Mitigating the industrial energy efficiency problem in China

Investigating the acceptance of energy services companies using the Theory of Reasoned Action

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Declaration

I hereby certify that the work embodied in this Dissertation Project is the result of original research and has not been submitted for a higher degree to any other University or Institution.

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24th May, 2012

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Abstract

The rapid growth of the Chinese heavy-industry sector has presented both opportunities and challenges to the country. While the heavy industrial sector contributes significantly to the growth of China's GDP, the energy-intensive nature of this sector has led to unprecedented problems in resource sustainability, pollution, and climate change.

Encouraging firms in the heavy industrial sector to use energy services companies (ESCOs) to improve energy efficiency has been a high-priority of the Chinese Government. According to the traditional view, regulations and incentives are believed to be important drivers for ESCO adoption. It is also believed that energy performance contracting (EPC) is an effective tool for ESCO deployment based on its economic viability. Thus, many policies and incentive schemes in China focus on promoting EPC. However, while there are some successful cases, the current level of adoption of ESCOs in the sector remains generally low.

This research uses the TRA framework to provide a quantitative investigation into how tangible factors such as government incentives and intangible factors such as the perceived capability of and trust in ESCOs are related to the adoption of ESCO services by firms in Chinese heavy industries. A proposed model incorporating the existing views about EPC has been developed and tested.

The results indicate that government incentives significantly predict intention to use ESCOs and the actual use of ESCOs, which is consistent with the traditional view. However, although preference for EPC is a significant predictor of the intention to use ESCOs, it has been demonstrated that attitude to use ESCOs is an even stronger predictor. The attitude is, in turn, strongly affected by the perceived capability of ESCOs and, to a lesser extent, Trust in ESCO. On the other hand, trust directly affects the intention to use ESCOs at a magnitude comparable to preference for EPC. Based on the research findings, we have recommended to develop an ESCO accreditation system and a sector-based collective guarantee scheme.

Chapter 1 Introduction

With the rapid growth of its heavy industries in recent years, China's extensive energy consumption has caused a lot of concerns. Questions about the sustainability of such growth and its associated environmental impacts have led to debates at national and international levels. To mitigate the problem, one of the approaches endorsed by the Chinese Government is to develop the energy services company (ESCO) sector so as to provide proper energy-efficiency improvement services to Chinese heavy industries. Governmental organisations, scholars and industrial practitioners have expressed different, and sometimes conflicting, opinions about the effectiveness and appropriateness of this approach. In reality, the level of acceptance of the ESCO approach varies remarkably within the heavy-industry sector. By applying the Theory of Reasoned Action, this research examines the behaviour of firms in the heavy industrial sector in China regarding the adoption of ESCOs.

1.1 Background to the Research

Since the beginning of the Industrial Age, the consumption of energy resources has been growing at an ever increasing rate. Today, the problem of resource sustainability and the impact on environmental and climate systems have become major concerns (Yoda 1995; IPCC_AR4 2007; Ertike & Hacioglu 2011; IEA 2011a).

China's energy consumption has demonstrated a rapid growth in recent years due to the accelerated growth of energy-intensive heavy industries (Wang & Zhao 2007; IEA 2007a; Price, Wang & Jiang 2010; Pun 2010). Being a country that is dominated by the manufacturing sector, China is the world's largest energy consumer and accounted for 18.7% of the world's total energy consumption in 2009 (IEA 2011a). In 2005, China's accounted for 15.2% of the world's total energy consumption (IEA 2007a) compared to 10.3% in 2000 (IEA 2002).

The energy-consuming and polluting nature of heavy industries has caused significant concerns about sustainability (IEA 2007a; Wu 2005; Wu 2006; Klare 2006; Bosworth & Collins 2008; Price, Wang & Jiang 2010; Pun 2010). Government policies to mandate improvements in energy efficiency in heavy industries have been issued and are currently being implemented (Price & Wang 2007; NDRC 2004; NDRC 2007; Zhou, Levine & Price 2010; MIIT 2012). Explored and discussed by many scholars, officials and industrial practitioners in China (Lin 2005; Wu 2005; Wu 2006; Zhao 2005; Jian & Yu 2006; NDRC 2006; Zhou 2007; SC_PRC 2010), the deployment of ESCOs to help industries to improve their energy efficiency is one of the approaches that has been promoted by the Chinese Government.

ESCOs are technical experts who help clients to evaluate their energy usage. ESCOs design and implement programs to improve the energy efficiency of their clients. In its most common form, ESCOs initially bear all the costs (or most of the costs) for such programs and are compensated by clients based on how much energy their clients save. The specific terminology for this contractual arrangement is known as Energy Performance Contracting (EPC). In theory, this form of contracting protects clients from any incorrect investment decisions an ESCO might make. Nevertheless, whether or not the ESCO/EPC approach is appropriate for China was debated extensively during 2004 to 2007 (Lin 2005; Wu 2005; Wu 2006; Zhao 2005; Jian & Yu 2006).

Whilst there are numerous theoretical arguments illustrating the advantages of employing the ESCO approach, the reality is that the level of acceptance of ESCO services varies considerably across Chinese heavy industries and level of acceptance is generally not high (Gan 2009; Shen 2008; Zhou 2007; Tang 2005, EMCA 2006). In fact, although the energy-intensive nature of the industrial sector would make it a huge market for ESCOs, the actual adoption rate of ESCOs in the industrial sector is low when compared with other sectors (Ellis 2009; WEC 2008; Bertoldi et al. 2007; Urge-Vorsatz et al. 2007; Bertoldi & Rezessy 2005; Vine 2005).

The adoption of ESCO services has not been systematically investigated. In other words, although ought-to-be aspects of ESCO services such as economic benefits, technology advantages, and sustainability have been comprehensively examined, the practical aspects of user behaviour in relation to the adoption of ESCO services are not well understood. This study makes a contribution to this issue as it provides an investigation of ESCO adoption and helps to improve our understanding of the

ESCO approach for mitigating the energy-efficiency problems faced by heavy industries in China.

1.2 Justification for the Dissertation Project

The aim of this study is to investigate, using the Theory of Reasoned Action (Fishbein & Ajzen 1975; Ajzen 1991), user behaviour in relation to the adoption of ESCO services in the heavy industrial sector in China. In the traditional view, government regulations and incentives are believed to be important drivers for ESCO adoption. It is also believed that EPC is an effective tool for ESCO deployment based on its economic viability (Gan 2009; Shen 2008; Li 2007; Sorrell 2007; Bertoldi et al. 2007; Urge-Vorsatz et al. 2007; BASE 2006; Vine 2005). Many policies and incentives in China are therefore built around promoting EPC, and the Government believes that this will quickly accelerate the adoption of ESCOs (NDRC 2004; SC_PRC 2010, MIIT 2012).

As mentioned in Section 1.1, EPC makes good economic sense for clients because it protects clients from incorrect investment decisions regarding energy efficiency. However, simple economic viability does not always lead to acceptance. The situation is analogical to some early smoking cessation campaigns which emphasised the health hazards of smoking and the benefits of quitting. By applying the Theory of Planned Behaviour (a variation of Theory of Reasoned Action), Norman, Conner and Bell (1999) found that focusing on perceptions of susceptibility and behavioural control rather than on hazards and benefits could lead to remarkably better outcomes regarding the intention to quit smoking. In addition, this example illustrates the importance of accurately understanding smokers' perceptions. Similarly, although it is reasonable to assume that the economic viability of EPC is important, it could be over-simplistic to assume that EPC is the only important factor that drives ESCO deployment in the heavy industrial sector. By investigating ESCO adoption in the heavy industry, the findings of this research can enhance our understanding of the practical aspects of ESCO services being adopted by heavy industries and thus can offer insights for policy makers to further examine and refine the ESCO approach to energy-efficiency improvement.

1.3 Research Questions and Hypotheses

The research question under investigation is as follows:

> ***How do government incentives, trust and perceived capability of ESCO, and preference for Energy Performance Contracting influence the adoption of ESCO services in heavy industries in China?***

Based on the Theory of Reasoned Action, a set of hypotheses is proposed and the rationale on which these hypotheses are based are provided in Section 2.5 of Chapter 2. In brief, it is postulated that the preference for EPC is positively correlated to the intention to use an ESCO, which, in turn, is positively correlated to the adoption of ESCO services. Furthermore, according to the model proposed in this study, preference for EPC is affected by both the attitude toward using ESCOs and the subjective norm to use ESCOs. Moreover, attitude toward using ESCOs is affected by trust in the ESCO and the perceived capability of the ESCO whilst the subjective norm to use ESCOs is affected by government incentives. Figure 1.1 provides a graphical representation of the proposed model.

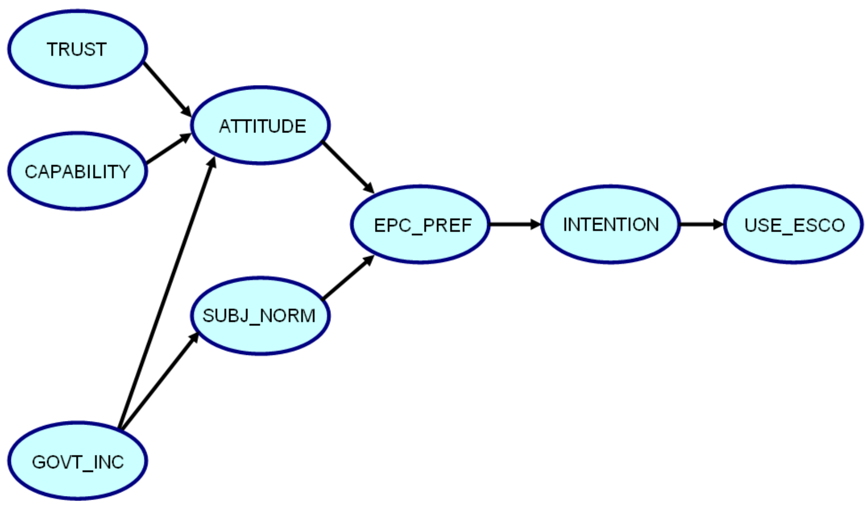


Figure 1.1 **Proposed conceptual model**

1.4 Research Methodology

Based on the Theory of Reasoned Action, a positivistic, quantitative, correlational, and cross-sectional approach was adopted for this research. A questionnaire was dispatched to participants in either electronic or printed format. The SPSS software package was used to perform data analysis.

1.5 Major Findings

The proposed model (Figure 1.1) has been supported by the findings and some exploratory analyses were conducted. Details of the analyses conducted and the results of the hypothesis testing are provided in Sections 4.4 and 4.5 of Chapter 4. The findings for the hypotheses that constitute the proposed model are presented in Table 1.1.

Table 1.1 **Summary of Hypotheses Testing Results**

Hypothesis	Supported
The relationship between trust in ESCO and preference for EPC is mediated by attitude to use ESCOs.	YES
The relationship between perceptions on ESCO capability and preference for EPC is mediated by attitude to use ESCOs.	YES
The relationship between government incentives and preference for EPC is mediated by attitude to use ESCOs.	YES
The relationship between government incentives and preference for EPC is mediated by subjective norm to use ESCOs.	YES
The relationship between attitude to use ESCOs and intention to use ESCOs is mediated by preference for EPC.	YES
The relationship between subjective norm to use ESCOs and intention to use ESCOs is mediated by preference for EPC.	YES
The relationship between preference for EPC and actual use of ESCOs is mediated by intention to use ESCOs.	YES

In the exploratory analyses, government incentives were found to significantly predict intention to use ESCOs and the actual use of ESCOs, which is consistent with the traditional view. However, the results have also indicated that perceptions of ESCO capability affect preference for EPC at a magnitude comparable to government incentives.

Regarding the importance of EPC, although preference for EPC was found to significantly predict the intention to use ESCOs, attitude to use ESCOs is a stronger predictor. The attitude to use ESCOs is, in turn, influenced by perceptions of ESCO capability and, to a lesser extent, by trust in ESCOs. On the other hand, trust in ESCOs directly affects the intention to use ESCOs to a similar extent as does preference for EPC.

While these findings do not contradict the idea that EPC is important, the results indicate that trust in ESCOs and perceived capability of ESCO are important determinants of the intention to use ESCOs. To enhance trust in and the perceived capability of ESCOs, we have recommended the development of an accreditation system for ESCOs and a sector-based collective guarantee scheme, details of which are provided in Chapter 5.

1.6 Limitations and Future Research

There are two important limitations for this research. Firstly, since this is an exploration into a new area, getting basic information quickly and efficiently is important. Therefore, convenient sampling based on membership of an energy technology related NGO was used and participants may therefore share similar viewpoints regarding EPC and ESCOs. Thus, an important risk for this research is that the findings may not be generalisable. However, as the target participants can only be reached effectively via this approach at the present stage, convenient sampling is employed despite this limitation.

Secondly, deploying ESCOs in the heavy industrial sector in China is still at an early stage. As a result, some practitioners may have had limited interactions with ESCOs and their views about ESCOs could therefore stem from their own assumptions instead of from their actual experiences with ESCOs. As this research is based on self-report data, the existence of such assumptions may cause common method variance and affect the validity of the findings. Therefore, the issue of common method variance was examined and details are provided in Section 5.5.

The current research has simply grouped major independent variables into only three categories (i.e., Perceptions of ESCO Capability, Trust in ESCOs and Government Incentives). To provide more in-depth insights to policy makers, it is recommended to refine the categories of variables and investigate their relationships with both quantitative and qualitative approaches in order to develop models that are better for describing the ESCO phenomenon. More sophisticated research designs such as a longitudinal designs could be used in future investigations.

1.7 Structure of the Dissertation

The remaining chapters of this dissertation are organised as follows:

Chapter Two starts with a broad review of energy supply and environmental issues, followed by an analysis of the economic situation in China, and the current status of China's heavy industries and their energy-efficiency problems. Conflicting viewpoints regarding possible mitigation measures are reviewed and the ESCO approach is discussed. A brief outline of the Theory of Reasoned Action and the Theory of Planned Behaviour is then provided. Finally, the research question, the proposed model, and the corresponding hypotheses are examined in detail.

Chapter Three provides an explanation of the research methodology and the design of the questionnaire design. Chapter Four provides the findings from the analyses that were conducted to test the hypotheses. Finally, Chapter Five provides a discussion of the major findings, the theoretical and practical implications of the findings, the limitations of this research, and recommendations for future research.

Chapter 2 Literature Review

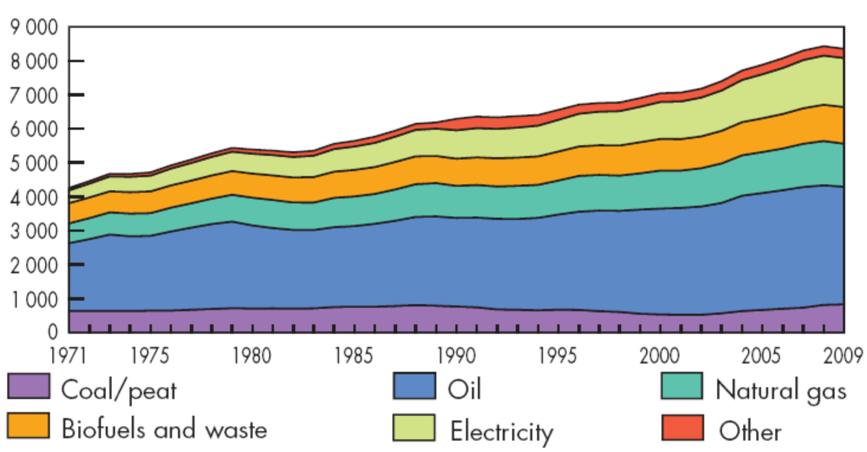
Energy supply, energy efficiency and the associated environmental issues are crucial topics for the 21st Century. These problems are growing at an unprecedented rate, which makes the collapse of the ecosystem a real possibility (Yoda 1995; Barret 2006; Ertike & Hacioglu 2011). This chapter starts with a review of the current status of these issues and the measures taken by various international societies to address them. Focus then moves to China, the fastest growing energy-intensive economy and the dominant source of pollution (IEA 2007a), to examine specific energy challenges faced by China (Klare 2006; Wang & Zhao 2007; Pun 2010). The research direction is then discussed and a brief review of the relevant theory, the Theory of Reasoned Action, is provided.

2.1 Overview of the Energy Issues

2.1.1 Energy Consumption and Modern Economies

Since the beginning of the Industrial Revolution, energy consumption has increased and continues to increase exponentially. With today's modern life, most human activities are connected to energy consumption in one way or another. Oil for cars and electricity for appliances are obvious daily examples. Even the clothes we wear are connected to energy in many ways in that textile processing machines operate on electricity, which is generated from natural gas or coal. Furthermore, cotton, the base material for a major proportion of clothes, consumes fertilizers that are produced in chemical plants that run on both coal and electricity.

Industrialisation has indeed led to revolutionary changes in human life. By consuming energy, the advancement of the materialistic aspects of life is made possible. As of today, aircrafts allow people to travel from one continent to another in a matter of hours, air-conditioners help to keep houses and offices cool during hot summer days, and high speed automated machines release workers from long working hours and at the same time make inexpensive products available. However, all these advancements must be enabled by an adequate energy supply. Figure 2.1 provides an overview of the world's actual energy consumption pattern from 1971 to 2009. While some details in the figure have to be explained and are discussed in the later sections of this dissertation, it is clear that the world today is increasingly dependent on energy.



Source: IEA 2011b

Figure 2.1 **Total Final Energy Consumption, 1971-2009** ***(in Million ton oil equivalent.)***

Concern about the sustainability of energy supplies has been raised by many researchers, international organizations, governments, and even corporations in the energy industry (Yoda 1995; Geller 2003; WEC 2007a; BP 2007; Sovacool & Brown 2010; Cherp & Jewell 2011). Table 2.1 summarizes consumption rates and reserves of various forms of energy. We will look into various sources of energy in detail in the forthcoming sections. At this point, however, it is important to point out that the reserves of conventional fossil fuel are just enough to support the world's consumption for at most a few hundred more years under the rate assumptions of 2003/2004. The projected period today will be even shorter as the consumption rate has increased significantly over the last few years. The most current estimation by British Petroleum (BP 2011) even predicts that fossil fuels with be used up in about 200 years.

Table 2.1 **Energy Consumption and Reserves**

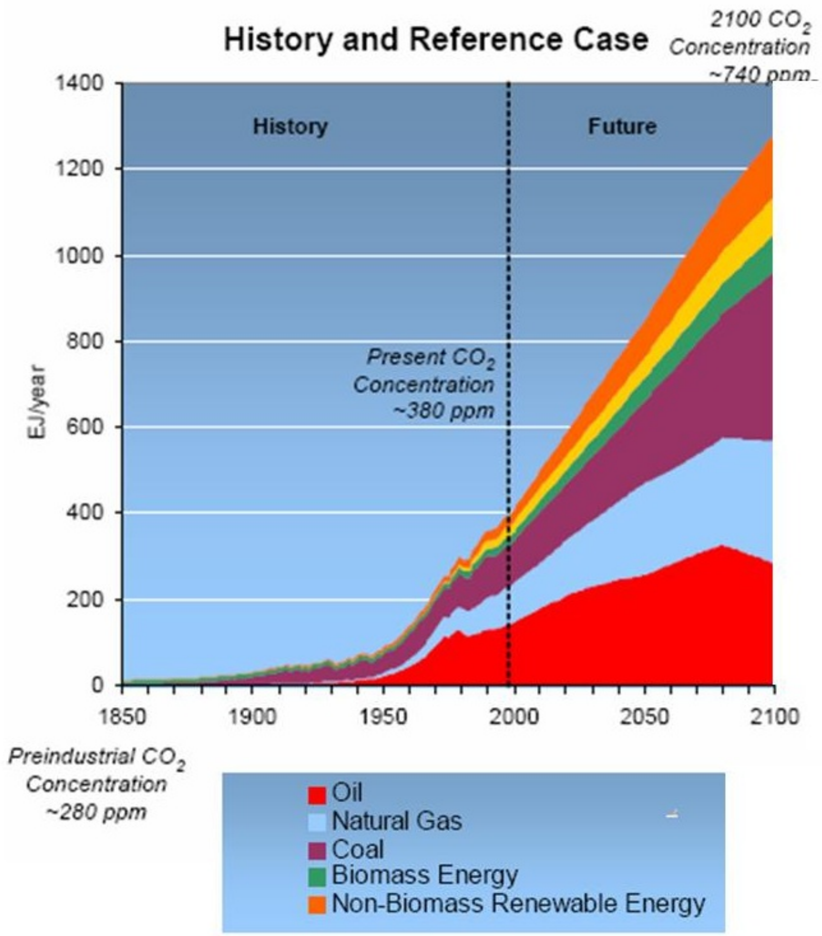
Source	Primary energy (exajoules, EJ)	Primary energy (10^9 tonnes of oil equivalent, Gtoe)	Percentage of total (%)	Proved reserves (10^9 tonnes of oil equivalent, Gtoe)	Static reserve-production ratio (years)	Static resource base–production ratio (years)	Dynamic resource base–production ratio (years)
Fossil fuels	332	7.93	79.4	778			
Oil	147	3.51	35.1	143	41	~ 200	125
Natural gas	91	2.16	21.7	138	64	~ 400	210
Coal	94	2.26	22.6	566	251	~ 700	360
Renewables	57	1.37	13.7				
Large hydro	9	0.23	2.3		Renewable		
Traditional biomass	39	0.93	9.3		Renewable		
'New' renewables	9	0.21	2.2		Renewable		
Nuclear	29	0.69	6.9	55			
Nuclear	29	0.69	6.9	55	82	~300to>10,000	
Total[f]	418	9.99	100.0				

Source: WEA 2004

As indicated in Table 2.1, fossil fuels (i.e. oil, natural gas and coal) are the dominant sources of energy. Although many studies have been conducted on alternative energy sources, an acceptable solution to reduce the world's dependence on fossil fuels has yet to be developed (IEA 2007a; GTSP 2007; IEA 2008; IEA 2010; Stirling 2010).

2.1.2 Energy Consumption, Environmental Issues and Climate Change

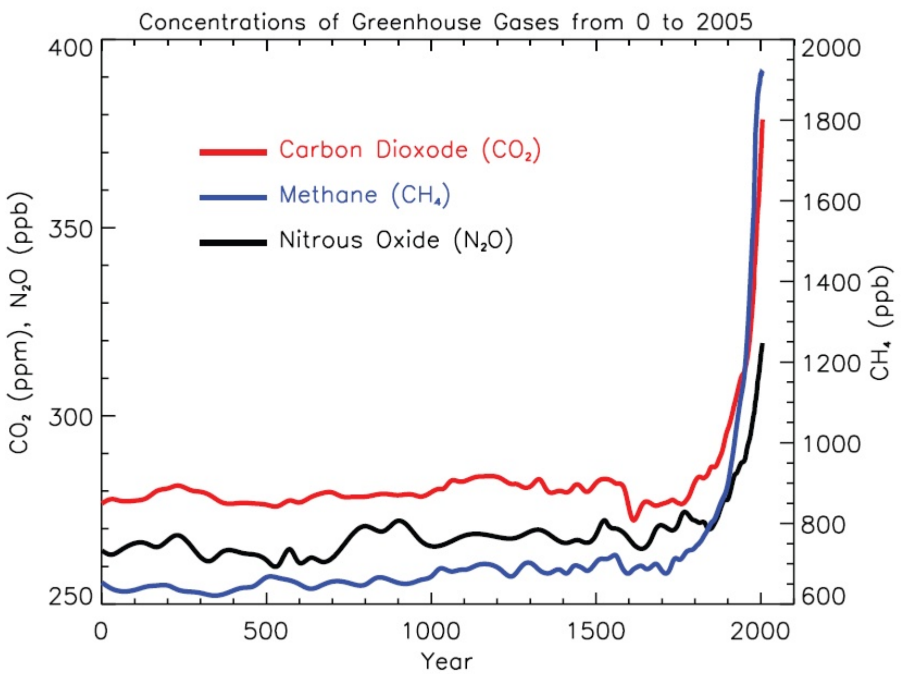
Another related concern is the environmental impact associated with energy consumption. As indicated earlier in Table 2.1, about 80% of the energy supply is derived from fossil fuels (IEA 2011a; BP 2011; WEA 2004). These fuels are consumed in different ways including the generation of electricity, providing heat for industrial processes and powering vehicles. Regardless of the way that these fuels are consumed, carbon dioxide and other pollutants are emitted. Coal, in particular, is the most commonly used fossil fuel (IEA 2011a; WEC 2007a). Unfortunately, a high percentage (peak at 28%) of the world's energy is currently supplied by coal and the proportion will remain high in the foreseeable future (IEA 2011a). Figure 2.2 illustrates the historical and projected energy consumptions, together with the carbon dioxide concentration in the atmosphere.



Source: GTSP 2007

Figure 2.2 **Historical and Projected Energy Consumption**

The amount of carbon dioxide in the atmosphere has increased from the pre-industrialization concentration of about 280 ppm (parts per million) to approximately 370 ppm at the beginning of this century: That is, an increase of approximately 32% since the beginning of industrialization. As measured by Mauna Loa Observatory and reported monthly on http://co2now.org , the atmospheric carbon dioxide content has consistently gone beyond 390 ppm since January 2011. As of February 2012, the figure is reported as 393.65 ppm. The current concentration is abnormal as the carbon dioxide content has only varied between 180 ppm and 300 ppm for a period of 650,000 years before the Industrial Era (IPCC_AR4 2007:Ch.2; GTSP 2007). Concentrations of other major greenhouse gases (e.g., methane CH_4, nitrous oxide N_2O, halocarbons) have also increased considerably over the last two hundred years (IPCC_AR4 2007:Ch. 2). Figure 2.3 illustrates these changes.



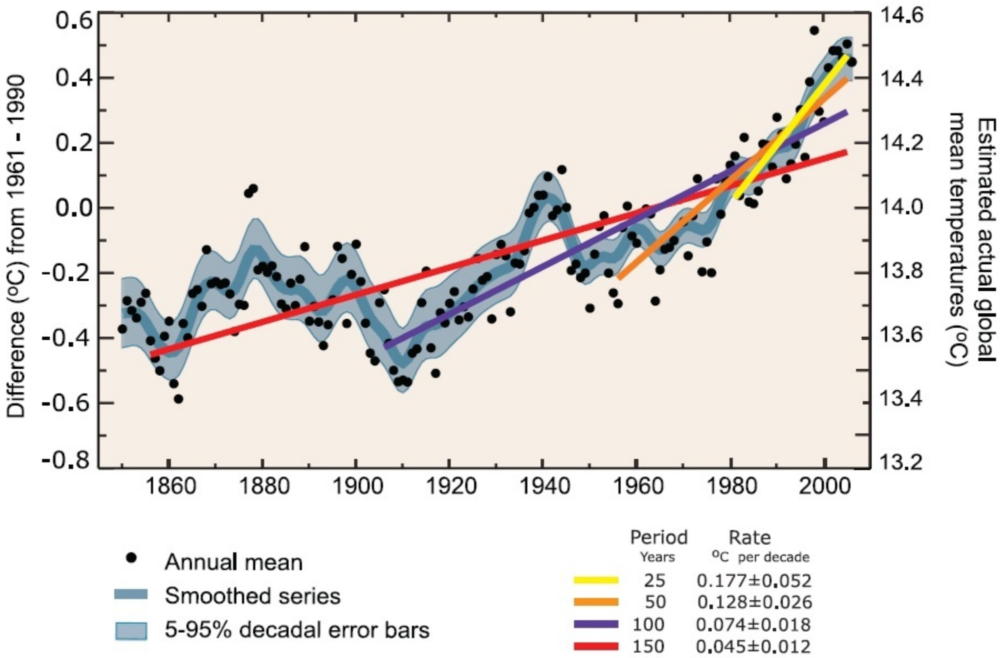
Source: IPCC_AR4 2007, CO_2 in parts per million, CH_4 and N_2O in parts per billion

Figure 2.3 **Green House Gases Concentration in the Atmosphere**

The increase in carbon dioxide is known to be due primarily to the consumption of fossil fuels and, to a lesser degree, to deforestation. The use of fossil fuels also contributes to the increase of nitrous oxide (IPCC_AR4 2007:Ch. 2; WEC 2007b). Thus, the extensive use of fossil fuel in the industrial era is a major factor that has dramatically altered the composition of the atmosphere over the last two centuries.

The change of the composition of the atmosphere has induced changes in climate. While it is still uncertain what climate change will ultimately lead to, the consensus is that some impacts are readily observable (e.g., melting of the polar ice caps and glaciers) (IPCC_AR4 2007: Ch. 5). It is also believed that the effects of climate change will occur at an accelerating rate under the current pattern of fossil-fuel consumption (WEC 2007b; IPCC_AR4 2007).

Based on UNFCCC (2002), WEC (2007b) and IPCC_AR4 (2007), the following summarize the major observed impacts of the use of fossil fuels. First, global warming. As shown in Figure 2.4, there is a clear trend that the mean global temperature has increased over the last one hundred years. In particular, the rate of this increase is significantly higher since 1960. Because of the complexity of the climate system and the interplay of human activities, a number of possible scenarios have to be assumed. The projection for the year 2100 is a 2.0°C to 4.5°C increase from 1990 (IPCC_AR4 2007:Ch. 10). However, even a 2.0°C rise would be larger than any century-timescale trend for the past 10,000 years. Based on today's understanding, it is virtually certain that "warmer and fewer cold days and nights over most land areas" and "warmer and more frequent hot days and nights over most land areas" will be the trend for the 21^{st} Century (IPCC_AR4 2007:Ch. 3).



Source: IPCC _AR4 2007

Figure 2.4 **Global Mean Temperature**

Second, rising global sea level. The ocean has been absorbing 80% of the heat added to the climate system (UNFCCC 2002). As a result of thermal expansion, the sea level is thus expected to rise with global warming. Melting glaciers also have had a remarkable impact on the global sea level. Based on a number of possible scenarios, it has been projected that the 2100 average global sea level will be 18cm to 59cm higher than the 1990 level (UNFCCC 2002; IPCC_AR4:Ch.5&10).

Third, changing precipitation and extreme weather. Precipitation (i.e. rainfall, snowfall, or other forms of H_2O from clouds) is changing in terms of amount, type, intensity, and frequency. While global precipitation is predicted to increase, local trends are unpredictable. These changes are associated with the increase of water vapour in the atmosphere, which is a consequence of global warming. From the data recorded between 1900 and 2005, it has been observed that Eastern America, North America, South America, Northern Europe and Northern and Central Asia are getting wetter, while Southern Africa, the Mediterranean and Southern Asia are becoming drier. Also, more precipitation comes in the form of rain rather than snow in Northern regions. Heavy precipitation events increased even for places where total amounts of precipitation decreased. Occurrences of both droughts and floods have also increased in some regions. Since the 1970s, longer and more intense droughts have been observed over wide areas, especially in the tropics and subtropics. There is also evidence that cyclones could be more intense in some areas (IPCC_AR4 2007: Ch.3 & 11).

As already mentioned, climate change is not uniform across the Globe. Its harmful consequences could also manifest in many different forms across different regions. For example, frequent and intensified storms in South Asia might cost the lives of millions of people while similar phenomena in the United States might kill less but lead to damage worth billions of dollars. The potential threats have aroused international concerns. Subsequent to extensive discussions, the United Nations Framework Convention on Climate Change (UNFCCC) came into force and envisaged two main strategies to address climate change: mitigation and adaptation. In UNFCCC's original wording (UNFCCC 2006), the two strategies are defined as follow:

> *"Mitigation involves finding ways to slow the emissions of greenhouse gases or to store them, or to absorb them in forests or other carbon sinks.*

Adaptation, on the other hand, involves coping with climatic change – taking measures to reduce the negative effects, or exploit the positive ones, by making appropriate adjustments. … Both need to be pursued actively and in parallel. Mitigation is essential and adaptation is inevitable. Mitigation is essential because, without firm action now, future generations could be confronted with climate change on a scale so overwhelming that adaptation might no longer be feasible. But mitigation will not be enough on its own. Even if today's efforts to reduce emissions are successful some adaptation will be inevitable because climate change occurs only after a long time-lag. Current global warming is the consequence of emissions decades ago, and the process will continue; even the most rigorous efforts at mitigation today will be unable to prevent climate changes in future."

