
Sarah Kok

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Abstract:
As living standards improve and population numbers increase in China and India, the demand and consumption of electricity will continue to intensify. Although both countries maintain a strong dependence on fossil fuels to meet energy demands, a recognition of the importance of a low carbon transition is apparent from the governments of both countries. China and India have both made commitments to abate global climate change, reduce poverty rates and enhance efforts to reduce fossil fuel dependence. Solar energy has experienced phenomenal growth in the last twenty years due to technological advances, priced reductions and governmental support policies. Yet in China and India policy development has been very erratic. This paper takes a case study approach to examine solar energy policies, particularly solar energy auctions, in China and India. Thus, this thesis aims to examine solar energy policy in China and India, and compare the potential of each country for energy security and sustainable development under the IRENA framework to Evaluate Renewable Energy Policy. The performance of solar energy policy in China and India is assessed on criteria of effectiveness, efficiency, equity and institutional feasibility. This study find that China has installed more cumulative solar capacity than India and that overall that solar energy policy in China is stronger than in India. However, at an individual policy level, India’s solar energy auction policy is stronger than China’s. Thus, the long-term sustainability of solar energy policy and deployment in both countries is a complex and multifaceted issue. This thesis concludes that for energy security and sustainable development the continuation of policy support is necessary in both countries to ensure that solar will continue to grow in significance.

Keywords: Sustainable Development, Solar Energy Policy, Solar Energy Deployment, China, India, Political Science.

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Summary:
By operationalising the framework to Evaluate Renewable Energy policy from IRENA, the effectiveness, efficiency, equity and institutional feasibility of solar energy policy has been examined in both China and India. Solar energy policy is at a more advanced stage of development in China due to greater access to resources, stronger leadership willingness and power, and international pressure to transition to a low carbon economy. Overall the Chinese government solar policy has displayed greater effectiveness, efficiency and equity than solar energy policy in India, which has enabled the Chinese solar energy deployment and manufacturing sectors to expand dramatically. The Indian solar energy policy is conversely less advanced due to an underdeveloped domestic market, deficient policies and a lack of standardisation and policy coordination. However, the scene is beginning to change as solar energy policy in India displays greater institutional feasibility and the government positions itself to improve solar energy deployment. Several lessons can be learnt from the Chinese solar energy sector; reliance on an international market can be unreliable, previous experience from the renewable energy sector can prevent future renewable energy policy complications and that the Chinese political model can be incredibly effective.

At the individual policy level, specifically solar energy auctions, India performed more strongly in each of the renewable energy policy indicators than China. Furthermore, the analysis indicated that India has stronger institutional feasibility than China. All of this could indicate that although India has been slow to start, it can successfully achieve energy security and sustainable development, or, it could indicate that the case of solar energy auctions in China was an unfortunate mistake for solar energy policy. Regardless, the vehement implementation of solar energy deployment in China and India is a successful example of technological leapfrogging and is a positive indicator for the development of a sustainable energy future.

Keywords: Sustainable Development, Solar Energy Policy, Solar Energy Deployment, China, India, Political Science.

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1. Introduction

The contemporary global environment is confronting major security challenges and transformations. There is overwhelming scientific consensus that the earth’s atmosphere is rapidly warming; mostly as the result of human activity, and that the consequences of this will be significant climate change (Hansen, et al., 2008; Raworth, 2012; Wijkman & Rockström, 2012). Wijkman & Rockström (2012), suggest that the biosphere is reaching some crucial tipping points as is apparent by the now visible effects of pollution, displacement, disruption to climate balance and the eradication of countless species and ecosystems.

Variations in climate change are nothing new, the earth has experienced prolonged periods of natural cooling and warming over the past 3 billion years (Flannery, 2005). However, the earth has been in a relative stable epoch, known as the Holocene, for the last 10,000 years, during which humans turned to agriculture and the human population expanded considerably. During this period the average temperature of the atmosphere has remained stable, but has begun to rise in the last century (Miller & Spoolman, 2015 [2012]). This is due to the amount of greenhouse gases (GHGs) in the atmosphere, which have risen since the industrial revolution with the increased use of fossil fuels (Boudri, et al., 2002). During the last century the environment has transformed in such a significant manner, as a result of human modification that it has departed from its natural Holocene geological epoch (Steffen, et al., 2007).

It is estimated that in order to limit global CO2 emissions from human activity to 15 Giga tonnes per year by 2050, the maximum level to limit global warming to two degrees Celsius above pre-industrial levels, will require an investment of $2 trillion per year (Shah, et al., 2013). This would approximately halve current CO2 emissions and would require all countries to make the transition to low carbon societies. However, global energy patterns are complex and concern relating to the security and sustainability of energy supply will require concentrated efforts to resolve. As such, there is a fundamental need for sustained political efforts to change energy trends. Action from well-informed policy-makers, industry and other stakeholders are essential to attempt to change global energy trends and ameliorate sustainability and energy security concerns (IEA, 2014). Furthermore, unsustainable production and consumptions systems limit future development and prosperity of humanity by gradually increasing the amount of irreversible damage on the environment must be reduced (Sachs, 1999).

Satisfying future global energy demands, whilst attempting to reduce GHG emissions is an incredibly complex matter, especially as approximately 27% of people in the world still do not have access to electricity (IEA, 2014). Renewable energy, with its technological innovation and improved energy efficiency are a cause for optimism for the future. Achieving these goals would require a focus on innovative technology that reduces energy usage, improves efficiency and reduces carbon dioxide emissions from energy sources (Hansen, et al., 2008). However, it is important to be cognisant that the impacts of technological innovation and improved energy efficiency are limited by the potential net increases in energy demand.

This thesis attempts to understand the impacts of implementing low-carbon policies and of the impact that these have on low-carbon technology deployment rates. The understanding of these factors is the foundation of identifying the impetus for implementing low-carbon policy and thereby increasing low-carbon technology deployment rates in the future. Due to the high-cost of low-carbon technologies and the need for an expensive modernised grid systems to distribute the power, the decision process involved in renewable energy technologies (RETs) investment is ambiguous and complicated: it is not simply a technical question of optimal asset allocation (Spratt, et al., 2014). Rather, understanding these decisions requires an interdisciplinary perspective of politics, economics and sociology, in order to assess the motivations and
incentives of the various different factors involved, and the way in which these factors interact. An understanding of these dynamics could be crucial for a renewable revolution.

For the purposes of this thesis, the Brundtland (1987) definition of sustainable development will be operationalised. The Brundtland Commission defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 15). These needs relate to economic development, social and human development and environmental and ecological health (Goldman & Gorham, 2006). There are a variety of definitions of sustainable development, that consider the concept at different scales, however, this definition is the most widely used academic definition of sustainable development.

The successful implementation of solar energy policy is instrumental in improving deployment, stimulating investment and encouraging the proliferation of solar energy development. Over the past decade extensive experience in policy design has been acquired, however, there is still a need to develop and implement innovative policies as well as learn from past experiences in order to address prevalent barriers to the deployment of solar energy technologies. Thus, the focus of this research is on understanding the determinants of low-carbon investment and the long-term sustainability of solar energy policies in the world’s two largest economies: China and India.

This thesis will examine the extent to which China and India have taken the concepts of effectiveness, efficiency, equity and institutional feasibility into consideration in their solar energy deployment policies? Secondly, do solar energy auctions improve solar energy deployment in China and India, which is examined in Case Study 2? Both of these questions will be evaluated and examined through the International Renewable Energy Agency (IRENA) framework of ‘evaluating renewable energy policy’ (Nicholls, et al., 2014).

This thesis considers the impact of solar energy policy implementation on cumulative installed capacity, securing investment and long-term energy security in China and India through the examination of case studies. The first case study is intended to provide insight into the contribution of various factors in the development of solar energy policies, installed capacity and industry in China and India. The second goes on to consider the long-term sustainability of a particular solar energy policy and to assess the impact of solar energy auctions.

China and India have been selected for exploration for a variety of reasons. There are numerous similarities between the two countries, including: that each contains more than a sixth of the world’s population, each has experienced dramatic economic growth in recent decades and remains beset by widespread poverty. Perhaps the most significant similarity relevant to this research is that the two countries are responsible for the biggest growth in carbon emissions in the last few years (Economist, 2013; Global Carbon Project, 2014). The significant impact that China and India could have on global climate change if unabated is devastating, especially considering that both countries are still developing and account for one third of the world’s population between them. However, simultaneously there are a great number of differences between the two, the two countries have radically different political systems, pathways to development and are at different junctures in social development. China is considered to be the worst polluter in the world but it is also the greatest investor in renewable energy (Economist, 2013; Rapoza, 2014). Similarly, India is amongst the top polluter, but experienced its highest growth rate in renewable energy between 2010 and 2011 and plans to invest $10 billion to set up 10 GW of renewable energy capacity over the next 5 years (Mittal, 2015). A recognition of the need to sustainably transform the foundation of energy systems from fossil fuels to renewable sources motivates this research.
While this research focuses on the development of China and India’s solar energy policies, as they are crucial to a sustainable future, it is also important to note that the need for low-carbon technologies, investment and policy development in other countries around the world is of great consequence. Ultimately the responsibility for achieving sustainable development should exist for the entire world population and subsequent generations, not only for particular nation-states (Swain, 2013).

The focus of this research is on solar energy, which is becoming increasingly popular. Solar energy has been increasing in popularity because solar technology is becoming increasingly efficient, it is a good source of energy security, it is increasingly cost-competitive and solar energy provides energy independence. In 2014, China invested a record $86.5 billion in renewable energy, which is up 32% on the previous year. This included a $30.4 billion investment into the solar sector (Bloomberg, 2015). Whilst, Indian investment into the renewable sector rose by 14% to $7.9 billion. China and India have both announced aggressive solar capacity expansion targets. China has set a target of 100 GW of solar power capacity installed by 2020, and India set a similar target but for 2022 (Chadha, 2015).

In order to progress and continue this positive pattern of growth in the solar industry it is important to understand the motivations behind solar investment and solar energy policy implementation in the two countries, in order to attempt to manipulate these motivators.

This thesis is organised as follows: Section 2, provides the ‘background for this thesis, and reviews the impact of RETs and solar energy technologies against the background of climate change; Section 3, the ‘solar energy policy and deployment background’, explores the motivations and potential explanations for policy implementation and solar energy investment; Section 4 describes the environment of solar energy policy in the Chinese and Indian contexts and the solar energy policy progress strategies that have been adopted in both countries; Section 5 scrutinises the system of methods used for case studies in this thesis; Section 6 inspects the reasons for the study; Section 7 describes the framework, criteria and indicators that are applied to analyse the solar energy policy in China and India; Sections 8 is an account of the findings of this thesis, including a summary of the solar energy policies made and related to the field in the two countries and a specific case study of solar energy auctions; Section 9 relates the findings to the theoretical background, which specifies effectiveness, efficiency, equity and institutional feasibility; Section 10, summarises and relates the findings of this thesis to the global ongoing debate; Section 11 concludes and outlines potential future research.

2. Background

The contemporary neoliberal economic paradigm has incurred a number of negative consequences, such as inequality, environmental degradation and reduced benefits of democracy in industrialising nations (Stiglitz, 2006). The neoliberal paradigm present a serious challenge to the objectives of sustainable development, specifically to the security of nations, the degradation of the environment and the intensification of anguish and deprivation (Swain, 2013). However, it is has simultaneously supported unrivalled technological, health and quality of life achievements.

2.1 Climate Change Background

The contemporary global environment is confronting major security challenges and transformations. Human modification and influence have caused the environment to transform in such a significant manner that the earth has departed from its natural Holocene geological epoch (Steffen et al., 2007). The Holocene was a relatively stable epoch in which humans
turned to agriculture and the human population expanded considerably. The less stable current geological epoch, termed the Anthropocene, is indicative of a radical divergence from the relative ecological and climatic stability of the Holocene (Lewis, 2009). The Anthropocene refers to the epoch in which human influence on ecosystems, biodiversity and the climate has become so pervasive and profound that humanity has become a collective force of nature.

Anthropocentric security threats to the global environment and to social stability are complex, multifaceted and interdisciplinary. These contemporary anthropocentric security threats pose significant risk to present human civilization, the environment and for the future in a number of ways. Firstly, the occurrence of extreme weather events, such as heat waves, extreme precipitation, and coastal flooding is currently estimated to be moderate by the IPCC. However, with a 1°C rise in temperature, this threat is upgraded to high. These extreme weather events are estimated to increase losses and loss variability in various regions, challenge insurance systems to offer affordable coverage while raising more risk-based capital, and threaten production resources, particularly in developing countries (IPCC, 2014).

Secondly, climate change is increasing the variability and uncertainty of conditions in which livelihoods are pursued, which directly affects living conditions especially for those in industrialising countries (IPCC, 2007). This is primarily through the effects of climate change on fishing, forestry, agricultural and pastoral resources that are the main source of livelihoods in rural areas. However, urban areas are also impacted through infrastructure, housing, employment and public services.

Furthermore, the risk of resource-driven conflicts, the scale of damage to coastal cities and infrastructure, and the risk of political radicalisation could all be exacerbated by climate change. Finally, due to the fact that these security threats are the consequence of human action there are additional socially constructed problems involved (Cannon & Müller-Mahn, 2010). These security threats threaten to alter international alliances, economic relations and create new security dilemmas.

Whilst the human species emerged 150,000 years ago, the degradation to ecosystems and the environment that has been caused in the last fifty-years is more pernicious than in any other comparable period of history (Reid, et al., 2005). Concern regarding global warming as a result of long-lived human-made GHGs has been the object of fierce debate. The European Union has adopted 2°C above pre-industrial global temperature as a goal to limit human made warming (Council of the European Union, 2005). However, an increase of 2°C above pre-industrial global temperatures with 450 ppm carbon dioxide could still be dangerous. This increase would increase the chance and severity of forest fires and drought, increase desert size, provoke water conflicts, decrease crop yields by 5-10%, bleach coral reefs, melt glaciers and raise sea levels (Miller & Spoolman, 2015 [2012]). Furthermore, due to the multifaceted nature of climate change the environmental problems would be exacerbated by rampant social issues that would prevail, such as mass migration and resource conflict.

Alternative academic perspectives suggest that 450 ppm carbon dioxide is too high and that instead humanity must aim to reduce GHGs by up to half the present global mean (Shah, et al., 2013). Hansen et al., (2008) asserts that the majority of climate models do not include slow feedback processes which may begin to accelerate sooner than expected, such as ice sheet disintegration, vegetation migration, and GHG release from soils, tundra or ocean sediments.

