barrier. Language is inextricably tied to awareness, knowledge and understanding. Responses from the interview participants indicate that there has to be understanding of the language in which information is presented before there can be knowledge from the information:

> *"So it is a case of having stuff in the right language covering the right information, which is real information and you having the knowledge to actually, or having someone employed to have the knowledge to assess it correctly."* – Project Manager #1

However perhaps surprisingly there was more disagreement on this issue than any other raised in the research. In analysis of the interview transcripts, 30 percent of participants consider that the use of different languages creates a communication barrier while 40 percent of participants consider that language does not influence the use of solar energy. This was consistent with responses in the survey to the statement "the use of solar energy in buildings is affected by English not being the common business language in Thailand" with 40 percent of participants answering on the agree side of the scale and 50 percent of participants answering on the disagree side of the scale. Ten percent of participants neither agreed nor disagreed. It seems that despite the influence of language on knowledge, language is not perceived to be a major barrier by stakeholders in the Thailand building industry.

5.3 Knowledge and Diffusion of Innovation

Diffusion is the process in which an innovation is communicated through the sending of new ideas (Rogers, 2003). As such the communication of knowledge and the development of awareness, knowledge and understanding in individuals is a vital component of an innovation being adopted. The research findings shown in the previous section indicates participants are aware of the importance of knowledge and recognise a lack of knowledge in themselves and others as a barrier to the use of solar energy.

The five stages in the decision process to adopt an innovation have been discussed previously. These stages are knowledge, persuasion, decision, implementation and confirmation. In section 5.1.1 it was outlined how the findings of this research support, to some degree, the first three stages of the innovation decision process. However the findings indicate that the first stage of the innovation decision process may be better termed awareness with a more in depth level of knowledge being added as an additional component before the decision stage. An alternative to the first three stages of the innovation decision model is shown in figure 20. This model outlines the stages required for individuals to make a decision to implement solar energy with awareness and knowledge treated as separate components both with the ability to influence perception.

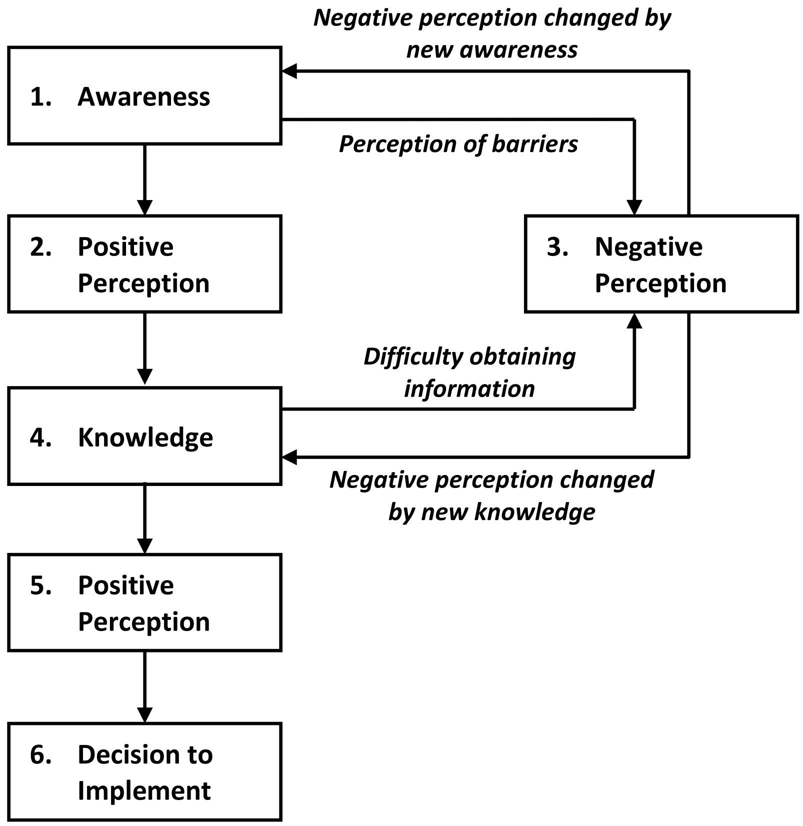

Figure 20: Alternative to the first three stages of the innovation decision process

The model outlines that initial awareness of solar energy leads to either a positive or negative perception. Awareness is used at this stage to describe a general knowing that an idea or concept exists. If after the stage of awareness the person develops a positive perception they are likely to seek further knowledge. The term knowledge here is used to refer to specific skills or information required in a construction project such as cost benefit analysis, building modelling or technical skills. Even after more knowledge is obtained a person may still develop a negative perception such as would be the case if barriers are encountered such as limited availability or unfavourable costs in relation to the project budget. A negative perception may also be a created if there is difficulty in obtaining further knowledge. Only if there is a positive perception after further knowledge is received will a decision be made to implement.