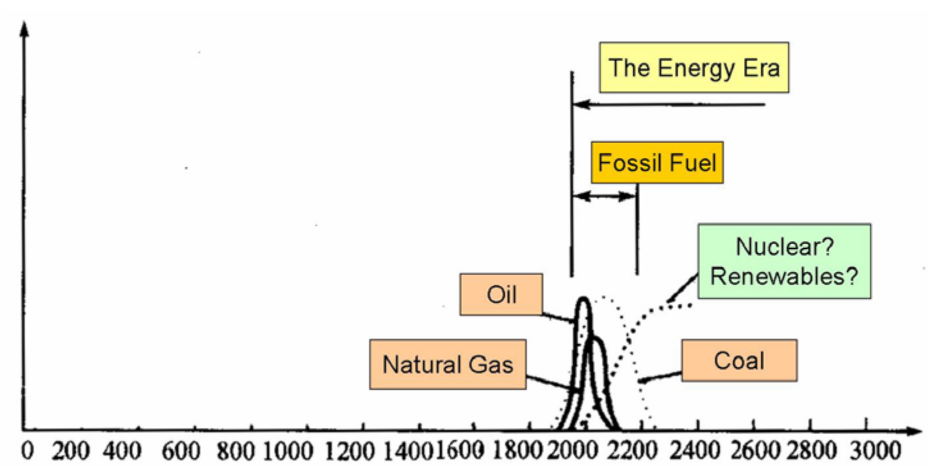
Source: UNFCCC 2006: P.7

Cleaner energy sources that generate less greenhouse gases and more efficient energy technologies, which reduce energy losses and hence reduce energy consumption, are both essential for mitigating environmental issues. The current status of various energy sources and energy efficiency policies are reviewed in the next section.

2.2 Energy Sources and Energy Efficiency

Since the Industrial Revolution, energy consumption has been growing tremendously. As pointed out earlier, our economy today relies heavily on energy. Prior discussions have covered briefly the concerns about energy supply and the related environmental issues. We are now going to examine today's energy supply situations, as well as the policies for energy conservation and energy efficiency improvement.

Over the last two hundred years, fossil fuels have been the dominant sources of energy (Yoda 1995; IEA 2011a). However, reserves of fossil fuel are limited and will be consumed in a few hundred years (WEA 2004, BP 2011). On the scale of economic history, the Era of Fossil Energy will last for only a few hundred years (Fig 2.5)



Source: Yoda 1995

Figure 2.5 **The Energy Era**

For the sustainability of modern society, both the efforts of (i) developing alternative energy sources and (ii) improving the effectiveness and efficiency of energy usage are necessary. We will examine these two aspects briefly in the following sections.

2.2.1 Current and Alternative Energy Sources

Energy sources are classified as non-renewable and renewable (Fanchi 2004). Non-renewable sources include primarily fossil fuel and thermal nuclear energy. The actual physical reservation of non-renewable resources is reduced once the resource has been consumed. The availability of renewable sources will not be physically, or at least practically, reduced by consumption. Examples are wind power, solar power, geothermal power, tidal power and hydro power. Some other energy sources such as biomass and fast neutron nuclear energy, for some technical reasons not related to our present discussions, fall between these two groups of energy sources. However, they are conventionally classified as renewable in the current literatures (Deutch & Moniz 2003).

It should be noted that the energy sources listed above are primary energy sources. Other forms of energy such as electricity are derived from these primary energy sources and hence are known as secondary energy. While the development of alternative energy sources is essentially an attempt to expand the primary energy portfolio, improving efficiency and effectiveness of energy usage is an energy-saving approach and is applicable to both primary and secondary energy sources. Table 2.2 contains a summary of the historical and projected consumption of various forms of primary energy. The major categories of energy sources are discussed in the following sections.

Table 2.2 **World Primary Energy Demand *(in Million ton oil equivalent)***

	1980	2009	2015	2020	2030	2035	2009-2035*
Coal	1 792	3 294	3 944	4 083	4 099	4 101	0.8%
Oil	3 097	3 987	4 322	4 384	4 546	4 645	0.6%
Gas	1 234	2 539	2 945	3 214	3 698	3 928	1.7%
Nuclear	186	703	796	929	1 128	1 212	2.1%
Hydro	148	280	334	377	450	475	2.1%
Biomass and waste	749	1 230	1 375	1 495	1 761	1 911	1.7%
Other renewables	12	99	197	287	524	690	7.8%
Total	**7 219**	**12 132**	**13 913**	**14 769**	**16 206**	**16 961**	**1.3%**

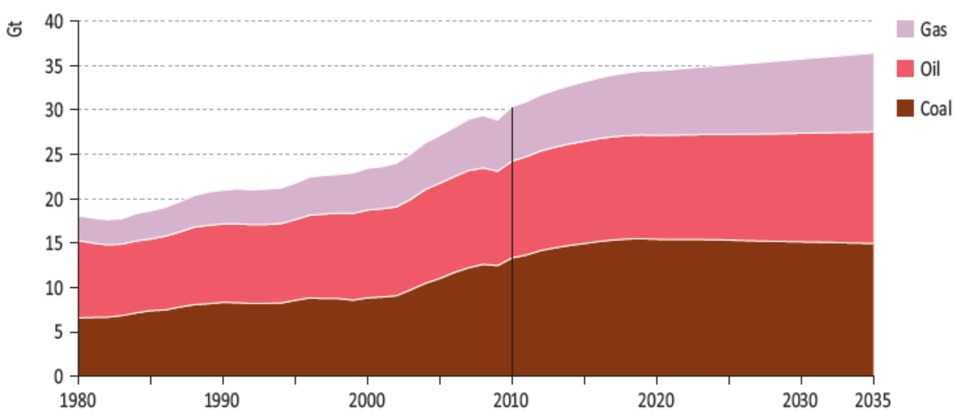
* Compound average annual growth rate.

Source: IEA 2011a

(a) Fossil Energy

Fossil fuels, including oil, coal, and natural gas, are the most widely used energy sources today. According to the International Energy Agency's (IEA) statistics (Table 2.2), oil, coal and natural gas contributed 32.9%, 27.2%, and 20.9%, respectively, of the total primary energy supply in 2009. In other words, 81.0% of total primary energy is supplied by fossil fuels. For electricity generation in the same year, coal, natural gas, and oil provided 40.6%, 21.4%, and 5.1%, respectively, of the world's total electricity in the same year. These numbers represent 67.1% of the world's total electricity generation (IEA 2011b). The corresponding percentage in 2005 is 66.6% (IEA 2007b).

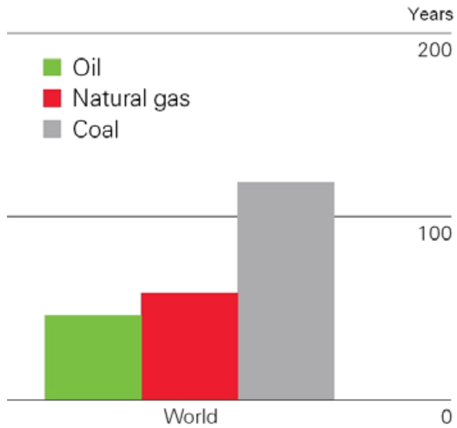
Carbon dioxide and other polluting greenhouse gases are released when fossil fuels are burnt. Everyday examples include emission from electricity generation and car emissions. Out of the three groups of fossil fuel, coal is the most polluting (IEA 2007b; WEC 2007a). As in Figure 2.6, the IEA has estimated a 12% increase in energy-related carbon dioxide emission from 2010 to 2035 under a so-called "New Policies Scenario" (IEA 2011a). This is a scenario based on the latest government policy commitments.



Source: IEA 2011a

Figure 2.6 **Energy-related Carbon Dioxide Emission, 1980-2035**

Regarding the availability of fossil fuels, coal reserves are currently most abundant and will last for about 120 years under the current rate of consumption. Oil and natural gas reverses will last for approximately 40-60 years (BP 2011).



Source: BP 2011

Figure 2.7 **Fossil Fuel Reserves-to-Production (R/P) Ratios at end 2010**

While it is clear that the reserves of fossil fuel will be exhausted in a relatively short period of time, over 80% of the total energy consumption today is derived from this category. As we will see in the next sections, the development of alternative energy sources still faces substantial challenges.

(b) Nuclear Energy

As of 2009, nuclear power contributed 5.8% of the total primary energy supply (Table 2.2). In terms of electricity supply, nuclear power provided 13.4% of the total (IEA 2011b).

Although nuclear energy does not lead to carbon dioxide emission as fossil fuels do, its use has induced many debates since the launch of the first batch of nuclear reactors at the end of the 1950s. Safety issues, in particular, have aroused a lot of public concerns after the Three Mile Island meltdown in 1979, the Chernobyl accident in 1986, Tokaimura incident in 1999 and, most recently, the Fukashima incident in 2011. Based upon the current status of nuclear power technology, Deutch and Moniz (2003) identified the following four major areas that must be addressed before the use of nuclear power can be further expanded: i) Cost – nuclear power is not yet cost-competitive against coal and natural gas. Credit for emission reduction would be helpful; ii) Safety – although today's reactors are rather safe, the safety of the whole fuel cycle (mining, enrichment, transportation, waste disposition) needs to be further examined and improved; iii) Waste – waste from current nuclear reactors remain highly radioactive for many centuries. No convincing case of long-term waste management has been made so far; and iv) Proliferation – it is possible to reprocess the waste and obtain weapon-usable materials. The international safeguards regime cannot counter these challenges. Based upon the current status of nuclear power technology, a more recent assessment by IEA (2010) still leads to similar conclusions.

Despite the safety concerns, it is a common perception that nuclear power is a viable alternative energy source because fuel is abundant and the technology is highly efficient. Researchers (Yoda 1995; Hannum, Marsh & Stanford 2005; Harvego & Kok 2006) have clarified that this perception is not accurate. According to the International Atomic Energy Agency (IAEA 2006), the identified uranium reserves of 2.3-3.2 million tonnes can last only until 2030 based on the current thermal nuclear power generation technology and a modest capacity growth rate of

2% per year. Even under the estimated total reserves of 5.1 million tonnes (WEA 2004), uranium reserves will be exhausted by 2050.

Regarding efficiency, the technology today is much less efficient than most people outside of the industry would expect. As Hannum, Marsh and Stanford (2005) pointed out, less than 1% of the energy in uranium ore is utilized by thermal nuclear reactors – the most common class of nuclear reactor in use at the current moment. The wastes from thermal nuclear reactors are energy-rich, highly radioactive, and usable for nuclear weapons.

To better utilize the uranium reserves, an alternative class of nuclear reactor, known as the fast neutron reactor, breeder reactor, Gen IV reactor, or simply fast reactor, is under development (Hannum, Marsh & Stanford 2005; Harvego & Kok 2006). With this technology, the utilization of the energy in uranium ore can be increased to 60-70%, making nuclear power as a viable energy source for a much longer time horizon. In simplistic terms, fast reactors can use the wastes of thermal nuclear reactors to effectively generate energy. Final wastes are therefore reduced. An additional advantage is that these final wastes are not usable for making nuclear weapons. At this moment, however, fast reactor technology is still at its early stage of development. Technological complexities and economic constraints will keep this technology from commercialization for at least quite some years. Figure 2.8 shows the estimates by US Department of Energy (US_DOE 2002).

System	Best deployment date
Sodium-Cooled Fast Reactor (SFR)	2015
Very-High-Temperature Reactor (VHTR)	2020
Gas-Cooled Fast Reactor (GFR)	2025
Molten Salt Reactor (MSR)	2025
Supercritical-Water-Cooled Reactor (SCWR)	2025
Lead-Cooled Fast Reactor (LFR)	2025

Source: US_DOE 2002

Figure 2.8 **Gen IV Systems and Best Deployment Date**

The nuclear power technologies mentioned above are fission based. In other words, energy is derived from the fission of heavy element nuclei. Another possible approach is the fusion of light element nuclei, which is essentially pollution free and does not produce hazardous waste. Raw materials for fusion, isotopes of hydrogen, are abundant and exist in sea water. However, this technology is very immature at this point and commercialization is very unlikely in the near future (Harvego & Kok 2006; Wang 2006: Ch.6).

Considering the present technological development, concerns, and potential, it is likely that nuclear power will remain as an option for developing sustainable energy sources. However, remarkable improvements in technical and safety aspects will be required in order to make nuclear power a viable choice for the future. As such, the projected growth rate of nuclear power is the lowest among all the categories (Table 2.2).

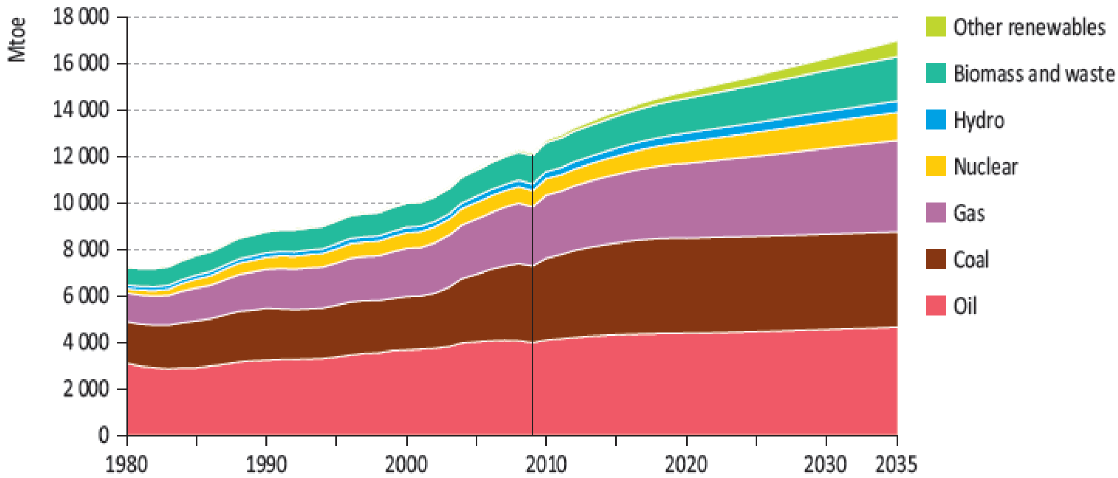
(c) Renewable Energy

The remaining 13.3% energy demand in 2009 was met by various forms of renewable energy (Table 2.2). These forms include hydro, biomass and waste.

Due to an increasing awareness of energy and environmental issues, renewable energy has become a popular topic in recent years. Among the general public, wind power and solar power are probably the two mostly recognized sources of renewable energy. However, if one examines Table 2.2 carefully, wind power, solar power, and some other technologies like geothermal and tidal power together (i.e. those under the "other renewables" category) contributed only 0.82% of the total energy consumed in 2009. Even with an aggressive projected growth rate, the estimated contribution from this category in 2035 will be only 4.07%. This percentage may appear to be small but the adoption of these new renewables is in fact subject to complicated economical, political and technological constraints. In simplistic terms, most new renewable energy technologies today are not cost competitive compared to existing fossil fuel-based technologies either due to unresolved technological constraints or to market distortions. Details are out of the scope of this research and readers are referred to the IEA (2006) and Christensen, Fatima et al. (2006) for further discussions.

The other two categories, "biomass and waste" and "hydro", are projected to grow at modest rates. As of today, the most dominating component of renewable energy is the "biomass and waste" category. This essentially refers to traditional biomass energy – burning faggot, agricultural residuals and waste to obtain thermal energy. While it is uncommon in the developed world, traditional biomass energy remains as the major form of energy in under-developed and developing countries - about half of the population in developing countries still depend on this form of energy (E4D 2004).

The preceding discussions indicate that while exploring new energy resources are crucial, it is practically infeasible to expect a substantial change in the structure of energy demand in the near future (Figure 2.9).



Source: IEA 2011a

Figure 2.9 **World Primary Energy Demand, 1980-2035**

In fact, demand for coal, which is the most polluting energy resource, is expected to grow most significantly among all fossil fuels. This is primarily due to the rapid growth of China where the dominating source of energy is coal (Zhou, Han, Gao et al 2005; IEA 2007a; Ni 2007; IEA 2010: Ch 10). The situation in China will be analyzed further in later sections. For now, it is important to realize that improving the efficiency of energy usage is, in the near term, the most practical approach to address energy and environmental issues, and is at least as critical as developing new energy sources.

2.2.2 Energy Efficiency

Energy efficiency improvement means reducing energy loss during the processes of converting and using energy. Taking electricity supply to households as an example (Warkentin-Glenn 2006), the processes include (i) combustion of fossil fuel to boil water into steam and drive the turbine to turn and generate electricity. About 60% of the energy stored in the fuel is lost in the form of heat and the remaining 40% is converted to electrical energy during these steps; (ii) transmitting electricity from the power plant to the user via the grid, which loses another 5-10% of electrical energy depending on the transmission distance and the technologies used; and (iii) home appliances such as washing machines convert the electricity into mechanical energy (i.e., rotation) in order to wash clothes. Again, not all of the electrical energy is converted to mechanical motion as some has been lost in the form of heat and sound. Similarly, other appliances also incur losses when operating. Percentage energy losses of general appliances average about 30-40%. Thus, only a small fraction of the fossil fuel energy has been utilized for washing the clothes. The majority of the energy has thus been wasted in one way or another in this electricity supply example. Manufacturing, transportation and construction suffer from similar energy-efficiency issues.

For the above example, energy efficiency could be improved in many ways: On the electricity generation end, one may could develop more efficient turbines and increase fuel-combustion efficiency as well as utilize the heat generated during combustion for some other purposes (known as cogeneration). For the grid, one may apply new technologies to reduce transmission loss. On the user end, a better motor in the washing machine will also help to improve overall efficiency. Obviously, the challenge is where to spend the limited resources so as to obtain the maximum benefits.

Many international organizations today believe energy efficiency is the most practical and economical “new energy source” (UNF 2007; Painuly 2009; IEA 2005; EU 2005; Yue, Bai & Dai 2006). Figure 2.10 provides a few examples of energy-efficiency strategies recently discussed by the United Nations (UNF 2007).

Sector:	Options
Crosscutting Policies and Measures	• Phase out subsidies for established energy sources in G8 countries, and work with governments in +5 and other countries toward a similar change. • Levy an "efficiency penny" surcharge on all energy end-users in G8 countries to support energy efficiency programs. • Accelerate capital deployment for mitigating risks and costs unique to improving demand-side energy efficiency. • Commit to government procurement of equipment, vehicles, and new facilities with the highest standards of efficiency. • Increase public awareness through information and education campaigns.
Buildings and Equipment	• Realize energy savings of 25 to 30 percent in equipment and appliances by 2020 (compared to business-as-usual) by instituting minimum energy performance standards and standardized product labeling. • Reduce energy consumption of the buildings sector by 30 percent by 2030 relative to present consumption by instituting minimum energy performance standards for new construction and building capacity to refurbish existing buildings to a higher efficiency level.
Industry	• Reduce industry sector energy consumption by 25 percent by 2020 and 40 percent by 2030. • Develop an energy management standard for large industrial energy users and support the use of energy management systems by smaller users. • Set binding targets to reduce industrial energy consumption over a 10 to 15 year period. • Adopt minimum energy efficiency standards for crosscutting technologies such as motors, boilers, pumps, compressors, and other large energy-using systems.
Transportation	• Establish a goal of a 35 percent increase in fuel economy by 2020 and a 60 percent increase by 2030 for new light-duty vehicles. • Increase the effective energy efficiency of heavy-duty vehicles and rail, air, and marine travel by at least 20 percent by 2020, and 35 percent by 2030, through a combination of technological improvements and actions to promote a changing pattern of freight and passenger movement. • Reduce vehicle travel and freight movement by 10 percent by 2020 and 15 percent by 2030.
Energy Supply	• Structure utility rates to provide higher rates of return on investments in end-use energy efficiency than on investments in energy supply, and ensure that at least 30 percent of demand for new capacity is met by demand-side management. • Introduce tradable certificates to encourage the most cost-effective approaches to energy efficiency. • Set an average efficiency standard for fossil-fueled electric power systems by 2030. Efficiency standards for new and recommissioned plants should be 50 percent for coal-fired and 60 percent for natural gas-fired by 2015. • Obtain 20 percent of electric power from combined heating, cooling, and power generation by 2020. • Produce 30 billion cubic meters (1.1 EJ) of marketable natural gas per year by eliminating losses from leaks and flaring.
Developing/ Transition Economies	• Create multiple energy efficiency loan guarantee funds in developing countries to offer guarantees for efficiency investments. • Invest in the people and institutions needed to capture the full benefits of energy efficiency in the buildings/appliances, transportation, industrial, and energy supply sectors. • Foster export of energy efficient technologies and limit trading of used equipment.

Source: UNF 2007

Figure 2.10 **Generic Energy Efficiency Strategies**

According to United Nations (UNF 2007), these strategies can provide the following:

" - Allow the world to hold CO_2 concentrations below 550 ppmv

- Avoid \$3.0 trillion worth of new generation

- Save consumers \$500 billion per year by 2030

- Eliminate the same amount of energy supplied by 2,000 coal power plants

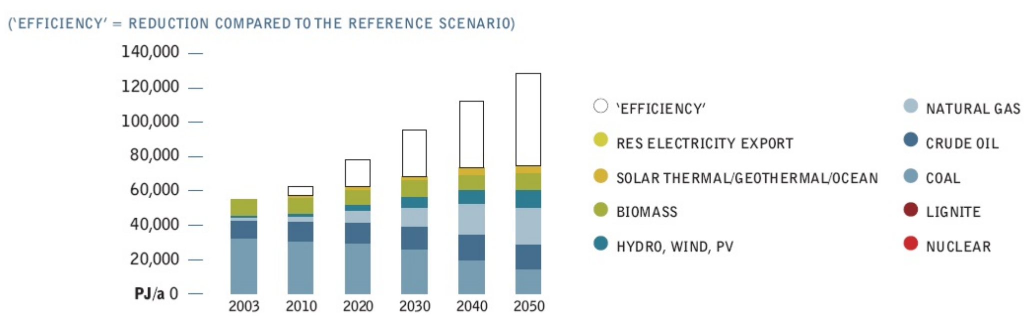
- Return the globe to 2004 energy consumption levels

- Drive business productivity improvements and new employment opportunities"

Although these strategies for improving energy efficiency are quite generic, different economies need different policies and implementation plans according to their economic structure, technology level, living and working habits, and other relevant factors. For example, while some improvement methodologies or technologies are good for developing countries, they may not be appropriate for developed countries because substantial changes in existing infrastructures are required. On the contrary, strategies for developed economies may not be applicable to developing economies due to resource limitations and other social constraints. Furthermore, energy efficiency improvement could be subjected to information, organizational and financial issues. However, these considerations deviate from the focus of this research and the reader is referred to Fey (2000) and to IEA (2007c) for a comprehensive discussion.

Since this research is concerned with the implementation of measures to improve energy efficiency in China, we will examine some specific details about China and the relevant policies. Before the analysis, however, it is necessary to point out that studies conducted between 2002 to 2005 found that the immediate energy-saving potential for China via energy efficiency improvement was over already 300 Mtoe (million ton oil equivalent), or over 17% of the total primary energy demand (Dai 2006; Shen 2004). Such a savings potential has led the international society to focus on the energy situation in China from 2006 onwards: A large portion of the report by the International Energy Agency's World Energy Outlook 2007 (IEA 2007a) is dedicated to China.

A sizable joint research project between Greenpeace and the European Renewable Energy Council was conducted in 2006 and the researchers estimated that over 25% of China's primary energy demand in 2030 could potentially be fulfilled via energy-efficiency efforts (Greenpeace 2007). Figure 2.11 provides projection details on China's potential energy saving via energy efficiency from this research. Another study funded by the United Nation Foundation in 2007 also produced similar results (Painuly 2009).



Source: Greenpeace 2007

Figure 2.11 **China's Potential Energy Saving via Energy Efficiency**

In response to the energy challenges it faces, the Chinese Government has established a comprehensive range of policies for improving the situation. Section

2.3 will examine the challenges and policies in details, followed by the central question of this research.

2.3 Energy and China

2.3.1 Industrial Development in China, 1980-2005

Since the 1980's, the Chinese economy has recorded rapid growth. In 2006, China became the second largest economy in the world in terms of purchasing power parity and the fourth largest in terms of market exchange rates. These represent, respectively, 15% and 5.5% of the world's GDP (IMF 2006; IEA 2007a). Table 2.3 provides a quick summary of China's progress since 1980.

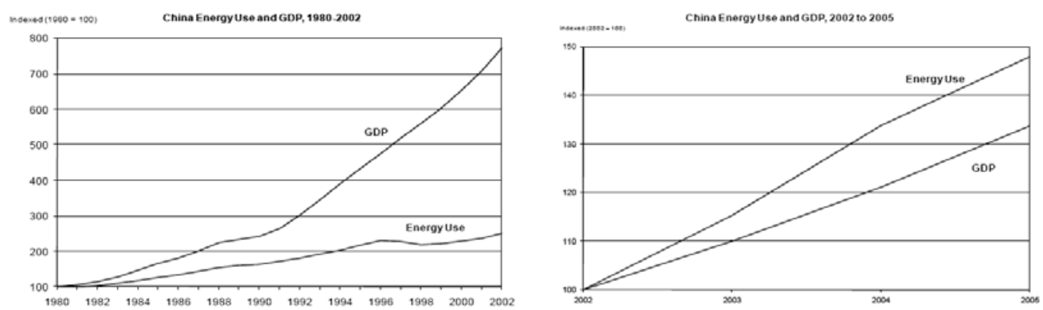
Table 2.3 **China GDP, 1980-2005**

	1980	1995	2000	2005
GDP (2006 $ PPP)	3.2	9.1	11.3	14.5
GDP (market exchange rates)	2.9	2.5	3.8	5.0
Trade	0.9	2.7	3.6	6.7
Foreign direct investment*	1.0	13.0	7.0	12.0
Ammonia production	17.0	27.0	29.0	30.0
Steel production	8.2	13.0	15.5	31.2
Cement production	9.0	33.6	37.4	46.6
Telecommunications equipment	–	–	6.7	20.4

*Includes Mainland China and Hong Kong.

Source: IEA 2007a

In association with this substantial GDP growth, a peculiar change in energy consumption is observed at the same time. Between 1980 and 2002, the GDP growth rate was significantly higher than the growth rate of energy use. For 2002-2005, the opposite is observed (Figure 2.12).

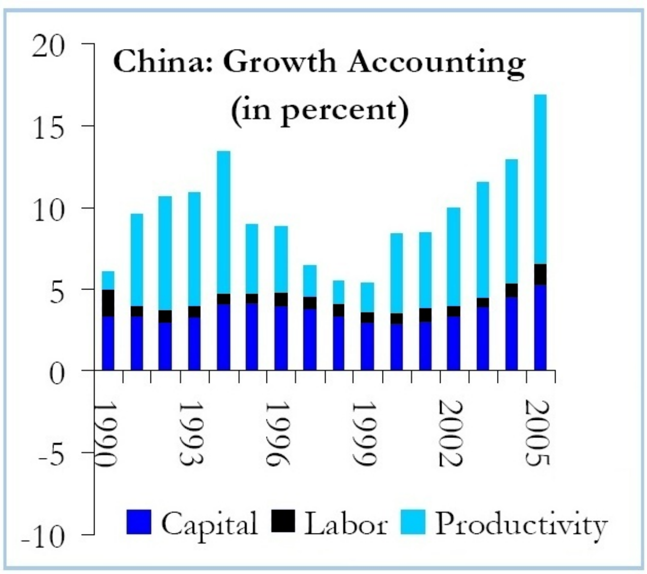


Source: Zhou , Levine & Price 2010

Figure 2.12 **GDP vs Energy Use, China 1980-2005**

This observation has led to concerns about the quality of growth. Extensive use of energy to drive GDP growth (i.e., a high energy intensity growth strategy) is not sustainable because (i) today's major energy resources, as discussed in Section 2.2, are limited. Extensive consumption will lead to rapidly increasing energy costs and negatively impact the economy; and (ii) climate change and pollution problems will be exacerbated. Thus, numerous studies have been carried out since 2004 to better understand the driving forces behind China's unprecedented economic growth. The following provides a summary of some important studies.

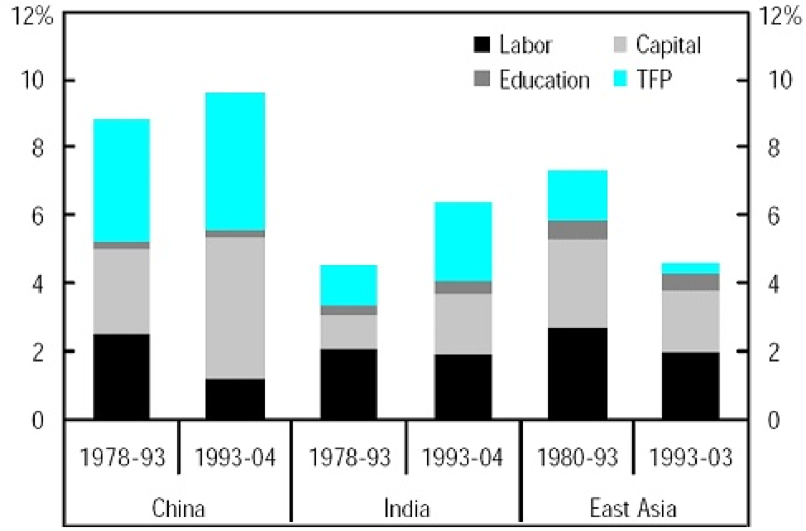
While the rapid growth of the Chinese economy is driven by a combination of complex factors that stem from political and economical activities, these factors can be broadly categorized as investment-based growth and innovation-based growth. Investment-based growth accounts for growth due to the increasing deployment of classical production factors such as labor and capital, and innovation-based growth measures the gains in the efficiency of using those inputs (i.e., productivity), and is termed as total factor productivity (TFP). Aziz (2006) analyzed China's GDP growth and observed an increasing weight of TFP as a driver of GDP growth in recent years: See Figure 2.13.



Source: Aziz 2006

Figure 2.13 **Composition of China's Percentage GDP Growth, 1990-2005**

In another study, Bosworth and Collins (2008) compared the GDP growth of China, India and East Asian countries. The results revealed that the proportion of TPF is greater for China compared to other major Asian economies: See Figure 2.14.



Source: Bosworth & Collins 2008

Figure 2.14 **Comparative GDP Growth Components, China, India and East Asia**

From the view of technological advancement, productivity of the industrial sector has indeed grown significantly. As indicated in Table 2.4, the 2003 labor productivity in the industrial sector is more than 13 times of that of 1952. For the same period, labor productivity in the agricultural sector has grown by a factor of less than 4.