However, regardless of whether the limit of 2°C above pre-industrial global temperatures is overly optimistic or not, it is apparent that GHGs must be significantly reduced. A reduced reliance on fossil fuels and increased energy efficiency could make an important contribution to the endeavour of reducing GHGs. The UNEP estimates that 35% of global greenhouse gases
in 2010 were from the energy sector (UNEP, 2013). That is, emissions from the energy sector account for the largest share of GHG emissions (IEA, 2013). The emissions reduction potential for the power sector is between 2.2-3.9 Gigatonnes of carbon dioxide equivalents (UNEP, 2013). In industrialised countries, emissions are dominated by the energy sector, and energy related fuel combustion accounts for 65% to 85% of the national total of GHGs (ibid). For these countries in particular energy efficiency and low carbon energy sources could be a major GHG mitigating option. The continued reliance on fossil fuels for another decade could eliminate the possibility of returning the atmospheric composition to beneath the tipping levels for catastrophic effects. Therefore, it is clear that remaining fossil fuel reserves must not be exploited and that instead replacing fossil fuels with renewable energy sources is a necessary transition. This view is further supported by Millennium Development Goals (UNDP, 2015).

Although the contemporary neoliberal development paradigm is profoundly problematic, simultaneously, Jackson (2009) suggests that there is no case to universally abandon the concept of growth. There is however convincing argumentation for industrialised countries to attempt to facilitate or make room for growth in industrialising nations. A prominent explanation for this is dependent upon the life-satisfaction paradox, which states that marginal utility diminishes significantly at higher income levels. That is, after a certain point of income level, approximately $15,000 per capita, life-satisfaction or happiness barely responds to increases in income, even to large increases in gross domestic product (GDP) (ibid). For example, Jackson (2009, p. 32) found that in the UK, since 1957 real incomes have more than doubled, but the percentage of people reporting themselves as “very happy” has declined from 52% to 36%. Therefore, it is apparent that the returns on further investment and development in industrialised countries is severely limited, in relation to the potential in industrialising nations. In industrialising countries development, growth and an increase in GDP makes a substantial difference to happiness and living standards. That is, in industrialising countries small rates of development can have huge positive impacts on living standards, literacy rates and life expectancy, whereas in richer countries the impacts would be meagre.

The transition to low-carbon involves a variety of changes of technologies and behaviours throughout many different sectors. The adoption of a specific low-carbon technology is one element in this transition. The trajectory and pace of low-carbon transitions tends to be erratic and unpredictable as they are shaped by a variety of political, economic and technological social forces. These forces impact the low-carbon transition as a whole, as well as determine the development and deployment of specific low-carbon technologies.

### 2.2 Advantages of Renewable Energy

It is estimated that as many as 1.3 billion people in the world still do not have access to electricity (IEA, 2014). The direct and indirect consequences of maintaining and expanding energy services to ensure energy access to all would be substantial, these could include; increasing educational opportunities, reducing poverty and improving gender equality. Thus, in many industrialising nations considerable resources are allocated to securing energy services. Sustainable development provides an unprecedented opportunity from renewable technologies to advance a transition to innovative energy services.

In a sustainable future the commitment to improving energy access is an important objective to abate for poverty and global inequality. However, electricity is increasingly important, as population numbers increase and standards of living improve, the demand for energy will intensify further. The transition from the contemporary unsustainable fossil-fuel energy systems to more sustainable RETs is increasingly frequent, with RETs accounting for an increasing share of new energy capacity. To transition towards clean reliable, competitive and
secure energy supplies there needs to be an increase of the deployment of RETs. The long-term objectives of sustainability, to mitigate the impacts of global warming, requires that an increase in low-carbon energy production technologies or RETs. The development of renewable energy sector over the past decade has surpassed all expectations (Ren21, 2014). Many nations have made progress in increasing the deployment and efficiency of RETs into their energy mix, however, obstacles to further deployment remain.

In most countries electricity generation is heavily dependent on fossil fuels. There are two major risks associated with fossil fuel dependence. Firstly, the continued use of fossil fuels increases the impacts and risks of climate change. Fossil fuels are the main source of carbon dioxide emissions into the atmosphere. The pervasive use fossil fuels continues because fossil fuels are considered to be cheaper than RETs (Becker & Fischer, 2013). However, the cost advantages of fossil fuels over RETs disappear in the long-term when externalised risks are considered. Secondly, the finite nature of fossil fuel resources means that countries that are reliant on fossil fuels are increasingly vulnerable to volatile international markets.

At this time in the discussion it seems pertinent to determine a mutual understanding of renewable energy and non-renewable energy. Renewable energy is “energy gained from resources that are replenished by natural processes in a relatively short time” whereas non-renewable energy is “energy from resources that can depleted and are not replenished by natural processes within a human time scale” (Miller & Spoolman, 2015 [2012], p. 42).

RETs are an instrument for improving energy security, as well as an approach for mitigating greenhouse gas emissions and providing direct and indirect social benefits. In the long-term RETs can improve reliability of electricity supplies whilst reducing energy costs. It is therefore not surprising that the evolution of RETs over the last decade has surpassed all expectations. In recent times the cost of the major RETs has declined significantly, global installed capacity and production of all renewable technologies has increased extensively and policies that are essential to the continued commitment to renewable energy technologies have continued to spread throughout the world (Ren21, 2014).

In recent times technological advances and innovation in policy and financing has improved the affordability and accessibility of RETs and renewable energy sources. Renewables are increasing perceived as crucial to achieve current and future energy demands. In addition to abating global climate change and helping to reduce poverty rates RETs have a number of associated benefits. These include; improves economic and energy security, unlimited sources of energy, decreased fossil fuel dependence, increased job opportunities and reduces pollution (Miller & Spoolman, 2015 [2012]).

### 2.3 Advantages of Solar Energy

There are a great number of advantages of solar energy, which mean that solar has become the fastest growing method to produce energy in the world (Miller & Spoolman, 2015 [2012]). There was a 74% increase of solar energy cells to produce electricity in 2011. This the result of the numerous advantages of solar, as well as, increased tax breaks for solar developers, improved policies and enhanced subsidies. Solar energy has a great number of benefits in comparison to fossil fuels, these include: solar panels are ecosystem friendly, reduces fossil fuel dependence and are easy to move and expand.

Advantages of solar energy include that solar cells emit no greenhouse gases; although they are not carbon free, because fossil fuels are used to transport and produce the cells. But, these emissions are small in comparison to those resulting from the use of fossil fuels. Furthermore,
solar energy is effective in industrialising countries, in rural regions, which are not connected to an electrical grid. It is estimated that 1.6 billion people live in these regions, many of them are now getting electrical service with the use of solar cells (Miller & Spoolman, 2015 [2012]).

The levelised costs of electricity (LCOE) generation from solar PV has fallen sharply over the last two decades. Consequently, an increasing number of solar energy projects are constructed without public financial support (Ren21, 2014). Furthermore, the sharp reductions in the cost of solar technology resulted in record levels of new solar installations in 2013, despite a 22% decline in dollars invested.

However, there are also some disadvantages associated with solar energy, these include: a need for access to the sun, electricity storage or backup systems are required, high costs for older systems, solar-cell power plants could disrupt desert ecosystems, decreased efficiency in cloudy weather. Furthermore, solar panels require a very large area that have large amounts of daily sunlight, this can increase costs of solar energy projects significantly.

3. Solar Energy Policy and Deployment Background

The primary impetus for this thesis is to understand the extent of the potential of solar energy policy and its implementation to achieve the long-term energy security and sustainable development of China and India. China and India are both industrialising nations and the potential that a rapid and uncomplicated transition to RETs could have on slowing down predicted climate change is astonishing. Understanding the impacts of existing solar energy policies on solar energy deployment within different political and economic contexts could provide a stable foundation for future solar energy policies in other industrialising nations.

Significant increases in the share of RETs in the global energy mix can be achieved more expeditiously as the result of a cooperation between public and private actors. Therefore it is essential that policy makers develop policies that will encourage investment and promote an environment that ensures investment security. Policy makers must incentivise solar energy deployment in order to secure investments from the private sector (Masini & Menichetti, 2012).

A well designed policy instrument can reduce the cost of renewable electricity by a minimum of 10% (Jager & Rathmann, 2008). Although a primary motivator for any investment in solar energy technology is that it is regarded as an effective means for governments to stimulate growth and accelerate the recovery from the recent financial crisis, the motivations to invest in renewable energy are considerably more complex than this (Spratt, et al., 2014).

Indeed, to increase stake-holder confidence and secure long-term investment and future interest in projects a clear political and societal commitment towards renewable energy is required. Contingent on this foundation of commitment to renewable energy, a stable and reliable mechanism can be designed, that effectively and efficiently achieves the objectives of the policy, at acceptable levels of investor risk, and at acceptable social costs (Jager & Rathmann, 2008). Regulatory risks can be reduced, stake-holder confidence can be improved and capital costs can be reduced by ensuring commitment, stability, reliability and predictability of the policy and of the government.

However, the relationship between policies and investment decisions in a dynamic environment are not this straightforward. The motivations that are created and withdrawn by governments are not enough to understand the levels and patterns of investment in RETs that occurs. For example, although there has been a global failure to implement a significant carbon price, global investment in RETs still continues to increase significantly (Spratt, et al., 2014). Thus, the differing levels of investment in renewable energy, between different countries, and
in the same countries over time, cannot be entirely explained by government’s policy implementation or disregard.

Governments and the private sector operate differently depending on the specific context. There is no universal way in which governments and or the private sector will react to any given situation. Each decision to invest in low-carbon technologies or implement RET policy is dependent on the alignments of interests between different stake-holders. That said, the successful transition to a low-carbon energy future is a priority for policy makers in many countries. However, investment in the high cost low-carbon technologies, especially solar, has been largely motivated by public policy, in particular feed-in tariffs have played a considerable part (Lüthi & Wüstenhagen, 2012). The implementation of FiT across different countries has been met with various degrees of effectiveness with regards to installed solar capacity. Early research in this area suggested that a sufficiently high policy support level and a perceived long-term stability of policy framework were paramount (Masini & Menichetti, 2012). Furthermore, perceived policy risk is considered to be an important factor; effective policies should successfully reduce the risk to investors.

However, recent development into the motivations for investment into RETs suggests that a perceived favourable risk return profile is an important factor. That is, those with the power to invest in solar technologies carefully compare feed-in tariff-induced returns against a set of policy risks to select a country with the most favourable risk-return profile (Lüthi & Wüstenhagen, 2012). Therefore, perceived policy risk is an important consideration in solar policy design.

The existence of alignments of interests between different stake-holders can influence behaviour, which results in changes to governmental policy or in the behaviour of the private sector. These alignments can occur naturally or they can be engineered. This research is interested in understanding these alignments and the impact that they have on solar energy investment and endorsement in China and India.

It is not essential for stake-holders to share motivations in order for these alignments of interests to be effective, but instead for the stake-holders to have sufficiently common interests or objectives. In India, for example, substantial support for the establishment of The Ministry or New and Renewable Energy (MNRE) was generated by politicians and the private sector concerned with energy security after the occurrence of two oil shocks in the 1970s (MNRE, 2015). However, the impact of the MNRE was insufficient until combined with actors concerned by environmental issues (Spratt, et al., 2014).

4. The Chinese and Indian Context

Solar energy policy has experienced exponential increases in global deployment for the last decade. In 2013, the world increased new solar PV capacity more than for wind power capacity for the first time ever and solar PV and hydropower have been circumscribed in global new capacity, each accounting for approximately one-third of new RET capacity (Ren21, 2014). The global cumulative installed capacity of solar PV exceeded 139 GW in 2013 (Ren21, 2014). Solar has been the source of consideration from many governments around the world, including China and India and is currently under rapid development. By the end of 2013, China and India were amongst the top countries for total non-hydropower total installed renewable capacity (Ren21, 2014).

For the last decade, China and India have both tediously promoted the deployment of solar energy technologies. China, experienced impressive installation capacity growth, accounting for nearly a third of the total globally added solar PV capacity added. China and India are both
abundant in solar resources with China receiving a daily average of 4 kWh/m² day of solar radiation and India receiving an average of between 4-7 kWh/m² day of solar radiation (MNRE, 2012; Zhang & He, 2013).

Although China has achieved impressive economic development in an exiguous time period, it is still considered to be a developing country. For China, economic, environmental and energy issues are all amplified by its population and stage in development. China’s contribution to global carbon emissions plays an indisputable role in the future of international security and prosperity, and the state of the global climate. As such, there is an imperative from a security, foreign policy and climate perspective to better understand China’s climate security challenges, response drivers, and their potential impact on regional security.

A large percentage of the world’s poor come from India, which makes development a crucial issue. India is the world’s second most populous country, is amongst the world’s fastest growing economies and it is still an emerging economy. The significance of renewable energy in India is reinforced by the concern for resolving energy poverty, in order to achieve the development goals of the nation (Bhide & Monroy, 2011). Reducing poverty will increase India’s energy demands, which in combination with the country’s eagerness for energy security emphasises the need to explore low-carbon alternatives to achieving these goals.

4.1 The Context of Solar Energy Policy in China

Development throughout the Anthropocene has been heretofore unprecedented and unrivalled by any other comparable period of history. The majority of this has been dominated by a single economic superpower, however, this power is being increasingly challenged most recently and most compellingly by China. China is such a conceivable rival for a number of reasons. The country has the world’s largest population, has a vast territory, is the world’s largest economy (in terms of purchasing power parity), is the worst polluter and invests the most in renewable energy (Flanders, 2012; Rapoza, 2014; Economist, 2013). Any of these reasons alone would be reason in itself to develop an interest for an informed understanding of the state of affairs in Chinese society.

The governmental actors at the ministerial level have dominated the renewable energy policy-making processes. The structure of the governance arrangements in the renewable energy power sector in China is an intertwined network of systems. These governmental actors are involved in formulating, implementing and assessing the development of policies to facilitate the deployment of RETs. The state council is the highest level actor in the formulation and development of energy policy (Spratt, et al., 2014). However, the department that is responsible for the implementation of a particular policy frequently is responsible for drafting specific policies for that sector (Zhang, et al., 2014).

For the purposes of this thesis the State Council, the National Leading Group on Energy Saving and Pollution Reduction, the National Development and Reform Commission and the National Leading Group on Climate Change are at the highest level of solar energy policy making and implementation. The central government maintains strict control over policy design. As climate change has emerged as an important issue, it is increasingly under the control of China’s senior leaders (Williams, 2014). The National Development and Reform Commission is central governmental agency that is the core policy coordinating actor in the policy network (Spratt, et al., 2014).

