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Cleantech Investments in China

Multiple perspectives on the trends, drivers and barriers

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Abstract

Cleantech—technologies with a reduced environmental impact—has emerged as an important set of solutions for addressing pollution and its impacts in China. The goal of this study is to map out wherein Chinese actors with first-hand knowledge of cleantech investments think the largest domestic investment opportunities are found, understand the underlying reasons, and then evaluate how consistently the investment preferences reflect the country's environmental problems, public discourse and policy. This is accomplished through a review of the Chinese cleantech discourse and semi-structured interviews with the mentioned actors. The study found pollution—in particular air pollution—to be the dominant area of concern among both the interviewees, throughout the public discourse and in the policy arena. This was largely reflected in the most preferred cleantech sub-sectors: energy efficiency, solar and wind energy, electric mobility, wastewater treatment, and energy storage. IoT (The Internet of Things), big data, IT and AI were found to be particularly important for delivering these solutions. However, some areas of major environmental concern, targeted by policy, indicated a disconnect, as they still evoked little interest for investments. These areas include solutions targeting water scarcity, solid waste, chemical exposure and the industrial sector broadly. Bio- and geothermal energy sources were also largely overlooked. The narrow focus on a few areas of cleantech is largely caused by the important directing role of policy in China, but also—as the mentioned disconnect indicates—by the investment culture, and the acuteness of the air pollution problem. Nonetheless, the study concludes that many opportunities remain largely overlooked, including several niche technologies, heat pumps, industrial symbiosis, and consulting-related services—besides the already mentioned areas of the disconnect, and bio- and geothermal energy sources. Further research is needed to explore not only the potential of these mentioned areas—in particular IoT, IT, big data and IoT—but of the complex matrix surrounding cleantech investments in China as a whole.

Keywords: Cleantech, China, investments, trends, drivers and barriers.

Executive summary

The rapid development in China during the last few decades has led to severe pollution in the air, water and soil. Cleantech solutions have come to play an increasingly important part in addressing these issues. While cleantech originally mainly focused on renewable energy, it includes environmentally related fields more broadly today. Along with increasing public concern around pollution, policy has come to provide more and more support for cleantech and investments into this sector. However, as there is a large research gap around perspectives on cleantech investments, this study is focused around the following research questions:

- Which specific cleantech sub-sectors and features do Chinese actors active in the cleantech sector consider promising for investing in?
- What are the underlying reasons for these investment preferences?
- In what ways do these preferences capture China's environmental problems, and cleantech-related public discourse and policy?

Method and methodology

The first part of the study consists of a literature review, in which cleantech and the Chinese business landscape are introduced, in order to facilitate the development of both apt research questions and a structure to provide answers for these. Thereafter, China's environmental problems, and cleantech-related public discourse and policy are introduced—later to be compared to the interviewees' preferences around cleantech. Thereafter follows the process of structuring, conducting, coding and analysing the interviews, which were carried out to map out what type of cleantech the Chinese cleantech community—based on a sample of 20 actors mainly with a background in private investments—is most interested in investing in, and what the underlying reasons are. Further reviews of literature, and ten additional interviews were conducted for data triangulation, and to provide a commentary on the findings. *Content analysis* was used to code the interview data, and to categorise the reasons behind the investment preferences, the *PESTEL* and *political economy* frameworks were consulted.

Main findings

The main findings are composed of the six interview questions. In line with the first interview question about environmental issues, air pollution was the issue around which the interviewees expressed the most concern, followed by water pollution, in turn followed by soil pollution. There was little mention of climate change, or any other issues, such as biodiversity or chemical exposure. In regard to the second question about the preferred cleantech sub-sectors, energy efficiency was seen as the most promising sub-sector for investments, followed by transportation (in particular electric mobility), solar and wind energy, wastewater treatment, and finally energy storage. Big data, AI and IoT were highlighted as key for enabling these solutions.