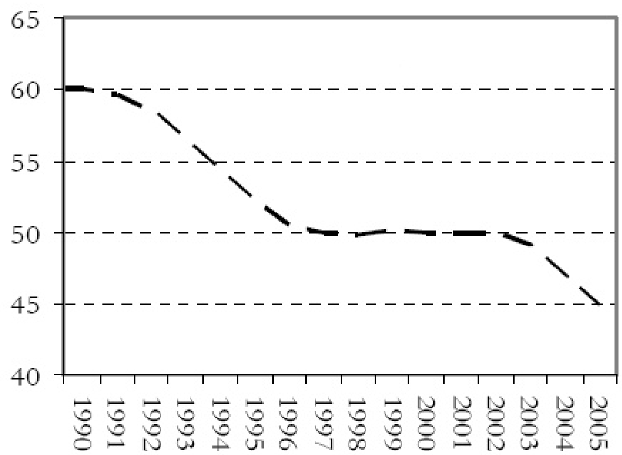
Table 2.4 **Comparative Performance in Agriculture, Industry and Services, China 1952-2003**

	Growth of Real Value Added, Employment and Labour Productivity (annual average compound growth rates)							
	Industry & Construction		Agriculture		Services		Whole Economy	
	1952-78	1978-2003	1952-78	1978-2003	1952-78	1978-2003	1952-78	1978-2003
Value Added	9.8	9.8	2.2	4.5	4.2	7.3	4.4	7.9
Employment	5.8	2.8	2.0	0.5	3.2	6.5	2.6	1.9
Productivity of Labour	3.7	6.5	0.2	4.0	2.0	2.0	1.8	5.8

	Levels of Labour Productivity (1987 yuan per person employed)		
	Industry & Construction	Agriculture, Forestry and Fisheries	Services
1952	1 482	748	2 292
1978	3 128	781	3 831
2003	19 454	2 858	6 345

Source: Maddison 2007

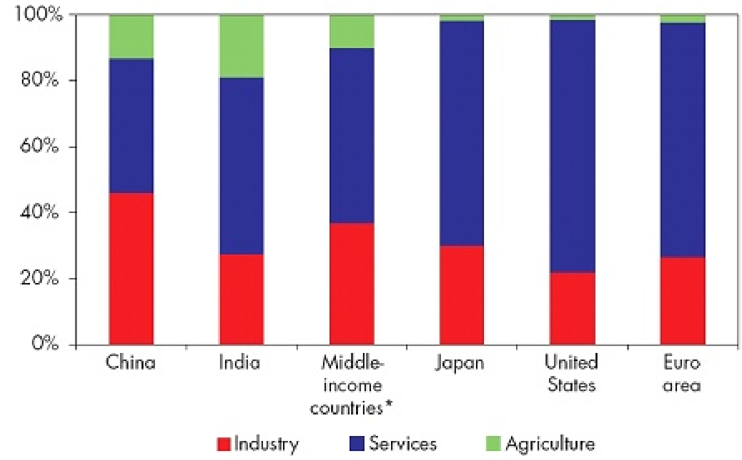
The increase in the proportion of TPF is, however, due not only to technological progress but also to a steady movement of labor from agriculture to industry and services. Comparing the changes in the percentage of rural population (Herd & Dougherty 2007), an approximately direct relation between the decrease in rural population and the increase in TFP is observed from the period of 1990-2005: See Figure 2.15.



Source: Herd & Dougherty (2007)

Figure 2.15 **Change in Rural Population, China 1990-2005**

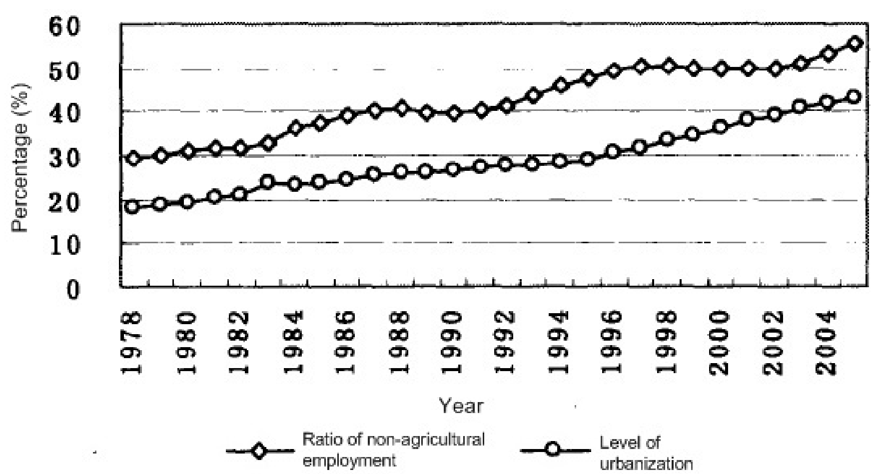
Combining the productivity improvement in the industrial sector and the movement from agriculture to industry, China's GDP composition is becoming rather unique. Examining Figure 2.16, it is evident that the GDP contribution of the Chinese industrial sector is remarkably higher than that of many other countries.



Source: IEA 2007a

Figure 2.16 **Comparative GDP Composition**

Associated with the growth of the industrial sector, China is undergoing rapid urbanization. The labor migration from agriculture to industry has significantly increased the population in urban areas and is reflected by the level of urbanization: See Figure 2.17.



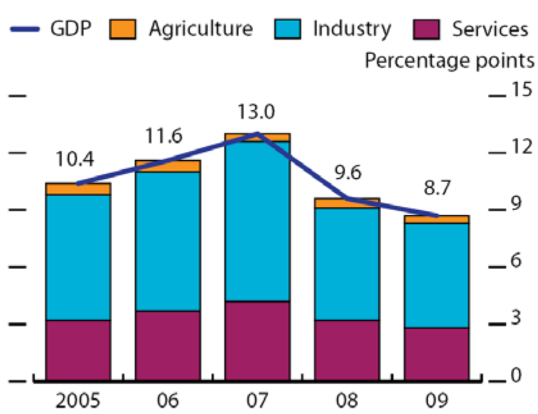
Source: Li 2007

Figure 2.17 **Urbanization and Non-agricultural Employment, China 1978-2004**

Rapid industrialization and urbanization have led to many challenges such as regional inequality, urban-rural inequality, financial risk and public health (Maddison 2007; Ding 2005), and energy supply is one of the most important issues. In the next section, the energy challenge faced by the Chinese economy will be examined in detail.

2.3.2 Energy and China's Economy

In real GDP terms, the Chinese economy has been growing at over 10% annually from 2003 to 2007 (ADB 2008; Data from the National Bureau of Statistics of China (www.stat.gov.cn). Consistent with the earlier analysis, the growth of China's overall GDP is driven mainly by the industrial sector (ADB 2010): See Figure 2.18.



Source: ADB 2010

Figure 2.18 **Recent GDP Growth, China**

According to the data from the National Bureau of Statistics of China, as shown in Table 2.5, the industrial sector has continued to expand and contributed close to half of the total GDP. While the importance of the industrial sector to China's economic growth is obvious, a closer look at the energy consumption pattern of the industrial sector reveals several critical issues.

Table 2.5 **GDP of China, 1981-2011**

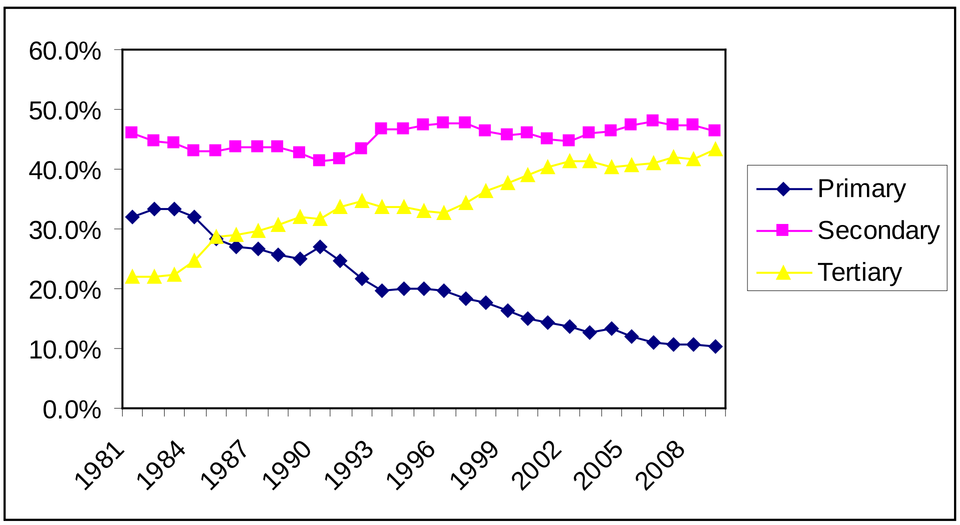
[Unit: 100 Million RMB. Data in this table are calculated at current prices.]

	Gross Domestic Product	Primary Production	Secondary Production	Tertiary Production	Primary Production as % GDP	Secondary Production as % GDP	Tertiary Production as % GDP
1981	4892	1559	2256	1077	31.9%	46.1%	22.0%
1982	5323	1777	2383	1163	33.4%	44.8%	21.8%
1983	5963	1978	2646	1338	33.2%	44.4%	22.4%
1984	7208	2316	3106	1786	32.1%	43.1%	24.8%
1985	9016	2564	3867	2585	28.4%	42.9%	28.7%
1986	10275	2789	4493	2994	27.1%	43.7%	29.1%
1987	12059	3233	5252	3574	26.8%	43.6%	29.6%
1988	15043	3865	6587	4590	25.7%	43.8%	30.5%
1989	16992	4266	7278	5448	25.1%	42.8%	32.1%
1990	18668	5062	7717	5888	27.1%	41.3%	31.5%
1991	21781	5342	9102	7337	24.5%	41.8%	33.7%
1992	26923	5867	11700	9357	21.8%	43.5%	34.8%
1993	35334	6964	16454	11916	19.7%	46.6%	33.7%
1994	48198	9573	22445	16180	19.9%	46.6%	33.6%
1995	60794	12136	28679	19978	20.0%	47.2%	32.9%
1996	71177	14015	33835	23326	19.7%	47.5%	32.8%
1997	78973	14442	37543	26988	18.3%	47.5%	34.2%
1998	84402	14818	39004	30580	17.6%	46.2%	36.2%
1999	89677	14770	41034	33873	16.5%	45.8%	37.8%
2000	99215	14945	45556	38714	15.1%	45.9%	39.0%
2001	109655	15781	49512	44362	14.4%	45.2%	40.5%
2002	120333	16537	53897	49899	13.7%	44.8%	41.5%
2003	135823	17382	62436	56005	12.8%	46.0%	41.2%
2004	159878	21413	73904	64561	13.4%	46.2%	40.4%
2005	184937	22420	87598	74919	12.1%	47.4%	40.5%
2006	216314	24040	103720	88555	11.1%	47.9%	40.9%
2007	265810	28627	125831	111352	10.8%	47.3%	41.9%
2008	314045	33702	149003	131340	10.7%	47.4%	41.8%
2009	340507	35226	157639	147642	10.3%	46.3%	43.4%
2010	401513	40534	187383	173596	10.1%	46.7%	43.2%
2011	471564	47712	220592	203360	10.1%	46.8%	43.1%

Source: Complied from China National Statistics Bureau Data Files (available at www.stats.gov.cn)

In Table 2.5, the terms "primary production", "secondary production" and "tertiary production" that are used by the National Bureau of Statistics of China correspond to the terms "agriculture", "industry" and "services", respectively, that are used in the literature referred to earlier. The exact definitions are available at the Bureau's website at www.stats.gov.cn. While there are minor differences when defining some very small sectors, they will not affect the result of this research as this study focuses on the dominant energy consumers. This will be elaborated further in the later parts of this section. Thus, the phrase “industry”, “industrial sector” and “secondary production” will be used interchangeably unless specified otherwise.

A graphical plot of Table 2.5 (Figure 2.19) reflects clearly the importance of the secondary production sector in the GDP composition.



Source: Complied from China National Statistics Bureau Data Files (available at www.stats.gov.cn)

Figure 2.19 **GDP Composition by Sector, China 1981-2009**

We will now consider energy consumption in relation to GDP. From 1996 to 2009, China’s secondary production related energy consumption reduced from over 83% of the total production related energy consumption (i.e., excluding residential energy consumption) to approximately 70% in 1999, and then gradually increased back to over 80% in 2003. Since then, the percentage remains over 80% (Table

2.6). It is important to note that the absolute amount of energy consumed is much larger than before due to rapid growth in production.

Table 2.6 **Energy Consumption by Sector, China 1996-2009**

	Production Related Energy Consumption (10000 tons of SCE)	Consumption of Primary Production	Consumption of Secondary Production	Consumption of Tertiary Production	% Consumption of Primary Production	% Consumption of Secondary Production	% Consumption of Tertiary Production
1996	121234	5717	101537	13980	4.7%	83.8%	11.5%
1997	121805	5905	101046	14853	4.8%	83.0%	12.2%
1998	117821	5790	95834	16197	4.9%	81.3%	13.7%
1999	130119	5832	92011	17724	4.5%	70.7%	13.6%
2000	115385	5787	90919	18679	5.0%	78.8%	16.2%
2001	119488	6233	93659	19597	5.2%	78.4%	16.4%
2002	131189	6514	103665	21010	5.0%	79.0%	16.0%
2003	151674	6603	121398	23673	4.4%	80.0%	15.6%
2004	181946	7680	146503	27763	4.2%	80.5%	15.3%
2005	199926	7972	161468	30487	4.0%	80.8%	15.2%
2006	217167	8395	175137	33635	3.9%	80.6%	15.5%
2007	234762	8245	190167	36350	3.5%	81.0%	15.5%
2008	255737	6013	209302	40422	2.4%	81.8%	15.8%
2009	268251	6251	219197	42803	2.3%	81.7%	16.0%

Source: Complied from China National Statistics Bureau Data Files (available at www.stats.gov.cn)

If we compare the percentage GDP figures against the percentage consumptions (Table 2.7), the effectiveness of using energy in the secondary production sector to generate GDP peaked in 1999 and then declined in subsequent years. Although the effectiveness of using energy increased after 2002 it was still considerably lower than what it was in 1999.

Table 2.7 **Percentage GDP vs Percentage Total Energy Consumption, Secondary Production**

	Secondary Production as % GDP	Energy Consumed by Secondary Production as % Total	% GDP / % Consumption
1996	47.5%	83.8%	0.5676
1997	47.5%	83.0%	0.5731
1998	46.2%	81.3%	0.5682
1999	45.8%	70.7%	0.6471
2000	45.9%	78.8%	0.5827
2001	45.2%	78.4%	0.5761
2002	44.8%	79.0%	0.5668
2003	46.0%	80.0%	0.5743
2004	46.2%	80.5%	0.5741
2005	47.4%	80.8%	0.5865
2006	47.9%	80.6%	0.5949
2007	47.3%	81.0%	0.5844
2008	47.4%	81.8%	0.5800
2009	46.3%	81.7%	0.5667

Source: Complied from China National Statistics Bureau Data Files (available at www.stats.gov.cn)

Note that percentage rather than absolute values are used for comparison because the dollar GDP figures are at the current price of each year. Direct measurement of dollar GDP per unit energy does not account for economic changes throughout the period.

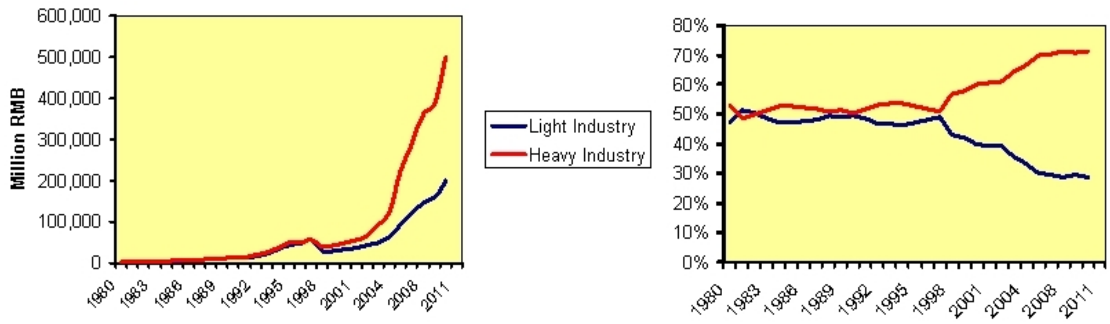
The apparent decline of energy efficiency of the secondary production sector has been investigated in detail by many Chinese researchers as well as by the relevant governmental organizations in China (Liu 2006; Tian 2005; Wu 2005; Wu 2006; Yang 2004; Yu 2006). The majority of these investigations concluded that China's manufacturing sector, which is a major part of the secondary production sector, is undergoing a transformation from light industry to heavy industry. Table 2.8 tabulates the change of the industrial composition. It should be noted that the light-to-heavy ratio has remained stable until the late 1990s. Beyond this point, the proportion of heavy industry has grown significantly.

Table 2.8 **Ratio between Light and Heavy Industries, China 1980-2010**

	Current Year Value			
Year	Light Industry (100 million yuan)	Heavy Industry (100 million yuan)	Light Industry(%)	Heavy Industry(%)
1980	2,430	2,724	47.1%	52.9%
1981	2,781	2,619	51.5%	48.5%
1982	2,919	2,892	50.2%	49.8%
1983	3,135	3,326	48.5%	51.5%
1984	3,608	4,009	47.4%	52.6%
1985	4,575	5,141	47.1%	52.9%
1986	5,330	5,864	47.6%	52.4%
1987	6,656	7,157	48.2%	51.8%
1988	8,979	9,245	49.3%	50.7%
1989	10,761	11,256	48.9%	51.1%
1990	11,813	12,111	49.4%	50.6%
1991	12,887	13,738	48.4%	51.6%
1992	16,123	18,476	46.6%	53.4%
1993	22,507	25,895	46.5%	53.5%
1994	32,491	37,685	46.3%	53.7%
1995	43,466	48,428	47.3%	52.7%
1996	47,932	51,663	48.1%	51.9%
1997	55,701	58,032	49.0%	51.0%
1998	29,082	38,655	42.9%	57.1%
1999	30,515	42,192	42.0%	58.0%
2000	34,095	51,579	39.8%	60.2%
2001	37,637	57,812	39.4%	60.6%
2002	43,356	67,421	39.1%	60.9%
2003	50,498	91,774	35.5%	64.5%
2004	62,654	124,567	33.5%	66.5%
2006	94,846	221,743	30.0%	70.0%
2007	119,640	285,537	29.5%	70.5%
2008	145,429	362,019	28.7%	71.3%
2009	161,498	386,813	29.5%	70.5%
2010	200,072	498,519	28.6%	71.4%

Source: Complied from China National Statistics Bureau Data Files (available at www.stats.gov.cn)

Due to the energy intensive nature of heavy industry and the relatively lower unit output value, the overall energy efficiency of the secondary production sector appears to have declined. As of 2010, output of the heavy industry represents 71.4% of the manufacturing sector output and therefore significantly affects China's overall GDP per unit energy. Figure 2.20 depicts the change of the dominance of heavy industry from 1980 to 2010.



Source: Complied from China National Statistics Bureau Data Files (available at www.stats.gov.cn)

Figure 2.20 **Weights of Heavy and Light Industries, China 1981-2010**

Zhao (2005) argued that the heavy industry classification system adopted by National Statistic Bureau has not appropriately reflected the situation as some light industries are grouped under the heavy industry category. However, if one examines the consumption of each major industry in the secondary production sector (see Table 2.9), the top five energy consumers in the manufacturing sector are all heavy industries and accounted for almost 50% of the total energy consumption of the secondary production sector in any typical year. Furthermore, the growth rates have often been high throughout the last few years. Thus, even though the classification system may not be perfect, most researchers and policy makers agree that the movement towards heavy industry exists (Wang & Zhao 2007).

In addition to the concern on excessive energy consumption, another issue is that added value of a big portion of products (e.g. cement, crude iron) from these Chinese heavy industries is low. Thus, large amounts of energy are consumed in order to generate a relatively small GDP. This is a serious issue from a national development point of view.

Although there is consensus about the increasing importance of heavy industry, there are two groups of distinctive, if not opposing, opinions about how the country should respond to this change. Extensive debates took place during 2004 to 2007 among the supporters of the two schools. In one school of thought (e.g., Yu 2006; Tian 2005), this transition is understood as normal and is an unavoidable step in the course of industrialization. This view is supported by the works of Hoffmann, Chaloner and Henderson (1958), Rostow (1960) and Chenery (1986) in analyzing economic growth. Ayres and Clark (1998) have examined the development patterns of a number of economies based on those theories and summarized the changes under normal development as follows:

> “ (1) *Economic growth (i.e., rising GNP and GDP per capita);*
>
> (2) *High rates of physical and human capital accumulation;*
>
> (3) *Industrialization;*
>
> (4) *The transformation of manufacturing characterized by a shift from light to heavy industry;*
>
> (5) *The transformation of international trade involving a rise in imports and exports, increasing specialization, and a move towards the export of industrial products*

(6) *High rates of technology transfer, followed by R&D and expanded indigenous of technological capability and a move to high technology production; and*

(7) *Rapid and sustained increases in (factor) productivity."*

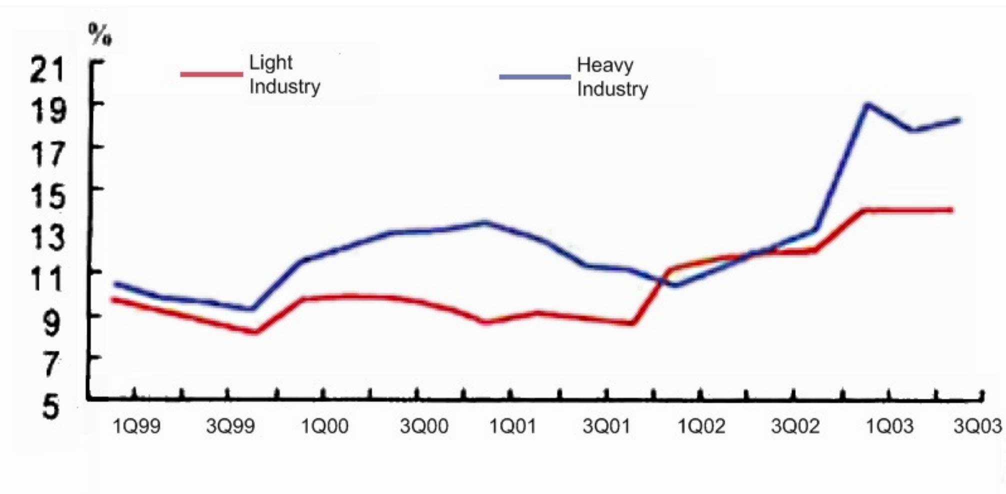
Source: Ayres and Clark 1998: p.90

As in the case of China, Points 1 to 3 (i.e. GDP growth, capital accumulation and industrialization) started as early as 1978 (Maddison 2007; Jian & Yu 2004). Applying elasticity analysis, Yu (2006) further argued that Point 4 (i.e., transitioning from light to heavy industries) kicked off on a large scale in 1999. The State Council Research Institute (SCRI 2003) supported this view. As discussed by Yang (2004) and indicated in Figure 2.21, the growth rate of heavy industry has remained higher than the growth rate of light industry most of the time since 1999. Extensive imports and exports in general and the export of industrial products in particular (i.e., Point 5 – rising import and export, increasing specialization and export of industrial products) are reported in the last few years (NBSC 2007; Maddison 2007). A remarkable increase in R&D expenses (i.e., Point 6 – increasing technological capacity and move towards hi-tech products) is also observed (NBSC 2007; OEDC 2007). According to this Classical Growth Model, the current transition to heavy industry is inevitable and the Government should put as

Table 2.9 **Detailed Energy Consumption by Sector, China 1995-2009**

	Energy Consumption in 10000 tons of SCE																	
	Primary Production	Seccondary Production												Tertiary Production				
	Farming, Forestry, Animal Husbandry, Fishery and Water Conservancy	Smelting and Pressing of Ferrous Metals	Manufacture of Raw Chemical Materials and Chemical Products	Manufacture of Non-metallic Mineral Products	Mining and Quarrying	Processing of Petroleum, Coking, Processing of Nuclear Fuel	Smelting and Pressing of Non ferrous Metals	**Manufacturing Industries Total**	Production and Supply of Electric Power and Heat Power	Construction	Production and Supply of Water	Production and Supply of Gas	**Secondary Production Total**	Transport, Storage and Post	Others Tertriary	Wholesale, Retail Trade, Hotels and Catering Services	Residency (Non-production)	**National Total**
1995	5505	18533	15822	13058	9941	5567	2842	78368	7053	1335	489	341	96191	5863	4519	2018	15745	131176
1996	3689	17790	19142	12826	9890	3663	3045	77556	8512	1449	495	395	96850	10011	5261	2726	14672	138948
1997	3693	17715	15292	12539	10965	6386	3290	75912	10066	1179	556	445	97391	10086	5283	2747	14677	137798
1998	3686	17570	14319	12572	10402	6666	3469	75989	9704	1612	546	518	97382	10138	5313	2779	14780	136184
1999	5993	18416	13628	13523	9288	6587	3870	78027	10346	1381	613	653	100248	10731	5540	2879	15258	140569
2000	3914	18962	14326	13768	10968	7220	4079	80772	10812	2179	616	605	103774	11242	5762	3048	15614	145531
2001	6400	19727	14626	13371	10729	7694	4309	83158	11373	1453	615	551	107138	11613	5932	3170	16183	150406
2002	6612	20640	16265	12889	10835	8019	4819	88181	12565	2410	575	594	113600	12313	6241	3373	17162	159431
2003	6603	25942	19047	15629	12433	9124	5883	102842	14013	2721	568	557	131168	14116	7153	3915	19765	183792
2004	7680	31399	21568	20496	12215	12373	6651	122999	15106	3115	666	553	152507	16642	8243	4484	22768	213456
2005	6071	39544	23849	21310	13915	11924	7404	137140	16327	3403	699	643	168724	18391	9255	4848	25305	235997
2006	8395	44730	25995	22638	14247	12499	8862	151275	18004	3761	756	663	184945	20284	10276	5314	27765	258676
2007	8245	50187	28621	23112	15241	13445	10868	164951	18892	4128	796	651	200532	21959	11158	5689	30814	280508
2008	6013	51863	28961	25461	17050	13747	11288	172107	18676	3813	834	635	209302	22917	11771	5734	31898	291448
2009	6251	56404	28946	26882	17585	15328	11401	180596	19575	4562	875	566	219197	23692	12690	6412	33843	306647
Out of total energy consumption (as of 2009)	2.04%	18.39%	9.44%	8.77%	5.73%	5.00%	3.72%	58.9%	6.38%	1.49%	0.29%	0.18%	71.5%	7.73%	4.14%	2.09%	11.04%	

Source: Complied from China National Statistics Bureau Data Files (available at www.stats.gov.cn) many resources as possible to accelerate the completion of this transition. The temporary excessive energy consumption is, in their opinion, unavoidable and the growing maturity of the sector will gradually reduce this problem because of increasing efficiency due to scale and cumulative technological improvements. The same argument also applies to other resources and environmental problems associated with heavy industries. The country can move on to the next steps only after the heavy industrial sector has matured.



Source: Yang 2004

Figure 2.21 **Growth Rate of Heavy and Light Industries, China**

The second school of thought proposes that growth does not necessarily involve a transition to heavy industry nor that the classical growth model is healthy with respect to China's actual situation. Wu (2005) argued that since the industrialization models mentioned were built upon a very different economic environment in a different era, they may not be able to account for current conditions. For example, the concept of tertiary production was virtually non-existent in Hoffmann's (1958) time. Furthermore, some researchers in this group (e.g., Wu 2006; Lin 2005) pointed out that the energy resources accessible to China might not be sufficient for the country to expand heavy industries in the traditional way adopted by the sector today. The environmental impact caused by such expansion is also unaffordable. Official Government publications (e.g. Xu, Yang & Zhu 2007; MEP 2007) have also mentioned these potential hazards. Thus, this school of thought suggests that the Government should not focus on providing resources to expand the heavy industry sector, but should instead facilitate the growth of tertiary sector services by utilizing experts who can improve the energy efficiency of heavy industry.

While both schools of thought expect heavy industrial products will continue to grow, the suggested growth paths are very different. With the Classical Growth Model, the approach is to expand capacity so as to produce more products to serve the national and international markets. Energy efficiency, as well as other efficiencies, will improve spontaneously as the sector moves toward maturity. Thus, this school encourages direct and rapid expansion of heavy industries by using public and private investment, imposing favorable government policies and providing governmental subsidies. In other words, resources are provided to the sector directly and the heavy industries themselves are responsible for the improvements.

The very obvious concerns about this classical growth model are based on the availability of energy supply, huge resources consumption and environmental impact. Another important criticism about this approach is the potential distortion of resource allocation: For example, undervalued land for the sector and unreasonably low interest rates for loans could lead to sub-optimal resource allocation as the scheme is no longer based on comparative advantages. This could consequently reduce the overall competitiveness of the economy and have serious economic consequences (Wu 2006; Lin 2005; Cai 2006).

The Alternative Growth School, on the other hand, recommends placing immediate efficiency improvement as the top priority instead of scale expansion. This approach proposes that the country should develop expertise to improve energy efficiency to help the heavy industries. The aim is to produce more products using fewer resources as soon as possible. The rationale is that it will be too risky to wait for spontaneous improvement as problems with resources, the environment and energy will likely be unaffordable for the country. In addition, this school suggests that, instead of expanding the scale for export, a certain portion of the demand of heavy industrial products should be served by importing from other countries.

In essence, this alternative growth approach emphasizes the development of services experts in order to improve the efficiency of the heavy industries. Thus, growth is centered at the tertiary production sector under this approach. For the heavy industrial sector, no or few privileges are offered in terms of resource allocation. It is up to companies in the sector to decide how they want to improve efficiency and hence maintain competitiveness. Under this scheme, the physical expansion of the heavy industry sector is likely to reduce but operating efficiency will increase.

Criticisms about the alternative growth model are based on the practicality of these suggestions. Firstly, the growth of heavy industries in the last few years was driven by actual demand from national and international markets, not by the industry itself. From a business point of view, it is a skeptical idea to slow down capacity expansion. Secondly, the viability of heavy industries has been demonstrated as China is already in a dominant position in quite a number of heavy industries: China produces and supplies 50% of the world's cement, 30% of the world's coal, and 25% of the world's steel (Tian 2005). As such, it is not possible to import a significant portion of these heavy industrial products from other countries because such production capacities do not exist overseas. Finally, R&D and good practices for efficiency improvement in heavy industries require not only knowledge but also very large monetary investments. Even if external experts are brought in and knowledge is provided, it is virtually impossible to implement those improvement measures due to financial constraints. Thus, the classical school maintains that rapid expansion for profit must come first and energy efficiency will then follow (Jian & Yu 2006; Yu 2006; Li 2004).

Examining the views of both schools, it is commonly agreed that there is a clear need to improve energy and other efficiencies even though disagreement about the path for such improvement remains. As one of the most important topics for the country's 11th 5-year plan, China announced in November 2005 an official target of reducing energy intensity, measured via energy consumption per unit GDP, by 20% in 2010 with respect to 2005. In relation to the heavy industries, the Chinese

Government has come up with directives for improving energy efficiency. Programs that are most significant to practitioners are the "Ten Key Projects" outlined in *Medium and Long-Term Energy Conservation Plan* (NDRC 2004) and the "Top-1000 Enterprise Energy-saving Program – Implementation Guideline" (NDRC 2006). These programs provide specific energy-saving targets down to individual companies. Interested readers are referred to NDRC (2007), Price and Wang (2007); Zhou, Levine and Price (2010), and Price, Wang and Jiang (2010) for a comprehensive discussion of the details of the programs and recent updates.

Ultimately, improving energy efficiency has to be achieved via better technologies, manufacturing processes, logistics, and many other operations in the heavy industrial sector. However, while the discussions above concentrate on which path is the right path, how the sector would respond to these proposals has not been addressed sufficiently.