Participants made a number of statements which show how awareness and knowledge about solar energy are disseminated:

> *"I would put it like evolution of the product you know, this model comes out and a few people used it and then word of mouth, product got better*

so more people used it, I think the same thing will happen here in Thailand." – Contractor #3

The reoccurring theme of this research is the importance of awareness and knowledge in individuals that contribute to a project team. This research has focused on individuals as the unit of study however organisational learning and the external business environment also impacts innovation in construction (Aouad et al., 2010). Riberio (2009) considers the importance of knowledge in today's society means the competitiveness of firms is directly tied to their ability to create and share knowledge.

One criticism levelled at diffusion research is the possibility of pro technology bias which is the implication of the research that the technology should be adopted. The aim of this research is not to argue that incorporating solar energy in buildings is an appropriate business decision but to ascertain why solar energy has been used to a limited degree in buildings in Thailand. Very few of the research participants could state that they had investigated the use of solar energy and decided not to incorporate it giving specific reasons. It is hoped that a greater understanding of how both awareness and knowledge contribute to negative or positive perceptions of solar energy will encourage more investigation in the early stages of building projects.

6. Conclusion

The previous chapters presented research into barriers to using passive solar design strategies or solar energy technologies in buildings in Thailand. The method used has not previously been applied to the study of stakeholder perceived barriers to solar energy in Thailand and was used here to allow theory to be developed as to why solar energy is not utilised more.

The main objective of this research is to identify what building industry stakeholders perceive as barriers to using solar energy in buildings in Thailand and determine future changes to encourage consideration of using solar energy in buildings. It is intended that a greater understanding of these barriers will make it easier for government and other industry stakeholders to take steps to overcome the barriers and develop more energy efficient buildings.

The research participants were people with experience working on building projects in Thailand. While both residential and commercial buildings were discussed, most participants were experienced in high end residential buildings.

6.1 Conclusion

The following conclusions have been drawn from this research:

- Building industry stakeholders perceive a range of barriers to the use of solar energy. The perception of these barriers limits the interest in solar energy and most often detailed analysis of whether solar energy, in one form or another, should be incorporated into a project is not undertaken. Many of the barriers identified by participants were based on perception and may not be accurate with further investigation.

- There is little knowledge of passive solar design strategies in Thailand. Only a limited number of participants understood elements such as glazing and building materials as contributing to energy efficiency and a form of using solar energy. While some participants are knowledgeable about the impact of glazing and building materials on heat gain, they did not associate this with solar energy.

- The primary barrier to the use of solar energy in buildings in Thailand is a lack of awareness and knowledge. The majority of participants made comments relating to awareness, knowledge, experience or understanding and recognised this as a barrier either in themselves or others.

- There is a difference between awareness and knowledge and any efforts to increase the consideration of solar energy in buildings needs to target those different levels encouraging both greater general awareness of solar energy as well as more specific knowledge required to use solar energy in buildings.

6.2 Recommendations

Painuly (2001) suggests that policies to increase the potential of renewable energy technologies can either remove barriers or create conditions that force the market to act in spite of barriers. The barriers identified in this research indicate six key areas where changes can be made to encourage greater consideration of solar energy. These are summarised in table 12 below.

Table 12: Summary of key policy areas to encourage greater use of solar energy

Recommendation	Relevant Barriers Identified in Research	Possible Solutions
1. Reducing the cost of solar energy	• Cost of solar energy • Payback periods & ROI • Responsibility for ongoing costs • Availability of financial instruments • High import duties	• Government subsidies to reduce initial cost. • Reduction of import duties for solar technologies. • Guarantee of rates for energy being sold back to the grid. • Financial incentives for manufacturers in Thailand. • Promoting greater awareness of traditional fuel costs and forecasts of cost increases.
2. Improving the performance of solar energy	• Performance issues • Maintenance required • Lack of experience • Limited people with current knowledge	• Research and development to improve efficiency of technologies. • Provide training on correct installation and maintenance of technologies.
3. Increasing support from government and institutions	• Availability of financial instruments • Corruption • Loss of profit from electricity generating companies • High import duties • Lack of standards and laws	• Review of building codes and regulations relating to renewable energy. • Greater formal education options in renewable energy. • Encourage greater promotion by industry bodies.