The third interview question highlighted the importance of policy in the cleantech landscape. However, while the importance of policy—in particular the Five-Year Plan—was unanimously recognised, few interviewees referred to specific policies. There were few recurring themes—especially with reference to policy constraints—except renewables, for which the policy was seen as facilitatory. Overall, subsidies were mentioned more than taxes—a less popular policy instrument in China. Also, the mention of market-based instruments was scant, but emphasised. In reference to the fourth question about what factors besides policy influence investment decisions, technology was seen as the second most important by most, followed by social aspects (especially public opinion), which in turn was followed by economic factors—presumed to be

more important. Half of the interviewees also alluded to the role of political structure. The fifth question explored which actors are most important for driving the demand for cleantech, and—unsurprisingly—the government was viewed as the dominant actor for driving this demand. The final interview question explores the Chinese cleantech market from outside, by exploring what Scandinavian cleantech companies have to consider for succeeding in China. The importance of having good Chinese business partners was the most mentioned aspect, followed by having excellent technologies and success records in the home market. Cost-effectiveness, a wariness of IP, high scalability, localised solutions, good political relations and more interests in China than merely monetary are aspects which were also mentioned.

Analysis & discussion

The analysis process undertaken in this work indicates that the interviewees' narrow focus on a few sub-sectors is largely a result of a highly policy-driven economy, but also of the tangibility of air pollution—which overshadows other environmental problems—and of investor behaviour. Public concern around environmental problems—in particular those with implications on health—is becoming an increasingly important factor for policy to consider. While the cleantech sub-sectors which were mentioned the most (energy efficiency, solar and wind energy, electric mobility, wastewater treatment, and energy storage) comprise areas that both address the pollution problem and are supported by policy, there were other areas in which the interviewees expressed little interest, even though they represent areas of growing environmental concern, and receive support from policy, in particular solutions targeting water scarcity, solid waste, chemical exposure and industry, but also geothermal energy. Bioenergy, on the other hand, was found to be overlooked by both the interviewees and policy-makers. Other potential missed opportunities include multiple niche technologies (e.g. components of conventional sectors), heat pumps, district heating, industrial symbiosis, and consulting-related services—the latter two are important as many of the problems of the sector are not technical, but rather connected to mindsets and behaviour. The attention given to big data, IoT and AI could be attributed to both cultural, market and economic reasons.

Outlook

Cleantech investments constitute an important part of addressing China's environmental problems. Targeted support from policy has been essential for developing parts of the sector, and it has allowed China to become the world leader in wind and solar energy, and it will likely lead in electric mobility big data, AI and IoT as well. To continue the development of the sector, it is important that the country addresses its many structural inefficiencies, embraces market-based instruments, carbon pricing and makes it easier for foreign actors to enter China. The risk that many promising sub-sectors are being forgotten is considerable, but if the mentioned areas are addressed, and if air pollution becomes less dominant, a gradual diversification which takes more environmental problems into account will inadvertently take place.

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Abbreviations and acronyms

EV = Electric vehicle

FYP = Five-Year Plan

IoT = The internet of things

IP = Intellectual property

REN21 = Renewable Energy Policy Network for the 21st Century

SOE = State-owned enterprise

VC = Venture capital

1. Introduction

1.1 Background of cleantech investments in China

China has experienced a dramatic economic growth for more than three decades. Between 1980 and 2006, the country's GDP grew by on average 9.8% annually (State Council Information Office of the People's Republic of China, 2007). While this growth has begun to slow down in the last few years (Wübbeke, 2015), it is still remarkable compared to most other countries (Trading Economics, 2017). Since the market reforms were initiated in 1978, more than 800 million people have been lifted out of poverty (The World Bank, 2017). However, this has occurred at a large cost to the environment. Large areas of the country have become severely polluted, and the country's contribution to climate change has skyrocketed. Estimates vary, but air pollution alone is thought to have cost China 6.5% of its GDP each year between 2000 and 2010 (Crane & Mao, 2015), and almost 10% in 2013 (Vidal, 2016).