Based on the arguments mentioned and in view of the energy and resource constraints discussed, a focus on developing services experts, more commonly known as energy services companies (ESCOs), to help improve the efficiency of heavy industries is appealing. Promoting ESCOs has been a clear direction from the Chinese Government since 2004 (NDRC 2004; SC_PRC 2006; SC_PRC 2010; MIIT 2012). On the other hand, the sector's acceptance of ESCOs is crucial. As of today, although there are some cases of using ESCOs for improving energy efficiency in certain areas, this approach is in general not a common practice among heavy industries (Zhang & Wu 2011; Gan 2009; Shen 2008; EMCA 2006; Tang 2005).

2.3.3 Analyzing ESCO Deployment

ESCOs have a relatively short history in China. Before 2003, there were very few ESCOs in the country and they were specifically focused on limited segments. The level of technology possessed by these ESCOs at that time was low in general (EMCA 2006; Gan 2009). In 2003, the Chinese Government attempted to promote the ESCO approach to more sectors by establishing the Energy Management Company Association (EMCA), which is China's official association for ESCOs. With the establishment of the EMCA, the number of ESCOs in China has increased significantly from tens of companies to over two hundred in the last ten years. With assistance from scientific institutions in China and also by entering into foreign technological cooperation, the technological levels of these companies have improved remarkably and they are ready to participate in many different sectors from iron and steel casting to environmental conditioning(Source: www.emca.cn). However, the actual deployment of ESCOs remains a small fraction of the total energy efficiency efforts in China (SC_PRC 2010; MIIT 2012).

While many factors such as awareness of the energy-utilization problem, perceptions of ESCOs, or company-specific issues can affect individual company's decisions to improve energy efficiency (Vine 2005; Urge-Vorsatz et al 2007;

Sorrell 2007), it is believed that a number of “critical” factors such as technological advantages, financing options and monetary savings can determine the deployment of ESCOs. Thus, many ESCO-promotion campaigns in China emphasize heavily those “critical” factors (Gan 2009; Shen 2008; Tang 2005). While these activities appear to be reasonable, they may be superficial as there are many less tangible forces that shape actual behaviour (see Section 2.4).

There are only a few very limited investigations of these less tangible forces such as credit risk, agency problem, fair valuation, and confidence in energy-saving technologies (Li 2010; Kleindorfer 2010; Zhang, Cai & Pou 2009; IEA 2007c; IEA 2005; Fey 2000). By applying the Theory of Reasoned Action (TRA), this research investigates the behaviour of bringing in ESCOs for the purpose of energy-efficiency improvement.

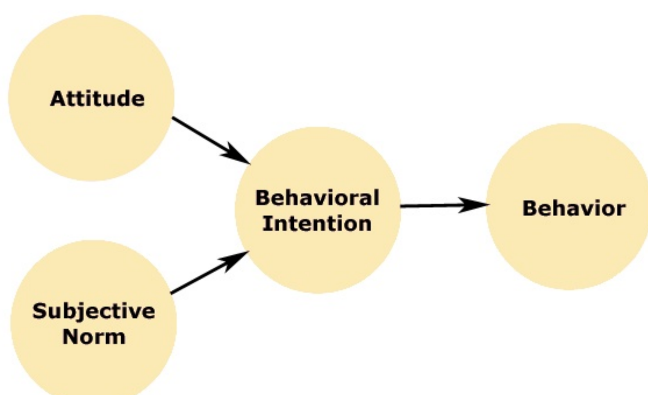
2.4 Theory of Reasoned Action

Introduced by Fishbein and Ajzen (1975), the Theory of Reasoned Action (TRA) has explained a lot of apparently inconsistent behaviours found in social science research. In 1980, the authors refined the theory and demonstrated that the TRA could be used to explain, predict, and influence human behaviour (Ajzen & Fishbein 1980).

As its name implies, the TRA assumes, as many theories do, that behaviour is rational, there is volitional control and a reasonable use of available information for decision making. The distinctive feature of the TRA is that it does not assume that attitudes can always predict behaviour. This assumption is frequently found in many early theories of behaviour and could be an important cause of erroneous prediction (Wicker 1969). In Wicker's (1969) words,

> *"There is little evidence to support the postulated existence of stable, underlying attitudes within individuals which influence both his [or her] verbal expressions and his [or her] actions."*

In the TRA framework (Fishbein & Ajzen 1975), it is proposed that performing an action is directly affected by intention (known as behavioural intention, BI), instead of by attitude, towards performing the action. This intention is, in turn, affected by attitude (AT) and the subjective norm (SN) towards performing the action.



Source: Fishbein and Ajzen 1975

Figure 2.22 **Theory of Reasoned Action**

The model often expresses behavioural intention as a linear combination of attitude and subjective norm, as shown in the following equation:

$$BI = w_{at} \times AT + w_{sn} \times SN$$

where w_{at} and w_{sn} are the respective weighting coefficients of attitude and subjective norm for the specific behaviour under consideration.

While the model appears to be quite intuitive, several explanatory remarks about the variables are made for the purpose of clarification.

(a) Behavioural Intention (BI)

Behavioural intention is a predictor of the actual behaviour. In order to predict, (i) the behaviour and the corresponding intention measurement must be specific in terms of action, target, context, and time, and (ii) the intention does not change before action (Ajzen & Fishbien 1977; Sheppard, Hartwick, & Warshaw 1988).

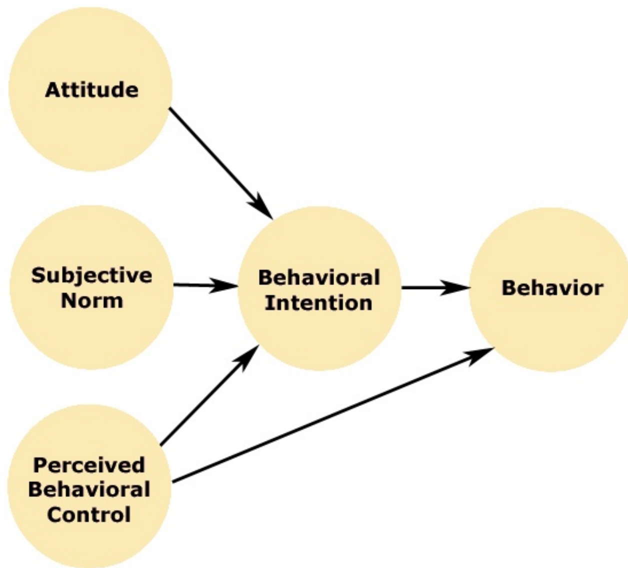
(b) Attitude (AT)

Attitude towards a behavior is the favourable or unfavourable evaluative reaction towards a specific behaviour (Eagly & Chaiken 1993). In the TRA framework, it is modelled as the sum of multiplicative products of the behavioural beliefs of certain attributes associated with the outcome and the evaluation of these attributes.

(c) Subjective Norm (SN)

The subjective norm is the belief of what others think about the behaviour. It is also modelled as the sum of multiplicative products of the normative beliefs of whether relevant others approve or disapprove the behavior and the motivation to comply with the normative belief.

As mentioned earlier, the TRA assumes volitional control. In cases where volitional control is low or even absent, the applicability of the TRA is questionable. Addressing this issue, Ajzen (1985, 1991) extended the TRA by adding another component called perceived behavioural control (PBC). The salient point of PBC is that it influences not only the behavioural intention but also the behaviour directly. This extension from TRA is known the Theory of Planned Behaviour (TPB).



Source: Ajzen 1985

Figure 2.23 **Theory of Planned Behaviour**

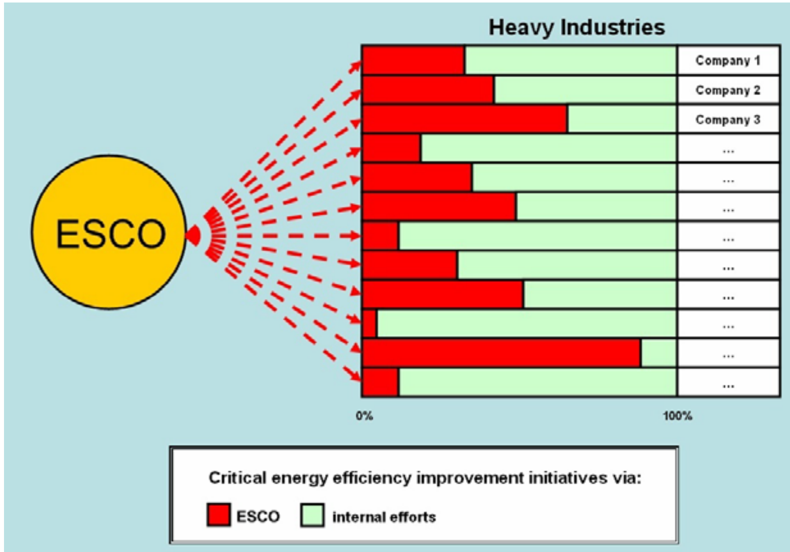
By including perceived behavioural control, it is intuitive that the TPB should have better explanatory power than the TRA. Indeed, some studies have supported this prediction under situations wherein volitional control is low: food, shopping (Madden, Ellen & Ajzen 1992; Armitage & Conner 1999). When volitional control is high, however, the difference between the TRA and the TPB is very small (Madden, Ellen, & Ajzen 1992; Armitage & Conner 1998). Ajzen (2002a) has further explored and clarified the nature of perceived behavioural control. It has been demonstrated that perceived behavioural control is comprised of two elements: (i) self-efficacy, which is an internal factor to the actor that measures the ease or difficulty to perform the behaviour; and (ii) controllability, which is an external factor to the actor that measures how much control he or she has to perform the behaviour. Thus, a person who aims to eat a low-fat diet may have a positive attitude to and a strong subjective norm for this behaviour, but behaves differently because he or she has little will-power to do so (i.e. self-efficacy), or his or her food is prepared by somebody else without consultation (i.e. controllability). For the purposes of this research, it is reasonable to assume that the decision maker has full control on ESCO deployment and therefore the controllability issue does not come into play. In other words, it is assumed that ESCO deployment is not forced by others externally but rather is a choice of the decision maker. For self-efficacy, it is also reasonable to assume that the decision maker will not have specific internal difficulty (Ajzen 2002a) to accept or decline the ESCO approach for his/her energy-efficiency project. With these assumptions, the volitional control for ESCO deployment should be high and therefore the TRA model is sufficient and will be applied in this research.

2.5 The Research Question

With regards to improving energy efficiency in heavy industries, it should be understood that every individual company will, in general, have many possible areas for improvement. Some of these areas could be directly related to the company's business while some other areas may not. For example, while improving the efficiency of the melting furnace is directly related to the business of an iron and steel producer, improving the efficiency of office lighting is considered to be an indirect improvement for the company.

This research attempts to understand the role of ESCOs in the possible growth paths of the heavy industries. Hence, the focus will be on improvements in energy efficiency in areas that are directly related to the company's business. For convenient referencing, these areas are referred to as "critical processes". With this definition, the basic theme of this study is whether heavy industrial enterprises are willing to use ESCOs to undertake initiatives for improving the energy efficiency of their critical processes.

The meaning of the basic theme of this study can be further elaborated. Firstly, it is assumed that a company in a particular industry must be equipped with a certain level of expertise in its field so some initiatives for efficiency improvement can be achieved by internal efforts. Therefore, the company may choose to deploy internal resources for some critical processes and use ESCOs for others. Secondly, 'energy efficiency improvement' initiative is only a collective term. The actual exercise can be further classified as energy audit, improvement plan design, and improvement plan implementation (Turner & Doty 2007). Companies may choose to involve an ESCO for some or all of these stages when improving their critical processes. Combining the internal-external alternative together with the many possible levels of involvement, the extent of ESCO deployment may vary significantly across companies as illustrated in Figure 2.24.



Source: Developed for this thesis

Figure 2.24 **Split of Energy Efficiency Improvement Initiatives**

As an early phase research attempting to understand the adoption of ESCO services by heavy industries in China using the TRA, this study takes a simplified approach to investigate whether or not practitioners intent to adopt ESCO services in their critical processes. The research does not attempt to consider the details about the level of ESCO involvement as it will be too complex for this study.

In this research, government incentives, trust and perceived capability of ESCO are treated as independent variables that affect ESCO deployment. This is postulated from numerous earlier studies performed in Europe and the United States (Vine 2005; BASE 2006; Bertoldi et al. 2007; Urge-Vorsatz et al. 2007; WEC 2008; Ellis 2009).

Government Incentives for using ESCOs is a well-investigated topic. The effects of regulation (Ellis 2009: Section 4.3; Urge-Vorsatz et al. 2007: Section 1.4.2; Zhou 2007: Section 1.1.2), the availability of tangible supports and incentives such as financial assistance, tax benefit, and technology centres (BASE 2006: Section 4.2.1.2; Ellis 2009: Section 4.1 & 4.3; Urge-Vorsatz et al. 2007: Section 1.4.4) are the focus of the current research.

For Trust in ESCO, there are two different aspects when measuring this variable. The first aspect is whether the client feels safe when providing propriety information to the ESCO. In order to design the energy-efficiency improvement program, the ESCO needs to audit many core processes in the client's manufacturing facilities and hence learn a lot of technological secrets of the client. This will lead to the concern about how the ESCO will use such confidential information because the ESCO will likely serve the client's competitors in the same industry. Bertoldi et al. (2007: Section 3.2.8) and Urge-Vorsatz et al. (2007: Section 1.3.2) reported that numerous companies do not allow ESCOs to check core processes.

The second aspect of Trust in ESCO is the classical principal-agent problem that may occur when split incentives and information asymmetry exist (IEA 2007c). In case of ESCO deployment, the client and the ESCO share the value of the energy saved. Since the ESCO is leading the project design and implementation, information asymmetry will make it possible for the ESCO to take advantage of this principal-agent relationship. Zhang, Cai and Pou (2009: Table 1) identified some tactics that ESCOs may deploy. In a broad sense, these acts are aimed at increasing the ESCO's profit and involve selecting sub-optimal technologies for designing and implementing the energy-efficiency improvement program.

Perceptions of ESCO Capability also has two aspects. The first is the client's opinion on whether the ESCO has the knowledge and ability to solve their energy efficiency problem. Ellis (2009: Section 3.4) has pointed out that many ESCOs find it difficult to convince potential clients regarding the energy savings that can be delivered and the reliability of the solution. This is particularly true in risk-averse societies such as China (Lee et al. 2003). Bertoldi et al. (2007: Sections 3.2.2 & 3.2.3) and Vine (2005: Table 4) also reported similar observations.

The second aspect is how the ESCO compares to the client's internal resources. That is, the client has to decide whether using an ESCO is a better solution than deploying internal resources in terms of the quality and reliability of the solution, the time frame, and economic considerations. This aspect is more pronounced in the industrial sector because the clients are, to varying degrees, technically competent. Many previous studies (Ellis 2009; WEC 2008; Bertoldi et al. 2007; Urge-Vorsatz et al. 2007; Bertoldi & Rezessy 2005; Vine 2005) have pointed out that while the energy-intensive nature of the industrial sector would make it a huge market for ESCOs, the reality is that the rate of ESCO adoption in the sector is not high. This observation is explained by several factors but one very important factor is that many companies in this sector have or believe that they have sufficient knowledge to design and implement energy-efficiency improvement programs more effectively than can ESCOs (Ellis 2009: Section 3.6; WEC 2008: Section 3.6.2; Urge-Vorsatz et al. 2007: Section 1.3.2).

An additional variable of interest is the preference for Energy Performance Contracting (EPC). In the traditional view, EPC, which is a mechanism whereby the ESCO is compensated by actual improvement in the firm's energy efficiency, is understood as a very important direct driver of ESCO adoption. Tangible factors such as high administration costs and difficulties in financing are believed to be the major barriers for EPC. Based on this assumption, many government policies and incentive programs aimed at encouraging the use of EPC are being developed. Examples include regulations, efficiency labels, tax benefits, low-interest government loans, and even direct subsidies (Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; Vine 2005; Sorrell 2007; Bertoldi & Rezessy 2005; BASE 2006; Shen 2008; Tang 2005). However, the success of these policies and incentive programs varies significantly across different countries and industrial sectors (Zhang & Wu 2011; Ellis 2009; WEC 2008; Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; Shen 2008; EMCA 2006; Tang 2005).

Although EPC appears to be an advantageous arrangement for the client, its acceptance is not universal. As Ellis (2009), WEC (2008) and Urge-Vorsatz et al. (2007) have specifically pointed out, the acceptance of EPC in industrial sectors is very low. Some prior studies (Li 2010; Zhang, Cai & Pou 2009; IEA 2007c) attribute this to the potential agency problem that could exist in the Client-ESCO relation. Bertoldi et al. (2007: Sections 3.2.5 & 3.2.6) pointed out that a client's concern about the fairness of measurement and verification methods and high administration costs affect the preference for EPC. Ellis (2009: Section 3.2) and Vine (2005: Table 4) have also reported similar observations. Others (Ellis 2009; WEC 2008; Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; Vine 2005) also discuss the subjective views of potential clients on the technical ability of ESCOs and hence the validity of EPC.

Based on the previous discussion, the research question for this project can be stated as follows:

> ***How do government incentives, trust and perceived capability of ESCO, and preference for Energy Performance Contracting influence the adoption of ESCO services in heavy industries in China?***

2.5.1 The Model

The variables to be included in the model for this research (i.e., government incentives, trust in ESCO, perceptions of ESCO capability, and preference for EPC) are summarized in Table 2.10.

Table 2.10 **Variables under investigation**

Variable	Explanatory Note	References
Perceptions of ESCO Capability (CAPABILITY)	General impression about ESCO's technical ability to improve energy efficiency	Ellis 2009; Bertoldi et al. 2007; Vine 2005
	Comparison with deploying internal resources in terms of economics, accuracy, speed, and knowledge enhancement.	Ellis 2009; WEC 2008; Urge-Vorsatz et al. 2007
Trust in ESCO (TRUST)	Concerning about confidentiality of core processes and related information	Bertoldi et al. 2007; Urge-Vorsatz et al. 2007
	Agency problem: whether ESCO is acting for the client's best interest	IEA 2007c; Zhang, Cai & Pou 2009
Government Incentives (GOVT_INC)	Legislation, energy efficiency obligations, funds and subsidies, demonstration program, and tax policy.	Ellis 2009; Urge-Vorsatz et al. 2007; Zhou 2007; BASE 2006
Preference for Energy Performance Contracting (EPC_PREF)	EPC works in a way that the ESCO is compensated by the actual results of the improvement program. Intuitively, this appears to be a reasonable approach for both the client and the ESCO. In the traditional view, EPC is understood as an important driver for ESCO adoption and many government incentives are built around policies to support EPC. However, the level of acceptance varies significantly across different countries and different industrial sectors.	Bertoldi et al. 2007; Ellis; 2009; WEC 2008; Urge-Vorsatz et al. 2007; Vine 2005

A special conceptual development in this research is an expanded view of EPC, which is reflected by the construct Preference for EPC (EPC_PREF) in the proposed model. Based on the discussion in Section 2.5, Preference for EPC could be affected by the three other variables (i.e. Trust in ESCO, Perceptions of ESCO Capability and Government Incentives). Thus, Preference for EPC is not treated as an independent variable but as a mediator in the proposed model.

As in the traditional view, government incentives play an important role in enhancing the tangible benefits of EPC. However, the above discussion also indicates that the preference for EPC is affected not only by these apparent benefits but also by the client's trust in ESCO and perception of ESCO capability.

As mentioned above, most of the prior studies have assumed that client's preference for EPC would be the key driving factor for enhancing ESCO adoption. Many analyses therefore focused on how policies and incentives can affect the preference for EPC. While it is completely reasonable to assume that preference for EPC can be affected by a tangible factor such as Government Incentives (e.g., subsidies, loans, laws, and regulations), it is also logical to postulate that preference for EPC will be affected by the client's view of the ESCO. Similar phenomena are found in other research areas. For example, researchers have consistently reported that consumer's acceptance of food produced with novel technologies is highly dependent on trust and perception even though these foods have been scientifically demonstrated to be safe and equally or even more nutritious than traditional products (Klingeman & Hall 2007; Siegrist, et al. 2007; Frewer, et al. 2011). In an analogous way, preference for EPC may depend on the client's trust in ESCO and the perceived capability of the ESCO despite the apparent benefits of the EPC scheme. Therefore, it is proposed that the intangible constructs Trust in ESCO and Perceptions of ESCO Capabilities will also affect the preference for EPC. In spite of this appealing logic, no systematic model has been established to simultaneously investigate the effects of both the tangible and intangible constructs. To explore the relations, a model based on the Theory of Reasoned Action is proposed. The model is shown in Figure 2.25.

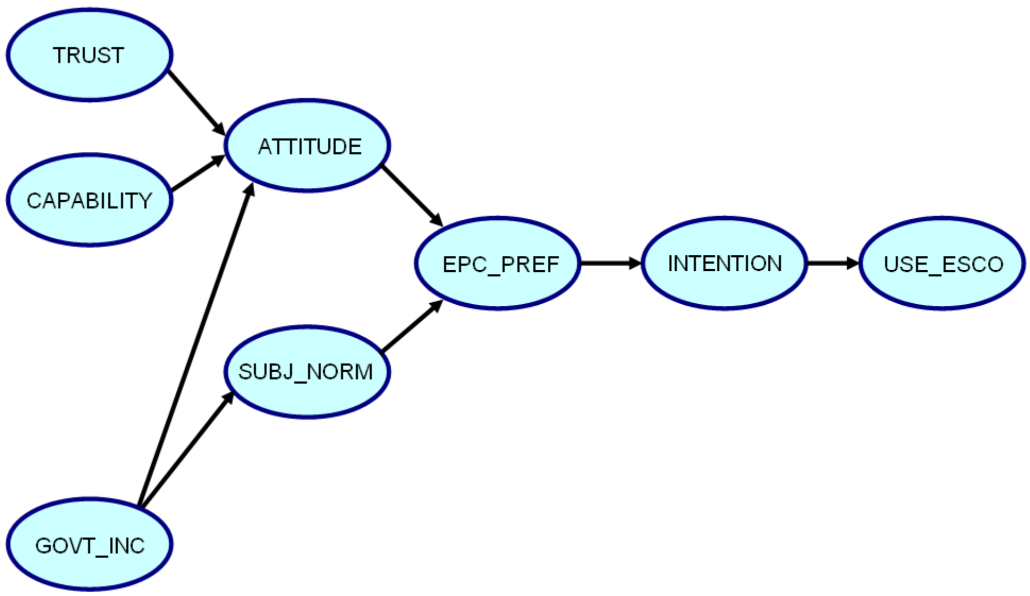


Figure 2.25 **The ESCO TRA model**

The framework of this proposed model is similar to the standard TRA model. In the conceptual model to be tested in this study, the independent variables Government Incentives (GOVT_INC), Perceptions of ESCO Capability (CAPABILITY) and Trust in ESCO (TRUST) predict Attitude to use ESCOs (ATTITUDE). Government Incentives also predicts the Subjective Norm to use ESCO (SUBJ_NORM). However, instead of Attitude to use ESCOs and Subjective Norm to use ESCOs directly predicting the Intention to use ESCOs as in the standard TRA model, Preference for EPC in this proposed model is a mediator of the relationship between Intention to use ESCOs (INTENTION) and Actual use of

ESCOs (USE_ESCO). While this is consistent with the traditional view that Preference for EPC is a very important driver for ESCO adoption, the model channels the effects of the tangible factor Government Incentives as well as the intangible factors Perceptions of ESCO Capability and Trust in ESCO towards Preference for EPC via the mediating variables Attitude to use ESCOs and Subjective Norm to use ESCOs.

As already mentioned, the assumption of Government Incentives affecting Preference for EPC is a traditional view that has been investigated extensively (Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; Zhou 2007; BASE 2006; Bertoldi & Rezessy 2005; Vine 2005). On the other hand, while the assumption of Perceptions of ESCO Capability and Trust in ESCO affecting Preference for EPC appears to be reasonable, relevant studies are rare and most, if not all, of them examine the relation qualitatively (Ellis 2009; WEC 2008; Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; Vine 2005; Fey 2000). This research serves as a pioneering attempt to explore the importance of government incentives, perceptions of an ESCO's capability and trust in the ESCO quantitatively in one unified model thereby providing insights into factors that affect preference for EPC and, ultimately, the actual use of ESCOs.

Table 2.11 contains the hypotheses that have been developed based on the model in Figure 2.25. The next section contains the rationale for these hypotheses.

Table 2.11 **Hypotheses for the TRA model**

Hypothesis 1a: Trust in ESCO and Attitude to use ESCOs are positively correlated. Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated. Hypothesis 1c: The relationship between Trust in ESCO and Preference for EPC is mediated by Attitude to use ESCOs.
Hypothesis 2a: Perceptions of ESCO Capability and Attitude to use ESCOs are positively correlated. Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated. Hypothesis 2c: The relationship between Perceptions of ESCO Capability and Preference for EPC is mediated by Attitude to use ESCOs.
Hypothesis 3a: Government incentives and Attitude to use ESCOs are positively correlated. Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated. Hypothesis 3c: The relationship between Government Incentives and Preference for EPC is mediated by its Attitude to use ESCOs.
Hypothesis 4a: Government incentives and Subjective Norm to use ESCOs are positively correlated. Hypothesis 4b: Subjective Norm to use ESCOs and Preference for EPC are positively correlated. Hypothesis 4c: The relationship between Government Incentives and Preference for EPC is mediated by Subjective Norm to use ESCOs.
Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated. Hypothesis 5b: Preference for EPC and Intention to use ESCOs are positively correlated. Hypothesis 5c: The relationship between Attitude to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC.
Hypothesis 4b: Subjective Norm to use ESCOs and Preference for EPC are positively correlated. Hypothesis 5b: Preference for EPC and Intention to use ESCOs are positively correlated. Hypothesis 6c: The relationship between Subjective Norm to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC.
Hypothesis 5b: Preference for EPC and Intention to use ESCOs are positively correlated. Hypothesis 7b: Intention to use ESCOs and Actual use of ESCOs are positively correlated. Hypothesis 7c: The relationship between Preference for EPC and is Actual use of ESCOs is mediated by Intention to use ESCOs.

Figure 2.2.6 illustrates the hypotheses in the proposed model.

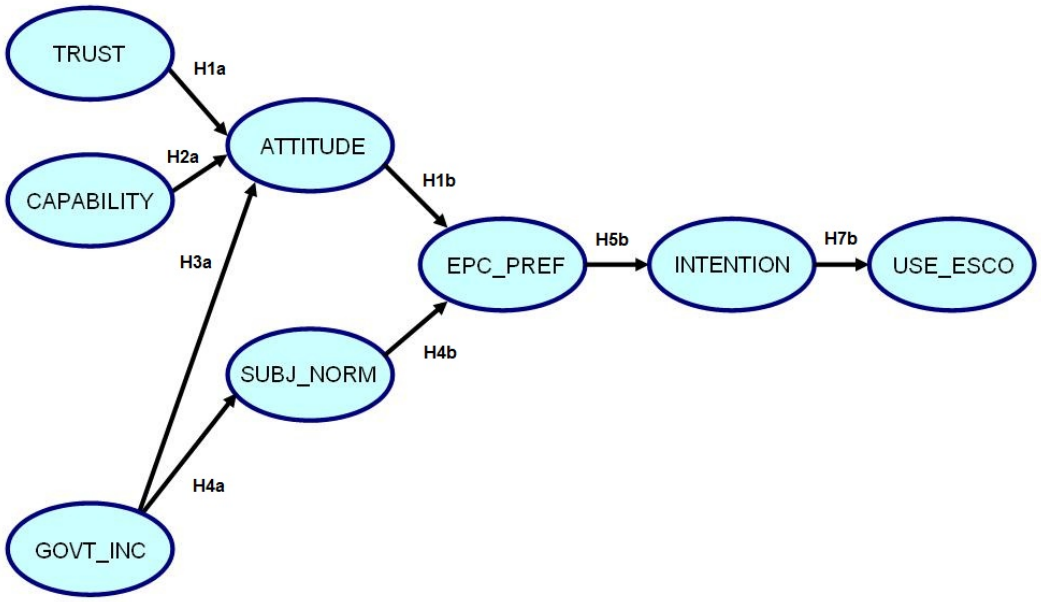


Figure 2.26 **Illustration of the hypotheses in the proposed model**

2.5.2 The Hypotheses

<u>Hypothesis 1</u>

The remuneration received by an ESCO is positively correlated with the amount of energy they help a firm to save (i.e., performance based). As a result, ESCOs may be likely to exaggerate the amount of savings attributable to an energy-reduction project. In fact, this is a common principal-agent problem that has been observed in numerous studies (Li 2010; Zhang, Cai & Pou 2009; IEA 2007c; Kleindorfer 2010).

Developing a system for measuring and verifying the amount of energy saved that is regarded by both the client and the ESCO as accurate is an important issue that needs to be resolved. However, because of the potential conflict of interest mentioned above, it is common for the client and the ESCO to find it difficult to agree on how the amount of energy saved will be measured and verified. Although there are recognized measurement and verification (M&V) guidelines such as IPMVP (2010), they have been applied to generic cases only.

Clients operate in unique environments and, particularly for heavy-industry firms, energy-efficiency improvement projects usually involve complex and costly modifications to production equipment and processes. Some of these modifications are unforeseen at the beginning of a project thereby making it extremely difficult for the ESCO and the client to define all of the M&V details at the outset of a project. Clients thus face the risk that the ESCO will mislead them to adopt M&V methods that are not in their best interests.

In simpler cases, clients may use another independent ESCO for M&V purposes (Hansen 2007). However, this would not work in most heavy-industry projects because of the complexity of the projects thereby making it impossible for a third party to comprehend the details fully without deep involvement. As such, there is a strong global calling for help in M&V as well as ESCO accreditation but there is no obvious solution (Li 2010). Under the circumstances, close regulation of ESCOs is not a practical solution, trust in the ESCO is thus vital.

Due to the practical constraints mentioned above, ESCOs may choose to adopt a particular M&V methodology that maximizes their own profits thereby reducing the overall benefits of the energy-efficiency project for the client. As a result, clients are susceptible to being exploited by ESCOs because the cost of an energy-efficiency project for the client depends on the M&V methodology used by the ESCO.

The client's trust in the ESCO and belief that the M&V methodology selected by the ESCO is in the best interests of the client should be one of the important determinants of whether or not the client wants to use the ESCO. If a client believes that the ESCO will look after the client's best interests and not act unfairly or opportunistically, then the client should be more likely to believe that using an ESCO to conduct a project will be beneficial and thereby result in a positive attitude towards ESCOs.

While the above discussions concentrate on whether the client would believe the ESCO will conduct the project and charge for it in a fair manner, there is still another equally important aspect of trust: as the ESCO will have to audit the client's core manufacturing processes in great detail in order to design the energy efficiency improvement plan, many of the client's technological and commercial secrets will be exposed to the ESCO. Obviously, this would a very serious concern because the ESCO, being an energy-efficiency specialist in a certain sector, will likely serve the client's competitors in the same industry (Bertoldi et al. 2007; Urge-Vorsatz et al.

2007). It is certainly possible for the client and the ESCO to sign up agreement for protecting those secrets. However, whether this is an effective safeguard is always questionable. Thus, it is expected that attitude towards an ESCO would also be positively correlated to the client's trust in the ESCO's integrity in handling the client's confidential information.

Based on the above rationale, the following hypothesis is proposed:

Hypothesis 1a: Trust in ESCO and Attitude to use ESCOs are positively correlated.

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The relation between Attitude to use ESCOs and Preference for EPC could be influenced by three independent variables: That is, Trust in ESCO, Perceptions of ESCO capability and Government Incentives.

Firstly, Energy Performance Contracting (EPC) is an approach that is commonly adopted by ESCOs when conducting energy-efficiency projects. According to the EPC approach, the ESCO will usually finance the project and receive remuneration from the client predominantly based on the actual amount of energy the client saves as a result of the ESCO's involvement. Since the ESCO bears the initial cost of the project and receives payment from the client based on actual savings, the client is, to a large extent, protected from making mistakes in technological, operational and economical decisions.