1 For a detailed overview of the renewable energy policy governance structures in China please see Appendix 1 on page 52.
The National Energy Administration (NEA) is at the median level of the governmental agency policy making hierarchy. The NEA was established in 2008 to formulate and implement energy development plans and industrial policies (NDRC, 2015). However, responsibility for energy development is under the framework of the 12th national Five-year plan and, as such responsibility for energy development responsibilities is still spread across different governmental departments. Consequently the NEA lacks the power to perform its assigned responsibility (Zhihong, 2010). Responsibility for the cooperation, exchange and coordination of renewable energy policy are delegated to the lower levels of the governmental agency policy making hierarchy. As such, these aspects of renewable energy policy tend to be designed around relevant programs and policies.

Local governments have been administered with the governance of policy incentives for RETs in a further attempt to decentralise energy decision making (Spratt, et al., 2014). The decentralization of energy governance to local governments and officials stimulates local economic growth. However, simultaneously, the further diffusion of RET responsibility weakens the authority of the central government, which results in inconsistency, conflict and ambiguity of policies. The central government has introduced policies to mitigate these weaknesses, which do improve efficiency and reliability but are time consuming and complex.

4.2 The Solar Energy Sector in China

China’s reliance on non-renewable energy sources is increasingly at risk (Downs, 2004). As non-renewable energy sources become scarcer and more costly, innovation becomes increasingly challenging. China’s reliance on non-renewable energy threatens its international standing, commercial activity and development. Therefore, it is important for China to reduce reliance on non-renewable energy sources, not only for China to meet climate change objectives, but to ensure China’s energy security and to reduce risk associated with resource scarcity.

China’s improvement of living standards, impressive economic growth and rise of its global stature in the last thirty year can be attributed to the dismantling of the Maoist economy (Keng, 2006). Since the disestablishment of Maoism, the poverty rate in China has decreased from 85% in 1981 to 15.9% in 2005, which accounts for 90% of the entire world’s poverty reduction for the same time period (Shah, 2011). Furthermore, the fervent endeavour to reconcile social imbalances, improve access to education and healthcare, and to expand social protection is concentrated on in China’s 12th Five-Year Plan (2011-2015) (Azuela, et al., 2014). As an economy advances and poverty rates are abated, energy needs rise significantly (Zhang, 2009). As China continues to achieve impressive economic growth and social progress, energy is becoming increasingly important (Hrayshat, 2007).

The Chinese solar PV industry expanded rapidly during the 11th Five-year Plan (2006-2010), prior to this, China maintained an insignificant Photovoltaic module manufacturing capacity of 5 MW, most of which did not meet modern international standards and, as such, for the last decade of the twentieth century the actual production of Chinese solar panels was only 1.4 MW (World Bank, 1996). At the end of 1994 there were only 3 MW of solar PV systems in use in China, of which approximately one third were in dispersed household systems. This improved marginally prior to the economic crisis and China’s solar power consumption reached nearly 10 MW, which was a diminutive fraction of the country’s total electricity consumption of 2.83 billion MW (Tschang, 2007).
The output of Chinese solar PV cells increased dramatically over the last decade, incited almost entirely by international demand. The solar industry instantaneously became one of China’s few internationally competitive technology industries with 98% of Chinese domestically produced solar panels being exported (Bo, 2012). China became the largest producer of solar panels in the world in 2008, when it accounted for one-third of worldwide total cell shipments, shipping 26,000 MW peak of PV panels (Zhang & He, 2013).

By 2012, China’s PV module manufacturing capacity reached 37 GW, which represented 37% of the world’s total (Zhang, et al., 2013). However, since the financial crisis of 2008, a diminution of the foreign market resulted in a sudden incremental overcapacity issue for Chinese PV manufacturers. A plethora of Chinese solar panel manufacturers went bankrupt in a short time, including the Chinese solar panel giant Suntech (Bradsher, 2013). The diminution was exacerbated in 2011 by the cut of solar incentives by Germany and other European countries and by anti-dumping, anti-subsidy and countervailing investigations against Chinese solar panels (European Commission, 2013).

The dramatic increases in PV manufacturing and the modest development with regards to PV power deployment have arisen as the result of an amalgamation of different policy programs. These solar PV policy changes, since the mid-1990 have been driven by both internal and external influences (Zhang & He, 2013). Internally the Chinese government recognised the need to support this critical growth industry with domestic demand and, externally the international financial crisis. Since 2011, a series of incentives have been implemented by the government to improve China’s domestic solar installed capacity.

4.3 The Context of Solar Energy Policy in India

Energy policy in India concentrates on providing a strong structure for rapid industrial growth, which provide modern energy services to the populace and attempt to mitigate climate change (Ahn & Graczyk, 2012). To resolve these energy challenges, India relies on an institutional framework that spans six different ministries, of which the Ministry of Power (MoP) is the largest and the Ministry of New and Renewable Energy (MNRE) is the smallest2. The responsibility for policy making is shared between the federal and state-level governments (Chaudhary, et al., 2014).

At the federal level the responsibility for power sector legislation is held by the Ministry of Power (MoP). The MoP functions through several publicly-owned firms that are delegated with duties. Although since the 1990s there has been a movement towards deregulation and private sector participation in the power sector, the MoP owned firms and state government owned firms maintain market monopolies of energy production, distribution and transmission. However, the majority of renewable energy generation capacity is owned by private companies (Spratt, et al., 2014). Both at the federal and state level, the public-sector operations are the instruments for energy production, distribution, transmission and deployment.

Similarly at the state level, the legislative power for power generation, transmission and distribution policy and deployment is held by the state department of energy, which operates in parallel to the MoP. The administerial responsibility within each state is the purview of the concerned ministry and the state-owned electricity boards that oversee generation, transmission, and distribution (Chaudhary, et al., 2014).

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2 For a detailed overview of renewable energy policy governance structures in India please see Appendix 2 on page 53.
The MNRE was established as an independent ministry in 1996 to develop and deploy RETs to supplement the energy requirements in the country. Additionally, the MNRE coordinates with other ministerial agencies to extend subsidies, tax breaks and other provisions for renewables. At the state level, the MNRE is facilitated by Energy Development Agencies which are responsible for technical assistance in developing RET policies and disbursing federal funds in the form of the aforementioned incentives.

4.4 The Solar Energy Sector in India

Since the 1990’s, India’s strategy has transformed from a national oriented, seeking self-reliance with distinct socialist policies and regulation to a strategy that encourages increasing market orientation and international participation (Spratt, et al., 2014). A number of sectors were de-regulated, financial and fiscal reforms were introduced, trade barriers reduced and incentive to foreign investors provided in order to encourage competition and private-sector participation. The consequence of this has seen a decline in poverty rates, an increase in the number with access to electricity and a steady rise of GDP.

The development of solar energy began in 2008 with the establishment of the Jawaharlal Nehru National Solar Mission (NSM) part of the MNRE (Ummadisingu & Soni, 2011). The NSM is a supply-side approach that aims to significantly increase the share of solar energy into the energy mix (Ahn & Graczyk, 2012). The NSM proposes and implements initiatives that encourage developers and is responsible for commissioning grid connected solar power projects in India. Thus, the primary impetus to develop solar energy capacity in India was a top-down decision. The governmental motivation for investment and endorsement of the solar sector originates from a recognition of the potential for the widespread application of solar energy technologies in order to meet future energy demand and to develop a competitive manufacturing sector (Kumar, 2015).

Recent research suggests that India is favoured with a perfect storm of factors for the development of solar in the country. The solar power potential of India has been determined to be 749 GW (MNRE, 2014). Furthermore, renewable energy is reportedly competing with fossil fuels, even without the added benefits of subsidies (Mittal, 2014).

However, there have been a number of issue associated with the implementation of solar energy policies in India. In particular there have been issues with infrastructure, domestic content, investment, and consistency of policy. The issue relating to infrastructure applies particularly to solar projects that are situated in the desert, dust can reduce energy output by up to 30% and as such it is essential that there is a water supply, with which to clean the panels (Sharma, et al., 2012). The domestic content and consistency of policy issues are both in regard to internally inconsistent, or even contradicting, policies that occur as the government attempted to achieve multiple policy objectives with one policy instrument. For example, the NSM’s primary objective is to increase solar energy deployment in India, however, it stipulates a mandatory domestic content for solar projects that intends to nurture a domestic solar industry but damages solar deployment by increasing costs (Ahn & Graczyk, 2012). Investment issues are associated with the solar energy auctions, the decreasing prices of projects could be attributed to technological innovation and capital cost reductions, however, and it could just be competitive bidding that result in incomplete or inefficient projects.

5. Methodology

For the purposes of this research, a Program Effects case study approach is taken to examine the sustainability of solar energy policy in China and India, and the impacts that different policy approaches have had on these two countries. The Program Effects approach investigates
causality and it involves the collection of a variety of different types of data (Morra & Friedlander, 1999). It endeavours to explain the relationship between different components of a policy.

The information and information supporting the development of the solar energy sector in China and India has been gathered from primary source information released directly by the Chinese and Indian governments, and from secondary source literature on the Chinese and Indian solar energy sectors, which includes but is not limited to news articles, articles from solar energy publications, and conference presentations. The same research tools are used in the case studies to systematically compare the manifestations of phenomena in two countries, over time (Hantrais, 2009).

Attempting to achieve an indisputable and conclusive consensus of a definition of case studies has proved to be fruitless. Each author presents a different definition of the concept of case studies (Morra & Friedlander, 1999; Boix & Stokes, 2007; Swanborn, 2010). A probationary definition of a case study is suggested by Morra & Friedlander (1999, p. 3) who propose “a method for learning about a complex instance, based on a comprehensive understanding of that instance obtained through extensive description and analysis of that instance taken as a whole and in its context.” To further clarify an understanding of case studies, the fundamental characteristics of case studies tend to exclude: studies that are specific to one exact moment and methodologies that involve manipulation or isolation from a natural context. For example, laboratory experiments because these tend to be isolated from the natural context.

This research applies an intensive approach, which, focuses on only a handful of instances in order to study phenomenon in depth. These case studies are decidedly context specific to study each instance in great detail and to provide profound insight into the context of these cases. The cases are followed over time by repeatedly measuring the variables, which helps to describe and explain; the changes during the study, the history and the complex structure of the phenomenon (Swanborn, 2010). Intensive approaches provide tentative ideas regarding the phenomenon studied, based on knowledge regarding the two countries and the solar energy policy implemented in both countries.

This largely qualitative study will focus on two areas of data. Firstly, Case Study 1 monitors the evolution of solar energy policy in China and India over time and the impact that this has had on cumulative installed capacity in each country. This is intended to provide insight into the general environment of solar energy deployment policy and the impetus for increasing installed domestic capacity within each country. Additionally, Case Study 1 intends to elucidate a number of factors, including; the level of resources available, the priority attached to solar deployment, leadership willingness, global pressure to transition to low carbon energy sources and commitment to the development of the solar sector. Secondly, Case Study 2 monitors the specific instance of the implementation of solar energy auctions over time, the pathway of development and the general feasibility of the solar policy in each country. This case study is intended to provide insight of a specific solar energy deployment policy. Case Study 2 will allow for a more in-depth examination of the implementation and the impact of single specific solar energy policy.

It is not intended that conclusions should be formed about the global effectiveness of solar energy auctions or the development of solar energy policies on the basis of this study. However conclusions can be drawn on the impact of differing policy pathways of development, political models and implementation eagerness have had in China and India.
As more than one case study has been selected for this research, a tentative theory of the sustainability of solar energy policy in each country will be proposed when the results of the first case study are known. A second theory will be suggested when the results of the second case study are known. The two theories will be compared and it may be that these two theories support each other, or it may be that these two theories need to be adjusted or reconstructed.

The integrity, validity and reliability of the case studies will be explored through the implementation of five somewhat overlapping tools: application, reliability, external reliability, internal validity and, external validity (Miles, et al., 2014). Firstly, application ensures adequate operational measures for the concepts investigated (Emory & Cooper, 1991). In this thesis the application is preserved by conducting a literature review and using multiple sources of evidence (Marshall & Rossman, 1989).

Secondly, reliability refers to the extent to which the study is consistent and stable across time and researchers. To attempt to ensure the reliability of this thesis, the research questions are clear, the basic paradigms and analytical constructs upon which this research has been formulated are specified and, data quality checks have been made. Thirdly, external reliability is concerned with the relative neutrality of research. To ensure the external reliability of this thesis, the methods and procedures of the study are described in enough detail to be audited by outsiders, competing hypotheses are considered wherever possible and all figures and tables are carefully referenced, so as to be available for reanalysis by others (Lincoln & Guba, 1985).

Fourthly, internal validity is the ability for the findings of a study to accurately describe reality (Hoepfl, 1997). The internal validity of this study is established by unambiguously distinguishing the units of analysis and the analysis is linked to theory and the literature (Yin, 1993). Finally, external validity is the extent to which the study can be generalised across different settings (Hoepfl, 1997). The external validity of this thesis is increased through the use of multiple case studies, which could, through replication logic improve the data analytic generalisations. However, replication logic is a limited instrument, as discussed in the disadvantages of case studies (p. 15). The extent to which the results can be generalised in other contexts is an open question that can only be answered by complementary case studies.

5.1 Advantages and Disadvantages of Case Studies

The case study research method has a variety of advantages. Firstly, case studies allow detail, which would not be easily obtained by other research designs, to be collected (McLeod, 2008). The data that is collected is normally more insightful than through other research approaches. Secondly, the research design measures the relevant variables at several moments, and simultaneously monitors changes in the environment, which is an advantages over static surveys. Insight into successive events and conditions is much favoured by longitudinal research compared to transversal research (Swanborn, 2010). Thirdly, the more that the observation of the phenomenon occurs the greater the chance that the theory that derives it is valid (Odell, 2001). A review of phenomena that has already been analysed can uncover alternative perspectives that cause a revaluation of an existing interpretation (McKeown, 1999).

This comparative case study of China and India represents two significant contributors to the future of energy, climate change, policy development and solar energy investments and endorsements. China and India have taken decidedly different approaches to the development of the solar energy sector. The different scales of energy consumption and anticipated future
development of solar in these countries indicates that these two cases represent two of the most significant instances of technological leapfrogging. Discerning the differences in the approaches between these two countries could have wider applications for the development of the solar energy sector in other developing countries.