Concerns over the environment have increased, as have the number of environmental protests. However, the impact of air pollution on human health has been the strongest driver for action (Hewitt, 2015). In recent years, the Chinese government has begun to direct more and more attention and resources to address the country's environmental issues. Renewable energy has been at the centre of attention, and in 2014, the country spent 73% more than the US, the second largest investor (The Climate Group, 2015). Also, the investments as a share of the country's GDP per capita reached 1% in 2015, compared to 0.3% in Europe (Mathews, 2016). Hydropower has accounted for the bulk of the country's renewable electricity for decades, and its installed capacity represents more than a quarter of the world's total (International Hydropower Association, 2017). More recently, increasing attention has been directed toward wind energy, and China today has over one fourth of the global installed capacity (Shukman, 2014). The fastest growing energy source today, however, is solar energy (Shankleman, 2016). Clean technologies—which either solve environmental problems or are more sustainable than conventional equivalents—have become an increasingly important part of addressing environmental problems, and renewable energy has been the largest sub-sector of cleantech in terms of investments both globally (CBI, 2017; Day, 2015), and in China, although this dominance has begun to decrease with more of a diversification into other sub-sectors (Caprotti, 2009), such as energy efficiency (Baker, 2010), wastewater treatment and waste-to-energy (Lin, N., pers. comm., August 07, 2017).

1.2 Problem definition

While there is some research available for both cleantech investments—although very scarce (Bjornali & Ellingsen, 2014)—and for doing business in China, specific research on cleantech investments in China is much scarcer, which a quick search with the words "cleantech", "investments" and "China" on the *Web of science* reveals, with only six search results of varying relevance. This dearth of information was found not only at the point of departure; it was reinforced during the later stages of the literature review. It is true that there are allusions to the topic elsewhere, but a large part of previous research has considered the Chinese market from the point of view of foreign firms. This study, on the other hand, is directed towards a veritable research gap, as it focuses more on the Chinese actors with experience and knowledge of cleantech investments and their points of view—an area surrounded by much confidentiality. Moreover, there are few actors in China which are solely involved in cleantech investments to begin with (Mialaret, J., pers. comm., July 31, 2017), which also helps explain the research gap. The existence of this gap implies that the sector is not working optimally, as more of a science-based approach could be applied to cleantech investments in China.

With the help of Chinese cleantech networks, the goal of this study is to better understand both the trends, drivers and barriers behind cleantech investments in China—information that both industry, investors, policymakers and other stakeholders could leverage to make more holistic decisions around how to approach cleantech. Perspectives around the trends of cleantech investments in China comprise data that—relatively speaking—can easily be collected and categorised. However, the complex matrix of factors (i.e. the drivers and barriers) which influence the investment trends require a framework around which they can be structured. For this end, the *political economy*—which is defined by the interest it takes in the complex relationship between the state and the market (Gamble et al., 1996)—is introduced, as the state in China is an actor that is more important than in many other countries.

The intention is to achieve the stated goal by—first of all—conducting an introductory literature review of the sector, by—secondly—capturing, coding and analysing the perspectives of various actors of the Chinese cleantech community through a series of semi-structured interviews, and—finally—by exploring to what extent these preferences capture the country's environmental problems, and cleantech-related public discourse and policy.

1.3 Research questions

- Which specific cleantech sub-sectors and features do Chinese actors active in the cleantech sector consider promising for investing in?
- What are the underlying reasons for these investment preferences?
- In what ways do these preferences capture China's environmental problems, and cleantech-related public discourse and policy?

1.4 Scope and limitations

As mentioned, there are few actors in China which are solely involved with cleantech investments (Mialaret, J., pers. comm., July 31, 2017). Not only are there few such actors, but this study has found that they are difficult to find, contact and interview. Also, the term *investor* has been found to be somewhat exclusive and difficult to define. With this in mind, this study focuses more broadly on the Chinese cleantech community, with actors that have knowledge of and experience from working with cleantech investments in China. These mostly—but not only—include actors from the private sector (See the full list of interviewees under Personal communications, after the list of references), with most representatives connected to VC (venture capital), investment firms and platforms, but perspectives from financial institutions, state-owned enterprises and academia are also included. Accordingly, the perceived investment opportunities (i.e. the sub-sectors and features the actors consider promising for investing in) mainly entail the potential returns on investment. No actors from the political sphere or NGOs are part of the sample. The rationale for the selection of interviewees has been reliant on the access to interviewees provided by the client, due to the difficulties of finding willing interviewees without contacts, as explained in more detail later. Accordingly, this study does by no means purport to offer an accurate representation of the perspectives of the entire Chinese cleantech community; instead it should be viewed as a snapshot where certain groups are overrepresented and others underrepresented, and where areas of further research can be recommended. In particular, the state is under-represented in this study, as in 2016, SOEs accounted for approximately 35% of the country's fixed-asset investments (The Economist, 2017c). Finally, while inbound (to China) investments—unlike outbound—are not excluded, the focus in this study is directed toward domestic investments. In this study, China refers to the mainland part of the People's Republic of China.