There are issues with the EPC approach simply because of the complexities that are inherent in energy-reduction projects. Developing M&V that are fair is one of the issues. Additionally, the ESCO may choose technologies based on its own interests rather than on the interests of the client. As a result, while the EPC approach appears to be beneficial to the client, the materialization of such benefits is dependent on how the ESCO acts.

Given that it is not practical to fully control the ESCO's actions, whether the client would prefer the approach should be related to the client's attitude to the use of ESCOs. If the client has a positive attitude towards ESCOs because the client trusts ESCOs to work for the client's benefit, then the client would most likely prefer the EPC approach because the client would likely believe that the EPC approach provides a form of insurance against the consequences of any incorrect or costly decisions the ESCO might make.

On the other hand, the ESCO may choose a suboptimal technology even when acting in good faith because the ESCO is not familiar with or does not have access to a specific technology that is best for the client. In another possible case, the ESCO may not have sufficient knowledge about the latest technology and therefore is not able to select the most appropriate technology.

It is usually quite difficult for the client to determine the appropriateness of the technology chosen by the ESCO because of the technical complexity involved and information asymmetry between the client and the ESCO (IEA 2007c; Kleindorfer

2010). Furthermore, interruptions to normal operations can be very costly for heavy-industry firms because such interruptions can lead to unexpected consequences such as long-term adverse effects on product quality. Whether the ESCO is able to minimize such interruptions is therefore another crucial factor in addition to technology choice. Unfortunately, this is again difficult for the client to determine at the outset. Thus, while the EPC approach appears to be beneficial to the client, the materialization of such benefits is dependent on the ESCO's capability.

If the client has a positive attitude towards the ESCO because the client trusts the ESCO to be capable, then the client would be more likely to prefer the EPC approach because the client would be likely to believe that the EPC approach offers a form of insurance against the consequences of any incorrect or costly decisions made by the ESCO. Based on this rationale, the following hypothesis is proposed:

> Hypothesis 1b: Attitude to ESCOs and is Preference for EPC are positively correlated.

According to the rationale provided for Hypothesis 1a, a client is likely to develop a positive attitude towards the ESCO if the client trusts the ESCO. According to the rationale provided for Hypothesis 1b, a positive attitude towards an ESCO is likely to result in the client preferring the EPC approach. It therefore seems reasonable to expect trust in the ESCO to result in a preference for the EPC approach because trust in the ESCO facilitates the development of a positive attitude towards the ESCO. Based on this rationale, the following hypothesis is proposed:

Hypothesis 1c: The relationship between Trust in ESCO and Preference for EPC is mediated by Attitude to use ESCOs.

Hypothesis 2

There are good reasons for clients to think carefully about the capability of ESCOs because energy-efficiency improvement projects for heavy-industry firms are significant investments and are practically irreversible. Besides the cost of the project itself, a suboptimal project could lead to mid-to-long term disadvantages in production costs and product competitiveness. The ability of the ESCO to choose the most appropriate technology for a particular project is therefore crucial (Ellis 2009; Bertoldi et al. 2007; Kleindorfer 2010; IEA 2005; Vine 2005; Fey 2000). The rapid development of energy technologies has made it more difficult to ensure that the chosen ESCO is fully competent and up-to-date with the latest technologies.

With EPC, the client is theoretically protected from making wrong initial investment due to the fact that the ESCO bears the cost of the project initially and is then compensated based on the amount of energy the client saves. However, small mistakes by the ESCO could lead to a suboptimal project outcome and possibly to substantial losses due to mid-to-long term disadvantages in production costs and product competitiveness.

Another important consideration for using an ESCO is the comparison against deploying internal resources within the firm. Since many clients in industrial sectors are, to various degrees, technically competent, they have the ability to design and implement some kind of energy-efficiency improvement programs too. Whether to engage an ESCO or not would likely be affected by the client's perceived strength-weakness comparison. Furthermore, interruption to the client's normal operations during program implementation is another factor somewhat in favour of deploying internal resources. Since each client's operating environment is different, unpredictable interruptions to normal production can often occur during the implementation of energy efficiency projects.

The extent of the interruptions to normal operations and productivity depends to a large extent on the technical expertise to resolve such problems in an effective and efficient manner. As clients understand their own processes in fine details, it is easier for them to manage this risk if they decide to use their own programs. In fact, it has been reported that many clients in the European industrial sector prefer deploying their own internal resources to implement energy-efficiency projects rather than using ESCOs (Ellis 2009; WEC 2008).

Based on the above discussion, the perception that ESCOs are capable will likely be an important factor that affects the attitude towards using an ESCO. The following hypothesis is therefore proposed:

Hypothesis 2a: Perceptions of ESCO Capability and Attitude to use ESCOs are positively correlated.

According to the rationale provided for Hypothesis 2a, a client is likely to develop a positive attitude towards the ESCO if the client perceives the ESCO as capable. According to the rationale provided for Hypothesis 1b, a positive attitude towards an ESCO is likely to result in the client preferring the EPC approach. It therefore seems reasonable to expect that the client will prefer the EPC approach when the ESCO is perceived as capable because the client is likely to develop a positive attitude towards the ESCO when the ESCO is perceived as capable. Based on this rationale, the following hypothesis is proposed:

Hypothesis 2c: The relationship between Perceptions of ESCO Capability and ts Preference for EPC is mediated by Attitude to use ESCOs.

Hypothesis 3

Government incentives can bring direct benefits to the clients and therefore are likely to affect clients' attitudes towards using ESCOs. In 2006, the Basel Agency for Sustainable Energy (BASE) conducted a comprehensive study for the United Nations regarding public finance mechanisms for increasing investment in energy-efficiency projects, and illustrated the effects and the importance of Government Incentives. The report (BASE 2006) examined the barriers of using ESCOs for energy efficiency projects and how various forms of government-support assistance programs in US, Canada, France, Bulgaria, Mexico, Brazil, and Thailand. have improved the situation. The programs include grants, loans, guarantees and their derivatives. It has been demonstrated that such programs are helpful for the acceptance of EPCs. Other studies (Vine 2005; Sorrell 2007; Urge-Vorsatz et al. 2007) have also demonstrated similar results. However, the incentives examined are primarily financial in nature. Effects of the other two variables proposed in this research (i.e. Trust in ESCO and Perceptions of ESCO Capability) have not been investigated.

Government incentives for using ESCO have gained popularity (IEA2007c; Kleindorfer 2010; Hansen 2007). In China, numerous Government Incentives for supporting ESCO deployment have been introduced in recent years (SC_PRC 2010; Zhang & Wu 2011). However, formal studies on the effects of these incentives in China are yet to be conducted. Based on the foreign experiences, the following hypothesis is proposed:

Hypothesis 3a: Government incentives and Attitude to use ESCOs are positively correlated.

According to the rationale provided for Hypothesis 3a, a client is likely to develop a positive attitude towards using ESCOs if Government Incentives are available. According to the rationale provided for Hypothesis 1b, a positive attitude towards ESCOs is likely to result in the client preferring the EPC approach. It therefore seems reasonable to expect that the availability of Government Incentives will result in a preference for the EPC approach because Government Incentives facilitate the development of a positive attitude towards ESCOs. Based on this rationale, the following hypothesis is proposed:

Hypothesis 3c: The relationship between Government Incentives and Preference for EPC is mediated by Attitude to use ESCOs.

Hypothesis 4

As discussed in Section 2.3, an important Chinese-Government initiative to improve the industrial structure of China is to develop its ESCO sector. Government incentives for using ESCOs indicate that the authorities are serious about deploying ESCOs to improve the energy efficiency of the heavy-industry sector. For China in particular, this would likely imply a degree of expectation to comply (Zhang & Wu 2011, Shen 2008). Therefore, Government Incentives are likely be an important factor that affects the subjective norm of involving an ESCO in an energy-efficiency project. The following hypothesis is therefore proposed:

> Hypothesis 4a: Government incentives and Subjective Norm to use ESCOs are positively correlated.

If the client has a positive Subjective Norm to use ESCOs because of Government Incentives, the client should be likely to prefer the EPC approach in order to benefit from the incentives. The following hypothesis is therefore proposed:

> Hypothesis 4b: Subjective Norm to use ESCOs and Preference for EPC are positively correlated.

According to the rationale provided for Hypothesis 4a, a client is likely to develop a positive Subjective Norm to use ESCOs if Government Incentives are available. According to the rationale provided for Hypothesis 4b, a positive Subjective Norm to use ESCOs is likely to result in the client preferring the EPC approach. It therefore seems reasonable to expect that the availability of Government Incentives will result in a preference for the EPC approach because Government Incentives facilitate the development of a positive Subjective Norm to use ESCOs. Based on this rationale, the following hypothesis is proposed:

Hypothesis 4c: The relationship between Government Incentives and Preference for EPC is mediated by Subjective Norm to use ESCOs.

<u>Hypothesis 5</u>

EPC is the approach uniquely used by ESCOs for implementing projects. Thus, an increase in the Preference for EPC is likely to increase the Intention to use ESCOs. The following hypothesis is therefore proposed:

Hypothesis 5b: Preference for EPC and Intention to use ESCOs are positively correlated.

According to the rationale provided for Hypothesis 1b, Preference for EPC is likely to increase as Attitude to use ESCOs increases. According to the rationale provided for Hypothesis 5b, Preference for EPC is likely to increase as Intention to use ESCOs increases. It therefore seems reasonable to expect that an increase in Attitude to use ESCOs will lead to an increase in Intention to use ESCOs because an increase in Attitude to use ESCOs should increase the Preference for EPC. Based on this rationale, the following hypothesis is proposed:

Hypothesis 5c: The relationship between Attitude to use ESCOs and Intention to use ESCOs is mediated by its Preference for EPC.

Hypothesis 6

According to the rationale provided for Hypothesis 4b, if the Subjective Norm to use ESCOs increases so too should the Preference for EPC. According to the rationale provided for Hypothesis 5b, as Preference for EPC increases so too should the Intention to use ESCOs. It therefore seems reasonable to expect that the Subjective Norm to use ESCOs increases the Intention to use ESCOs because the Subjective Norm to use ESCOs increases the Preference for EPC. Based on this rationale, the following hypothesis is proposed:

Hypothesis 6c: The relationship between Subjective Norm to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC.

Hypothesis 7

An increase in the Intention to use ESCOs will likely lead to an increase in the use of ESCOs based on the TRA. Therefore, the following hypothesis is proposed:

Hypothesis 7b: Intention to use ESCOs and use of ESCOs are positively correlated.

According to the rationale provided for Hypothesis 5b, 6b and 7a, the Intention to use ESCOs will increase when the client has a Preference for EPC. According to the rationale provided for Hypothesis 7b, an increase in the Intention to use ESCOs is likely to result in ESCOs being used based on the TRA. It therefore seems reasonable to expect that an increase in the Preference for EPC will lead to an increase in the use of ESCOs because the Preference for EPC is positively related to the Intention to use ESCOs. Based on this rationale, the following hypothesis is proposed:

Hypothesis 7c: The relationship between Preference for EPC and use of ESCOs is mediated by Intention to use ESCOs.

In this Chapter, we have defined the research question, and provided the rationale for the hypotheses. In the next chapter, we will discuss the research methodology and develop the tools that will be used to test the hypotheses.

Chapter 3 Research Methodology

3.1 Introduction

3.1.1 Summary of the Current Situation

In the previous chapter, global energy-supply issues as well as the relationship between energy consumption and climate change have been examined. To elaborate, the following three issues were discussed: i) developing new energy sources; ii) improving energy efficiency; and iii) changing energy consumption patterns. Out of the three categories, improving energy efficiency is most attainable in the short- to mid-term. As such, major countries have developed their own energy-efficiency improvement programs. Since every economy has its own peculiarities, the focus of different countries' energy-efficiency improvement programs can be quite diverse (Lee 2003; Vine 2005; Bertoldi et al. 2007; WEC 2008; Urge-Vorsatz et al. 2007; Ellis 2009).

Being the world's largest energy consumer and, at the same time, a rapidly growing economy, the implementation results of China's energy-efficiency improvement initiatives will be crucial to the global-energy situation. As mentioned in the last chapter, about 70% of China's total energy usage is consumed by the secondary industrial sector. Within this sector, heavy industries such as metal casting, petroleum, chemical and cement are the dominant energy consumers. In 2009, the top five heavy industries accounted for close to 50% of the country's energy consumption (Table 2.9). Another issue faced by China's heavy industries is that the added value of their products is quite low. In other words, large amounts of energy are consumed for generating a relatively small contribution to GDP. From the view of sustainable development, improving energy efficiency for heavy industries is critical. As mentioned in Section 2.3.2, the Chinese Government has specifically issued directives for improving energy efficiency. Concerning the heavy industries, the country's top one thousand energy consuming enterprises have entered into consumption-reduction agreements with the government. In addition, rigorous and specific energy-intensity reduction targets have been established for the relevant sectors.

While the importance of improving the energy efficiency of heavy industries is agreed upon by all concerned parties, the Classical Growth Model and the Alternative Growth Model, as discussed in Section 2.3.2, have different views on how this improvement should be achieved. Specifically, the Classical Growth Model, as outlined in Section 2.3.2, suggests that further expansion of heavy industries is an inevitable stage of industrialization and the government should directly allocate resources to the heavy industries in order to accelerate growth and attain maturity: That is, efficiency improvement will be a natural consequence of maturity. In contrast, the Alternative Growth Model, also outlined in Section 2.3.2, argues that the Classical Growth Model will lead to resource misallocation and hence to serious economic consequences. The Alternative Growth Model suggests that the government should provide resources for developing energy-services experts (commonly referred as ESCOs, or energy-services companies) in order to effectively help heavy industries to attain energy-efficiency goals. Details of the two schools of thought were outlined in the previous chapter.

Since many supporters of the Alternative Growth Model are prominent Chinese economists and social scientists, many theoretical works have been provided to promote the advantages of the model (Wu 2006; Lin 2005). However, one important practical aspect has not been thoroughly investigated: That is, industry’s acceptance of this model. This issue is vital because the Alternative Growth Model assumes that heavy industries will, from an economic point of view, make good use of ESCOs for energy-efficiency improvement exercises. If the industry behaves differently, the viability of the model may diminish. As illustrated by Zhang and Wu (2011), Shen (2008), EMCA (2006) and Tang (2005), while some successful cases have been reported, the ESCO approach is not a common practice among all heavy industries. To understand the practicality of the Alternative Growth Model, comprehensive studies on the industry’s attitudes and behaviour towards using ESCOs are essential.

3.1.2 Applying the Theory of Reasoned Action to Organizations

As outlined in Section 2.4, the Theory of Reasoned Action (TRA) provides a theoretical framework for investigating behaviour. A model has been proposed in Section 2.5 for this study. It is worth pointing out that the theory is concerned with the behaviour of a specific individual. As such, when investigating the behaviour of the heavy industries, the study explores the attitudes and behaviour of relevant decision makers. The target participants will be executives of major heavy-industrial companies who make decisions on whether or not to use ESCOs. Details about research paradigms, design, methods and on how participants are to be selected will be provided in Sections 3.2 – 3.5.

3.2 Research Paradigms

Having established the hypotheses, an appropriate research paradigm has to be selected. This section will briefly outline the two major paradigms, positivism and interpretivism, and explain the rationale for choosing one over the other.

3.2.1 Positivism and Interpretivism

In a general sense, business research can be positivistic, interpretive, or something in between (Cavana et al. 2001). Positivistic questions are, in most cases, quantitative in nature and are primarily concerned with "how many" or "how much". Interpretive questions are usually qualitative in nature and are primarily concerned with "why" and "how". The "what" question may fall into both categories depending on whether it is part of an explanatory study or part of a quantification study. While it is obvious that quantitative and qualitative methodologies are catered to answer questions of a different nature, it is important to recognize the different philosophical orientations of the positivistic and interpretive paradigms (Wilson & Natale 2001).

Positivism deals with variables that are observable and measurable. It is assumed in this approach that some relatively stable cause-and-effect relations may exist among variables and that quantitative techniques are applicable for verifying the existence of these relationships. In this sense, positivism assumes that there exists an objective reality. Performing research is understood as a process of discovering relationships between variables in this objective reality. Thus, this approach is most suitable for discovering and explaining strict facts (Cavana et al. 2001).

There are also situations where relationships between variables can be defined conceptually but measurability and observability are less straightforward: For example, the relationship between product quality and price. Nevertheless, as long as a real and relatively stable relationship between variables exists, quantification of the relationship is theoretically possible by building proper constructs and applying appropriate quantitative techniques.

Interpretivism and therefore qualitative research has very different assumptions to those of positivism and quantitative research. Intrinsically, this paradigm does not assume the existence of strict cause-and-effect relationship or that there exists an objective reality (Cavana et al. 2001). With interpretivism, reality comprises complex interwoven events and generalization is thus not possible nor is it particularly useful given the subjectivity of perceptions. Rather, the interpretivist approach aims to interpret phenomena in terms of meanings given by individuals or groups who are attached to a specific context (Denzin & Lincoln 2000). In other words, the interpretivist approach attempts to discover the reasons, feelings and opinions of the groups or individuals under specific conditions. Generalization is neither possible nor meaningful. The desired outcome of qualitative research is an understanding of the subject and the processes involved. Unlike positivism, therefore, this approach aims to explore and explain phenomena from a holistic perspective in a specific context.

3.2.2 Justification for Choosing the Positivistic Paradigm

The positivistic paradigm has been selected for this study because the proposed research model, which represents an overview of the hypotheses, needs to be tested. Quantitative studies are appropriate for testing hypotheses and for examining relationships between variables. Additionally, the Theory of Reasoned Action has been tested numerous times via quantitative studies and consequently, there are well-established scales in the literature that can be used to measure the key variables in the model. Furthermore, the independent variables in the model were selected based on relevant prior studies, as shown in Table 2.10, and on the opinions of industrial practitioners, including companies and consultants. These details will be addressed in a later section on the limitations of this research.

3.3 Research Design

Having determined the research paradigm, this section discusses the research design. Cavana et al. (2001) recommend that the following five basic aspects of research design should be considered: i) the kind of design, ii) the type of investigation, iii) researcher interference and study setting, iv) unit of analysis, and v) time horizon. The following discussion will be based on these five aspects.

(a) The Kind of Design

The kind of design refers to whether the study is exploratory, descriptive, or hypothesis testing. As explained in Section 3.2.2, this research aims to test the hypothesised relationships between the variables shown in the theoretical model. This study therefore calls for a research design that is hypothesis testing in nature.

(b) Type of Investigation

Type of investigation can be clarification, correlational or causal. With this research, the focus is on whether some variables change together with the others and, if so, to what extent. It is important to realize that the purpose of this study is not to explain causal connections between the variables in the model, but rather to investigate if these variables are associated with each other. Thus, this investigation is correlational in nature.

(c) Researcher Interference and Study Setting

The variables involved in this research are assumed to exist objectively and to be external in nature. The researcher will only test hypotheses about the correlations between these variables. Therefore, besides collecting objective data from the subject of study via tools such as a questionnaire, the researcher does not have to interfere with the subject's normal activities. Thus, researcher interference is minimal and the study setting is non-contrived.

(d) Unit of Analysis

Although this research is concerned with the acceptance of ESCOs in the heavy industry sector, it is important to realise that the deployment decision is made by individual executives who conduct projects to improve the energy efficiency of their organisations. Therefore, the unit of analysis for this research is the individual executive in the industry rather than the organisation.

(e) Time Horizon

Since this research aims to investigate the correlations between external, objective variables, this study does not involve any experiments to alter the variables. Given the scope of this study, the relationships of interest will be examined only at a single point in time due to the resource demands of conducting a longitudinal study, even though longitudinal studies have the capacity to trace how the relationships change over time. To meet the research objective, only cross-sectional data will be used. Hence, the research design will be cross-sectional.

3.4 Sampling

3.4.1 The Population

According to the National Statistic Bureau of China, there are close to 170,000 heavy industrial companies in the country (information available at www.stats.gov.cn). Although all these companies are characterized by high levels of energy consumption, they belong to a range of sectors. Going across different sectors, some behavioural variations towards the use of consultants is possible (Maier 2005). Therefore, detailed sectoral classification is needed in the sampling process. As mentioned in Section 2.3.3, about two-thirds of the industrial energy usage, or equivalently half of the country's total energy usage, is consumed by producers of (a) Iron and steel (i.e. smelting and pressing of ferrous metal), which represents 18.4% of the country's 2009 energy consumption, (b) chemical and petrochemicals, which represents 14.4%, and (c) non-metallic minerals, which represents 8.8% (Table 2.9). Due to the importance of these three sectors, each survey respondent will be classified into one of these sectors, or grouped as "Others".

3.4.2 Sampling

Sampling schemes can be divided into probability sampling and non-probability sampling. Table 3.1 provides a summary of common schemes.

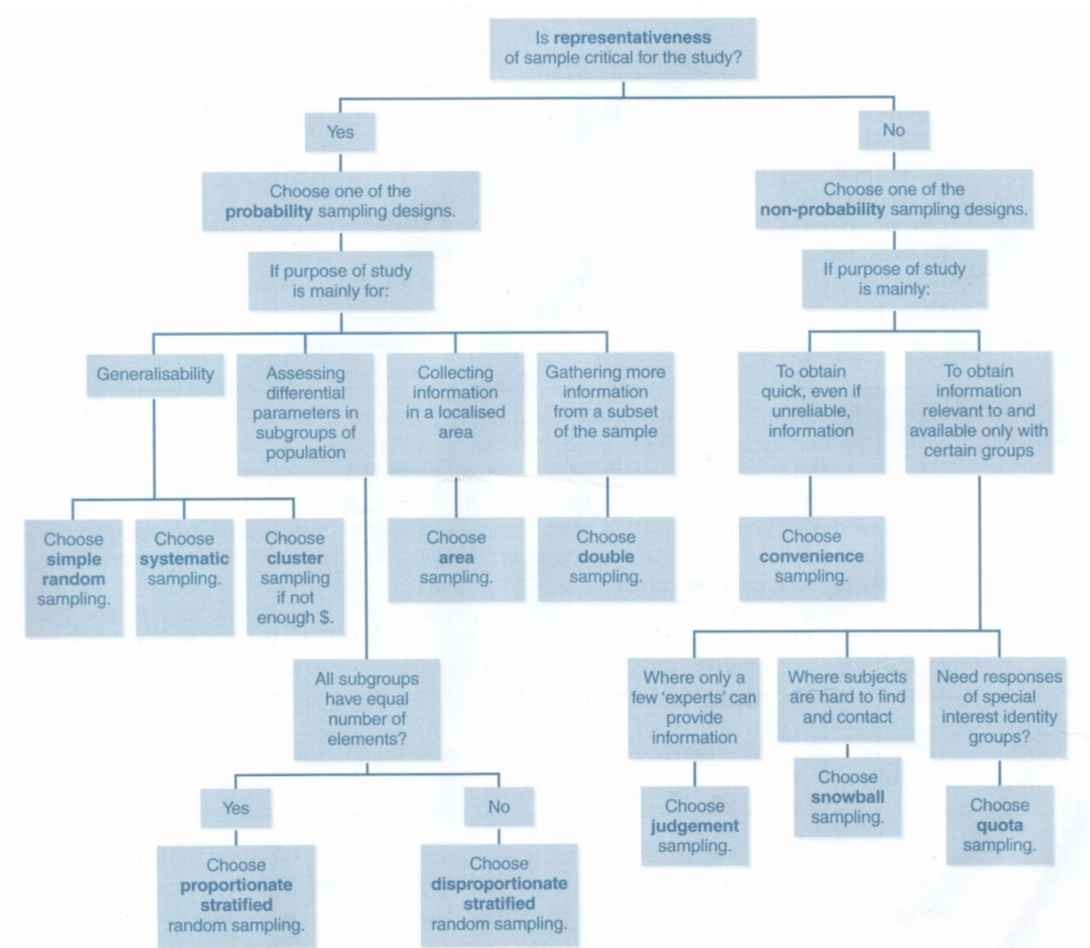
Table 3.1 **Sampling Schemes**

Sampling design	Description	Advantages	Disadvantages
Probability sampling			
1. Simple random sampling	All elements in the population are considered and each element has an equal chance of being chosen as the subject.	High generalisability of findings	Not as efficient as stratified sampling
2. Systematic sampling	Every *n*th element in the population is chosen starting from a random point in the sampling frame.	Easy to use if sampling frame is available	Systematic biases are possible
3. Stratified random sampling (Str.R.S.) Proportionate Str.R.S. in the population. Disproportionate Str.R.S.	Population is first divided into meaningful segments; thereafter subjects are drawn: • in proportion to their original numbers • based on criteria other than their original population numbers.	Most efficient among all probability designs. All groups are adequately sampled and comparisons among groups are possible.	Stratification *must* be meaningful. More time-consuming than simple random sampling or systematic sampling. Sampling frame for *each* stratum is essential.
4. Cluster sampling	Groups that have heterogeneous members are first identified, then some are chosen at random; all the members in each of the randomly chosen groups are studied.	In geographic clusters, costs of data collection are low.	The least reliable and efficient among the probability sampling designs since subsets of clusters are more homogeneous than heterogeneous
5. Area sampling	Cluster sampling is done within a particular area or locality.	Cost-effective. Useful for decisions relating to a particular location	Takes time to collect data from an area
6. Double sampling	The same sample or a subset of the sample is studied twice.	Offers more detailed information on the topic of study	Original biases, if any, will be carried over. Individuals may not be happy responding a second time.
Non-probability sampling			
7. Convenience sampling	The most easily accessible members are chosen as subjects.	Quick, convenient, inexpensive	Not generalisable at all
8. Judgement sampling	Subjects are selected on the basis of their expertise in the subject investigated.	Sometimes the only meaningful way to investigate	Generalisability is questionable; not generalisable to entire population
9. Snowball sampling	Initial sample is identified, then more subjects are selected from referrals.	Useful when subjects have required characteristics but are hard to find and contact	Not normally generalisable
10. Quota sampling	Subjects are conveniently chosen from targeted groups according to some predetermined number or quota.	Very useful where minority participation in a study is critical	Not easily generalisable

Source: Cavana et al. 2001

3.4.3 Selection of Sampling Scheme

According to Cavana et al. (2001), a sampling scheme can be chosen by using the decision tree shown in Figure 3.1.



Source: Cavana et al. 2001

Figure 3.1 **Sampling Decision Tree**

To select the appropriate scheme, the followings factors are considered: i) this research is at the exploratory phase so getting basic information quickly and efficiently is important. Representativeness will be enhanced by further studies; ii) because of the enormity of the heavy-industry sector, it is difficult to identify and reach all decision-making executives. At the present stage, these target participants can only be effectively reached via Asia Energy Platform (AEP) connections *{Remark: AEP is a non-profit oriented organisation in energy sector. A large portion of the AEP members are responsible for energy-efficiency improvement and hence relevant targets of this research}*; and iii) time constraints.

Referring to Table 3.1 and Figure 3.1, convenience sampling is most appropriate for this research. Table 3.2 summarizes the sampling design.

Table 3.2 **Sampling Design**

Step	**Description**
1. Population	Approximately 170,000 heavy industrial companies in China
2. Sampling units	Executives in these companies who make decision on deploying energy efficiency consultants
3. Sample type	Convenience sampling via surveying members of AEP
4. Size of sample	> 384 samples (Canava et al. 2001, p.278)
5. Sampling plan	Assuming 15% response rate, 2700 electronic questionnaires will be sent to executives listed in the database of AEP

3.5 Data-Collection Methods

Ticehurst and Veal (2000) discussed the following four common methods for collecting data: mail survey, telephone survey, face-to-face survey and web-based survey. Mail surveys and web-based surveys are based on self-administered questionnaires. With a self-administered questionnaire, the researcher does not provide assistance on how to complete the questionnaire or on how to interpret the questions. Furthermore, whether or not the questions are answered honestly depends solely on the respondents. Face-to-face surveys and web-based surveys are administered by the interviewer and some assistance could be provided to participants. Table 3.3 contains a summary of the advantages and disadvantages of these methods as discussed by various authors (i.e., Ticehurst & Veal 2000; Cavana et al. 2001).

Table 3.3 **Data Collection Methods**

Method	**Advantages**	**Disadvantages**
Mail	• Relatively low cost • Good for large sample size • Can cover wide geographical area • Does not require excessive staff and facilities • Respondents have time think clearly • Anonymity is assured	• Response rate is usually low • Not for open-ended questions
Telephone	• Response rate is usually better • Getting immediate response • Opportunity for clarification	• Access limitation • Need more staff • May not be good for sensitive subjects
Face-to-face	• Best in terms of response rate • Getting immediate response • Can obtain "rich" information • Opportunity for clarification	• High cost • Need more staff • Lengthy process • Anonymity could be a problem
Web-based	• Very low cost • Good for very large sample size • Can cover very wide geographical area • Does not require excessive staff and facilities • Convenient for populations with Internet access • Respondents have time think clearly	• Access limitation • Response rate is usually low • Not for open-ended questions

A Web-based survey is selected as the survey method for this research for the following reasons: i) due to the size of population, a large sample is required in order to obtain representative results; ii) For such a large sample, telephone and face-to-face surveys are impractical due to the time required to conduct such surveys; iii) respondents are dispersed across several geographical locations throughout China, thus rendering a face-to-face survey unfeasible; iv) a mail survey will be too costly for such a large sample. Also, it will take a long time to receive the completed questionnaires from participants; v) the problem of low response rates with web-based survey is partially mitigated by assistance from AEP to inform potential participants of this survey. As AEP correspond regularly with their members, it is believed that potential participants would have a greater awareness of the survey and, hopefully, this will improve the response rate; and vi) the respondents, who are executives in the heavy industry, are familiar with the issues being surveyed. Furthermore, open-ended questions will not be used. Hence, it is reasonable to expect that the respondents can answer the questions without assistance. The questionnaire and related documents are provided in both Chinese and English.

To administrate the research, a webpage has been setup using SQL programming (http://surveys.3tiersolutions.com/survey.php?lang=en&id=57). AEP communicates about this research to its members and forwards the invitation for participation together with a bilingual Participant Information Letter (Appendix B) via email. Respondents answer the questionnaire on the website and the data are automatically entered into an Excel file. The process is completely anonymous and the researchers can access the data but cannot identify individual participants.

3.6 Scaling, Reliability and Validity

3.6.1 Scaling

This research attempts to quantitatively represent the effect of self-perceived factors on actual behaviour. The practical way to identify these perceptions is by asking respondents if they agree or disagree with statements about relevant issues. A Likert scale is commonly used for this purpose. With the exception of questions about the respondent's basic information such as industrial sector and organization size, the following five-point Likert scale will be used for all the questions: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5).

3.6.2 Goodness of Data

Quality assurance plays a vital role for research. Goodness of data is measured by validity and reliability (Cavana et al. 2001). Validity concerns about the "intrinsic correctness" of the instrument for identifying relationship between variables. In other words, how can one reasonably ensure that the questions asked are measuring the concept one intended to measure and not something else? To illustrate, the ability to answer the question "19 + 73 = ?" could probably be a reasonable measure of basic knowledge about arithmetic, it is doubtful whether this is a valid measure of intelligence. Table 3.4 summarizes various types of validity.

Table 3.4 **Validity**

Validity	Description
Face validity	Does a sample of respondents validate that items are clear and understandable?
Content validity	Does the measure adequately measure the concept as based on the relevant literature, previous research or the opinion of experts?
Criterion-related validity	Does the measure differentiate in a manner that helps to predict a criterion variable?
Concurrent validity	Does the measure differentiate in a manner that helps to predict a criterion variable concurrently?
Predictive validity	Does the measure differentiate individuals in a manner that helps to predict a future criterion?
Construct validity	Does the instrument tap the concept as theorised?
Convergent validity	Do two instruments measuring the concept correlate closely?
Discriminant validity	Does the measure have a low correlation with a variable that is supposed to be unrelated to this variable?