There are several disadvantages that comparative case study methods provide relative to other research approaches. Firstly, although this research is macro-level, the data cannot necessarily be generalised more widely to other cases, in other countries. Different countries at different stages of development will have different energy objectives and whilst China and India are industrialising countries they are categorized as rapidly emerging economies. The GDP annual growth rates for the last five years averaged 8.5% for China and 6.8% for India \(^3\) (Magnier, et al., 2015; Economist, 2015; World Bank, 2015). Many developing countries are increasing solar energy production and capacity, however, China and India are increasing solar energy production and capacity alongside developing robust solar technology industries. While China and India have been selected for this research for a number of valid reasons, it may be that both of these cases are irregular and potentially have little relevance to the development of the solar energy sectors in other countries. That is, despite the significance of the development of the solar energy sector in China and India, they are not representative of the entire diversity of all industrialising countries or even Asian industrialising countries.

In addition to this, the findings of this thesis cannot even necessarily be generalised to account for other specific renewable energy policy in China and India. This research is restricted to focusing on the solar energy sector, which is one specific type of renewable energy technology. For example, the case of solar energy auctions cannot be more widely generalised to provide insight into other alternative forms of renewable energy auction, such as wind energy auctions (Swanborn, 2010). These cases cannot be regarded as unbiased or representative without further examining the same indicators and phenomena in other cases. Proponents of comparative case study research methods suggest that there is much to ascertain from in-depth studies of specific renewable technologies.

Thirdly, the importance of culture, context and access to resources are important factors in the development of the solar energy sector in developing countries and as such, there can be no best-fit of practices, instead there can be lessons learned. Policies, practices and circumstances that have cultivated the solar energy sector in China and India may not be easily duplicated in other countries with different levels of political stability, indigenous technical capacity or access to resources.

A further disadvantage of this comparative case study is that there are factors that are not discussed in this paper. This thesis is not an exhaustive comparison of the solar energy policy development in the two countries, there may be additional factors that have been overlooked that could impact on the data used. One such factor that has been overlooked by this project is intellectual property right. There are different intellectual property rights regimes of China and India. Research has suggested that there is some variance in the relationship between the strength of the intellectual property regime in the recipient country and the preferred mode of technology transfer but overall the relationship is modest (Mansfield, 1994).

Furthermore, this thesis is severely restricted by the data that is available, this could be a significant source of bias. Moreover, it is important to note that China and India are the two

\(^3\) For a comparison of GDP in China and India please refer to Appendix 3.
largest transitional countries and growing economies in the world, however, they are in two entirely different categories in terms of growth, energy use, scale of investment in low-carbon technologies and installed capacity of renewable energy technologies.

6. Justification

This research examines the potential for solar energy policies to achieve the long-term energy security and sustainable development in China and India. The contemporary relevance of the solar industry to emerging economies is apparent by the scales of commitment to solar energy and a recent growth of solar development projects. However, the success of these projects has been varied, perhaps, at least to some degree, dependent on the political structure of the industrialising economy. The motivation for this thesis is an acute awareness that within the renewable energy sector, similar incentives and policies are met with different scales of success or failure and that understanding this phenomenon is crucial for an effective transition to low-carbon energy alternatives.

There are a variety of reasons for selecting China and India for this research. Firstly, there is an assumption that the challenges of poverty and development preoccupy industrialising countries to the extent that consideration for environmental protection is often overlooked (Steinberg, 2001). This is a rhetoric that persists, particularly in the international climate change arena, but that does not necessarily hold true. Thus, it follows that sustainability practices and leadership in low-carbon technology innovation and investment are inconceivable in the developing world. In the two largest coal consuming industrialising countries in the world, it seems even more in implausible that low-carbon energy technologies would thrive.

Therefore, a principal rationale for investigating solar energy policy and solar energy deployment in China and India is to reinforce that this persisting rhetoric is not apparent in empirical reality. China is an emerging economy, is the world’s is the largest emitter of GHGs and approximately 6.3% of China’s population still live in poverty (World Bank, 2013) but, simultaneously, China is the highest investor in renewable energy (Economist, 2013). Similarly, India is an emerging economy, has approximately 21.9% of its population living in poverty and is the world’s fourth largest emitter of GHGs (World Bank, 2013a; CAIT, 2011). Yet, at the same time India’s Prime Minister aims to make India one of the world’s largest renewable energy markets, which will require an investment of $100 billion US dollars and is targeting 100,000 MW of output by 2022 from the current 3,000 MW (Das & Wilkes, 2015).

Presenting considerable evidence that instead of focusing on the challenges that poverty and development present, environmental concerns are increasingly integrated into national development and poverty alleviation strategies (Lewis, 2007). Renewable energy technologies are embraced as a strategy for energy diversification that contributes to energy security, industrial diversification into a global growth sector and improving energy availability, access and affordability (MNRE, 2015). Therefore, if the successful development of the low-carbon industry occurs in the two emerging economies with the greatest dependence on coal, then it should be possible elsewhere too.

Secondly, the significant differences in political systems. China is the world’s largest non-democratic nation in the world. State power within China is exercised through the Communist Party, the Central People’s Government and provincial or local representation. Since 1949 the
Communist Party has been China’s only ruling party and continues to dominate government with more than eighty-two million members (CPC, 2012). Whereas, India is the world’s most populous democracy. India is a federation with a parliamentary system, which is governed by the Constitution of India (India Government, 2015). Thus, posing a unique opportunity to compare policy implementation and endorsement in different political settings.

These comparative case studies have been selected in order to attempt to determine the potential of the solar energy policies and the subsequent policy implementation to achieve the long-term energy security and sustainable development in China and India. These case studies should provide insight to the contribution of various factors to the development of solar energy policies, installed capacity and investment in two of the world’s largest emerging economies. The first case study explores the relevance of different levels of access to resources, leadership willingness, demand and international pressure on the development of solar energy policies, installed capacity and industries in China and India. The second case study attempts to develop an understanding of the effect that the different political systems and agendas have on development of solar energy policies, installed capacity and industries.

The contemporary neoliberal economic paradigm poses an unrivalled threat to sustainable development. The environmental costs that have occurred as a by-product of the neoliberal paradigm is fundamentally the consequence of the vast discrepancy between the intrinsically open-ended nature of development and the finite quantity of natural resources and services available (Sachs, 1999). The neoliberal system provokes society’s infatuation with material possessions and a predisposition for overconsumption but ignores the scarcity of natural resources.

Scrutinising the neoliberal paradigm provides insight into the impact of humanity on ecosystems, biodiversity and the environment. The neoliberal discourse has distorted the understandings of the concept of development, which consequently has become politically loaded (Esteva, 2010). Arguably, prevailing perceptions of development originate from Harry Truman’s inaugural speech, in 1949 (Sachs, 1999). The speech was intended to discretely emphasise American post-war hegemony to reinforce the notion that America was at the top of a hierarchy in which all countries were endeavouring towards homogenous progress objectives. The concepts of developed and underdeveloped became updated representations of colonial discourses that depicted the North as “advanced” and the South as “primitive”. The connotations of which are that countries which are less economically developed must strive in order to “escape from the undignified condition called underdevelopment” (Esteva, 2010, p. 2). Thus, somewhat superciliously, Truman imposed the Western model of development on to the entire world, without consideration to history, culture or rationale (Sachs, 1999).

Historical responsibility for global climate change is with industrialised countries, who remain the largest greenhouse gas polluters and who have done little to abate this (Wei, et al., 2012). However, this research does not intend to explore the issue of historical emissions, the subject of industrialised countries externalising production nor the topic of consumption. These are important and complex issues, however, the discussion of such issues could be an entirely different thesis of its own. This thesis is concerned with China and India, not as a conscious effort to ascribe responsibility but merely because China and India account for approximately one third of the world’s population. This is one third of the population that will shape the future as well as experience it. Regardless of attempting to ascribe responsibility, the transformation to a global green economy will require technology transition in both industrialised and industrialising countries. After all, China and India are still developing, it is estimated that by
2020 emerging economies’ cumulative emissions of greenhouse gases will be greater than those from rich countries (Jervey, 2013).

The two countries have been selected because they have achieved tremendous technological progress and development in the renewable energy sector in recent years. China and India, in particular, have quickly established significant technological capabilities in the low carbon energy sector, such as solar, wind and hydroelectric. It is apparent that there is a genuine possibility that these two emerging economies could develop their own pathways to development and leapfrog into a low-carbon economy.

7. Policy Framework Assessment Criteria

This research is concerned with the assessing the extent of the potential of the solar energy policies and the subsequent policy implementation of China and India to achieve the long-term energy security and sustainable development of China and India. Therefore it is important to identify a framework of comprehensive criteria and indicators that can be applied to case studies of China and India that assess renewable energy policies. This thesis has a particular focus on application in industrialising countries, an area which, in the past, has been little researched. However, the IRENA has produced a report that investigates the criteria and indicators implemented to evaluate renewable energy deployment policies (Nicholls, et al., 2014). IRENA is an intergovernmental organisation, which facilitates countries in a transition to a sustainable energy future (IRENA, 2015).

IRENA was created with the intention of fulfilling a global gap in the development of renewable energy sources. IRENA was established in 2009 by 75 nations of the world that signed the IRENA Statute to cultivate a new organisation aimed at advancing the deployment, implementation and development of renewable energy (Etcheverry, 2011). As of April 2015, 140 States including the European Union are members of IRENA and another 32 countries had applied to be signatories, and their applications were under process.

The report provides an extensive framework for assessing the long-term sustainability of renewable energy policies: “Evaluating Renewable Energy Policy: A review of Criteria and Indicators for Assessment” (hence after IRENA report) (Nicholls, et al., 2014). The IRENA report explores existing literature regarding indicators of policy success for renewable energy deployment. The report identifies four crucial criteria for evaluating government policy. The criteria that are identified are: effectiveness, efficiency, equity and institutional feasibility. Each Criteria identifies indicators and methods that can be implemented to conduct an evaluation of the long-term sustainability of renewable energy policies.

Solar energy deployment is becoming increasingly important for sustainable energy production and to improve the share of renewables into the global energy mix. The release of the IRENA report in 2014, offers a comprehensive framework for evaluating renewable energy policy. The IRENA report, conducts a thorough literature review to identify four important criteria and indicators to evaluate renewable energy policy.

The regular evaluation of renewable energy policy is important. One reason for this is that policies involving significant financial support need to be carefully monitored and controlled (IRENA, 2012). In 2014, $26.5 billion was invested into solar energy projects and new capacity of solar installations increased by 32% (Marcacci, 2015; Ren21, 2014). The solar sector is becoming increasingly attractive to investors based on low risk attractive dividend yields (Marcacci, 2015). Furthermore, continuous evaluation facilitates the efficient identification of opportunities to improve and adapt policies (Nicholls, et al., 2014). This is
especially important for long-term support policies because conditions can change radically in unexpected manners over time.

Thus it is crucial to develop solar energy policies that are increasingly appropriate to the objectives of sustainable development. The IRENA report provides a comprehensive overview of renewable energy policy evaluation criteria that incorporates the most widely applied and discussed indicators and criteria (effectiveness, efficiency, equity and institutional feasibility). The IRENA report adopted a hybrid structure of system review to best suit energy policy evaluation and research purposes. IRENA established and introduced its constructive and innovative way of renewable energy policy evaluation with four important criteria.

7.1 Effectiveness

For the purposes of this thesis, effectiveness is defined using the Intergovernmental Panel on Climate Change’s (IPCC) Special Report on Renewable Energy Sources and Climate Change Mitigation definition, as “the extent to which intended objectives are met, for instance the actual increase in the amount of renewable electricity generated or share of renewable energy in total energy supply within a specified time period” (Mitchell, et al., 2011, p. 883).

Effectiveness indicators provide a simple indicator for the successful deployment of RETs. These simple indicators that can be effortlessly employed, include cumulative installed capacity and electricity generated. Cumulative installed capacity is the most straightforward and most common metric implemented for assessing the effectiveness of renewable energy policies (Nicholls, et al., 2014). As such, a comparison between countries provides a means to assess relative success. Furthermore, the minimal data requirements and simple implementation with little requirement for specialist knowledge mean that these simple indicators have obvious benefits.

However, simple indicators do not account for numerous variables, such as, differences in resource potentials. Furthermore, the potential or aspirations of a country are not factored in to calculations nor, is any consideration given the probable future development of RETs in a country.

There are more sophisticated measures of effectiveness, such as the ‘effectiveness indicator’ and the ‘deployment status indicator’, however, these indicators produce considerable data and processing requirements that make use for this thesis and in lower income countries more challenging. Furthermore, given the limited nature of the data available, especially for China, it is apparent that for the appropriate application of these more complex methods, first hand data is necessary. Thus, for the purposes of this thesis, only the simple indicators will be used.

Effectiveness indicators offer limited explanatory insights, these indicators are merely a means to track deployment. Effectiveness indicators provide little insight as to why deployment was successful, whether it will continue in the future, or how economically efficient or socially acceptable deployment was perceived to be. Recording deployment is a first step to assessing effectiveness, but alone it is not enough to assess the long-term sustainability of a countries solar energy policies.

7.2 Efficiency

The IRENA Report suggests that the efficiency of renewable energy policy is primarily concentrated on evaluating the economic efficiency of a policy in terms of the resources expended in delivering renewable energy (Nicholls, et al., 2014). For the purposes of this thesis, efficiency is defined as the “ratio of outcomes to inputs, for example, renewable energy targets
realised for economic resources spent, mostly measured at one point of time, and also called cost-effectiveness” (Mitchell, et al., 2011, p. 883).

The static efficiency of a policy is measured relative to capacity, in terms of United States Dollars per MW (USD/MW), and given that different RETs have significantly different cost profiles, should be qualified by technology type (IRENA, 2012). However, this indicator of efficiency is focused on the short-term and ignores changes that occur over time, most notably cost reductions. This focus on short-term static efficiency can conflict directly with the long-term efficiency of a policy (Nicholls, et al., 2014). For example, if expensive RETs are subsidised in the short-term because of a perceived potential for cost reduction in the long-term. In the short-term costs would increase and could be determined to be economically inefficient in comparison to simply supporting cheaper RETs. The efficiency of a particular RET varies through time due to technological innovation and the forces of completion.

The generation costs of renewable energy can alter in unanticipated ways, therefore an efficient renewable energy policy must maintain a degree of adaptability. Furthermore it is important that RET subsidies avoid over-compensating generators whilst continuing to incentivise RET deployment, as over-compensating generators results in overly increasing a markets appeals and causes distorted cost valuation. The challenge of balancing the degree of incentive with the degree of financial attractiveness is apparent in policy creation and implementation.

Understanding contingent factors that explain policy efficiency are important to understanding the long-term sustainability of a policy. Successful renewable energy policies must be comprehensive, sustained and implemented against a background of strict but reasonable objectives (IRENA, 2012). These criteria increase investor certainty. This is important because as the investment risk of a project is reduced, then investor certainty increases, and as a result it becomes cheaper to raise finance for RET deployment. Furthermore, the previous success of a nations deployment policies at differentiating technology ensures that costs are reasonable.