As seen in the research questions, both sub-sectors and features are considered in the investment preferences. While the focus is on the sub-sectors, *features* was included to allow for also capturing important themes and aspects. Furthermore, the investment landscape is seen as a subset of the business landscape, and while both are considered, the focus is directed toward the previous. Also, while the role of policy for cleantech constitutes an important part of this study, it should be mentioned that the author is not a policy expert, and this study is merely a snapshot with reference to policy. The FYP (Five-Year Plan) is not the only proxy of key government policy areas, but in this study, it constitutes an important part.

1.5 Audience & ethical considerations

This study has been conducted in cooperation with Sweden-based *Cleantech Scandinavia*, a company which scouts and collects a wide range of mainly Nordic cleantech start-ups into an international cross-sectoral network. While this platform is mainly focused on Scandinavia, *Cleantech Scandinavia* is also looking to China. Accordingly, gaining insight into the Chinese investment landscape in general and the cleantech landscape in particular will be a key factor for succeeding in the Middle Kingdom. Outsiders' perspectives of China can be valuable, but to gain insight into this landscape, it is ultimately key to include the Chinese actors with knowledge and experience of cleantech investments, and how they view domestic investments. These actors—along with foreign investors interested in China—are part of the intended audience, as are, on a more general note, people interested in China and cleantech—in conjunction or not.

As the interviewed actors, for the most part, are representatives of corporations, and as investment trends in general are of a secretive nature (especially in China), measures have been taken to safeguard their anonymity. Also, to minimise the risk of misinterpretations of the interviewees' perspectives, summaries of the interviews were sent out after they had been conducted. Furthermore, to ensure that the participants had understood what they had agreed to, the interview questions were sent out prior to the interviews.

1.6 Disposition

Chapter 2 contains a description of the applied methods and the methodology. The first section describes the literature review, while the second section lays out the interview strategy. The coding process then follows in the third section, and both the methods of categorisation and the interview questions are introduced. The final section covers the analysis of the results.

Chapter 3 serves two purposes. The first three sections function as an introductory literature review of cleantech and the Chinese business landscape. The last three sections then provide the structure for the last research question by introducing the environmental trends, public discourse and policy, which constitute the foundation of cleantech.

Chapter 4 then follows with the main results, i.e. the answers of the six interview questions. This directly covers the first research question, while it touches on the second.