Recommendation	Relevant Barriers Identified in Research	Possible Solutions
4. Incorporating the use of solar energy earlier in the building process	• Limitations of the building design process • Increased complexity	• Giving foreign architects the ability to sign off designs in Thailand. • Promote consideration of energy efficiency early in a project.
5. Increasing the availability of technology and expertise in Thailand	• Availability in Thailand	• Greater promotion of technology manufactured in Thailand. • Suppliers becoming more active in promoting their products and serving clients based throughout Thailand.
6. Increasing awareness and knowledge	• Mindset • Maintenance required • Lack of experience • Lack of knowledge • Lack of awareness • Limited understanding • Limited desire to increase knowledge • Language of information • Limited people with current knowledge	• Creating general awareness of environmental issues and renewable energy through the media. • Increase availability of training materials directed at both the general public and building industry. • Increase knowledge of analysis tools such as cost benefit analysis, building modelling. • Establish greater availability of energy efficiency / renewable energy as a professional career option.

6.3 Suggestions for Future Research

This research provides a starting point for closer examination of the role of knowledge in energy efficiency and the use of renewable energy in buildings in Thailand. Given how important knowledge is to the use of solar energy it would be interesting to determine whether awareness and knowledge are disseminated differently and the most effective channels for distribution.

It would also be interesting to examine the differences in knowledge held by individuals and by organisations and how organisations in the building industry can promote greater use of solar energy despite the limitations of the project by project nature of the industry.

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8. Appendices

Appendix 1: Research Participants

List of interview participants in order that interviews conducted:

1	Project Manager #1	Expatriate
2	Owner #1	Expatriate
3	Contractor #1	Thai
4	Contractor #2	Thai
5	Contractor #3	Expatriate
6	Project manager #2	Expatriate
7	Architect #1	Expatriate
8	M&E/Technical Consultant #1	Expatriate
9	M&E/Technical Consultant #2	Expatriate
10	M&E/Technical Consultant #3	Thai
11	M&E/Technical Consultant #4	Thai
12	M&E/Technical Consultant #5	Thai
13	M&E/Technical Consultant #6	Thai
14	Architect #2	Thai
15	Project manager #3	Expatriate
16	Project manager #4	Expatriate
17	Project manager #5	Thai
18	Project manager #6	Expatriate
19	Environmental Consultant #1	Expatriate
20	Developer #1	Thai
21	Owner #2	Expatriate
22	Developer #2	Expatriate
23	M&E/Technical Consultant #7	Expatriate
24	M&E/Technical Consultant #8	Expatriate
25	Designer #1	Thai
26	Supplier #1	Expatriate
27	Environmental Consultant #2	Thai
28	Designer #2	Expatriate
29	Environmental Consultant #3	Expatriate
30	Owner #3	Expatriate

Appendix 2: Survey Instrument

Barriers to the Use of Solar Energy in Thailand's Buildings – Survey
อุปสรรคต่อการใช้พลังงานแสงอาทิตย์ในอาคารไทย – การสำรวจ

In considering the use of solar energy in buildings in Thailand, please indicate whether you agree or disagree with the following statements.

ในการพิจารณาการใช้พลังงานแสงอาทิตย์ในอาคารในประเทศไทยกรุณาระบุว่าคุณเห็นด้วยหรือไม่เห็นด้วยกับข้อความดังต่อไปนี้

1. The building industry sees higher capital costs as a barrier to using solar energy.

   อุตสาหกรรมการก่อสร้างอาคารมองเห็นต้นทุนที่สูงขึ้น
   เป็นอุปสรรคในการใช้พลังงานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

2. Solar energy would be used more in buildings if payback periods were shorter.

   พลังงานแสงอาทิตย์ จะใช้มากในอาคารหากมีระยะเวลาคืนทุนเร็วขึ้น

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

3. Cost is the only factor considered when deciding to use solar energy in a building.

   ค่าใช้จ่าย(ต้นทุน) เป็นเพียงปัจจัยในการพิจารณาเลือกใช้พลังงานแสงอาทิตย์ในอาคาร

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

4. The subsidy of electricity costs in Thailand reduces the need to use solar energy.

การอุดหนุนค่าใช้ไฟฟ้าในประเทศไทยทำให้ลดความต้องการ การใช้พลัง งานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

5. Perceived risk reduces the use of solar energy in buildings.

ความเข้าใจที่ไม่ชัดเจน ลดความต้องการในการใช้พลังงานแสงอาทิตย์ ในอาคาร

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

6. The use of solar energy in buildings is affected by English not being the common business language in Thailand.

การใช้พลังงานแสงอาทิตย์ในอาคารได้รับผลกระทบจากการที่ภาบาอังกฤษไม่ใช่ภาษาที่ใช้ทั่วไปในวงการธุรก์จ

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

7. Whether project staff has studied solar energy as part of their formal education affects the use of solar energy in buildings.