### 7.3 Equity

Defining, evaluating and assessing the equity of a RET policy is a contentious task. There are a variety of methods to evaluate the equity of a RET policy, but there are two consistent themes that arise; the allocation of revenues and expenditures by the support mechanism and the polluter pays principle. The allocation of revenues and expenditures by the support mechanism expostulates that low-carbon energy systems are the reference point for a sustainable transition from fossil fuels (Verbruggen & Lauber, 2012). The polluter pays principle assigns the responsibility for the transition to RETs primarily to industrialised countries and legitimates the obligation of existing power companies to pay the costs (UN, 1992).

Additional methods to evaluate the equity of RET policies include; the distributed impacts across different groups, or the fairness of the design of the policy or, the impact on stakeholders and their participation in the development of the policy. A consensus on a single comprehensive interpretation of a policy’s equity has yet to be achieved and as such interpretations of equity remain diverse (Vaillancourt & Waaub, 2004; Mitchell, et al., 2011). However, for the purposes of this thesis equity is defined as the “incidence and distributional consequences of a policy, including dimensions such as fairness, justice and respect for the rights of indigenous peoples” (Mitchell, et al., 2011).

The distinct lack of a consensus with which to judge the equity of RETs means that it is difficult to determine a method by which to assess the equity of RETs. The diverse interpretations of equity include discussions of fuel poverty and the equity of RETs in the context of GHG
reductions, especially in regard to the distribution of mitigation and adaptation costs of climate change. Given the interdisciplinary nature of the impacts of climate change attempting to contextualise GHG emissions reductions and the factors that influence equity are even more extensive than those directly related with renewable energy deployment.

A quantitative approach for evaluating equity in energy access has been developed by the IEA in order to understand the function of energy in human development (IEA, 2012). The Energy Development Index (EDI) tracks progress in a country’s transition to the use of modern fuels. The EDI is composed of four indicators, including; electrification rate, per-capita residential electricity consumption, share of modern fuels in residential total final consumption, per capita services electricity consumption and share of economic energy uses in total final consumption. The contribution of a RET deployment policy towards energy access rates within a country can be calculated by longitudinally tracking these indicators.

### 7.4 Institutional Feasibility

Institutional feasibility is the impact of political factors on policy support, that is, the appropriateness of a nations institutions and the human and institutional capacity that is required to implement and supervise policy driven interventions (Nicholls, et al., 2014). For the purposes of this thesis institutional feasibility is defined as the “extent to which a policy or policy instrument is seen as legitimate, able to gain acceptance and able to be adopted and implemented” (Mitchell, et al., 2011). Institutional feasibility considers the specifics of a specific policy in conjunction with the political, economic and administrative environment in which the policy functions. As such, indicators of institutional feasibility are incapable of estimating the institutional feasibility of a policy in isolation, rather they facilitate the development of a multifaceted understanding of the intuitional environment and its interactions with policy.

There are a diverse range of issues that can be considered pertinent to institutional feasibility, however the indicators that are selected for evaluation varies significantly according to the resources available to conduct the evaluation, the objectives of the evaluation, any preconceptions of the institutional environment and the nature of the policy under review (Nicholls, et al., 2014). Four significant themes emerge from institutional feasibility policy indicators, these include; political viability and organisational capacity indicators; endogenous and exogenous indicators; rules, governance structures and characteristics of actors indicators; and, capacity levels and observation fields indicators (Nicholls, et al., 2014).

Political viability and organisational capacity indicators are divided to represent the public acceptability and the potential organisational capacity available to implement it. Endogenous indicators relate to the complexity of instruments that affect the transparency and predictability of compliance to a policy, whereas exogenous indicators refer to the conditions and prerequisites that required for a policy to be implemented successfully (Verbruggen & Lauber, 2012). Rule and governance represent the existence, appropriateness and design of the context of a policy, whereas, characteristics of actors are the beliefs and values between actors (Theesfeld, et al., 2010). Capacity levels and observation field indicators categorise observation fields into hierarchical capacity levels.

Institutional feasibility is crucial to the performance of a RET policy. The successful implementation of a policy is not possible without institutional feasibility, regardless of the effectiveness, efficiency or equity of a policy. Policies that are implemented or designed without consideration for the institutional feasibility conditions may not perform as anticipated. In industrialising nations relatively limited institutional capacity and uncertain political climate
determines that institutional feasibility is a deciding factor of the effectiveness, efficiency and equity of policy (Nicholls, et al., 2014).

8. Results of the Comparative Case Studies

Having examined the introduction, background, solar energy policy and deployment background, the Chinese and Indian context, methodology, justification and policy framework assessment criteria, an account of the findings will be described. Case studies of the solar energy sector in China and India are undertaken to address the research questions discussed in Section 1. This section takes a comparative approach and organises them into the following case studies: periods of solar energy policy development and investment to expand domestic installed capacity and; the implementation of solar energy auctions. For each case study, examples from each country are examined and compared.

8.1 Case Study 1: Periods of Solar Energy Policy Development and Investment to Expand Domestic Installed Capacity.

Since the early 2000’s solar has been the fastest-growing renewable power technology worldwide. In 2000, the global total installed capacity of solar PV was a mere 1.5 GW, in 2014 this figure had increased significantly to 177 GW (IEA, 2015). In 2014, the solar PV market grew by 38.7 GW. Both India and China were amongst the top countries for solar and in general the Asia Pacific region was responsible for a contribution of 60% to the global increase in solar installed capacity. Chinese solar installations appear to be stabilising, with 10.6 GW of increased capacity in 2014 (Business Standard, 2015). In 2013, China invested more in renewable energy than all of Europe combined (Frankfurt School of Finance and Management, 2014). However, India has made a recent commitment to solar recent, the country’s installation number for 2014 was 950 MW, which is a 56% increase in installed solar capacity (Chadha, 2014)

At the turn of the twenty-first century new investment in the solar sector was small in comparison to other clean energy sectors. Despite extensive resources, Hydropower and wind were prioritised over solar energy in both India and China. There was little interest as to the development of the solar energy sector until the mid-2000s.
<table>
<thead>
<tr>
<th>Year</th>
<th>China</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Under the ninth five-year-plan (henceforth FYP) the government recognised the importance of the involvement of the private sector for the development of the Indian solar sector. Consequently many of the grid-transmission hurdles were tackled.</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>China’s tenth FYP made a commitment to the development and popularisation of clean energy resources, which included solar. The plan targeted a total installed capacity of 80 MW of solar PV.</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>The Township Electrification Program was launched. The plan targeted 688 towns with inadequate electricity access, for construction of solar PV power stations, with a total installed capacity of 20 MW. Under the Tenth FYP Village Energy Security was approved as part of a remote village electrification program. There were about 80,000 un-electrified villages in the country. Of these, 18,000 could not be electrified through extension of the conventional grid. Objectives to electrify more than 4000 of these villages with 5 MW of solar were planned.</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Plans for renewable energy law were set in motion that identified solar as a key area.</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>The Rural Electrification Corporation (REC) is appointed as the nodal agency by the Ministry of Power. Under schemes set-up by the REC, 90% of the capital subsidy for the overall cost of projects in rural areas is provided by the Government.</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>The eleventh FYP contained objectives for the vigorous development of the renewable industry. A Renewable Energy Law was launched, which established national targets for renewable energy and a framework to promotion of domestic installed renewable energy. The MNRE formulates the NSM. The NSM is a major initiative that addresses India’s energy security challenges through sustainable means.</td>
<td></td>
</tr>
</tbody>
</table>
2007
The Eleventh FYP detailed a National Action Plan on Climate Change (NAPCC).

2008
Energy Performance Standards were introduced. Overcapacity of manufacturing capacity becomes a problem. To resolve this, Chinese cities sign PV plant contracts. The NEA initiated utility-scale PV Projects with fixed feed-in tariffs (FiT).

2009
The "Golden Sun" solar stimulus plan is announced in an attempt to wean solar PV companies off dependence on overseas markets. Provincial FiT issued by Jiangsu provincial DRC. Strategy developed for PV industry deployment. The first public bidding for a small solar project is organised by the NEA under the Solar PV Concessions Program.

Large-scale PV Power Station Concession Bidding Projects was formulated to encourage a large scale PV market.

2010
Chinese solar PV manufacturing capacity reaches over 8 GW, accounting for 53% of total global manufacturing capacity. FiT introduced by some provinces. CDB provides more than US $40 billion in support of the domestic renewable manufacturer industry further increasing production capacity.

Phase one of the NSM is launched. The MNRE provides 70% subsidies on the installation cost of a solar photovoltaic power plants in North-East Indian states and 30 percentage subsidies in other regions. The Asian Development Bank commits US$400 million to solar projects but project size is capped at 5 MW. 30 projects are allocated.
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>The twelfth FYP included new policies that support the solar industry. The plan outlined a shift in focus for the solar industry from export-orientated manufacture towards domestic orientated. The CNREC is established. The CNREC assists China's energy authorities in researching renewable energy policy, managing the industrial sector and coordinating policy, law and the grid. A national FiT scheme is launched. MNRE encourages research and development to make the Indian solar industry competitive. The 5 MW cap on small solar project size is increased to 20 MW. The Solar Energy Corporation of India (SECI) is set up under the supervisory control of the MNRE, as a non-profit dedicated to the implementation and facilitation in the solar energy sector. PPAs are now directly signed with SECI. PPAs for the first batch of projects were signed for 610 MW.</td>
</tr>
<tr>
<td>2012</td>
<td>The Chinese government sets an annual installation target of 5 GW of distributed solar power generation per year. Several PV enterprises went bankrupt or were reorganised worldwide. The USA and European anti-dumping, anti-subsidy trade investigation began. The development of the NSM becomes a major initiative Twelfth FYP. The Indian Renewable Energy Development Agency commissions thirty-four small Solar Power Projects.</td>
</tr>
<tr>
<td>2013</td>
<td>Start of Carbon Emissions Trading Pilot schemes. Introduction of solar guidelines to increase quality and improve research and development. Phase 2 of NSM initiated, during which capacity will be aggressively scaled up.</td>
</tr>
<tr>
<td>2014</td>
<td>NEA publishes distributed solar PV policy. The comprehensive policy allows distributed projects to be developed at a faster rate. An emphasis on quality and a planned establishment of nationwide monitoring and reporting systems was also outlined. The NSM sanctions seventy new off-grid solar applications, seventeen of which have already been completed.</td>
</tr>
</tbody>
</table>

*Table 1: The evolution of solar energy policy in China and India. Sources: (Zhang & He, 2013; MNRE, 2014a; Spratt, et al., 2014; Zhang, et al., 2014)*
8.1.1 Analysis of Case Study 1: Periods of Expansion to Increase Solar Domestic Installed Capacity

The importance of energy security has been on the agenda of the Indian government since independence and numerous solar energy initiatives have been implemented in pursuit of that objective, yet, the impact of these initiatives has been marginal. Moreover, a dependence on coal imports remains in India’s electric power sector, which contributes to trade deficits and environmental degradation.

There has long been a recognition amongst India’s leaders of the importance of a renewable sector in achieving energy security, and the significance of a private sector in developing this, however, it wasn’t until 2008 that solar energy was actively promoted with specific policies to support the solar sector at both a regional and a national level. Prior to this hydropower and wind were prioritised over solar energy and investment in the solar sector remained small in comparison to other clean energy sectors. In 2007, there were still over 400 million people in India without access to electricity (IEA, 2007). The electrification rate of urban areas was only 93.1% and in rural areas the electrification was even lower at 52.5% (Arora, et al., 2010).

Thus, the primary impetus to develop solar energy capacity in India was a top-down decision. The governmental motivation for investment and endorsement of the solar sector originated from a recognition of the potential for the widespread application of solar energy technologies in order to meet future energy demand, a recognition of the importance of energy security and desire to develop a competitive manufacturing sector (Kumar, 2015). The cost of renewable energy technology has been the most salient barrier to prevent the diffusion of renewable energy technologies, however, in circumstances in which resources and supply chains are favourable renewables can already compete with fossil fuels, even without the added benefits of subsidies (Mittal, 2014). Furthermore, recent research suggests that India is favoured with a perfect storm of factors for the development of solar in the country. The solar power potential of India has been determined to be 749 GW (MNRE, 2014).

The development of solar energy sector in India began in 2008 with the establishment of the Jawaharlal Nehru National Solar Mission (NSM) (Ummadisingu & Soni, 2011). The NSM is part of the National Action Plan on Climate Change (NAPCC), which proposes considerable investments into the infrastructure and development of the solar sector in India. The NSM proposes and implements initiatives that encourage developers and is responsible for commissioning grid connected solar power projects in India.

According to Abdullah, minister of the MNRE, the objective of the NSM is to technologically leapfrog so that India can become a global leader in the development, manufacturing and deployment of solar energy technologies (MNRE, 2010a). The current cumulative installed capacity of solar energy in India is 3 GW and the NSM has announced the decision to install 100 GW of solar capacity by 2022. Furthermore, the number of people in India without access to electricity has been reduced to 300 million, with electrification rates reaching 94% in urban areas and 67% in rural areas (IEA, 2014).

Similar to India, domestic demand for solar capacity was negligible in 2008. However, whereas, India was only beginning to develop a solar sector, China had already become the largest producer of solar panels in the world, shipping 26,000 MW of PV panels. China had established a globally competitive solar manufacturing sector, which was driven by increases in investment and listings in overseas stock markets. At this time, China’s solar energy industry was entirely driven by international demand; domestic demand was almost none. However, a sudden drop of international demand causing a manufacturing overcapacity, left Chinese solar manufacturers with enormous inventories but not enough demand. Chinese solar
manufacturers were compelled to appeal to the provincial governments that had been instrumental in supporting the rapid expansion of the industry.

The solution was to absorb the excess supply by expanding domestic demand. Further motivation to expand domestic demand came from the “anti-dumping” and “anti-subsidy” investigations, the bankruptcy of several Chinese solar manufacturers, increasing domestic energy demand and supply security concerns at a national level. The forceful advancement of Chinese domestic demand for solar is intermingled with economic instability, trade concerns and national interests.

In 2009, amidst this backdrop, China launched programs to wean the Chinese solar manufacturing industry off a dependence on overseas markets. However, expectations of the programs were not achieved and the programs resulted in discouraging investors, private solar equipment suppliers and energy companies from investing in China’s domestic solar market. Lobbying from the Chinese solar manufacturing industry for better incentives for investing in domestic deployment of solar cells eventually resulted in the launch of a national Feed-in-tariff scheme in 2011.