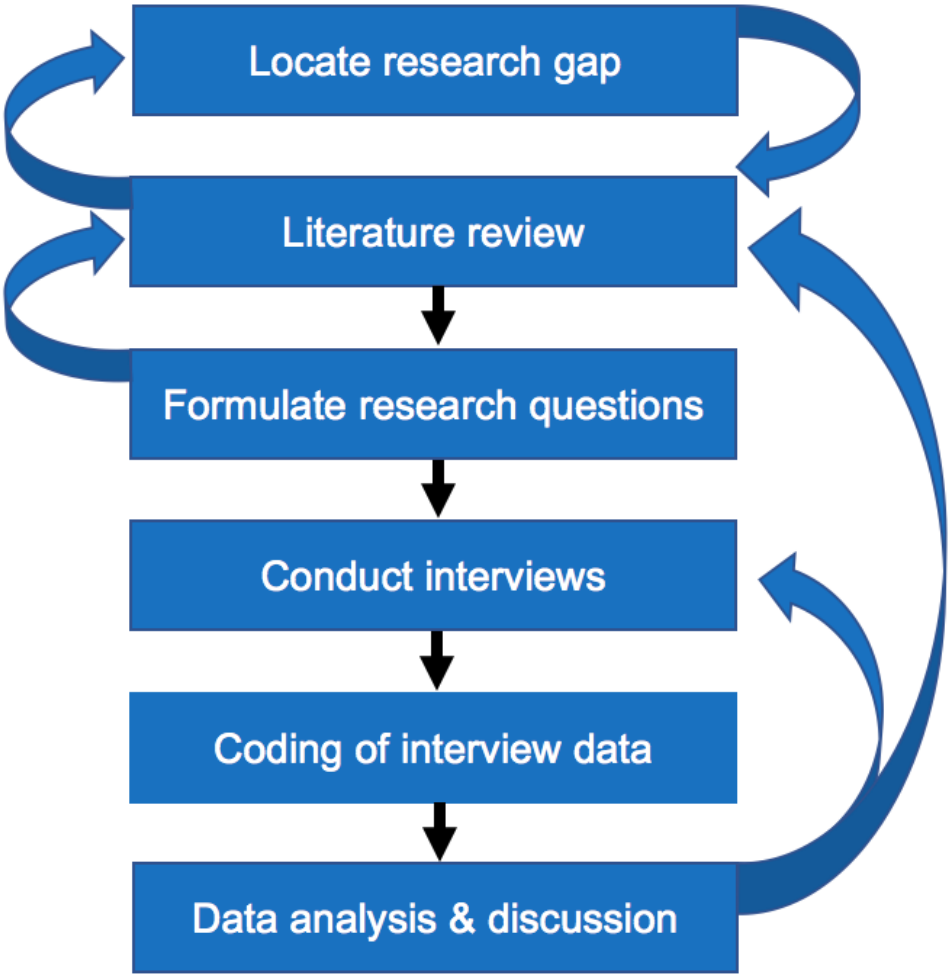
Chapter 5 holds the analysis and discussion, which is centred around the reasons underlying the investment preferences and the extent to which they capture the environmental, public and political aspects introduced in sections 3.4–3.6. Lastly, the methodology is discussed.

Chapter 6 offers a conclusion of the main findings of the study and provides an outlook of China's cleantech sector.

2. Methodology

This chapter introduces the methods which have been applied in this study, and presents the rationale for selecting these. The different steps of which this chapter is composed are demonstrated below, in *Figure 1*. As seen in this figure, the two topmost boxes represent an iterative research approach. This was required due to the dearth of previous research to guide the author toward existing research gaps at the outset. Thus, it was necessary to consult the existing literature in order to locate such a gap. Conversely, however, it is difficult to direct such reading without any suppositions around a research gap. Accordingly, these two steps—which gradually reinforced each other—were largely conducted in parallel during the initial phase. Also, please note that the backward arrows do not imply that each ensuing step is to be repeated. Instead, the arrows from *Data analysis & discussion* imply that additional interviews and reviews of literature were conducted to compare with and comment on the coded data.

Figure 1. Flowchart of research design.



2.1 Literature review

After the iterative process of conducting an initial literature scan and locating a research gap had been finalised, it became possible to formulate apt questions to lay a foundation for the study. As a first part of the study, the general background of cleantech is explored, followed by an introduction of the Chinese business and investment context. Thereafter, to amalgamate these two areas, *cleantech* in *China* specifically follows in the third section. However, the literature review does not end with these three sections, and the three which ensue are intended to provide more underlying information for the Chinese cleantech investments—in line with research question two—and each of these sections introduces one of the themes from the third research question—environmental problems, public discourse and policy. In section 3.4, the various cleantech sub-sectors are presented according to the trends and environmental problems which they address. First of all, Chinese megatrends—which could be connected to both the environmental, public and political dimensions from the third research question—are introduced, followed by a sub-section on pollution—an equally important underlying factor as the megatrends. Thereafter, the framework presented by Eyraud et al. (2013) is applied to first categorise the sub-sectors into supply and demand factors, on the basis of energy, which is a key theme in cleantech. Section 3.5 provides a brief synthesis of Chinese public discourse. Then, in 3.6, besides providing a general background to cleantech-related policies in China, it dissects the overarching FYP and highlights every mention of cleantech-related topics.