การ ที่เจ้าหน้าที่ได้ศึกษาโครงการพลังงานแสงอาทิตย์เป็นส่วนหนึ่งของการศึกษาอย่างเป็นทางการของพวกเขามีผลต่อการใช้พลังงานแสงอาทิตย์ในอาคาร

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

8. Lack of awareness is the reason passive use of solar energy through building orientation, selecting appropriate glazing & thermal mass of materials is often not considered.

การขาดความรู้คือเหตุผลที่เพิกเฉยต่อการใช้พลังงานแสงอาทิตย์เป็นเป้าหมายหลักในอาคาร วัสดุที่เหมาะสมสำหรับพลังงานแสงอาทิตย์มักจะไม่ได้รับการพิจารณา

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

9. More research and case studies specific to buildings in Thailand would increase the use of solar energy.

การวิจัยเพิ่มเติมและกรณีศึกษาเฉพาะอาคารในประเทศไทยจะเพิ่มการใช้พลังงานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

10. Use of solar energy is not limited by availability of solar energy technologies in Thailand.

การใช้พลังงานแสงอาทิตย์จะแพร่หลาย หากมีเทคโนโลยี่ที่หาได้ง่ายในประเทศไทย

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

11. Lack of Knowledge about operation and ongoing maintenance limits the use of solar energy technology

การขาดความรู้เกี่ยวกับการดำเนินงานและการบำรุงรักษาอย่างต่อเนื่องข้อ จำกัดการใช้เทคโนโลยีพลังงานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

12. Lack of demand from investors/buyers reduces the likelihood of solar energy being used.

การขาดความต้องการจากนักลงทุน / ผู้ซื้อ ลดโอกาสของการใช้พลังงานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

13. Industry experience in installing solar energy technologies affects whether solar energy is included in the building.

ความเชี่ยวชาญของอุตสาหกรรมการติดตั้งเทคโนโลยี่พลังงานแสงอาทิตย์
จะมีผลต่อการที่จะใช้ หรือ ไม่ใช้ พลังงานแสงอาทิตย์ในอาคาร

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

14. The perception of solar energy technologies being unreliable or having variable output is a barrier to the use of solar energy in buildings.

การรับรู้เทคโนโลยี่พลังงานแสงอาทิตย์ที่ ไม่น่าเชื่อถือ หรือน่าเชื่อถือ
มีผลเป็นตัวแปรต่ออุปสรรคการใช้พลังงานแสงอาทิตย์ในอาคาร

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

15. Lack of an integrated approach to building design impacts the use of solar energy.

การขาดการบูรณาการในการออกแบบอาคาร สร้างผลกระทบต่อการใช้พลังงานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

16. Cost competitiveness in the building industry influences whether solar energy is incorporated in the building.

ค่าใช้จ่ายในการแข่งขันมีผลต่ออุตสาหกรรมก่อสร้างว่าพลังงานแสงอาทิตย์เป็นนิติบุคคลที่จัดตั้งในอาคาร

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

17. Industry bodies encouraging the use of solar energy in buildings would increase the use of solar energy.

องค์กรอุตสาหกรรมส่งเสริมการใช้พลังงานแสงอาทิตย์ในอาคารจะเพิ่มการใช้พลังงานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

18. The building industry considers that using solar energy in a building increases the complexity of the project.

อุตสาหกรรมก่อสร้างอาคารเห็นว่าการใช้พลังงานแสงอาทิตย์ในอาคารเพิ่มความซับซ้อนของโครงการ

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

19. Energy efficiency regulations in Thailand would increase the use of solar energy.

การมีกฎระเบียบการใช้พลังงานอย่างมีประสิทธิภาพในประเทศไทยจะเพิ่มการใช้พลังงานแสงอาทิตย์

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐

20. A lack of consistent energy and green building rating tools and standards impacts the use of solar energy in buildings.

การขาดความสอดคล้องของพลังงาน , การประเมินผลอาคารสีเขียวและระบบมาตรฐานส่งผลกระทบต่อการใช้พลังงานแสงอาทิตย์ในอาคาร

Completely Agree เห็นด้วยอย่างแน่นอน	Mostly Agree เห็นด้วยเป็นส่วนใหญ่	Slightly Agree เห็นด้วยเพียงเล็กน้อย	Neither Agree or Disagree เห็นต่าง หรือ ไม่เห็นด้วย	Slightly Disagree ไม่เห็นด้วยเล็กน้อย	Mostly Disagree ไม่เห็นด้วยเป็นส่วนใหญ่	Completely Disagree ไม่เห็นด้วยอย่างแน่นอน
☐	☐	☐	☐	☐	☐	☐