Source: Cavana et al. 2001

The concept of validity can be further divided into internal validity and external validity. For internal validity, the central issue is the authenticity of the causal relationships between variables. For external validity, the concern is whether the relationships are generalizable under different external environments.

Reliability refers to the stability and internal consistency of the measures. Table 3.5 provides a summary of reliability tests.

Table 3.5 **Reliability**

Measure	Reliability Test	Description
Stability	Test-retest reliability	Reliability coefficient obtained on a second test should be similar
	Parallel-form reliability	Two comparable sets of construct should be highly correlated
Internal consistency	Inter-items consistency reliability	Independent measures of the same concept should be highly correlated
	Split-half reliability	Two halves of an instrument should be correlated. However, it would depend on how the items in the measure are split.

In this research, factor analysis will be deployed to test the convergent validity of the measures whilst Cronbach's Alpha will be used to test the internal reliability of the measures (Cavana et al. 2001)

3.7 Questionnaire Design

This section examines briefly how the variables are measured and explains the questionnaire development approach for this research. Each variable will be measured using multiple items. Items can be direct or indirect (Ajzen 2002b; Francis et al. 2004). Following the guideline by Francis et al. (2004), three to eight items are to be used to measure each variable.

According to the TRA, behavioural intention is not only affected by beliefs but also by the strength of these beliefs (Ajzen & Fishbein 1980; Ajzen 1991). Thus, the questionnaire must be developed in a way that can identify both the respondent's beliefs and the strength of these beliefs. To accomplish this objective, it is possible to use direct measures or indirect measures (Francis et al. 2004).

With direct measures, the respondent is directly asked if s/he agrees or disagrees with a certain belief (e.g., exercise is good, fatty food is harmful), or a qualified statement concerning a behaviour (e.g., good/bad, pleasant/unpleasant, harmful/beneficial). With indirect measures, the respondent is asked if s/he is likely to perform a certain behaviour, and is then asked how s/he evaluates the particular behaviour. The scores of these two questions are multiplied together to form a measure of the strength of a particular belief.

While direct measures are more intuitive and easier to develop, it is assumed the respondent can spontaneously give an accurate self-assessment. Indirect measures do not make this assumption and hence may provide an additional possibility for validity verification. However, there are concerns about the effect of scaling when a product-term is used as a measure of beliefs (Evans 1991; French & Hankins 2003). Various solutions have been proposed but the practicality of these solutions is questionable (Ajzen 2002b; French & Hankins 2003; Francis et al. 2004).

For the purpose of this research, all of the questions will be direct in nature for the following two reasons: i) this research is exploratory so further complication due the scaling issue of indirect measures approach should be avoided; and ii) the respondents are professionals who should possess a sound understanding of energy-efficiency issues so it is believed that they are able to make a thorough assessment without assistance from anyone.

Measurement of each of the variables is discussed in the following. The final questionnaire is attached in Appendix A. For easy reference, the proposed TRA model is reproduced below (Figure 3.2).

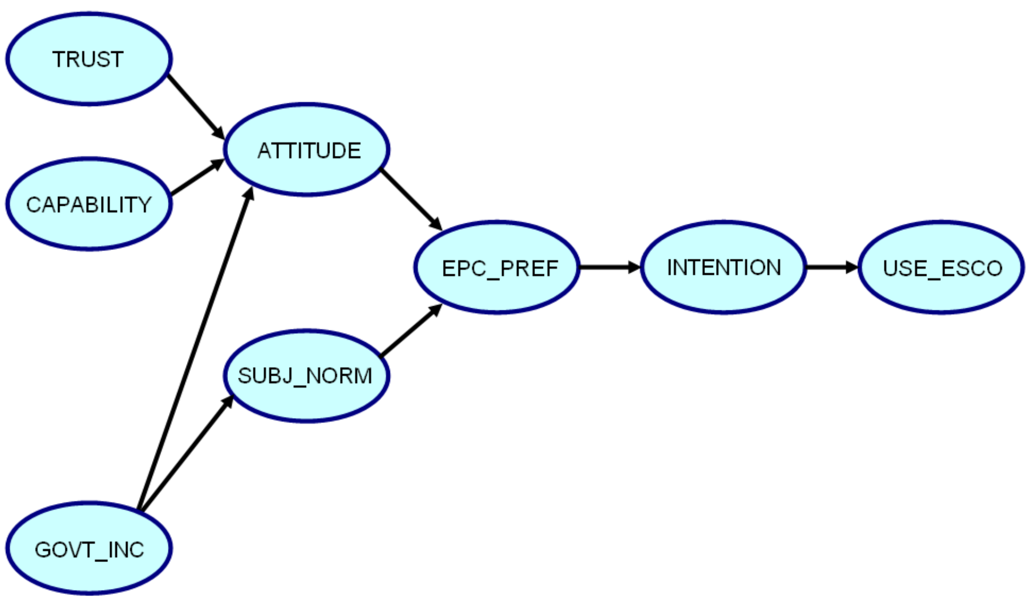


Figure 3.2 **The ESCO TRA model**

Measurement of Perceptions of ESCO Capability

As discussed in Section 2.5, Perceptions of ESCO Capability have two aspects. The first is the client's opinion on whether the ESCO has the knowledge and ability to solve their energy efficiency problem. Ellis (2009: Section 3.4) has pointed out that many ESCOs find it difficult to convince potential clients regarding the energy savings that can be delivered and the reliability of the solution. This is particularly true in risk-averse societies (Lee et al. 2003). Bertoldi et al. (2007: Sections 3.2.2 & 3.2.3) and Vine (2005: Table 4) also reported similar observations.

The second aspect is how the ESCO compares to the client's internal resources. That is, the client has to decide whether using an ESCO is a better solution than deploying internal resources in terms of quality and reliability of the solution, speed and economics. This aspect is more pronounced in the industrial sector because the clients are, to varying degrees, technically competent. Many previous studies (Ellis 2009; WEC 2008; Bertoldi et al. 2007; Urge-Vorsatz et al. 2007; Bertoldi & Rezessy 2005; Vine 2005) have pointed out that while the energy-intensive nature of the industrial sector would make itself a huge market for ESCOs, the reality is that the ESCO adoption rate in the sector is not high. This observation is explained by multiple factors but one very important factor is that many companies in this sector have or believe that they have sufficient knowledge to design and implement energy-efficiency improvement programs more effectively than ESCOs (Ellis 2009: Section 3.6; WEC 2008: Section 3.6.2; Urge-Vorsatz et al. 2007: Section 1.3.2).

The items used to measure Perceptions of ESCO Capability are presented in Table 3.6. The first aspect is measured with Items 2, 4 and 7, and the second aspect is measured with Items 1, 3, 5 & 6 in the questionnaire.

Table 3.6 **Measurement of Perceptions of ESCO Capability**

Item 1	With respect to our internal capabilities, ESCOs have a more in-depth understanding about our energy efficiency problems than we do
Item 2	ESCOs have successfully tackled similar problems that we currently face
Item 3	ESCOs can provide a better solution than our internal resources
Item 4	ESCOs can identify issues that are currently unknown to us
Item 5	ESCOs can solve our energy efficiency problems at a lower cost than if we do it ourselves
Item 6	We can accomplish our energy efficiency targets faster if we use ESCOs
Item 7	ESCOs can provide useful suggestions on how we can improve our energy efficiency

Measurement of Trust in ESCO

As discussed in Section 2.5, there are also two different aspects when measuring Trust in ESCO. The first one is whether the client feels safe when providing propriety information to the ESCO.

In order to design the energy-efficiency improvement program, the ESCO needs to audit many core processes in the client's manufacturing facilities and hence learn a lot of technological secrets of the client. This will lead to the concern about how the

ESCO will use such confidential information because the ESCO will likely serve the client's competitors in the same industry. Bertoldi et al. (2007: Section 3.2.8) and Urge-Vorsatz et al. (2007: Section 1.3.2) reported that numerous companies do not allow ESCOs to check core processes. This aspect is measured with Items 8 and 9 in the questionnaire (Table 3.7).

The second aspect is the classical principal-agent problem that will possibly occur when split incentives and information asymmetry exist (IEA 2007c). In case of ESCO deployment, the client and the ESCO share the value of the energy saved. Since the ESCO is leading the project design and implementation, information asymmetry will make it possible for the ESCO to take advantage of this principal-agent relationship. Zhang, Cai and Pou (2009: Table 1) has illustrated some typical faults that ESCOs may commit. In a broad sense, these acts are aiming at increase ESCO's own profit by selecting sub-optimal technologies for designing and implementing the energy-efficiency improvement program. This aspect is measured with Items 10 and 11 in the questionnaire (Table 3.7).

Table 3.7 **Measurement of Trust in ESCO**

Item 8	I will show our core processes to ESCO
Item 9	A non-disclosure agreement with ESCO is an acceptable safeguard for confidentiality concerns
Item 10	Instead of choosing the most appropriate technology, ESCO may choose alternative technologies that are familiar to them
Item 11	Instead of choosing the most appropriate technology, ESCO may choose alternative technologies that provide more profits to them

Measurement of Government Incentives

As discussed in Section 2.5, Government Incentives for using ESCOs is a well-investigated topic. Regulatory aspects (Ellis 2009: Section 4.3; Urge-Vorsatz et al. 2007: Section 1.4.2; Zhou 2007: Section 1.1.2) and the availability of tangible supports and incentives such as financial assistance, tax benefits, and technology centres. (BASE 2006: Section 4.2.1.2; Ellis 2009: Section 4.1 & 4.3; Urge-Vorsatz et al. 2007: Section 1.4.4) are the focus of current research. Items 12, 13 and 14 in the questionnaire are used to measure these aspects (Table 3.8).

Table 3.8 **Measurement of Government Incentives**

Item 12	Energy efficiency laws and associated policies encourage the deployment of ESCO
Item 13	In terms of financing, taxation, information, and technological support. the government has provided a reasonable policy framework for using ESCO
Item 14	Under the current system, there are concrete incentives for utilising ESCO

Measurement of Preference for Energy Performance Contracting

As mentioned in Section 2.5 and Section 2.5.1, EPC appears to be an advantageous arrangement for the client. However, acceptance of EPC is not universal.

Furthermore, Ellis (2009), WEC (2008) and Urge-Vorsatz et al. (2007) have specifically pointed out that the acceptance of EPC in industrial sector is very low. Item 15 in the questionnaire is used to measure this general acceptance (Table 3.9).

Bertoldi et al. (2007: Sections 3.2.5 & 3.2.6) pointed out that client's concern about fairness of measurement and verification methods and high administration costs affect the preference of EPC. Ellis (2009: Section 3.2) and Vine (2005: Table 4) have also reported similar observations. Items 16 and 17 in the questionnaire measure these two factors (Table 3.9).

Table 3.9 **Measurement of Preference for EPC**

Item 15	In general, we prefer EPC
Item 16	The administrative costs associated with EPC are too high
Item 17	I have doubts on measurement and verification (M&V) methods and hence the trustworthiness of EPC
Item 18	The time horizon of EPC is usually too long

Since ESCO's compensation is based on actual energy saved, the time span of EPC is usually long (i.e. getting the compensation over a certain period of time) in order to ensure the solution provided by ESCO is reliable in long-run. However, according to Ellis (2009: Section 3.6), WEC (2008: 3.6.2); Urge-Vorsatz et al. (2007: Section 1.3.2), and Vine (2005: Table 4) the long time span will also affect the preference of EPC. Item 18 in the questionnaire is used to measure this factor (Table 3.9).

Measurement on Attitude to use ESCOs

Attitude to use ESCOs is measured by client's belief on what ESCOs should deliver. Examples are the improvement in energy efficiency, knowledge enhancement, and competitiveness. (Ellis 2009: Section 1.0 & 1.2). These are used as the first few measures in the questionnaire (Items 19, 20 & 21 in Table 3.10).

In addition, client's belief on how ESCO working processes should be will also reflect the attitude to use ESCO. Ellis (2009: Section 3.2), Bertoldi et al. (2007: Section 3.2.6) and Vine (2005: Table 4) pointed out that the complex and costly contracting and administration procedures affects the attitude to use ESCO. These are used as the next two measures in the questionnaire (Items 22 & 23 in Table 3.10)

Finally, Bertoldi and Rezessy (2005: Section 6) and Vine (2005: Table 4) identified perceived high technical and business risks as another factor reflecting client's attitude to use ESCO. This is used as the last measure in the questionnaire (Item 24 in Table 3.10)

Table 3.10 **Measurement of Attitude to use EPC**

Item 19	Using ESCO will significantly improve our energy efficiency
Item 20	Using ESCO will enhance our internal knowledge
Item 21	Using ESCO will improve our competitiveness
Item 22	Using ESCO is glitch-free
Item 23	Using ESCO is cost-effective
Item 24	Using ESCO will minimise project risk

Measurement on Subjective Norm to use ESCOs

Government influence on ESCO adoption is an extensively studied topic. Therefore, in addition to the conventional measures for subjective norm (e.g. management expectation, general behaviour of the industry and peer's influence.), government expectation is also added. Items 25 – 29 in the questionnaire represent these issues (Table 3.11).

Table 3.11 **Measurement of Subjective Norm to use ESCOs**

Item 25	Our management expect us to use ESCO
Item 26	The government expects my company to utilise ESCO
Item 27	Our industry generally prefers to use ESCO
Item 28	Relevant peers suggest that I should use ESCO
Item 29	Competitors generally use ESCO

Measurement on Intention to use ESCOs

Straightforward questions are used to measure Intention to use ESCOs (Table 3.12).

Table 3.12 **Measurement of Intention to use ESCOs**

Item 30	For critical projects, I will use ESCO
Item 31	I intend to use ESCO for critical projects
Item 32	For critical projects, I will select ESCO and work out contract scope
Item 33	I will deploy ESCO in order to achieve the prescribed results of critical projects

Measurement on Actual use of ESCOs

Straightforward questions are used to measure the Actual use of ESCOs (Table 3.13).

Table 3.13 **Measurement of Actual use of ESCOs**

Item 34	For critical projects, I have used ESCO
Item 35	I have evaluated and contracted ESCO for critical projects
Item 36	For critical projects, I have selected ESCO and worked out contract scope
Item 37	I have deployed ESCO in order to achieve the prescribed results of critical projects

In addition to the above items, descriptive questions about the respondent's age, gender, education, industrial sector, level in organization, and work experience are included in the questionnaire.

All of the items were presented in English and Chinese. The researcher is fluent in both languages and translated the English versions of the documents to Chinese. The Chinese versions of the items were then back-translated by a colleague of the researcher to ensure consistency in meaning. The colleague is native Chinese with over ten years of experience in the energy industry.

3.8 Ethical Considerations

There are three basic principles governing a researcher's ethical conduct: i) integrity, respect for persons, beneficence and justice; ii) consent; and iii) research merit and safety (NHMRC 2007). Based on these principles, Bouma (2000: pp.190-202) suggested the following five practical rules for researchers: i) must conduct the research with openness and accountability to community and participants; ii) must treat participants with dignity and respect; iii) must be supervised by qualified persons in order to ensure safety; iv) participants of the research must be able to make voluntary and informed consent; and v) potential benefit of the research must be substantially larger than its potential harm.

Based on Bouma's (2000) rules, the cover letter of the questionnaire package will clearly explain the following to participants: i) the purposes of the survey; ii) how the information collected will be used; iii) anonymity; iv) their right to not answer any question; and v) their right to withdraw from the survey at any time.

Human Research Ethics Committee has granted ethics clearance to this research (Approval Code: H-2009-0193).

3.9 Conclusion

In this chapter, the research question, paradigm, design and methodology have been discussed. It has been decided that a positivistic, quantitative, correlational and cross-sectional approach will be suitable for this research. Convenience sampling, based on the databases of AEP, and a Web-based survey will be used to collect data due to the exploratory nature of this research, the geographically dispersed population, and the time constraints faced by the researcher. The next chapter provides the results of the analyses that were conducted on the data.

Chapter 4 Data Analysis and Findings

4.1 Introduction

The results from the analyses that were conducted on the data are provided in this chapter. The data were analyzed using SPSS (Statistical Package for the Social Sciences) version 14.0. Of the 2,930 questionnaires that were sent out, 237 completed questionnaires were returned. The response rate is therefore 8.1%. All of these questionnaires were completed correctly and were therefore included in the analyses.

This chapter is organised as follows: Descriptive statistics of the demographic variables are presented in Section 4.2, details of the principal component analyses and the internal reliability analyses are presented in Section 4.3, the results from the hypothesis testing are provided in Section 4.4, and details of some exploratory analyses are provided in Section 4.5, and a summary of the major findings is presented in Section 4.6.

4.2 Demographic Variables

Descriptive statistics of the participants' demographic variables are shown in Table 4.1.

Table 4.1 **Descriptive statistics of the participants**

Gender	Frequency (%)
Male	212 (89.5)
Female	25 (10.5)
Total	237 (100)
Sector	
Iron and Steel	107 (45.1)
Chemicals and Petrochemicals	69 (29.1)
Non-metallic Minerals	24 (10.1)
Others	37 (15.6)
Total	237 (100)
Education	
Diploma	32 (13.5)
University	129 (54.4)
Grad School	76 (32.1)
Total	237 (100)
Job Level	
Senior Management	49 (20.7)
Management (Technical)	113 (47.7)
Management (Non-technical)	9 (3.8)
Non-management (Technical)	66 (27.8)
Total	237 (100)

Table 4.2 contains information about the age and years of industrial experience of the participants.

Table 4.2 **Age and work experience of participants**

	Mean (SD)
Age	40.5 years (9.5)
Work experience in current post	7.2 years (5.5)
Work experience in similar posts	11.5 years (6.2)
Work experience in the industry	13.9 years (7.3)

As shown in Tables 4.1 and 4.2, the majority of respondents are male. This is consistent with the perception that employees in heavy industries in China are predominantly malehigher. Over 45% of the respondents work in the Iron and Steel industry. This is likely due to the specific membership structure of the AEP, which is the organization assisting with the distribution of the questionnaire to its members. 86.5% of the respondents have attained University education or higher and 72.2% are in management positions. The average sector experience of the respondents is 13.9 years. The profile appears to be relevant for the purposes of this research.

4.3 Principal Component Analyses, Internal Reliability

"The primary purpose of factor analysis is to define the underlying structure among the variables in the analysis" (Hair et al. 2005: p. 104). To examine the structure of the measures used in this study, principal component analysis is used. Factor analysis and principal component analysis are data-reduction techniques that aim to 'reduce' the data by combining several correlated items into a single factor or component that represent the underlying latent variable being measured by the items (Coakes & Steed 2007).

Principal components analysis was conducted for each of the eight constructs separately in the conceptual model measure due to the sample size being insufficient to conduct an overall principal components analysis. A cut-off value of .50 was used to indicate a satisfactory loading.

A single-component solution was sought for the Capability scale because this construct is unidimensional. As shown in Table 4.3, a principal component analysis revealed a satisfactory single-component solution for the Capability scale. The average of the items shown in Table 4.3 was used as an overall score for Capability. Cronbach's Alpha for this scale is .95. A Cronbach's Alpha of .7 or more indicates satisfactory internal reliability (Nunnally 1978). The Capability scale therefore has satisfactory internal reliability.

Table 4.3 **Principal Component Analyses for CAPABILITY**[a]

	Component
CAPABILITY 1	.75
CAPABILITY 2	.90
CAPABILITY 3	.85
CAPABILITY 4	.93
CAPABILITY 5	.91
CAPABILITY 6	.90
CAPABILITY 7	.92

[a] R-square = .778

A single-component solution was sought for the Trust scale because this construct is unidimensional. As shown in Table 4.4, a principal component analysis revealed a satisfactory single-component solution for the Trust scale. The average of the items shown in Table 4.4 was used as an overall score for Trust. Cronbach's Alpha for this scale is .97.

Table 4.4 **Principal Component Analyses for TRUST**[a]

	Component
TRUST 1	.94
TRUST 2	.97
TRUST 3	.96
TRUST 4	.97

[a] R-square = .921

A single-component solution was sought for the Government Incentives scale because this construct is unidimensional. As shown in Table 4.5, a principal component analysis revealed a satisfactory single-component solution for the Government Incentives scale. The average of the items shown in Table 4.5 was used as an overall score for Government Incentives. Cronbach's Alpha for this scale is .80.

Table 4.5 **Principal Component Analyses for GOV_INC** [a]

	Component
GOVT_INC 1	.90
GOVT_INC 2	.85
GOVT_INC 3	.79

[a] R-square = .722

A single-component solution was sought for the Attitute scale because this construct is unidimensional. As shown in Table 4.6, a principal component analysis revealed a satisfactory single-component solution for the Attiude scale. The average of the items shown in Table 4.6 was used as an overall score for Attitude. Cronbach's Alpha for this scale is .95.

Table 4.6 **Principal Component Analyses for ATTITUDE** [a]

	Component
ATTITUDE 1	.93
ATTITUDE 2	.92
ATTITUDE 3	.91
ATTITUDE 4	.87
ATTITUDE 5	.91
ATTITUDE 6	.85

[a] R-square = .805

A single-component solution was sought for the Subjective Norm scale because this construct is unidimensional. As shown in Table 4.7, a principal component analysis revealed a satisfactory single-component solution for the Subjective Norm scale. The average of the items shown in Table 4.7 was used as an overall score for Subjective Norm. Cronbach's Alpha for this scale is .97.

Table 4.7 **Principal Component Analyses for SUBJ_NORM** [a]

	Component
SUBJ_NORM 1	.93
SUBJ_NORM 2	.95
SUBJ_NORM 3	.95
SUBJ_NORM 4	.94
SUBJ_NORM 5	.96

[a] R-square = .893

A single-component solution was sought for the Preference for EPC scale because this construct is unidimensional. As shown in Table 4.8, a principal component analysis revealed a satisfactory single-component solution for the Preference for EPC scale. The average of the items shown in Table 4.8 was used as an overall score for Preference for EPC. Cronbach's Alpha for this scale is .89.

Table 4.8 **Principal Component Analyses for EPC_PREF** [a]

	Component
EPC_PREF 1	.81
EPC_PREF 2	.88
EPC_PREF 3	.91
EPC_PREF 4	.90

[a] R-square = .767

A single-component solution was sought for the Intention scale because this construct is unidimensional. As shown in Table 4.9, a principal component analysis revealed a satisfactory single-component solution for the Intention scale. The average of the items shown in Table 4.9 was used as an overall score for Intention. Cronbach's Alpha for this scale is .99.

Table 4.9 **Principal Component Analyses for INTENTION** [a]

	Component
INTENTION 1	.99
INTENTION 2	.99
INTENTION 3	.97
INTENTION 4	.99

[a] R-square = .979

A single-component solution was sought for the Use ESCO scale because this construct is unidimensional. As shown in Table 4.10, a principal component analysis revealed a satisfactory single-component solution for the Use ESCO scale.

The average of the items shown in Table 4.10 was used as an overall score for Use ESCO. Cronbach's Alpha for this scale is .99.

Table 4.10 **Principal Component Analyses for USE_ESCO** [a]

	Component
USE_ESCO 1	.98
USE_ESCO 2	.98
USE_ESCO 3	.97
USE_ESCO 4	.98

[a] R-square = .962

As shown in Tables 4.4 to 4.10, principal component analyses revealed a satisfactory single-component solution for each scale. Cronbach's Alphas for all of these scales are higher than .7 and therefore indicate satisfactory internal reliability.

For all of the constructs, the average of the items in the relevant scale was used as the overall score for the construct in order to preserve the information contained in the Likert scale. The overall scores are used in all subsequent analyses. The correlations between the measured variables are presented in Table 4.11.

Table 4.11. **Correlation coefficients and Cronbach Alphas [a] for the measured variables**

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. AGE	--												
2. GENDER	-.20	--											
3. Yrs Job	.75	-.14	--										
4. Yrs Similar Job	.89	-.14	.84	--									
5. Yrs Industry	.91	-.18	.81	.93	--								
6. CAPACBILITY	.06	-.10	-.02	.06	.07	**.95**							
7. TRUST	.09	-.10	-.02	.07	.08	.88	**.97**						
8. GOVT_INC	.06	-.12	-.01	.06	.06	.85	.79	**.80**					
9. ATTITUDE	.06	-.11	.00	.07	.07	.95	.88	.91	**.95**				
10. SUBJ_NORM	.06	-.08	-.02	.07	.07	.94	.83	.87	.97	**.97**			
11. EPC_PREF	.08	-.10	.01	.06	.06	.91	.82	.89	.95	.95	**.89**		
12. INTENTION	.06	-.12	-.03	.05	.05	.91	.86	.89	.94	.91	.91	**.99**	
13. USE_ESCO	.05	-.08	-.02	.07	.05	.85	.81	.86	.89	.87	.87	.88	**.99**

$r > .12$, $p < .05$; $r > .16$, $p < .01$; $r > .20$, $p < .001$. [a] Cronbach Alphas are presented in bold on the diagonal

Construct validity refers to whether or not a scale or set of items measures the variable of interest (Hair 2005). Two widely accepted forms of validity that are related to construct validity are convergent validity and discriminant validity (Peter 1981). Convergent validity occurs when items within a scale are highly correlated (Cavana et al. 2001). The principal component analyses and the internal reliability analyses show that all of scales have acceptable convergent validity.

Discriminant validity can be claimed if constructs that should theoretically be uncorrelated are found to be uncorrelated. That is, the items used to measure the different constructs discriminate between the constructs by correlating with one but not the other constructs (Cavana et al. 2001). As shown in Table 4.11, the correlation coefficients between the constructs are relatively high. Therefore, careful examination of discriminant validity is necessary. There is satisfactory discriminant validity between two constructs when their correlation coefficient is less than 1 minus two times the standard error of the correlation coefficient (Bagozzi & Warshaw 1990). According to this criterion, Table 4.12 is constructed and all of the constructs have satisfactory discriminant validity despite the strong correlations between them.

Table 4.12 **Discriminant Validity Test**

Construct Pair	Correlation Coefficient (r)	Standard Error (SE)	1- 2*SE -r	Discriminant Validity
CAPABILITY - TRUST	.877	.021	0.081	Yes
CAPABILITY - GOVT_INC	.849	.030	0.091	Yes
CAPABILITY – EPC_PREF	.914	.029	0.028	Yes
CAPABILITY - ATTITUDE	.953	.015	0.017	Yes
CAPABILITY - SUBJ_NORM	.944	.016	0.024	Yes
CAPABILITY - INTENTION	.908	.017	0.058	Yes
CAPABILITY – USE_ESCO	.849	.018	0.115	Yes
TRUST - GOVT_INC	.793	.051	0.105	Yes
TRUST - EPC_PREF	.818	.060	0.062	Yes
TRUST - ATTITUDE	.879	.036	0.049	Yes
TRUST - SUBJ_NORM	.825	.041	0.093	Yes
TRUST - INTENTION	.860	.031	0.078	Yes
TRUST - USE_ESCO	.805	.030	0.135	Yes
GOVT_INC - EPC_PREF	.889	.037	0.037	Yes
GOVT_INC - ATTITUDE	.913	.024	0.039	Yes
GOVT_INC - SUBJ_NORM	.868	.028	0.076	Yes
GOVT_INC - INTENTION	.886	.022	0.070	Yes
GOVT_INC - USE_ESCO	.858	.020	0.102	Yes
EPC_PREF - ATTITUDE	.951	.015	0.019	Yes
EPC_PREF - SUBJ_NORM	.946	.015	0.024	Yes
EPC_PREF - INTENTION	.910	.016	0.058	Yes
EPC_PREF - USE_ESCO	.865	.016	0.103	Yes
ATTITUDE - SUBJ_NORM	.966	.016	0.002	Yes
ATTITUDE - INTENTION	.939	.018	0.025	Yes
ATTITUDE - USE_ESCO	.893	.019	0.069	Yes
SUBJ_NORM - INTENTION	.905	.023	0.049	Yes
SUBJ_NORM - USE_ESCO	.866	.022	0.090	Yes
INTENTION - USE_ESCO	.884	.025	0.066	Yes

4.4 Hypothesis Testing

As discussed in Chapter 2, the ESCO TRA model has been proposed and is depicted in Figure 4.1.

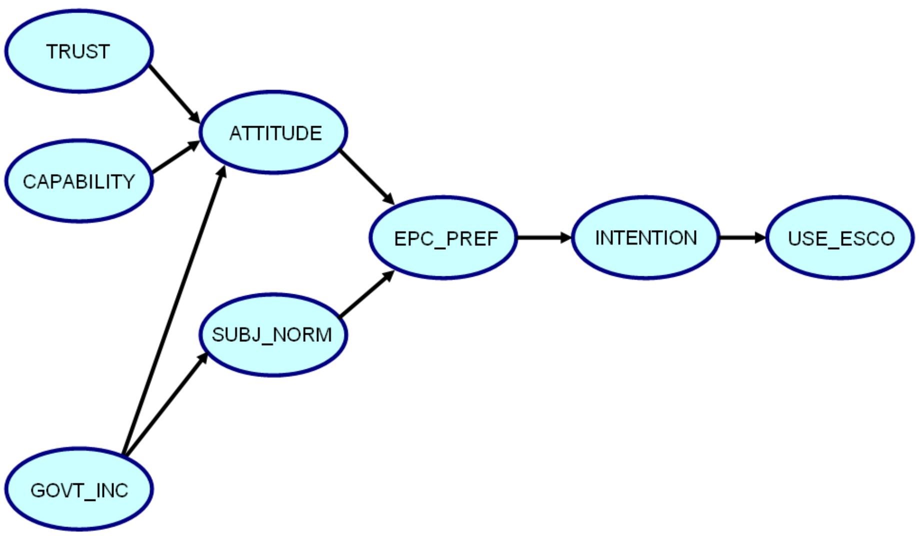


Figure 4.1 **The ESCO TRA Model**

Judd and Kenny's (1981) method for testing a mediation effect is used. According to Baron and Kenny (1986), a mediation effect exists when the following three conditions are met:

Condition 1:

The independent variable significantly predicts the dependent variable;

Condition 2:

The independent variable significantly predicts the mediator variable; and

Condition 3:

When the dependent variable is regressed on both the mediator and the independent variable, the mediator significantly predicts the dependent variable while the predictive utility of the independent variable is reduced. If both the mediator and the independent variable are significant in this regression, the mediation is partial. If the mediator is significant and the independent variable is becoming significant in this regression, then there is full mediation.

Results for Hypothesis 1

The relationship between Trust in ESCO and Preference for EPC is mediated by Attitude to use ESCOs

Trust in ESCO significantly predicts Preference for EPC ($r = .82$, $p < .001$: Condition 1 met) and Attitude to use ESCOs ($r = .88$, $p < .001$: Condition 2 met). Hypothesis 1a is therefore supported. Attitude to use ESCOs has a significant positive correlation with Preference for EPC ($r = .95$, $p < .001$). Hypothesis 1b is therefore supported. Preference for EPC was then regressed on both Trust in ESCO and Attitude to use ESCOs ($r = -.08$, $p > .05$ and $r = 1.02$, $p < .001$, respectively):

Condition 3 met. Hypothesis 1c is therefore supported as Attitude to use ESCOs fully mediates the relationship between Trust in ESCO and Preference for EPC.

Results for Hypothesis 2

The relationship between Perceptions on ESCO Capability and Preference for EPC is mediated by Attitude to use ESCOs

Perceptions on ESCO Capability significantly predicts Preference for EPC ($r = .91$, $p < .001$: Condition 1 met) and Attitude to use ESCOs ($r = .95$, $p < .001$: Condition 2 met). Hypothesis 2a is therefore supported. Attitude to use ESCOs has a significant positive correlation with Preference for EPC ($r = .95$, $p < .001$). Hypothesis 1b is therefore supported. Preference for EPC was then regressed on both Perceptions on ESCO Capability and Attitude to use ESCOs ($r = .08$, $p > .05$ and $r = 87$, $p < .001$, respectively): Condition 3 met. Hypothesis 2c is therefore supported as Attitude to use ESCOs fully mediates the relationship between Perceptions on ESCO Capability and Preference for EPC.