To identify and extract information, the databases *LUBSearch, Google Scholar* and *Web of Science* were used. While academic peer-reviewed journal articles constitute the core of the sources, news articles, and various reports from state agencies, intergovernmental organisations and NGOs complement the study. The intention of this mix is not solely to provide a more holistic account for the cleantech sector in China; the research gap makes it difficult to obtain a comprehensive understanding solely based on articles from for example only academic journal. While such journals help establish a degree of academic legitimacy, they focus on specific niches to a large extent, and more rarely offer introductory overviews in the way reports do. That is why the latter preceded the coverage of articles from academic journals.

In terms of the search process, the search strings applied for the first two sections in the literature review need little explanations, as they—in line with their sections—were confined to *cleantech* and *business in China*. With reference to the third section which combines the topics of the previous two sections, a Boolean search string consisting of the words *cleantech* (with different spellings), *China*, and *invest(ment)* was used. *Invest(ment)* was also emitted in order to generate more results (A search on the *Web of Science*, with all three words, only generated six search results). The ensuing fourth section for the most part relied on data provided by the same Boolean search strings as the third section, and it was written in parallel with the previous section. More specific search strings which directly target specific cleantech sub-sectors could help circumvent the challenges posed by the research gap. However, in order to avoid an arbitrary selection of sub-sectors which do not reflect the overall discourse around cleantech, these follow-up searches were only conducted after a firm grasp around cleantech in China had been established. In fact, these secondary searches were limited as most of the follow-up review was based on references provided in the first sample of sources. A portion of the follow-up search sought to capture the Chinese perspective by consulting Chinese sources, although only 20 Chinese-language sources were cited. Finally, it should be mentioned that all along the process of this study, complementary searches were conducted to strengthen the literature review, for example as the interviews introduced themes not initially considered, and as the findings from the interviews needed further analysis.

2.2 Interview strategy and rationale

In order to map out the investment preferences in China's cleantech sector, it is important to take into consideration the perspectives of those active in this sector, especially as the existing research gap means that few such accounts are available. Accordingly, a large portion of this study is based on interviews. Generally speaking, interviews can be divided into three categories, namely structured, semi-structured and non-structured (Bryman & Bell, 2007). The semi-structured approach has mainly been applied in this study, as it offers both structure and flexibility, and as it is suitable for capturing data of a more qualitative character—which is key for answering the second research question on underlying reasons. All questions are open-ended (although examples of applicable categories are included in brackets after two of the questions) to avoid any nudging—here defined as "*a rearrangement of a choice context that gently suggests a specific choice"* (Marchiori et al., 2017, p. 1). Such care is important if the perspectives are to be captured with accuracy and objectivity. Also, the interview questions were only formulated after a substantial part of the literature review had been synthesised, to ensure that questions that could generate pertinent information were posed. The answers to these questions were coded according to the categorisations introduced in the next section, 2.3.

It has been important to remember the Chinese context and when conducting the interviews with the Chinese actors. The desire to save *face* and the fear of disclosing sensitive information can sometimes make it difficult to obtain meaningful answers; identifying the right person can be as important as finding the right company (Fang, 2005). Accordingly, *guanxi*—social capital in the form of informal networks, personal relations, trust and respect (Steinz et al., 2016)—is essential for overcoming this barrier. With this in mind, the key in this study has been to make use of the network of *Cleantech Scandinavia*; the introductions made by its Managing Director provided many of the participants, and facilitated the process of establishing contact with these. Fortuitously, these actors (many of which are partners, CEOs and managers) turned out to be the type of actor required by Fang (2005). Besides *Cleantech Scandinavia*, the IIIEE Chinese alumni network provided further contacts, as did some of the contacts of *Cleantech Scandinavia*. Of the 20 interviewees, 18 are Chinese nationals, while two are Europeans with long work experience from China, where they are currently based.