The launch of first phase of the national solar mission demonstrates the successful implementation of solar policy. The involvement of federal government players and experience from the less successful implementation of policies in the wind energy sector, such as schemes to reduce costs, enabled the government to reduce the financial risk for investors. However, developers circumventing local solar panel regulations and the initial 5 MW cap on project size reduced the efficiency of the form of solar energy available. The 5 MW cap has since been increased to 20 MW.

![Figure 1: Cumulative Installed Solar Capacity in China and India by Year (MW).](image)

Although it was anticipated that there would be a clear correlation between governmental enthusiasm, policy reinforcement and subsequent private sector investment this does not seem to be the case. Despite the longstanding existence of governmental support for renewable energy policies existing, in both China and India cumulative installed capacity of solar remained insignificant into 2009. However, the NSM’s implementation of strong policy and proactive measures since 2009, advanced the total installed capacity, reaching 3 GW in 2015. Furthermore, since the financial crises of 2008, there has been an effort to advance domestic solar deployment and to reduce sectorial dependence on the export market in China. Domestic
cumulative installed capacity of solar has been significantly boosted through the implementation of a number of initiatives since 2009. In 2014, solar capacity in China reached almost 30 GW. However, it is apparent that with regards to strategy, policy and motivations, this matter is not simply as straightforward as examining cumulative installed capacity.

8.1.2 Discussion of case-study 1: Periods of Solar Energy Policy Development and Investment to Expand Domestic Installed Capacity.

The expansion of cumulative capacity of solar energy in both countries seems to be the result of strong policy and proactive measures, based on experience in existing renewable energy sectors, which are specific to the culture and context of each country. The expansion of the cumulative capacity of the solar energy sector in India, was a top-down decision made by the government, however, in China the decision was pressured by the manufacturing sector in need of support. As a consequence of this India suffers from technical barriers, policy barriers and socio-economic barriers in the development of the solar sector. Whereas, China’s problems in the solar sector stem from disunited and uncoordinated planning, implementation and support for the sector and, as such include: the underdevelopment of the domestic market, policy deficiency and capacity surplus. Additionally, the Chinese solar manufacturing sector is confronted with issues of overcapacity.

8.2 Case Study 2: Implementation of Solar Energy Auctions

In terms of cumulative installed solar capacity Case Study 1 indicates that China has increased cumulative installed capacity more than India, possibly as the result of policy. However, Case Study 1 is reflective of the current and past situation in China and India. It is a shallow examination of the short-term results of policy implementation, without a profound examination of the methods, structures and procedures that have motivated these results. Thus, it is apparent that examining the long-term sustainability of existing solar energy deployment policies in China and India is not as straightforward as simply examining cumulative installed capacity. In attempting to understand the long-term sustainability of solar policies a further examination of the implementation of policy will provide insight as to the long-term motivations and strategy of the policies. It could be the case that China has installed ten times as much solar capacity as India, but that these are all in the wrong areas, so that efficiency is greatly reduced or, that in India the solar power production facilities are inferior quality and will collapse after only a few years.

Determining an appropriate initiative to develop solar energy deployment in a country is dependent on a variety of factors. Renewable energy auctions have been an effective method for stimulating investor competition and providing price disclosure, whilst eliciting high levels of investment and offering revenue stability through long-term contracting.

8.2.1 Implementation of Solar Energy Auctions in China.

In China the legal foundation for the pricing system of solar is determined by the Renewable Energy Law (REL) and the regulations it implements. The REL was the result of pressure from the international community to reduce environmental degradation and emissions. The REL was originally intended to be a supporting policy for the introduction of a feed-in-tariff, however, key stakeholders could not reach an agreement on the FiT levels.

Therefore an auction based concession was introduced to support the setting of FiT and establish market-based tariffs (Wang, et al., 2014). The 2009 and 2010 solar energy auctions constituted a price-discovery mechanism for solar energy in an environment in which FiTs had
not been established (Elizondo-Azuela & Barroso, 2014). The auction scheme was implemented prior to a FiT in order to attract international organisations, foster competition among investors and stimulate the development of an incipient domestic solar sector. Solar energy auctions facilitate the compilation of cost information from solar energy project developers in order to establish appropriate FiTs, in which auction prices are used as a proxy for the actual costs of projects. Thus, after two rounds of solar energy auctions in 2009 and 2010, China introduced a unified FiT for grid-connected solar in 2011 (IRENA, 2013). The government was able to determine a benchmark for power generated from solar energy by improving the competitiveness of concessions auctions.

The NEA published the auctions along with the auction instructions. The practical management of the bid is controlled by bidding agencies. In some of the solar concessions, the prices that were bid were lower than the actual construction costs and as a result, some of the awarded contracts were not implemented. This is a reflection of the inexperience of the bidders and the auctioneers, not conducting feasibility studies, lacking data on the potential of the source and not implementing policy that could qualify the legitimacy of bidders.

The evaluation committee is constituted by members of the NEA, state-owned grid companies, provincial development and reform commissions, provincial power companies, bidding agencies and technical experts. The evaluation procedure for the first solar auctions, held in 2009 and 2010, were limited to awarding the contract to the lowest bidder.

8.2.2 Implementation of Solar Energy Auctions in India.

In India solar energy auctions were implemented as a primary supporting mechanism of the NSM. The NSM commissioned reverse-auctions are the primary policy instrument towards increasing solar energy deployment in India (Chaudharya, et al., 2015). The amount that policy makers must contribute to support solar energy deployment is minimized by the use of the auction scheme in which project developers and investors bid the minimum FiT for the development of a solar project. The first solar auctions constituted solar power demonstration plants, to develop pricing mechanisms for determining tariff for solar power in an environment in which prices have yet to be established (MNRE, 2011). The NSM was cogitated to attach greater importance to auction mechanisms in earlier stages due to the nascent solar sector. Incipiently between fifty to a hundred percent of the NSM’s Phase 1 planned grid-connected solar power would be contracted through the NSM Phase 1 centralised auctions. The solar auctions in India additionally intended to ensure technology transfer and that indigenous content was maximised.

The Phase 1 solar auctions priced solar favourably at 17.91 rupees per kWh for solar PV\(^4\), which compares to 3.5 rupees per kWh for electricity sourced from fossil fuels (CCC, 2011). Thus, the revenue of solar power generation in India is over five times higher than the cheapest price mandated for solar power in India. This encouraged an enthusiastic response to the first auction for the NSM. The MNRE anticipated that during Phase 2 of the NSM state policies would account for 60% of solar capacity additions. States were given a greater degree of autonomy to set and implement solar energy policies locally, and auction schemes remain popular among states to ensure solar capacity expansion at minimum cost (Khana & Barroso, 2014). The decentralised scheme has posed a challenge for harmonising policies, improving coordination and sharing best practices among states.

\(^4\) 17.91 rupees is approximately 0.28 USD.
The higher price of solar energy compared to energy from renewable sources is ultimately passed on to the consumer. As such, reducing the impact of solar energy development on electricity tariffs is a major hurdle for both the central and state governments. In Phase 1 of the NSM auction schemes in combination with a “bundling” scheme were implemented to minimise the cost to consumers (Bridge to India, 2012). The auction process closely mirrors price fluctuations and reduces margins to a bare minimum. The bundling of solar energy with unallocated low cost power from federally owned power generators diluted the costs of the more expensive solar energy into a cheaper generation portfolio. The federally owned power generators ensured a reliable guarantee to bidders because the low cost power was provided by a profitable state-owned subsidiary. In Phase 2 a viability gap funding (VGF) mechanism was implemented to dilute the costs of solar energy. The VGF scheme was introduced due to the lack of viable sources for unallocated low cost power sources. The VGF scheme operated through funding from the National Clean Energy Fund and the scheme stipulates that the government pays part of the plant’s capital cost up front and ensures a fixed per unit price for energy delivered for the contract’s duration.

8.2.3 Analysis of Case Study 2: Implementation of Solar Energy Auctions.

In China solar auctions were carried out in 2009 and 2010 under a sealed bid, pay-as-bid auction format (Zhang, et al., 2014). The auction guidelines stipulated that project construction would be completed within 24 months and that exclusive rights to operate the plant for 25 years with an on-grid price would be granted without escalation (Azuela, et al., 2014). Guidelines for the auctions detailing penalties for incomplete projects or non-compliance, pre-qualification criteria and feasibility studies is unclear. The criteria for the selection of the project winner was lowest price wins based for pre-identified sites was used. The Chinese solar energy auctions resulted in a significant reduction in the cost of solar PV electricity.

Whereas, in India solar auctions under the first phase of the NSM used a closed envelope, pay-as-bid auction format with fully disclosed ceiling prices. The NSM Phase 1 auction was a 25-year duration PPA with no escalation clauses (Azuela, et al., 2014). The auction guidelines stipulated additional bidder requirements that included, firstly, a hard domestic content requirement of crystalline silicon solar PV modules to support the domestic solar PV manufacturing sector (JNNSM, 2010). Secondly, to encourage wider participation from Solar Power Developers, only one application per company was permitted for the development of one project. Thirdly, financial criteria detailing the company’s net worth was stipulated, in order to ensure the financial feasibility of the bidding company. Fourthly, technical requirements of PV module for sure in grid solar power plants ensured the quality of the PV modules used in grid solar power projects. Fifthly, the guidelines stipulated that the plant should be designed for interconnection with the state grid. Projects that met the auction guideline criteria were shortlisted and evaluated on the basis of discount to be offered.

<table>
<thead>
<tr>
<th>Country</th>
<th>Time period</th>
<th>pre-qualification criteria</th>
<th>Penalty for delays etc.</th>
<th>deadline (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>2009</td>
<td>Basic</td>
<td>None</td>
<td>18</td>
</tr>
<tr>
<td>China</td>
<td>2010</td>
<td>Basic</td>
<td>None</td>
<td>18</td>
</tr>
<tr>
<td>India</td>
<td>2009</td>
<td>Basic</td>
<td>None</td>
<td>12</td>
</tr>
<tr>
<td>India</td>
<td>2010-2012</td>
<td>Good</td>
<td>Simplistic</td>
<td>12</td>
</tr>
<tr>
<td>India</td>
<td>2013-2014</td>
<td>Advanced</td>
<td>Yes</td>
<td>13</td>
</tr>
</tbody>
</table>

*Table 2: The feasibility of the solar energy auctions and the resulting projects, based on auction guidelines. Sources: (JNNSM, 2010; IRENA, 2013; Khana & Barroso, 2014; MNRE, 2014a; Wang, et al., 2014)*
The efficacy of Chinese solar energy auctions was severely limited. The absence of strict compliance guidelines for projects and a lowest price wins criterion resulted in auction winners that were almost invariably state-owned power providers that could leverage financial support from financial institutions to underbid for solar projects (Azuela, et al., 2014). Furthermore, an environment which favoured the lowest bidder, fostered a situation in which bids were below marginal investment costs as project developers bid below ordinary profit hurdles in an attempt to gain market share (Wigmore, et al., 2011).

The aggressive bidding resulted in auction prices that were lower than industry participants anticipated and was detrimental to the long-term sustainability of these projects, to the achievement of national solar energy objectives and to the future of solar auctions in China. The expectedly low auction prices deterred the development of the solar energy sector. An early recognition from private solar companies that state-owned power providers could not be outbid and that at the prices bid private investors would barely break even, and even far less likely to be adequately remunerated discouraged energy power companies and private solar equipment suppliers from investing in China’s solar market.

However, despite these disadvantages, the solar energy auction schemes were instrumental in the development of large-scale solar projects and local solar industries in China. In the early stages of the development of domestic solar installed capacity 300 MW of solar capacity was contracted through the auction scheme. As such, the solar auction concessions in China have helped to reduce market barriers and encourage the large-scale deployment of solar based electricity in China through incentives and the significant price decreases of solar energy. Solar auctions also served to discover the real price of solar energy resulting in the replacement of auctions by FiT. Furthermore, the auction schemes attracted the attention and investment of international solar companies, fostered competition among investors and enabled the rapid development of solar domestic installed capacity.

Whereas, in India, solar auctions have been efficiently encouraged solar investment and development. Auctions held in the Phase 1 of the NSM achieved prices that made India among the cheapest places for solar power in the world (Khana & Barroso, 2014). However, as opposed to the underbidding that occurred in the Chinese solar energy auction, the Indian government implemented various safeguards to attempt to protect against the risk of under bidding. From the earliest solar auctions the government implemented pre-qualification criterion to ensure the quality of bidders, provided strict deadlines, requested bidding fees and clearly outlined the penalty scheme for projects that were delayed or inadequate (CCC, 2011).

Regardless of the precautions, there have been complications with NSM auction projects and some of the solar projects may not materialise. Of the Batch 1 auctioned projects only twelve out of the thirty fulfilled the predetermined legal requirements for the projects (Altenburg & Engelmeier, 2013). The majority of the delays have been penalised to demonstrate an unambiguous signal of the unacceptability of under bidding. The majority of delays are the result inexperienced bidders’ miscalculations that caused overly low bids. Furthermore there were glitches with executing policy, such as authorizing too many projects to a single project developer or certifying due project progress when investors had made no tangible investment (Altenburg & Engelmeier, 2013). The greatest potential threat to the future of solar auction is perhaps that non-compliance, which delays solar energy deployment and in turn results in a loss of investor, developer, banks, energy supplier and manufacturer trust.

However, in general the NSM solar auctions have been successful and instead of causing the market to derail these issues have been regarded as the teething problems of a maturing market. In Phase 1 of the NSM 500 MW of solar capacity was contracted through the auction scheme.
The Phase 1 solar energy auctions mobilised investors and determined the lowest tariff rate at which investors would pursue solar projects. The solar auctions have established solar energy development on the political agenda and formulated an equilibrium of investors, regulators and technology companies.

The auction format and supporting policy design is the consequence of experimentation and adapting. Guidelines and policies have been modified from the Phase 1 solar auctions to close policy gaps and to increase the long-term sustainability of the solar energy sector. The solar auctions in India have been well designed, with initial small experiments of the auctions that reduced prices, to peak investor interest and identify loopholes in the bidding process that could be eliminated in later auctions (Altenburg & Engelmeier, 2013).

8.2.4 Discussion of Case-Study 2: Implementation of Solar Energy Auctions.

Renewable energy policy implementations require trade-offs, therefore it is important for the implementing country’s core renewable energy objects to be clearly clarified in order to identify areas in which these trade-offs can be made. Furthermore the establishment of a coherent and cohesive long-term plan for the development of solar energy and more generally renewable energy would provide insight as the overall long-term sustainability of solar energy auction projects. Regulatory stability and trustworthiness are crucial to secure long-term investment into a strong manufacturing and developer solar energy base.