Results for Hypothesis 3

The relationship between Government Incentives and Preference for EPC is mediated by Subjective Norm to use ESCOs

Government Incentives significantly predicts Preference for EPC ($r = .89$, $p < .001$: Condition 1 met) and Attitude to use ESCOs ($r = .91$, $p < .001$: Condition 2 met). Hypothesis 3a is therefore supported. Attitude to use ESCOs has a significant positive correlation with Preference for EPC ($r = .95$, $p < .001$). Hypothesis 1b is therefore supported. Preference for EPC was then regressed on both Government Incentives and Attitude to use ESCOs ($r = .13$, $p \leq .01$ and $r = .84$, $p < .001$, respectively): Condition 3 met. Hypothesis 3c is therefore supported as Attitude to use ESCOs partially mediates the relationship between Government Incentives and Preference for EPC.

Results for Hypothesis 4

The relationship between Government Incentives and Preference for EPC is mediated by Subjective Norm to use ESCOs

Government Incentives significantly predicts Preference for EPC ($r = .89$, $p < .001$: Condition 1 met) and SUBJ_ NORM ($r = .95$, $p < .001$: Condition 2 met). Hypothesis 4a is therefore supported. Subjective Norm to use ESCOs has a significant positive correlation with Preference for EPC ($r = .95$, $p < .001$). Hypothesis 4b is therefore supported. Preference for EPC was then regressed on both Government Incentives and Subjective Norm to use ESCOs ($r = .28$, $p < .001$ and $r = .71$, $p < .001$, respectively): Condition 3 met. Hypothesis 4c is therefore supported as Subjective Norm to use ESCOs partially mediates the relationship between Government Incentives and Preference for EPC.

Results for Hypothesis 5

The relationship between Attitude to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC

Attitude to use ESCOs significantly predicts Intention to use ESCOs ($r = .94$, $p < .001$: Condition 1 met) and Preference for EPC ($r = .95$, $p < .001$: Condition 2 met). Hypothesis 1b is therefore supported. Preference for EPC has a significant positive correlation with Intention to use ESCOs ($r = .91$, $p < .001$). Hypothesis 5b is therefore supported. Intention to use ESCOs was then regressed on both Attitude to use ESCOs and Preference for EPC ($r = .76$, $p <.001$ and $r = .19$, $p \leq .01$, respectively): Condition 3 met. Hypothesis 5c is therefore supported as Preference for EPC partially mediates the relationship between Attitude to use ESCOs and Intention to use ESCOs.

Results for Hypothesis 6

The relationship between Subjective Norm to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC

Subjective Norm to use ESCOs significantly predicts Intention to use ESCOs ($r = .91$, $p < .001$: Condition 1 met) and Preference for EPC ($r = .95$, $p < .001$: Condition 2 met). Hypothesis 4b is therefore supported. Preference for EPC has a significant positive correlation with Intention to use ESCOs ($r = .91$, $p < .001$). Hypothesis 5b is therefore supported. Intention to use ESCOs was then regressed on both Subjective Norm to use ESCOs and Preference for EPC ($r = .42$, $p <.001$ and $r = .51$, $p <.001$, respectively): Condition 3 met. Hypothesis 6c is therefore supported as Preference for EPC partially mediates the relationship between Subjective Norm to use ESCOs and Intention to use ESCOs.

Results for Hypothesis 7

The relationship between Preference for EPC and Actual use of ESCOs is mediated by Intention to use ESCOs

Preference for EPC significantly predicts Actual use of ESCOs ($r = .87$, $p < .001$: Condition 1 met) and Intention to use ESCOs ($r = .91$, $p < .001$: Condition 2 met). Hypothesis 5b is therefore supported. Intention to use ESCOs has a significant positive correlation with Actual use of ESCOs ($r = .88$, $p < .001$). Hypothesis 7b is therefore supported. Actual use of ESCOs was then regressed on both Preference for EPC and Intention to use ESCOs ($r = .35$, $p <.001$ and $r = .56$, $p <.001$, respectively): Condition 3 met. Hypothesis 7c is therefore supported as Intention to use ESCOs partially mediates the relationship between Preference for EPC and Actual use of ESCOs.

In summary, the findings support the relationships proposed in the ESCO TRA model.

4.5 Exploratory Analyses

To explore other possible relationships among the constructs that were not considered at the outset, multiple regression analyses were conducted to examine which of the different constructs are the best predictors of other constructs in the conceptual framework. Four such analyses were conducted.

Multiple Regression on Attitude to use ESCOs

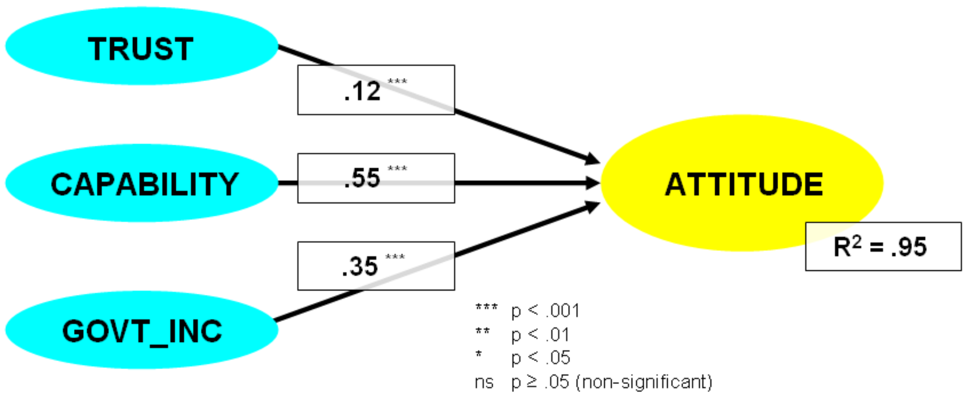


Figure 4.2 **Multiple Regression on Attitude to use ESCOs**

The findings shown in Figure 4.2 are consistent with the ESCO TRA model in that Trust in ESCO, Perceptions on ESCO Capability and Government Incentives significantly predict Attitude to use ESCOs.

Based on the standardized regression coefficients calculated, Perceptions on ESCO Capability (0.55) has the highest predictive power for Attitude to use ESCOs, followed respectively by Government Incentives (0.35) and Trust in ESCO (0.12).

Multiple Regression on Subject Norm to use ESCOs

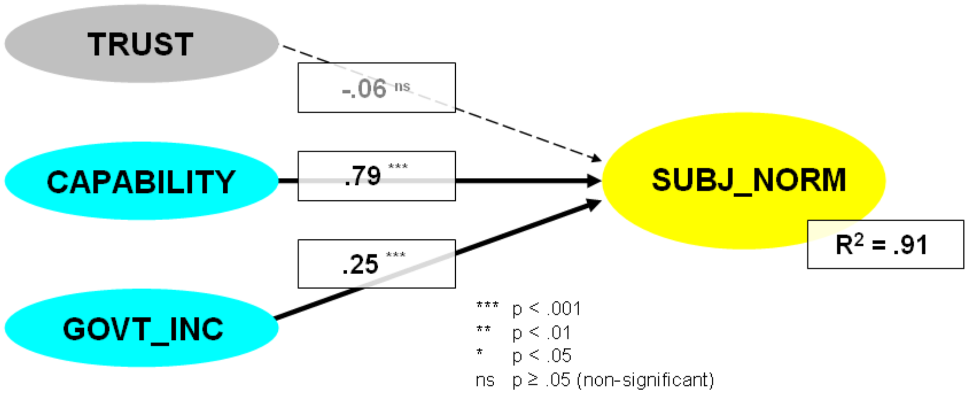


Figure 4.3 **Multiple Regression on Subjective Norm to use ESCOs**

The findings shown in Figure 4.3 are consistent with the ESCO TRA model in that Government Incentives significantly predicts Subjective Norm to use ESCOs. In addition, Perceptions on ESCO Capability also significantly predicts Subjective Norm to use ESCOs. Predictive power of Perceptions on ESCO Capability, as represented by the standardized regression coefficient, is considerably higher (0.79) than Government Incentives (0.25).

Multiple Regression on EPC Preference

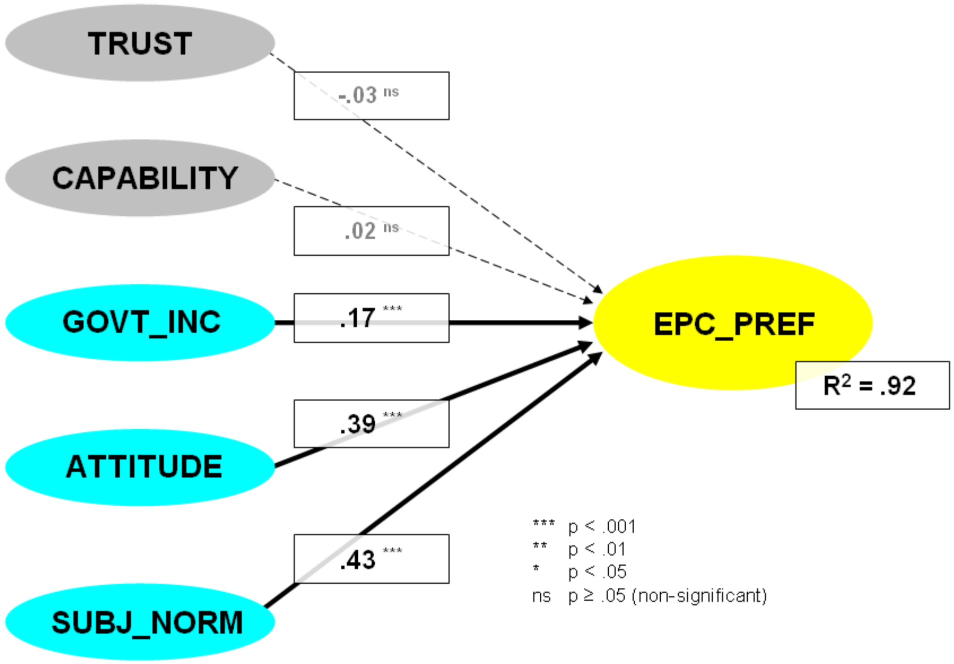


Figure 4.4 **Multiple Regression on Preference for EPC**

As shown in Figure 4.4, Attitude to use ESCOs and Subjective Norm to use ESCOs significantly predict Preference for EPC, which is consistent with the ESCO TRA model. Trust in ESCO and Perceptions on ESCO Capability are non-significant predictors, which is consistent with the results for Hypothesis 1c and Hypothesis 2c where these two constructs relate to Preference for EPC via full mediation through Attitude to use ESCOs. An additional observation is that Government Incentives also significantly predicts Preference for EPC although the degree of influence is lower.

Based on the standardized regression coefficients, Subjective Norm to use ESCOs (0.43) has the highest predictive power for Preference for EPC, followed by Attitude to use ESCOs (0.39) and Government Incentives (0.17).

Multiple Regression on Intention to use ESCOs

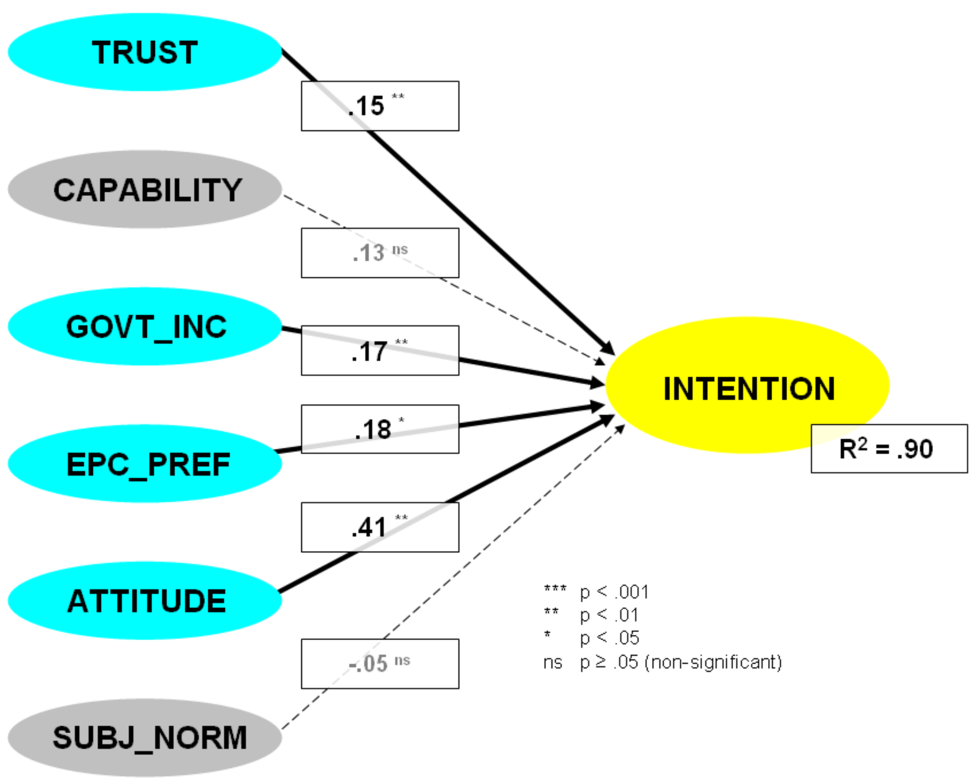


Figure 4.5 **Multiple Regression on Intention to use ESCOs**

As shown in Figure 4.5, Preference for EPC significantly predicts Intention to use ESCOs, which is consistent with the ESCO TRA model. In contrast to the standard TRA model, Subjective Norm to use ESCOs in this model does not directly predict Intention to use ESCOs. Attitude to use ESCOs, however, remains a significant predictor of Intention to use ESCOs and is actually the strongest predictor. It is noticeable that Trust in ESCO and Government Incentives also significantly predict Intention to use ESCOs although their levels of influence are considerably lower than that of Attitude to use ESCOs.

Based on the standardized regression coefficients calculated, Attitude to use ESCOs (0.41) has the highest predictive power for Intention to use ESCOs, followed respectively by Preference for EPC (0.18), Government Incentives (0.17) and Trust in ESCO (0.15).

Multiple Regression on Actual use of ESCOs

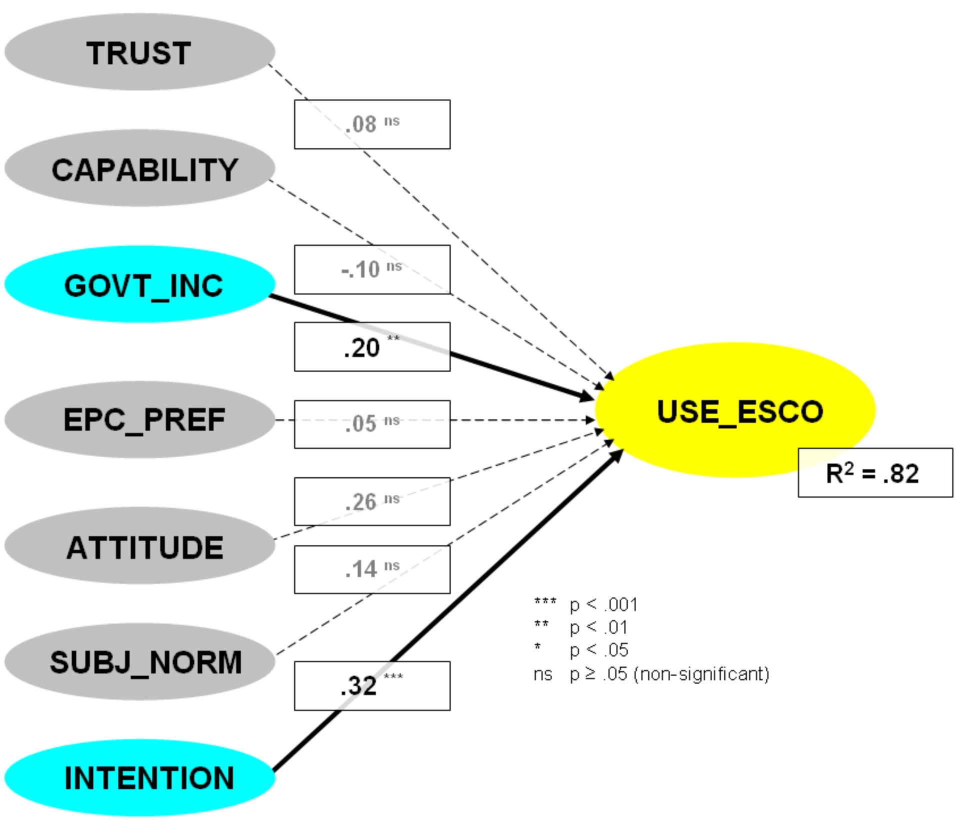


Figure 4.6 **Multiple Regression on Actual use of ESCOs**

As shown in Figure 4.5, Intention to use ESCOs significantly predicts Actual use of ESCOs, which is consistent with the ESCO TRA model as well as the standard TRA model. Additionally, Government Incentives also significantly predicts Actual use of ESCOs. The predictive power of Intention to use ESCOs, as represented by the standardized regression coefficient, is higher (0.32) than Government Incentives (0.20).

4.6 Summary

Table 4.13 contains a summary of the hypothesis testing.

Table 4.13 **Findings for the ESCO TRA model**

Hypothesis	Supported
Hypothesis 1a: Trust in ESCO and Attitude to use ESCOs are positively correlated.	YES
Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated.	YES
Hypothesis 1c: The relationship between Trust in ESCO and Preference for EPC is mediated by Attitude to use ESCOs.	YES
Hypothesis 2a: Perceptions on ESCO Capability and Attitude to use ESCOs are positively correlated.	YES
Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated.	YES
Hypothesis 2c: The relationship between Perceptions on ESCO Capability and Preference for EPC is mediated by Attitude to use ESCOs.	YES
Hypothesis 3a: Government Incentives and Attitude to use ESCOs are positively correlated.	YES
Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated.	YES
Hypothesis 3c: The relationship between Government Incentives and Preference for EPC is mediated by Attitude to use ESCOs.	YES
Hypothesis 4a: Government Incentives and Subjective Norm to use ESCOs are positively correlated.	YES
Hypothesis 4b: Subjective Norm to use ESCOs and Preference for EPC are positively correlated.	YES
Hypothesis 4c: The relationship between Government Incentives and Preference for EPC is mediated by Subjective Norm to use ESCOs.	YES
Hypothesis 1b: Attitude to use ESCOs and Preference for EPC are positively correlated.	YES
Hypothesis 5b: Preference for EPC and Intention to use ESCOs are positively correlated.	YES
Hypothesis 5c: The relationship between Attitude to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC.	YES
Hypothesis 4b: Subjective Norm to use ESCOs and Preference for EPC are positively correlated.	YES
Hypothesis 5b: Preference for EPC and Intention to use ESCOs are positively correlated.	YES
Hypothesis 6c: The relationship between Subjective Norm to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC.	YES
Hypothesis 5b: Preference for EPC and Intention to use ESCOs are positively correlated.	YES
Hypothesis 7b: Intention to use ESCOs and Actual use of ESCOs are positively correlated.	YES
Hypothesis 7c: The relationship between Preference for EPC and Actual use of ESCOs is mediated by Intention to use ESCOs.	YES

The results of the exploratory analyses are consistent with the proposed model. In addition, a few correlational relationships that were not considered in the proposed model were found. Most noticeably, Attitude to use ESCOs was found to be a stronger predictor for Intention to use ESCOs than was Preference for EPC. In other words, Preference for EPC only partially mediates the relationship between Attitude to use ESCOs and Intention to use ESCOs, which is consistent with the result for Hypothesis 5c). Although this does not contradicting the traditional view that EPC is important, our findings offer a wider perspective to understand ESCO adoption. It is also observed that Government Incentives is significantly predicting Preference for EPC, Intention to use ESCOs and Actual use of ESCOs in the corresponding analyses, which is consistent with the traditional view regarding the importance of regulations and incentives. Another important observation is that Trust in ESCO significantly predicts Intention to use ESCOs. Finally, Perceptions of ESCO Capability significantly predicts Subjective Norm to use ESCOs.

In the next chapter, we will discuss these findings and their implications, as well as the limitations of this research and directions for future studies.

Chapter 5 Findings and Conclusions

5.1 Introduction

The rapid growth of the heavy industrial sector in China has presented both opportunities and challenges to the country. On one hand, this growing sector has significantly contributed to China's GDP growth. On the other hand, the energy-intensive nature of heavy industries has led to unprecedented problems in resource sustainability, pollution, climate change, and many others.

Encouraging firms in Chinese heavy industries to use ESCOs to improve their energy efficiency has been a high-priority policy of the Chinese Government in the last few years. While there are some successful cases, the level of adoption of ESCOs in the sector remains generally low.

Although numerous studies have been conducted on tangible factors that influence the adoption of ESCOs, there are only a few comprehensive investigations into intangible factors. Government policies and incentives, for example, are discussed by many prior studies. However, only very limited and non-specific studies about clients' potential concerns about ESCOs can be found.

This research is a pioneering attempt to use the TRA framework to provide a quantitative investigation into how tangible factors such as government incentives and intangible factors such as the perceived capability of and trust in ESCOs are related to the adoption of ESCO services by firms in Chinese heavy industries.

As discussed in Section 2.5.1, a special conceptual development in this research is an expanded view of EPC, which is reflected by the construct Preference for EPC in the proposed model. From an investing-for-energy-efficiency perspective, EPC, which is commonly used in the business models of ESCOs, would, in principle, protect the client from the majority of any potential losses due to unsuccessful project design and/or implementation.

Most prior analyses have assumed that policies and incentives are key drivers of a preference for EPC and therefore for enhancing ESCO adoption. However, whilst it is quite obvious that the client's view about the contracting partner (i.e. the ESCO) will likely affect preference for EPC, very limited investigations have been conducted so far. To investigate the relationships, connections among the relevant constructs have been proposed in the model (reproduced as Figure 5.1) and have been tested under a positivistic, quantitative, correlational and cross-sectional framework.

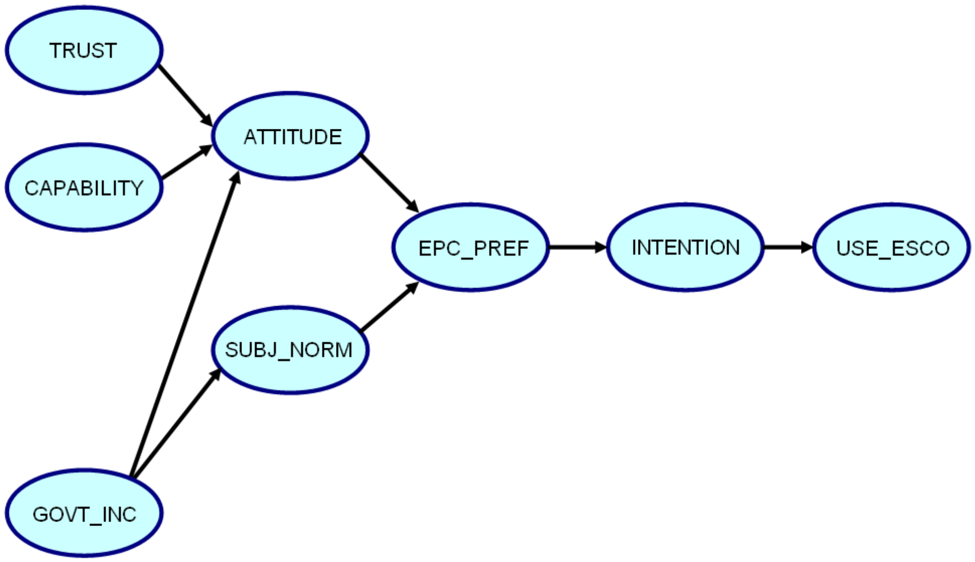


Figure5.1 **The ESCO TRA model**

5.2 Major Findings

5.2.1 Hypotheses

The relationship between Attitude to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC. This is a unique structure in our model for reflecting the traditional view that EPC is a key driver for ESCO adoption. Instead of using Attitude to use ESCOs as a direct predictor for Intention to use ESCOs (as in standard TRA model), Preference for EPC is inserted as a mediator in order to illustrate its direct effect on intention. However, although Preference for EPC is a significant predictor of Intention to use ESCOs and mediates the relationship between Attitude to use ESCOs and Intention to use ESCOs, the direct effect of Attitude to use ESCOs on Intention to use ESCOs is strong. This finding leads to a reflection about the role and importance of Preference for EPC in ESCO adoption, which is discussed in Section 5.2.2.

The relationship between Subjective Norm to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC. Similar to the case with Attitude to use ESCOs, Preference for EPC mediates the relationship between Subjective Norm to use ESCOs and Intention to use ESCOs.

Finally, the model resumes to the standard TRA structure that Intention to use ESCOs predicts Actual use of ESCOs. The relationship between Preference for EPC and Actual use of ESCOs is mediated by Intention to use ESCOs, which is, again, consistent with the view that Preference for EPC is a significant predictor of ESCO adoption.

5.2.2 Exploratory Analyses

Exploratory analyses revealed some potential relationships among the variables that were not considered when developing the hypotheses. These relationships are summarized by the purple dotted lines in Figure 5.2 and are examined below.

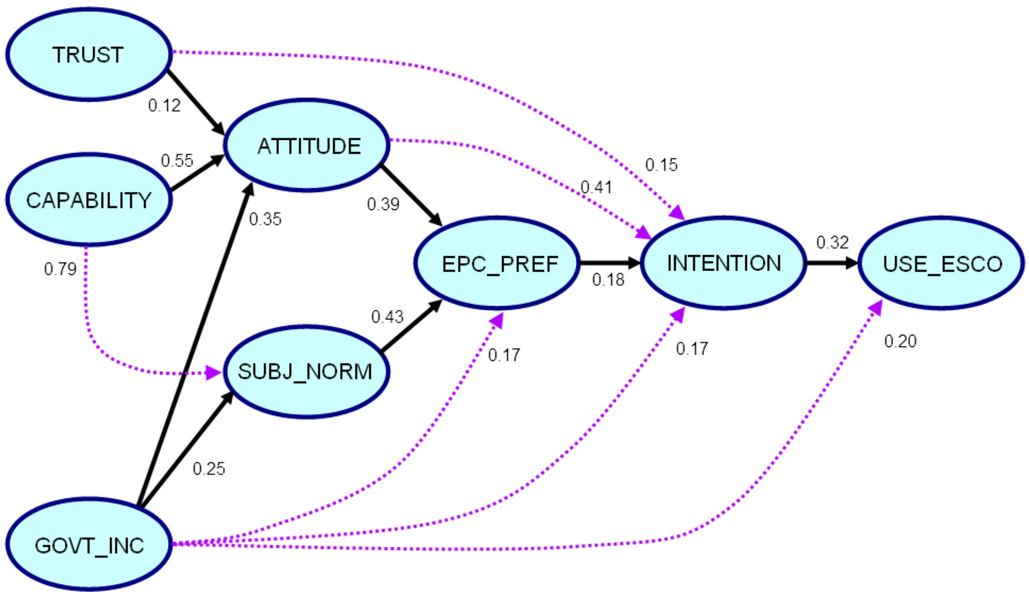


Figure5.2 **Results of Exploratory Analyses**

(a) The direct effect of Attitude to use ESCOs on Intention to use ESCOs remains very strong

In our proposed model, the relationship between Attitude to use ESCOs and Intention to use ESCOs is mediated by Preference for EPC. The exploratory analyses, however, found that Attitude to use ESCOs is also a strong predictor for Intention to use ESCOs. Although this is not surprising since attitude does predict intention in the standard TRA model, there is a deeper implication: since we have, based on the traditional view of the criticalness of EPC (Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; Vine 2005; Sorrell 2007; Bertoldi & Rezessy 2005; BASE 2006; Dan 2009; Shen 2008; Tang 2005), inserted Preference for EPC as a mediator between Attitude to use ESCOs and Intention to use ESCOs, the importance of this observation is that the effect of Attitude to use ESCOs in our model remains very strong. By comparing the standardized regression coefficients, the effect of Attitude to use ESCOs on Intention to use ESCOs is stronger than that of Preference for EPC.

While this observation does not contradict the traditional view that Preference for EPC is an important direct driver of ESCO adoption, the finding leads to the need for a deeper review about the current EPC-centric approach of ESCO promotion. Details are discussed in Section 5.3.

(b) Government Incentives predicts Other Variables

It has been found that Government Incentives predict not only Attitude to use ESCOs and Subjective Norm to use ESCOs, but also directly predicts Preference for EPC, Intention to use ESCOs, and the use of ESCOs. On one hand, this observation is consistent with the traditional view that Government Incentives are extremely crucial at any stage of energy efficiency movement (BASE 2006; Shen 2008; Tang 2005). On the other hand, activities being strongly driven by government policies instead of natural demand and supply may also reflect the immaturity of the Chinese ESCO sector in providing services to heavy industries. This may contribute to some biased views among participants and ultimately common method variance, which is discussed in Section 5.5.

(c) Trust in ESCOs predicts Intention to use ESCOs

Trust not only has an indirect relationship with Intention to use ESCOs via the Attitude to use ESCOs and Preference for EPC, but also directly predicts Intention to use ESCOs. As shown by the standardized regression coefficients in Figure 5.2, the effect of Trust in ESCOs on Intention to use ESCOs is comparable to Preference for EPC. This observation supports our view about the importance of Trust in ESCOs on the actual use of ESCOs.

(d) Perceptions of ESCO Capability predicts Subjective Norm to use ESCOs

This observation suggests that if a client believes ESCOs are capable, the client will also tend to believe relevant parties (i.e. management and government) would expect them to use ESCOs. In fact, this influence, as reflected by a standardized regression coefficient, is very strong. Again, this is logical because if one thinks ESCOs are capable (i.e. more capable than his or her internal resources), one would probably also expect his or her management wants him or her to use ESCOs. This offers the insight that enhancing ESCOs' capabilities and ensuring correct understanding about their capabilities is important for improving the Subjective Norm on use ESCOs.

In summary, we have quantitatively compared the effects of the three fundamental independent variables (i.e. Perceptions of ESCO Capability, Trust in ESCOs and Government Incentives) on Preference for EPC and Intention to use ESCOs. Also, the effect of Preference for EPC on Intention to use ESCOs is compared to the effects of these independent variables. The comparisons are summarized as follow:

(i) Perceptions of ESCO Capability (mediates via both Attitude to use ESCOs and Subjective Norm to use ESCOs) and Trust in ESCOs (mediates via Attitude to use ESCOs) affects Preference for EPC at a degree comparable to Government Incentives;

(ii) Preference for EPC is an important factor that affects Intention to use ESCOs, but the effect of Perceptions of ESCO Capability (mediated via Attitude to use ESCOs, which directly affects Intention to use ESCOs) is comparably strong;

(iii) Trust in ESCOs directly affects Intention to use ESCOs at a degree comparable to Preference for EPC.

These findings have added to the current understanding about regulations and incentives, as well as the role and importance of EPC in ESCO adoption. Implications of the findings are discussed in Sections 5.3 and 5.4.

As a remark, some researchers have argued about the applicability of standardized regression coefficients for comparing the influence of variables particularly when correlations among variables are high (Howell 2010). According to Howell, the regression coefficients could possibly be very unstable under such situation. An example was given to illustrate that two rather different regression equations, and hence two different conclusions about which variables are more important, will be resulted based on two sets of data from the same source (Howell 2010: Section 15.12). Since our discussions above are also based on comparing standardized regression coefficients, we have further validated our arguments by randomly extracting two reduced models (N = 200) from the original model (N = 237) and computed the regression coefficients to tested their stabilities (Figure 5.3).