The long-term sustainability of solar power projects implemented through the Chinese solar auction schemes is uncertain. The sustainability of the solar projects commissioned through auctions is ambiguous for a variety of reasons: sites were selected by the government, the level of feasibility studies conducted is ambiguous, pre-qualification criterion was severely lacking, the absence of penalties for delays or inadequacies, ineffective governmental entity coordination and the overly generous deadlines (Azuela, et al., 2014). The lack of strict and concise project guidelines raises the issues of long-term efficiency and feasibility of these projects.

The long-term sustainability of solar auction schemes requires the careful design of solar energy policies and schemes. Successful solar auction concessions in China would require the introduction of additional criterion to the project pre-qualification stage and to the project evaluation stage. Additional pre-qualification criterion would involve the introduction of penalties for non-compliance and underperformance, as well as financial credibility assessments of bidders. Project evaluation requirements to ensure the success of solar auctions would include; technical experience requirements, requirements to provide local economic benefits and requirements that ensure the overall efficiency of panels.

It was against a backdrop of auction under bidding and discouraged energy power companies, private solar equipment suppliers and Chinese solar manufacturers which were pressuring the government for better solar incentives, that China launched a nationwide FiT scheme for solar PV. The nationwide FiT attempts to expand China’s domestic solar industry and increase the share of solar power in China’s energy sources (Wigmore, et al., 2011). The Chinese government considered the period of solar auctions in the development of the solar market as an experimental phase for demonstration purposes (Zhang, et al., 2013). The FiTs are better suited to the rapid development of the solar capacity than the auction based schemes. The FiT has more structured guidelines, provides price guarantees to investors and minimises bureaucracy and transaction costs (Elizondo-Azuela & Barroso, 2014).

It is difficult to assess whether India is achieving its strategic policy objects for climate change or to assess the long-term sustainability of solar energy auction schemes in India. India
implements strict guidelines for investors and developers in solar auctions. However simultaneously there has been leniency with the issuing of penalties for delayed and inadequate projects, as well as, a strong focus on short-term price reductions. This can cause energy power companies and private investors to be discouraged from investing in the development of India’s solar energy market.

9. Analysis

The transition to low-carbon technologies is essential to mitigate future climate change. Although there has been a downward trend in investment in low-carbon energy technologies, due to unstable policy frameworks, the solar energy market has experienced unprecedented deployment, due, at least in part, to decreasing per-unit costs (Ren21, 2014). Solar is becoming an important sector in electricity generation in some countries, and in China and India is a substantial part of newly added energy production capacity. Solar PV module prices are beginning to stabilise, efficiency is increasing and production costs are decreasing steadily (IRENA, 2012b).

The analysis of the extent of the potential of the solar energy policies and the subsequent policy implementation of China and India to achieve the long-term energy security and sustainable development of China and India involves an analysis of the two countries within a framework to analyse renewable energy development policies. The IRENA report framework provides criteria and indicators that can be used to analyse renewable energy deployment policies. For the purposes of this analysis the indicators and criteria that are used are based on the data that is available. The criteria are: effectiveness, efficiency, equity and institutional feasibility.

9.1 Effectiveness

The effectiveness of China and India’s solar energy policy is analysed according to the IRENA Report (Nicholls, et al., 2014). The simplest indicator of effectiveness according to the IRENA report is installed capacity (Nicholls, et al., 2014).

9.1.1 Case Study 1: Effectiveness

The effectiveness of solar energy policy in China and India is analysed according to cumulative installed capacity. In the case of examining China and India, this simple indicator has been operationalised, it is not considered that this is the best possible indicator of efficiency, however, given the limited nature of data that has been released by the NEA a deeper analysis of effectiveness is not possible. Effectiveness is a basic indicator. The principle limitations of this indicator are that the aspirations and potential for solar in the two countries are not examined (Ölz, 2008).

<table>
<thead>
<tr>
<th>Year</th>
<th>China Total Installed Capacity (MW)</th>
<th>India Total Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>28,050</td>
<td>2632</td>
</tr>
</tbody>
</table>

Table 3: The cumulative installed capacity of solar in China and India in 2014. Source: (MNRE, 2014a; Defang, 2015).

It is apparent that purely on the simplest effectiveness criteria, China is more than ten times as effective as India, with regards to solar energy policy deployment. Effectiveness indicators provide a simple indicator for the successful deployment of RETs. Therefore based purely on this data China could be regarded as more successful than India for solar energy deployment.

However, this simple comparison fails to take into consideration a number of factors including:
- The amount of solar energy which has been deployed in rural areas where grid connectivity is not feasible.
- Solar curtailment rates.
- The two countries are at different stages of industrialisation.
- The two countries have different energy security objectives, renewable energy priorities, political leaderships, economic situations and external pressures to transition to RETs.

These factors limit the usefulness of installed capacity as a measure of the success of solar energy deployment in a country. However, when examined in combination with the other indicators, the limitations of this indicator are mitigated significantly (IRENA, 2012).

### 9.1.2 Case Study 2: Effectiveness

Solar energy auctions are also analysed according to IRENA report frameworks to evaluate renewable energy policy. Similarly to Case Study 1 the effectiveness criteria will be analysed based on the total auctioned capacity. However, some projects have experienced delays and it is therefore difficult to analyse the final installed capacity. For this reason, for the purpose of this analysis the figures of commissioned solar energy auction capacity will be used instead.

<table>
<thead>
<tr>
<th>National Round of Solar Energy Auctions</th>
<th>China total auction capacity (MW)</th>
<th>India total auctioned capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>10</td>
<td>500</td>
</tr>
<tr>
<td>Second</td>
<td>280</td>
<td>310</td>
</tr>
</tbody>
</table>

*Table 4: The amount of solar capacity that was auctioned. Source: (Khana & Barroso, 2014; Wang, et al., 2014).*

The effectiveness of the first round of solar energy auctions was higher in India than in China, but this gap was already vastly narrowed by second round of solar energy auctions. However, the format of solar energy auctions in China and India were very different. The comparative success of solar energy auctions in India appears to be the result of a structured and researched auction, which was based on previous renewable energy auction experience. By comparison, solar energy auctions were only implemented in China in 2010 and in 2011 the auctions incurred a variety of challenges, which included under-bidding. Subsequently a FiT was introduced in China for solar energy projects. It should be noted that under the FiT scheme in China the total capacity of sanctioned solar energy projects has been greater than the total sanctioned solar energy projects in India. In the first year of FiT alone, 2.5 GW of solar PV was installed in China (IEA, 2014a).

### 9.2 Efficiency

The efficiency of China and India’s solar energy policy is analysed according to the IRENA Report (Nicholls, et al., 2014). The static efficiency indicator that compares total installed capacity with kWh has been operationalised for the purposes of this thesis.

#### 9.2.1 Case Study 1: Efficiency

The distinct ways of generating electricity incur significantly different costs in electrical power generation. The figures that are used in Case Study 1 are taken from an IRENA comparison of different types of energy generation in different countries (IRENA, 2012a). It is therefore important that a mutual currency is used, for the purposes of this study and for the IRENA studies, United States dollars are used as a standard. Further because different methods of
electricity were compared a LCOE was implemented. A LCOE is an economic analysis of the average build cost to build and operate a power-generating facility for the duration of its lifetime divided by the total power output of the asset over that lifetime (Ueckerdt, et al., 2013). The LCOE’s that are examined have been taken from the IRENA research and have been calculated rigorously (IRENA, 2012a).

The findings here are mixed. China’s weighted average LCOE and typical LCOE range maximum are lower than India’s; however India’s typical LCOE range minimum is lower than China’s. Furthermore, the data is somewhat outdated, especially given that the price of solar PV panels has fallen considerably since 2011. More recent data is available for both China and India, however the minimum and maximum LCOE was not available, only the weighted average, which is why it has not been used here.

Figure 2: The 2011, typical LCOE ranges and weighted averages for solar power generation technologies in China and India in terms of USD per kWh. All figures assume a 10% cost of capital. (IRENA, 2012a).

The average weighted LCOE of utility-scale solar PV in China and India from 2011 to 2014 in USD per kWh. Source (IRENA, 2012a, p. 5; Taylor, et al., 2015, p. 36).

Figure 3: Weighted Average LCOE of utility-scale solar PV in China and India from 2011 - 2014.
This would suggest that overall China appears to be more efficient than India in terms of solar policy and solar deployment, however, the price of solar in India appears to be decreasing at a more rapid rate than in China.

9.2.2 Case Study 2: Efficiency

Case Study 2 measures static efficiency relative to capacity, in terms of USD/MW. It is important to acknowledge that a significant challenge for efficiency analysis can be in fully capturing costs. For example, this comparison of two solar auction schemes omits supplementary support mechanisms such as loans, grants and tax credits because data are not available.

Figure 4 indicates that the first solar energy auction commissioned projects in India were more expensive in terms of USD/MWh compared to those commissioned in China. However, by 2011 the cost of commissioned solar energy projects in India fell more significantly than in China. It is important to acknowledge however, that the final figure for figure 4 is based on China’s FiT level in 2014, which is higher in USD/MWh than India’s average 2014 solar auction projects. China’s FiT level has been used as an indication of anticipated solar energy auction price.

Figure 4 demonstrates that solar energy auctions, together with alternative solar energy policies and an enabling framework, has helped to reduce market barriers and encourage the large-scale deployment of solar energy electricity in both China and India. The solar energy auctions in both countries have been instrumental in the development of solar energy deployment: for instance, a total of 1.1 GW of solar energy projects were commissioned through solar energy auctions between the two countries between 2010 and 2011. The auctions also assisted with discovering the real price of solar energy, which for China resulted in the replacement of auctions by FiT. Overall, with regards to the solar energy auction policy, India appears to be more efficient than China.

9.3 Equity

There is little international consensus on the judgement of the equity of a renewable energy policy so it is difficult to develop an internationally applicable indicator. This means that it is not possible to directly comparatively analyse the equity of solar energy policies applied in countries that implement various different distributional criteria. Indicators should reflect the
concept of equity as understood by stakeholders and these interpretations may not necessarily correspond between the two nations. Therefore, in order to provide a quantitative approach to analysing solar energy policy equity in China and India the EDI approach has been implemented.

9.3.1 Case Study 1: Equity

The EDI provides a multi-dimensional indicator that analyses the development of China and India. The first, the household level, two dimensions are analysed: access to electricity and access to clean cooking facilities. The second, the community level, analyses per-capita public services electricity consumption and share of economic energy uses in total final consumption. This approach has been used to attempt to identify the equity of the two countries, however, it was not possible to collect data for some of the areas post-2012, and as such the data in Table 5 is from 2012. Thus, given the recent rapid development that has occurred in both countries these indicators are merely a guideline, they are not to be considered absolute.

For this analysis of equity the focus is on specific criteria, which include: electrification rate, per-capita residential electricity consumption, share of modern fuels in residential total final consumption, per capita services electricity consumption and share of economic energy uses in total final consumption. However, it does not expanded aspects, such as; distribution of costs, impacts on producers and other players, and the remaining issues. The decision to focus on specific criteria and to exclude others is not a suggestion that these aspects are any less important to equity analysis, it is merely a reflection of the lack of feasible alternative quantitative methodological approaches.

<table>
<thead>
<tr>
<th></th>
<th>Country</th>
<th>China</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDI</td>
<td></td>
<td>0.49</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Household level energy access

<table>
<thead>
<tr>
<th>Access to electricity indicator</th>
<th>Electrification rate</th>
<th>Per-capita residential electricity consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0.33</td>
</tr>
</tbody>
</table>

| Electricity access indicator | 0.57 | 0.29 |
| Access to clean cooking facilities indicator | Share of modern fuels in residential total final consumption | 0.19 | 0.14 |
| Household level indicator | 0.38 | 0.22 |

Community level energy access

| Public Services | Per-capita public services electricity consumption | 0.34 | 0.06 |
|                | Share of economic energy uses in total final consumption | 0.85 | 0.69 |
| Community level indicator | 0.6 | 0.38 |

Table 5: The EDI in China and India, based on indicators. Data sourced from (IEA, 2012)
Based on Table 5 China outperforms India in each of the four indicators, and thus China has a higher EDI than India. The greatest similarity in figures for the two countries was the share of modern fuels in residential total final consumption, which is an indicator of access to clean cooking facilities. The greatest divergence in the two countries was between per-capita public services electricity consumption, which is an indicator of the overall economic development of a country.

However, the relative advantages of solar technology are dependent on local conditions for a number of reasons. Firstly, the local contextual interpretations or definitions of equity are different, between China and India. For the purposes of this thesis, an IPCC definition of equity has been adopted (Mitchell, et al., 2011). However, this definition may not be accepted by either nation. The definition that is adopted ultimately determines whether the solar energy policy can be determined to be equitable, therefore, different perspectives and interpretations of equity must be included in order to provide a valid and reliable analysis of the equity within the context of each nation.

Secondly, the feasibility of a solar energy project is dependent on local conditions, factors that could affect the efficiency of solar energy production facilities include; quantity of sun intensity, regularity of cloud cover, relative humidity. Given that typically, solar energy production and fossil fuel energy production have differing production costs, in a region in which solar can provide a lower LCOE than fossil fuels, or in remote areas, in which conventional technologies are not financially viable and solar energy can facilitate human development the challenges of differing production costs can be economically justified. However, in many situations the cost of solar energy production is greater than that from fossil fuel energy production. The question of how and by whom these additional expenses should be funded is an important issue in the analysis of equity.

Finally, the importance of regional specification in solar energy policy implementation is emphasised by the existence of fixed rate solar energy policies, which are offered regardless of the region or installation method, such as China’s FiT. It could encourage solar energy investors, manufacturers or project developers to increase solar energy deployment in solar resource rich provinces, such as Xinjiang and Qinghai (Wigmore, et al., 2011). However, these are remote areas that located far from demand and the connection of these projects to major energy grids is cause for concern.

Furthermore, the implementation of solar energy technology is more expensive than the most commonly implemented fossil fuel equivalents. Additionally, there are higher costs associated with other aspects of solar energy systems in comparison with fossil fuel equivalents, such as measures to manage intermittent generation or required upgrades of existing transmission and distribution grids (Nicholls, et al., 2014). The consequential taxes or subsidies introduced or increased to major energy suppliers could result in an increase in energy prices across the market, which for industrialising countries could be detrimental to the ultimate objective of energy poverty reduction.