As shown in Figure 5.3, the coefficients are relatively stable in our case. Although some variations are observed, the magnitudes of the changes are not significant enough to alter our interpretations.

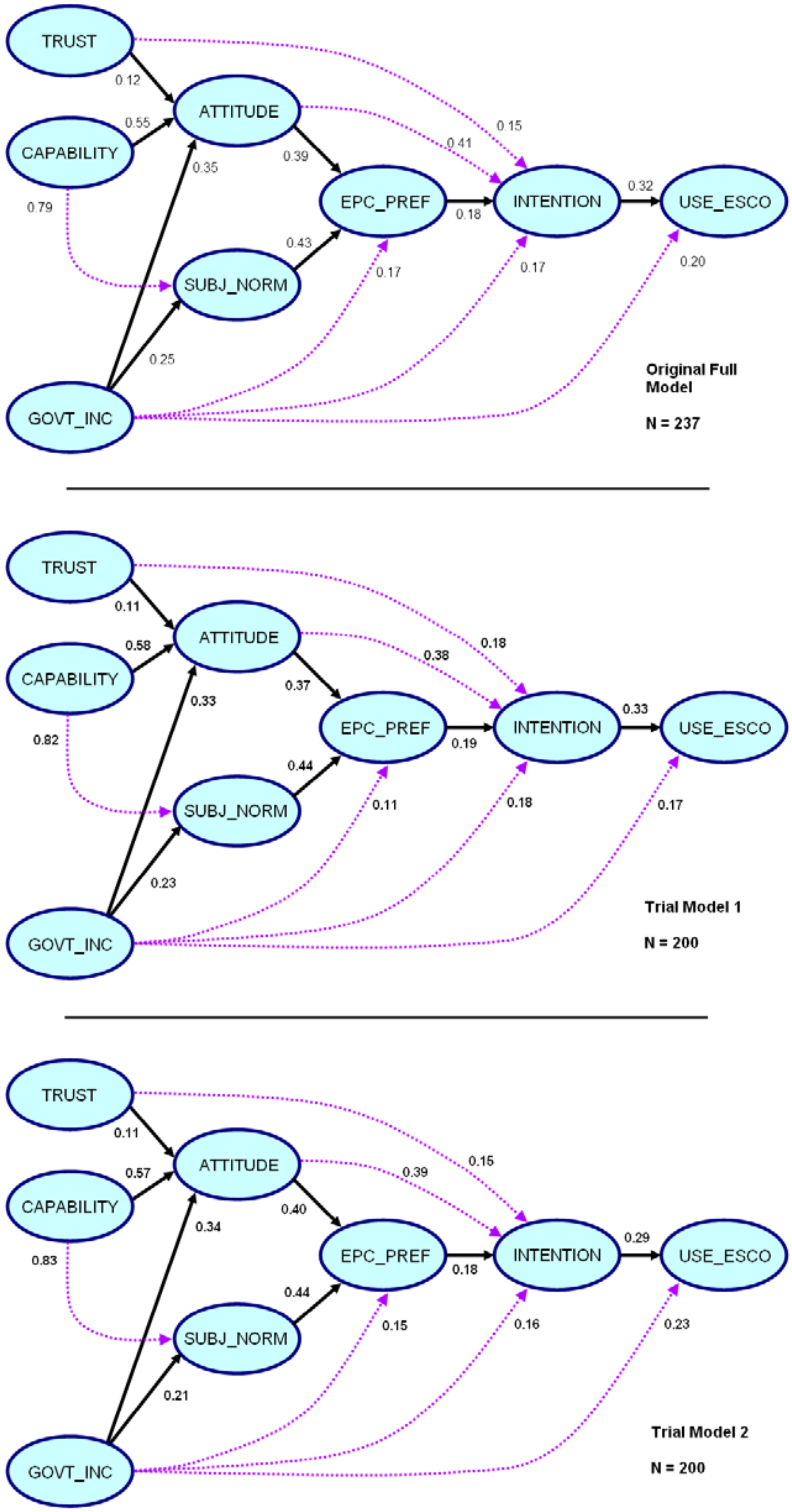


Figure 5.3 **Comparison of Full Model and Reduced Models**

5.3 Implications of the Findings for Practice

The first practical implication of this research is that our findings have led to an enhanced understanding the role and importance of EPC, and hence providing insights for policy makers regarding how to encourage the industrial sector to use ESCOs.

The traditional view believes Government Incentives can improve Preference for EPC. As discussed in Section 5.2.2, the view is vital but the effect of Perceptions of ESCO Capability on Preference for EPC is comparable to Government Incentives. To effectively increase Preference for EPC, efforts to ensure the actual ability of ESCOs and enhance the heavy industrial sector’s understanding about ESCOs are equally important.

Another even more significant implication is derived from the finding that the effect of Attitude to use ESCOs on Intention to use ESCOs is stronger than the effect of Preference for EPC. This would mean that the current EPC-centric policies may not be most effective because Attitude to use ESCOs has not been sufficiently addressed. Examining the standardized regression coefficients in Figure 5.2, Attitude to use ESCOs is strongly influenced by Perceptions of ESCO Capability, followed by Government Incentives and Trust in ESCOs. To increase the Intention to use ESCOs, ensuring the actual ability of ESCOs and enhancing the heavy industrial sector's understanding about ESCOs' capability will be comparably important to efforts for enhancing Preference for EPC.

The significance of Trust in ESCOs also needs to be taken into careful consideration. As indicated by the standardized regression coefficients in Figure 5.2, Trust in ESCOs directly affects Intention to use ESCOs at about the same magnitude as does Preference for EPC. The current EPC-centric policies have paid little attention to the trust aspect and should be re-examined.

As far as we have identified, our results are the first research findings that show the relative importance of factors affecting ESCO adoption in a quantitative manner. Some prior studies (Ellis 2009; WEC 2008; Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; Vine 2005; Fey 2000) have discussed how factors such as trust, concerns about confidentiality and ESCOs' capability may influence ESCO adoption in a qualitative way. However, none of them have quantifiable results that can be used to compare with the effect of incentives and regulations. The traditional belief of incentives and regulations are predominant in increasing Preference for EPC and also adoption of ESCOs continues to prevail.

Based on these findings, policy makers should, in addition to Government Incentives, pay attention to Perceptions of ESCO Capability and Trust in ESCOs when coming up with policies that aim to improve Preference for EPC and Intention to use ESCOs. Currently, the majority of the polices issued by the Chinese Government primarily concentrate on tangible financial incentives and regulations

(SC_PRC 2010; MIIT 2012; Zhang & Wu 2011; Zhou, Levine & Price 2010; Zhou 2007). Little concrete measures for enhancing Perceptions of ESCO Capability and Trust in ESCOs have been introduced. To improve these two aspects, we propose to examine accreditation and collective guarantees for the ESCO industry.

(a) Accreditation Scheme

For enhancing Perceptions of ESCO Capability and Trust in ESCOs, some researchers (Vine 2005; Urge-Vorsatz et al. 2007; Ellis 2009) have suggested establishing an accreditation system for ESCOs. These suggestions, however, do not seem to have attracted sufficient attention from governments so far. As of today, accreditation in most countries is done via acquiring membership of organizations formed by the ESCOs themselves. These organizations are self-regulated in nature and there is no mandatory requirement for individual ESCOs to join these organizations. Although most of these organizations have their practicing guidelines for their members, this voluntary, self-regulated system would not properly answer clients' questions about Perceptions of ESCO Capability and Trust in ESCOs.

There could be multiple reasons for governmental organizations not to be involved directly in ESCO accreditation. For example, over-intervention is a sensitive topic and will be avoided in many cases. However, it should be aware that many governments are actively providing financial and tax incentives for EPC in order to enhance the Preference for EPC. Therefore, we believe one of the important reasons that the governments are relatively inert in ESCO accreditation is the availability of quantifiable data to illustrate the relationship among Preference for EPC, Perceptions of ESCO Capability and Trust in ESCOs. This research fills the gap by quantitatively relating the variables, and thereby demonstrates that improving Perceptions of ESCO Capability and Trust in ESCOs will promote the Chinese Government's mission of increasing the Preference for EPC. Based on our research findings, we would recommend that the Government should take a more active role in facilitating the accreditation scheme.

(b) Collective Guarantee Scheme

As far as we can identify, a sector-based collective guarantee scheme has not been formally discussed in the ESCO industry. However, this approach has been used in the tourism industry to protect customers. Hong Kong, for example, imposes a 0.3% stamp duty on the sales of licensed travel agencies. This duty is managed under a specific fund and will be used to compensate customers of any licensed travel agency who is running into problems.

For clients to develop a higher trust level, ESCOs are, in addition to technical competence, expected to take up more liabilities to warranty project success. To a certain degree, the EPC mechanism is protecting the client as ESCOs, in most cases, have bared the investment risk. However, unsuccessful projects will still interrupt production and may even lead to adverse longer term consequences. Due to the inevitable technical uncertainties in energy-efficiency improvement projects, it is difficult for individual ESCOs to commit to extensive liabilities. In this case, a sector-based collective guarantee scheme appears to be helpful in protecting clients and making them more confident to deploy ESCOs. By contributing a fraction of the ESCOs' fees to a centralized fund, clients will be provided with the financial resources to deal with unexpected problems in case of unsuccessful project implementation. In fact, this scheme is not only protecting the clients but also the ESCOs from excessive liabilities.

Another possible advantage of this proposal is making the accreditation scheme easier to implement. By restricting the collective guarantee scheme to accredited ESCOs only, practitioners will likely have a stronger motivation to seek accreditation.

Certainly, this sector-based collective guarantee scheme is a very preliminary idea and many practical problems such as administration, compensation mechanisms, and verification. have to be investigated in detail in order to determine its feasibility. However, because of its significant potential advantages, we would recommend the Government to further examine such a scheme.

5.4 Implications of the Findings for Theory

Our findings have theoretical implications for both ESCO business models and for TRA model application.

(a) For ESCO Business Dynamic

In ESCO business today, regulations and incentives are believed to be very critical for ESCO adoption and EPC is believed to be a very important driver of ESCO adoption. Although some researchers have discussed the importance of less tangible factors such as trust in and perceived capability of ESCOs (Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; BASE 2006; Vine 2005), those investigations are primarily qualitative in nature, making comparison of the relative importance of the variables extremely difficult. Up to the current moment, efforts for quantifying the relationships among variables are rare.

Due to the few quantitative analyses that are available, the importance of intangible factors has not been investigated thoroughly. This research has used a quantitative approach to explore those relationships under a proposed model (Figure 5.1). As discussed in Section 5.2.2, it has been illustrated that the influence of Perceptions of ESCO Capability and Trust in ESCO on Preference for EPC are comparable to that of Government Incentives. Furthermore, it has also been demonstrated that the effect of Attitude to use ESCOs, which is heavily affected by Perceptions of ESCO Capability, may influence Intention to use ESCOs more than does Preference for EPC. Finally, Trust in ESCOs and Preference for EPC appear to have a similar level of influence on Intention to use ESCOs.

Whilst findings from the quantitative approach do not contradict current views that regulations and incentives are important and EPC is a significant driver of ESCO adoption, the results indicate that the existing assumption about the relative importance of the variables, and hence also the understanding of the ESCO business dynamic, could be inaccurate.

In this exploratory research, we have simply grouped major independent variables into three categories (i.e. Perceptions on ESCO Capability, Trust in ESCOs and Government Incentives) and demonstrated some possible inaccuracies about the current assumptions. In order to better understand the ESCO business dynamic, more comprehensive theoretical investigations about the interactions among variables under refined categories will be necessary.

(b) TRA Model Application

While providing energy-efficiency improvement is the primary function of ESCOs, the extensive use of the EPC approach is a unique situation in this industry. Since EPC is an integrated approach to provide technology together with financing, it would potentially accelerate energy-efficiency improvement initiatives amongst clients who do not have sufficient technological know-how or financial resources. To a great degree, this is also the origin of the belief that Preference for EPC is a key direct driver of ESCO adoption (Urge-Vorsatz et al. 2007; Bertoldi et al. 2007; BASE 2006; Vine 2005). Unlike other more common professional services where the client pays directly to the provider in exchange for the value of the services, the EPC mechanism alters the value delivery model by rewarding the ESCO from future energy savings based on a mutual agreement. In this case, the client's valuation on energy savings alone is not sufficient to determine if the transaction is successful. Whether the client prefers this value delivery model is an additional factor that will also affect the transaction decision. This factor does not exist in those other more common professional services.

In this research, we have attempted to modify the standard TRA model in order to better describe the effect of this value delivery model. As the primary service provided by ESCOs is energy-efficiency improvement, the construct Preference for EPC, which originated from the delivery model (i.e. the EPC mechanism), is not regarded as an independent variable but an intermediate one. In our proposed model, Preference for EPC is the mediating variable between Attitude to use ESCOs and Intention to use ESCOs, as well as between Subjective Norm to use ESCOs and Intention to use ESCOs (Figure 5.1). In other words, instead of using Attitude to use ESCOs as a direct predictor for Intention to use ESCOs (as in standard TRA model), Preference for EPC is inserted as a mediator in order to illustrate its direct effect on intention. The successful validation of the model in

Section 4.4 has demonstrated that it is possible to adopt the TRA model structure for different situations by introducing appropriate intermediate variables. With this modified TRA structure, we have been able to demonstrate that the effect of Attitude to use ESCOs on Intention to use ESCOs can even be stronger than Preference for EPC, thereby suggesting a more comprehensive review about the assumption of the importance of EPC.

5.5 Limitations and Future Research

Whilst the heavy-industry sector in China is huge, decision makers are usually hard to reach because of limited communication channels. This is an obvious but important barrier for our research. As discussed in Section 3.4, being an exploratory study, getting basic information quickly and efficiently is important. Therefore, convenient sampling based on membership database of an energy technology related NGO was used and 237 Chinese practitioners responded to our questionnaire. As all the respondents are members of the NGO, the first limitation of this research is that the respondents may possibly share certain similar viewpoints regarding energy efficiency in general and ESCO deployment in particular. Thus, an important risk of this convenient sampling is that the sample in this research may not precisely represent the population.

The generalizability of the findings is questionable because of the sample that was used. Firstly, non-response bias may be present. Secondly, over 45% of the respondents worked in a single industry (i.e. iron and steel), and all respondents belonged to a particular organization. Finally, all of the respondents are employees of Chinese firms and this may have influenced their responses due to cultural factors (e.g., attitude to outsourcing services) and situational factors such as the state of the economy (e.g. energy costs) at the time of data collection.

Another important challenge for exploring the industrial sector's views on using ESCOs is the sector's knowledge of ESCOs. In other words, do practitioners know much about various aspects of ESCOs before deciding whether or not to employ an ESCO, or is the decision to employ an ESCO simply based on the practitioners' general impressions of ESCOs. As the deployment of ESCOs in heavy industries in China is still at a very early stage, it is not surprising that many practitioners have not interacted deeply with ESCOs and therefore their views about ESCOs could stem from their own assumptions instead of actual dealings with ESCOs.

When using a self-report design, the possible existence of such assumptions could be problematic: The correlations between variables may be distorted by the consistency motif, which suggests that people will try to maintain consistency between their cognitions and attitudes, and leniency biases, which occur because raters tend to rate someone they like higher than someone they dislike (Podsakoff et al. 2003). These biases are part of the Common Method Variance (CMV) problem that frequently occurs with self-report designs (Podsakoff & Organ 1986; Donaldson & Grant-Vallone 2002).

To test the CMV problem with the Harman's single factor test method (Podsakoff et al. 2003), a principal component analysis on all items reveals that the first component explains 77% of the variance, which is remarkably high and indicates a potential CMV problem. However, there is no clear guideline to define the threshold for determining the existence of a CMV problem, nor to what extent the CMV problem would affect the validity of the findings (Podsakoff et al. 2003). Gorrell et al. (2011) argued that the conceptual foundation of using Harman's single factor test for CMV is over-simplified. According to their analysis, CMV is likely if there exists a pervasive factor that significantly correlates to all items and, at the same time, there also exists at least one pair of orthogonal items. For this research, some of the items have non-significant correlations and all of the items correlate strongly with the first component thereby indicating CMV based on Harman's test. However, according to Gorrell et al. (2011), CMV is indeterminate even when Harman's test indicates a potential CMV issue.

Using a simple self-report design can potentially lead to CMV problem and its effect on the findings of this study is difficult to determine. The concern about CMV can be alleviated by examining the differential relationships amongst variables (e.g., how one variable predicts some variables, but not others). This approach of validation has been used by Parker and Collins (2010) in their research on proactive behaviours in organisations. Furthermore, if CMV is problematic in this study, different independent variables would be unlikely to have significant unique effects on various dependent variables. Specifically, the mediation effects reported in Section 4.4 would be unlikely if CMV is a serious issue in this study.

Although the self-report method is relatively straightforward, its limitations, in particular the CMV issue, have been discussed by many scholars (e.g., Podsakoff & Organ 1986; Donaldson & Grant-Vallone 2002). As an initial exploration into a new area, however, it is more practical for this research to start with a self-report method in order to develop and examine hypotheses (Spector 1994, 2006).

Another limitation of this study was that it is a cross-sectional design. A longitudinal design is required for inferences about causality to be made between the variables in the model. The data were collected at a single point in time and therefore it is not possible to know if, for example, attitude toward ESCOs changed over time. Based on the findings from the current study, more sophisticated research designs, such as a longitudinal design, could be used in future studies.

As mentioned in Section 5.4, we have simply grouped major independent variables into only three categories (i.e. Perceptions on ESCO Capability, Trust in ESCO and Government Incentives) and demonstrated some possible inaccuracies about the common current assumptions about regulations, incentives and EPC. To provide more in-depth insights to policy makers, further studies on ESCO business dynamics are essential. We recommended to refine the variable categories and investigate their relationships with both quantitative and qualitative approaches in order to come up with more accurate models for describing the ESCO business.

Finally, it is recommended that the type of respondents should be widened for future studies. As pointed out in Section 4.2, respondents are mainly from three industries and those from the iron and steel industry constitute over 45% of the sample. In order to better understand ESCO deployment in the heavy industrial sector, respondents from a wider range of industries in the heavy industrial sector is necessary.

5.6 Summary and Concluding Remarks

Owing to the pressing need to improve the energy efficiency of the Chinese heavy industrial sector, the Government has introduced a number of regulations and measures since 2004. One of the important measures is promoting ESCO adoption in the sector. However, using ESCOs is currently not a general practice in the sector. This research attempts to explore the following question:

> ***How do government incentives, trust and perceived capability of ESCO, and preference for Energy Performance Contracting influence the adoption of ESCO services in heavy industries in China?***

In the ESCO business today, regulations and incentives are believed to be very critical for ESCO adoption and EPC is believed to be a very important driver for ESCO adoption. Based on these views, we proposed a modified TRA model as shown in Figure 5.1. Our hypotheses were supported. This has confirmed our view that Preference for EPC can be properly represented as an intermediate variable driven by the more fundamental independent variables Government Incentives, Perceptions of ESCO Capability and Trust in ESCOs.

It has been demonstrated that Government Incentives significantly predict Intention to use ESCOs and the use of ESCOs, and is consistent with the traditional view. However, the results have also illustrated that Perceptions of ESCO Capability affects Preference for EPC at a magnitude comparable to Government Incentives. Regarding the assumption about the importance of EPC, however, although Preference for EPC is a significant predictor of the Intention to use ESCOs, Attitude to use ESCOs is an even stronger predictor. Attitude to use ESCOs is, in turn, strongly affected by Perceptions of ESCO Capability and, to a lesser extent, by Trust in ESCO. On the other hand, Trust in ESCOs directly affects the Intention to use ESCOs at a magnitude comparable to Preference for EPC. Although these findings do not contradict the view that EPC is important, the results also suggest that trust in ESCOs and perceived capability of ESCO play critical roles.

To enhance trust in and perceived capability of ESCOs, we recommended the development of an ESCO-accreditation system and a sector-based collective guarantee scheme.

Appendices:

A. The Questionnaire

B. Participant Invitation Letter

Appendix A: The Questionnaire

Demographic Information 统计资料

1. Age 年龄: ____________

2. Gender 性别: __________

3. Education 教育程度:

__ High School 高中 __ Diploma 专科 __ University 本科 __ Graduate School 研究院

__ Others 其他 (Please specify 请注明: ____)

4. Industrial Sector 行业:

__ Iron and Steel 钢铁类 __ Non-metallic Minerals 非金属矿类 __ Chemicals & Petrochemicals 石化类

__Others 其他 (Please specify 请注明: ____)

5. What is your level in the organisation? 您在公司的职别是:

__ Senior Management 高层管理人员 __ Management (Technical) 技术部门管理人员

__ Management (Non-technical) 非技术部门管理人员

__ Non-management (Technical) 非管理人员 - 技术部门

__ Non-management (Non-technical) 非管理人员 - 非技术部门

6. How long have you served in the current position?

您在现时的岗位上工作了多久? _____ Years 年

7. How long have you served in the similar position?

您在类似的岗位上工作了多久? _____ Years 年

8. How long have you served in this industrial sector?

您在这行业工作了多久? _____ Years 年

Please rate the following statements using the scale below 请以如下尺度，对下面的命题作出评价: ***SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree*** ***SD = 非常不同意 D =不同意 N = 中立 A = 同意 SA = 非常同意***						
		Rating 评价				
Perceptions of ESCO Capability						
1	With respect to our internal capabilities, ESCO have a more in-depth understanding about our energy efficiency problems than we do 相对我司内部的能力而言，ESCO 对我们的能源效益问题有更深刻的了解	SD	D	N	A	SA
2	ESCO have successfully tackled similar problems that we currently face 对于类似我司现时面对的问题，ESCO 有成功处理的经验	SD	D	N	A	SA
3	ESCO can provide a better solution than our internal resources 对比使用我司内部资源而言，使用 ESCO 能提供更优秀的解决方案	SD	D	N	A	SA
4	ESCO can identify issues that are currently unknown to us ESCO 能发现我司目前尚未知注意到的问题	SD	D	N	A	SA
5	ESCO can solve our energy efficiency problems at a lower cost than if we do it ourselves 相对于我司自行操作而言，ESCO 能以更低廉的成本解决我们的能源效益问题	SD	D	N	A	SA
6	We can accomplish our energy efficiency targets faster if we use ESCO 相对于我司自行操作而言，ESCO 能以更快速地解决我们的能源效益问题	SD	D	N	A	SA
7	ESCO can provide useful suggestions on how we can improve our energy efficiency 对于我司可以如何提高能源效益，ESCO 能提供有用的建议	SD	D	N	A	SA
Trust in ESCO						
8	I will show our core processes to ESCO 我愿意把我们的核心工艺对 ESCO 展示	SD	D	N	A	SA
9	A non-disclosure agreement with ESCO is an acceptable safeguard for confidentiality concerns 就保密问题而言，与 ESCO 签定保密协议是一种可接受的保障	SD	D	N	A	SA

10	Instead of choosing the most appropriate technology, ESCO may choose alternative technologies that are familiar to them ESCO 可能采用他们自已最熟识的技术，而非最合适的技术	SD	D	N	A	SA
11	Instead of choosing the most appropriate technology, ESCO may choose alternative technologies that provide more profits to them ESCO 可能采用让他们得到最大利润的技术，而非最合适的技术	SD	D	N	A	SA
Government Incentives						
12	Energy efficiency laws and associated policies encourage the deployment of ESCO 能源效益的法例和相关政策均鼓励使用 ESCO	SD	D	N	A	SA
13	In terms of financing, taxation, information, and technological support, the government has provided a reasonable policy framework for using ESCO 从财务、税务，资讯、技术支持等各方面来看，政府对使用 ESCO 提供了合理的政策	SD	D	N	A	SA
14	Under the current system, there are concrete incentives for utilising ESCO 目前的制度对于使用 ESCO 提供的激励是踏实的	SD	D	N	A	SA
Preference for Energy Performance Contract						
15	In general, we prefer EPC 一般来说，我们都会倾向选择 EPC	SD	D	N	A	SA
16	The administrative costs associated with EPC are too high 与 EPC 相关的行政费用太高	SD	D	N	A	SA
17	I have doubts on measurement and verification (M&V) methods and hence the trustworthiness of EPC 我对测量和验证(M&V)方法有所怀疑，因此认为 EPC 并不可信	SD	D	N	A	SA
18	The time horizon of EPC is usually too long EPC 的时间跨度一般都太长	SD	D	N	A	SA
Attitude to use ESCOs						
19	Using ESCO will significantly improve our energy efficiency 使用 ESCO 能显著地改善我司的能源效益	SD	D	N	A	SA
20	Using ESCO will enhance our internal knowledge 使用 ESCO 能帮助提高我司内的相关知识水平	SD	D	N	A	SA
21	Using ESCO will improve our competitiveness 使用 ESCO 能增加我司的竞争力	SD	D	N	A	SA

22	Using ESCO is glitch-free 使用 ESCO 是简易无碍的	SD	D	N	A	SA
23	Using ESCO is cost-effective 使用 ESCO 是具成本效益的	SD	D	N	A	SA
24	Using ESCO will minimise project risk 使用 ESCO 能使项目的风险降到最低	SD	D	N	A	SA
Subjective Norm to use ESCOs						
25	Our management expect us to use ESCO 我司的管理层预期我们会使用 ESCO	SD	D	N	A	SA
26	The government expects my company to utilise ESCO 政府预期我司会使用 ESCO	SD	D	N	A	SA
27	Our industry generally prefers to use ESCO 我们这行业一般都倾向使用 ESCO	SD	D	N	A	SA
28	Relevant peers suggest that I should use ESCO 相关的同事们都建议我使用 ESCO	SD	D	N	A	SA
29	Competitors generally use ESCO 竞争对手一般都使用 ESCO	SD	D	N	A	SA
Intention to use ESCOs						
30	For critical projects, I will use ESCO 对重要的项目，我将会使用 ESCO	SD	D	N	A	SA
31	I intend to use ESCO for critical projects 我打算用 ESCO 去进行重要的项目	SD	D	N	A	SA
32	For critical projects, I will select ESCO and work out contract scope 对重要的项目，我将会选择 ESCO 及制定合同范围	SD	D	N	A	SA
33	I will deploy ESCO in order to achieve the prescribed results of critical projects 我将会使用 ESCO 以取得重要项目的预期成果	SD	D	N	A	SA
Actual use of ESCOs						
34	For critical projects, I have used ESCO 对重要的项目，我曾经使用 ESCO	SD	D	N	A	SA
35	I have evaluated and contracted ESCO for critical projects 我曾经评核及聘用 ESCO 去进行重要的项目	SD	D	N	A	SA
36	For critical projects, I have selected ESCO and worked out contract scope 我曾经评核及聘用 ESCO 去进行重要的项目	SD	D	N	A	SA
37	I have deployed ESCO in order to achieve the prescribed results of critical projects 我曾经使用 ESCO 以取得重要项目的预期成果	SD	D	N	A	SA

Appendix B: Participant Information Letter

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Faculty of Business and Law
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THE UNIVERSITY OF NEWCASTLE AUSTRALIA

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Date:

Participant Information Letter for the Research Project

予研究项目参与者的信件

Subject: Mitigating the industrial energy efficiency problem in China – Investigating the acceptance of energy services company using the Theory of Reasoned Action

命题**:** 缓解中国工业能源效益问题 **–** 采用行为确立理论**(Theory of Reasoned Action)**分析业介对能源服务公司**(Energy Services Company, ESCO)**的认受性

Dear Sir/Madam,

尊敬的先生/女士，

You are invited to participate in a study that is being conducted by Mr. Chun-Fung Li and Dr. Gian Casimir from the Newcastle Graduate School of Business. Mr. Chun-Fung Li is conducting this study as part of his Doctor of Business Administration Degree and Dr. Gian Casimir is his research supervisor. This aim of the study is to investigate the behaviour of Chinese industrial practitioners on adopting ESCO services.

我们诚意邀请阁下参与由 Newcastle Graduate School of Business 的李振峰先生和 Gian Casimir 博士主持的研究。是次研究属於李振峰先生攻读的博士学位课程的部份内容，而 Gian Casimir 博士是他的导师。本研究的目的是分析中国工业企业的人员在决定是否采用 ESCO 服务时的行为。

We are interested only in collecting data from Chinese practitioners who are working in energy intensive heavy industry and have the responsibility of conducting energy efficiency improvement projects. The confidentiality of your responses is assured as only Mr. Chun-Fung Li and Dr. Gian Casimir will have access to the completed questionnaire. The questionnaires will be shredded after final acceptance of the thesis by the Office of Graduate Studies. An electronic copy of the data will be securely stored at the Newcastle Graduate School of Business, University of Newcastle, for a minimum period of 5 years from the date of final acceptance of the thesis. Prior to being shredded, all data will be securely stored in Mr. Chun-Fung Li's office and only the two researchers will have access to the data.

我们只会由从事高能耗重工业、并有责任推行能源效益提升项目的中国业者里搜集数据。您提供的回覆是会被保密的，只有李振峰先生及 Gian Casimir 博士可以取得填妥的问卷。当学院通过接受论文後，这些问卷就会被销毁，而有关的电子数据会被保密地于 Newcastle Graduate School of Business, University of Newcastle 保留不少于 5 年(由通过接受论文日起计算)。在问卷被销毁之前，它们会被妥善地存放于李振峰先生的办工室，并只有上述两位研究人员可取得其数据。

Participation in this study entails no risks or benefits to you. However, on completion of the study, a report will be provided to your organisation and we will recommend that this report be provided to all employees of your organisation. Alternatively, you can contact the researchers for a copy of the report. The findings of this study may be published in a scholarly journal but neither you nor your organization will be named or be able to be identified from the published report.

参与此项研究不會令阁下承担任何风险，亦不会带来任何利益。在研究完成後，我们将会把一份报告提供与贵机构，并建议贵机构把此报告提供给所有员工。除此以外，您亦可以联络上述研究人员以索取报告。研究的发现可能会在一些学术性的期刊发表，但您和您的机构都不会在当中被识别出来。

Participation in this study is **entirely voluntary**. There are no inclusion or exclusion criteria. Your decision to participate or not to participate will not affect you in any way and no one will know whether or not you have participated in this study. Additionally, non-participation will not affect your relationship with the University of Newcastle.

参与这项研究是属於完全自愿性的。我们对参与者没有特定的采纳或排挤条件。您作出参与或不参与的决定都不会对您造成任何影响，而且亦没有人会得悉您有否参与。再者，不参与此研究并不会影响您和 University of Newcastle 的关系。

If you wish to take part in this study, it will take about 20 minutes to complete the survey. Please note that, given the questionnaires are to be completed anonymously, you will not be able to withdraw from the study after you have returned the completed questionnaire to the researchers or after you have completed the online survey.

如果您愿意参与这项研究，填写此问卷大约需时 20 分钟。请注意：由於问题是完全匿名的，阁下一旦寄回或在网上提交填妥的问卷，就无法退出。

If you would like more information about this study, please contact Mr. Chun-Fung Li or Dr. Gian Casimir.

如您需要更多有关这项研究的资料，请与李振峰先生或 Gian Casimir 博士联系。

Thank you for taking the time to consider this invitation.

感谢您花时间去考虑这邀请。

Yours sincerely,

祝好!

Mr. Chun-Fung Li **Dr. Gian Casimir**

Complaints Clause:
投诉条款

The University requires that should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, telephone (+61 249 216 333, email HumanEthics@newcastle.edu.au)

大学的促请: 作为研究的参与者，如您对您的权益有任何疑问，或对进行这项研究的方式作出投诉，您可以转达给研究人员。如果您希望通过中立人士处理，请联络人文研究项目道德标准主任(Human Research Ethics Officer): The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, 电话: (+61) 249 216 333, 电邮: HumanEthics@newcastle.edu.au

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