Therefore, although the quantitative data suggests that China’s solar energy policies are more equitable than India’s solar energy policies, the qualitative indicators of equity suggest that actually this matter is far more complex than the quantitative data suggests. It would require in-depth interviews with stakeholders in order to provide a truly comprehensive perspective of the equity of solar energy policies in China and India.
9.3.2 Case Study 2: Equity

The solar energy auction policy in India has been determined to be more equitable than the solar energy policy in China. The equity indicators of impact on stakeholders and the participation in the development of policy are strongly in support of India as more equal than China. India is a democracy and even a vaguely representative government has a greater encompassing interest in the economy’s development than authoritarian regimes (Fidrmuc, 2003). Thus, the policies implemented in democracies tend to be more equitable as a greater range of perspectives are involved in decision making.

Furthermore, with regard to the allocation of revenues and expenditures by the support mechanism indicator, in Phase 1 of the NSM solar energy auctions a bundling scheme was used to dilute these costs in a cheaper generation portfolio. The reference point was derived from solar energy systems and instead of solar energy deployment increases inflicting increasing costs on existing power systems, unallocated low cost power from federally owned power generators was implemented to diluted costs. Finally, with regards to the fairness of the design of the policy indicator, India proved to be more equitable. China’s lowest price wins based selection criteria designated the probability of success to existing state-owned power providers that could leverage financial support from financial institutions to underbid for solar projects.

9.4 Institutional Feasibility

Institutional feasibility is a mechanism for analysing the motivations and reasons behind policy performance. As such, it is most appropriate to analyse the ex-ante potential of a policy and for developing a policy that is suitable for local conditions, rather than measuring a policy’s performance ex-post. That said, institutional feasibility is notoriously difficult to measure, analysis is more amenable to qualitative review. The analysis of the institutional feasibility of the two countries is by no means straightforward, as such, criteria has been selected based on the availability of the data rather than based on the selection of appropriate indicators. There are apparent themes in the institutional feasibility literature but none of them appear to be dominant or persistent (Nicholls, et al., 2014).

Case Study 1 and Case Study 2 are analysed together rather than separately because institutional feasibility indicators do not offer a metric for the performance of a policy. Instead, institutional feasibility describes the suitability of a policy to its institutional environment, which may help to explain why the policy is performing in a certain way (Nicholls, et al., 2014).

9.4.1 Case Study 1 & 2: Institutional Feasibility

Indicators for political viability that will be analysed are: political system, policy origins, rationale for deploying solar energy technologies and results achieved. Firstly, the political system. China has an unrivalled single party communist system, whereas India is a federal parliamentary democratic republic. Secondly, the solar energy deployment policy origins and the rationale for deploying solar energy technologies of the two nations. In China solar energy policies to increase domestic deployment were the result of pressure from provincial solar manufacturers on local governments (Spratt, et al., 2014). Evidence of this is the existence of regional specific solar energy deployment policies in regions with huge solar manufacturers prior to a national support policy. However, the implementation of solar energy policies in India is the result of a governmental eagerness to increase energy security and improve access to energy. Thirdly, the result achieved. China has achieved impressive solar energy deployment in a short period, whereas, India has made a committed effort to solar energy deployment.
Both China and India have progressed in terms of solar energy deployment but not in the same way or to the same scale. China has achieved sustained GDP increases for a number of years and as such the global pressure to transition to low-carbon technologies is much greater than for India. Furthermore, India does not have the resources, leadership power, or industrial demand to transition. In this sense, based on the fact that China has such a strong government institutional feasibility in terms of political viability is greater in China than in India.

The indicators of organisational capacity analysed will be authority to act and historical performance in compliance enforcement. In each country the power that the government has to take action is impeded by a lack of intergovernmental coordination. However, this problem is more perverse in China, where responsibility for solar energy deployment policies is diffused across a number of different governmental sectors and an incongruence in solar energy policy objectives (Zhang, et al., 2009). The resulting inconsistency of policy, undermines the state macro-control and results in high curtailment rates. This challenge of curtailment rates is further exacerbated by inadequate grid regulations and management in some regions, which make it difficult to achieve grid connections for large scale solar projects (IRENA, 2012b).

Furthermore, with regard to historical performance in compliance enforcement, India enforces penalties for failure to complete projects to standard or in a timely manner; however, penalty enforcement structures are weak or incomplete in China. In China realising the solar energy potential is a larger process of energy reform, because policy making in China is fragmented and inhibiting progression through conflict between state departments. As such, the indicators of organisational capacity more strongly support solar energy policies in India than in China.

Endogenous aspects of institutional feasibility analyse the complexity of instruments, which affect transparency, predictability, participation and compliance (Verbruggen & Lauber, 2012). The endogenous aspect of institutional feasibility in solar energy policy in India, especially the solar energy auction scheme is transparent, predictable and attracted participation by many agents outside the conventional electricity sector that are well placed to develop solar energy deployment in India. However, the solar energy policy in China is far from predictable nor transparent. For example, the solar energy auction scheme project criteria was limited, and the winner tended to be state-owned energy companies. Furthermore, the continued development of solar deployment in China requires increased transparency, especially in regard to quality, to achieve adequate funding (IRENA, 2012b). Therefore, for endogenous aspects of institutional feasibility, India’s solar energy policy is stronger than China’s.

Therefore, China’s indicators for political viability outperformed India’s. However, India outperformed China in indicators of organisational capacity and endogenous aspects of institutional feasibility. Scott (2013) asserts that it is plausible to assume satisfactory institutional feasibility when a policy that is found to be effective, efficient and equitable in its implementation. Regardless, as it is difficult to analyse, which indicators are more important than others, in this circumstances the decision regarding which nation is more institutionally feasible is based on the nation that was considered institutionally feasible for the most categories. Based on this India outperforming China in 4/5 of the indicators of institutional feasibility and is therefore considered to be more institutionally feasible than China.

10. Discussion

The analysis of Case Study 1 and Case Study 2 has produced unambiguous results. Ultimately, the long-term sustainability of solar energy policy and projects can only truly assessed with hindsight. The quantitative data from the analysis provides an indication of the strength of the renewable criteria and indicators, however, examining the quantitative data alone provides a
distorted depiction of reality. The qualitative data helps to clarify this depiction, the qualitative data provides information about the quantitative data and fills some of the gaps in the data. However, qualitative indicators are subjective and bias to the availability of data. As data was collected on the basis of availability rather than selected based on its assumed relevance or a predetermined knowledge of its significance to the overall indicator, both quantitative and qualitative data is subject to bias.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Case Study 1</th>
<th>Case Study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>China</td>
<td>India</td>
</tr>
<tr>
<td>Efficiency</td>
<td>China</td>
<td>India</td>
</tr>
<tr>
<td>Equity</td>
<td>China</td>
<td>India</td>
</tr>
<tr>
<td>Institutional feasibility</td>
<td>India</td>
<td>India</td>
</tr>
</tbody>
</table>

*Table 6: summarised overview of the country that more strongly displayed indicators for Case Study 1 and Case Study 2. This table is based entirely on the results of the analysis.*

Table 6 provides a summarised overview of the IRENE Report indicators; effectiveness, efficiency, equity and institutional feasibility. The country that displayed each indicator most strongly, based on the analysis, has been listed. Case Study 1 summaries the solar energy policies in China and India since 2000. The analysis of Case Study 1 reveals that China scored more auspiciously in effectiveness, efficiency and equity. As previously mentioned institutional feasibility is crucial for the sustainability of renewable energy policy. Although Case Study 1 sites India having a stronger institutional feasibility than China, as Scott (2013) stipulates, it is plausible that China has satisfactory institutional feasibility because it has been found to be effective, efficient and equitable. Therefore, Case Study 1 reveals that solar energy policy in China displays more indicators beneficial to solar energy deployment than India.

Case Study 2 provides a thorough account of solar energy auctions in China and India. The analysis of Case Study 2 reveals that India scored more auspiciously than China in each of the policy indicators: effectiveness, efficiency, equity and institutional feasibility. Therefore Case Study 2 displays that the solar energy auctions policy in India displays more indicators beneficial to solar energy deployment than China. Thus, for Case Study 1 solar energy policy in China is stronger than solar energy policy in India. However, the solar energy auctions policy in India is stronger than the solar energy auctions policy in China. As such, the results of the analysis are somewhat inconclusive.

Case Study 1 indicates that China is at a more advanced stage in its development of its solar energy sector than India. These results are also indicative of the fact that China has more resources, greater political influence and more international pressure to transition to low-carbon technologies. These results reflect the differences in maturity of domestic markets, incentive levels and structures, local labour and manufacturing costs and a wide range of other factors. However, progress in both of these countries is rapid and India’s GDP is anticipated to overtake China’s in 2015 (Chan, 2015). Therefore, the fact that India is already vehemently implementing renewable energy is a positive indicator that in India the continued pathway of development will contain renewable energy policy that is established on the foundation of experience and knowledge in the sector. This is a positive indication for India’s sustainable energy future.
11. Conclusion

Both China and India’s demand and consumption for electricity is increasing with their rapid economic development. Although the primary source of electricity power is still fossil-fuel based, the governments of both countries have recognised the significance of a renewable energy transition. China and India have both made commitments towards low-carbon technologies and have enhanced their efforts to promote these technologies. Solar energy is an important component in the strategy of both countries to achieve sustainable energy production. Solar energy will continue to grow in popularity as the alternatives have significant downsides as technological innovation continues to improve the efficiency and cost effectiveness of solar.

With a total of 30 GW of cumulative installed capacity between the two countries, both countries have been ambitious with policies to increase deployment and this is set to continue into the future, with both countries setting ambitious targets for the future of solar energy. In India the current NSM target of 20 GW of cumulative installed solar capacity by 2022 has been increased significantly to 100 GW (Katakey & Watanabe, 2015). Similarly, China, the world’s biggest carbon emitter, intends to speed up solar power deployment and set a target of 70 GW of solar installed capacity by 2017 to cut its reliance on coal (Landberg, et al., 2014). Thus far, China has a greater cumulative installed solar capacity than India, however, the reasons for this are not limited to those examined in the analysis. The global financial crisis, the anti-dumping, anti-subsidy and countervailing investigations against Chinese solar panel manufacturers, excess solar manufacturing panel capacity and global pressure to transition to low carbon have all impacted the decision making process to increase solar deployment in China.

Furthermore, using the IRENA report framework for assessing the long-term sustainability of renewable energy policies: “Evaluating Renewable Energy Policy: A review of Criteria and Indicators for Assessment”, has been used to assess both case studies. When it comes to the sustainability of overall solar energy policy, the results suggest that China is stronger than India. However, at the individual policy level, specifically solar energy auctions, the results of the analysis suggest that India’s solar energy policy is stronger than China’s. The solar energy auction scheme in India was implemented based on previous domestic and international experience. This suggests that India has given serious consideration to previous renewable energy sector experience and the sustainability of policies when developing the solar auction policy. Whereas, the solar energy auction scheme in China made many of the same mistakes that the first wind power auctions did, suggesting that experience and sustainability were not given reasonable consideration. In China the policy and procedure has developed for wind power auctions, these lessons were mostly ignored by the solar energy auction scheme (Wang, et al., 2014).

The greatest limitation of this research is that the data available is very restricted. The two countries studied are both infamous for a lack of transparency, the Indian government proved to have a higher degree of transparency than China. The Indian government published the figures, data and guidelines for solar energy policy. However, the figures and data from China are resoundingly sourced from other studies of renewable energy policy in the country. To conduct a truly valid and reliable evaluation of the potential of the two countries to achieve the long-term sustainability of solar energy policy would require more data. A more in-depth examination, including the use of fieldwork would be essential to provide further insight into the long-term sustainability of solar energy policy in the two countries. Such in-depth data could be used to validate or refute the theoretical hypothesis of this thesis. Thus, for future projects it would be interesting to conduct further research that provides insight as to the decision making process that motivate solar energy policy. However, further in-depth research was not possible within the limited scope of this master thesis study.
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biggest-jerk-on-climate-change/
[Accessed 10 12 2014].


**Appendix 1:**

Appendix 1: A detailed overview of the governance structures for renewable energy policy in China, adapted from (Tsang & Kolk, 2010).
Appendix 2:

Appendix 2: A detailed overview of the governance structures for renewable energy policy in India, adapted from (Spratt, et al., 2014).

Appendix 3:
Appendix 3: Displays the GDP growth in percent per year in China and India. The graph was compiled from data collected from the World Bank, 2015; Magnier et al., 2015 and the Economist 2015.

Appendix 4:

<table>
<thead>
<tr>
<th>Year</th>
<th>China</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>(Xu, et al., 2012; Fang, et al., 2013)</td>
<td>(Kapoor, et al., 2014)</td>
</tr>
<tr>
<td>2008</td>
<td>(Xu, et al., 2012; Fang, et al., 2013)</td>
<td>(MNRE, 2008)</td>
</tr>
<tr>
<td>2009</td>
<td>(Xu, et al., 2012; Fang, et al., 2013)</td>
<td>(MNRE, 2009)</td>
</tr>
<tr>
<td>2010</td>
<td>(Xu, et al., 2012; Fang, et al., 2013)</td>
<td>(MNRE, 2010)</td>
</tr>
<tr>
<td>2011</td>
<td>(Xu, et al., 2012; Fang, et al., 2013)</td>
<td>(MNRE, 2011a)</td>
</tr>
<tr>
<td>2012</td>
<td>(Montgomery, 2013; Fang, et al., 2013)</td>
<td>(Kapoor, et al., 2014) (sum of grid + off grid, in different forms)</td>
</tr>
<tr>
<td>2013</td>
<td>(Masson, 2014)</td>
<td>(MNRE, 2013)</td>
</tr>
<tr>
<td>2014</td>
<td>(Defang, 2015)</td>
<td>(MNRE, 2014a)</td>
</tr>
</tbody>
</table>

Appendix 4: provides the references for Figure 1.

Appendix 5:
Figures for 2010 and 2011 solar energy auctions in China is sourced from “Renewable Energy Auctions in Developing Countries” (IRENA, 2013). The figure for 2011 has been averaged.

Calculation for Chinese FiT in 2014 are based on figures listed in Forbes (Trefis Team, 2014)

The article states that the FiT for large-scale ground mounted power plants are between $0.14 and $0.16 per kilowatt-hour (kWh) of energy generated. The article sites that distributed projects get a payment of between $0.10 and $0.12 per kWh.

In order to work out an average FiT for solar PV that will be USD/MWh.

\[
\begin{align*}
(0.14+0.16)/2 &= $0.15 \\
(0.10+0.12)/2 &= $0.11 \\
(0.15+0.11)/2 &= $0.13
\end{align*}
\]

To convert from kWh to MWh must multiply kWh by 1000.

Therefore:

\[0.13 \times 1000 = 130 \text{USD/MWh}\]

All figures for India are sourced from “Promoting Renewable Energy through Auctions: The Case of India” (Khana & Barroso, 2014).