The paucity of available research and the difficulties related to finding willing interviewees meant that it was difficult to have a niched sample of interviewees, and an umbrella of actors with experience from having worked with cleantech investments had to be applied, with 15 of the 20 interviews being contacts of *Cleantech Scandinavia*. These actors can be categorised differently, and these groups are non-exclusive, although they provide an indication: nine representatives from investment companies (including five VC firms), four from investment platforms, three more actors from the private sector, two active in state-owned enterprises (SOEs), one from a business accelerator, and one active in academia. As mentioned, the relative composition of different actors has largely been contingent on the client's actors, and this sample is not presumed to accurately represent the Chinese cleantech community as a whole. Regardless of affiliation, it is important to remember the risk that the perspectives presented by the interviewees may be those of their businesses. As an example, an employee of a wastewater treatment firm will likely consider water pollution concerning. However, no rigid dichotomy exists; even if the individual perspectives of the sector are sought—which was the case in this study—these perspectives are largely contingent on the experiences gained from the firms in which the individual has worked. Nonetheless, the author highlights cases where the perspectives presented were clearly those of the interviewees' firm.

In regard to how the interviews were conducted, a brief initial contact was established as an introduction, and a follow-up email ensued to provide the interview questions (however, one

final question about the role of the FYP was not included, as it likely would have influenced the answers of the question on the role of policy), both in order to ensure that the interviewees had correctly understood and were comfortable with answering the questions. For these reasons, the questions were also translated into Chinese. Furthermore, after the interviews, summaries were sent out to the interviewees to allow for further input and to avoid misinterpretations. While the questions were used as a template, they were not meant to exclude contingent digressions that could shed light on topics not anticipated by the author. However, follow-up questions were minimised in order not to influence the answers. For example, if someone mentioned energy efficiency, follow-up questions for specifying the area of application were avoided in order to avoid extracting perspectives not genuinely held. However, where clarity was lacking, be it because of phrasing, language barriers, or an unstable connection, the information—as understood by the author—was then repeated back to the interviewee, so as to ensure that the information had been correctly understood.

In line with this thinking, the *cold-start approach* was favoured for initiating the interview. This means that the interviewees were not provided with an introduction to the topic which could nudge their perspectives. A study in which both *warm-* and *cold-star*t approaches were used in the same poll on animal experimentation found that people were more likely to agree with the practice when the poll was introduced by a brief rationale (Aldhous et al., 1999). As the interviews were not polls, as the interviewees already have considerable expertise, and as nudging was avoided as far as possible, no introduction was made. That being said, although there was no *warm start* per se, the first question on China's environmental problems may have been seen as an introduction with reference to cleantech. Also, examples of categories were listed in the fourth and fifth questions, to clarify the intended direction of these questions.

To the largest extent possible, the interviews were conducted over *WeChat Call*, *Skype*, and telephone, but for three of the 20 interviews, this was not possible, and the answers had to be obtained in written form. Despite being a suboptimal medium, these were still included due to the meagre data pool.

2.3 Coding procedure

The interviews were dissected using *content analysis*, a research method which is used make valid inferences from texts and transcripts of human communication (Weber, 2008). There are numerous applications, as originally introduced by Berelson (1952), but of these, the ones which mostly relate to this study include: coding open-ended questions, revealing social attention, and reflecting the focus of different groups around a certain topic. *Content analysi*s can be divided into conventional, directed, or summative (Hsieh & Shannon, 2005). The research gap around cleantech investments in China makes the directed approach difficult, as it bases the coding on theories built upon previous research. Instead, the summative approach was deemed most suitable for the purposes of this study, as it focuses on counting and comparisons, usually of content or keywords, followed by interpretations of the underlying context (ibid). Thus, the single most important allowed follow-up question in this study has been "why?", and recurring themes produced by this question constitute an important part of the findings. That being said, these categories are not mutually exclusive, and the coding still draws upon the conventional approach, which bases the coding on categories derived ad hoc from the text data (ibid), even though the introduced categorisations form the bases for this derivation. In particular, this was the case for the third question—which is entirely exploratory.

The following three sub-sections provide the basis of the coding process, as different methods of categorisation are introduced. The interview questions are listed toward the end of each sub-section on which they are contingent. There were two factors which determined the weight

attributed to the interviewees' answers: how many of the 20 interviewees that mentioned the same answer and the emphasis. The emphasis was assessed according to how the interviewees ranked the categories which they mentioned. As the interviewees were not instructed to provide a relative ranking—in order to avoid extracting opinions not actually held—the total for assessing the emphasis varied; for some of the questions, most interviewees provided a ranking of importance, while fewer did so for other questions. Ultimately however, the assessment is largely subjective, as it relied on weighting the number of mentions against the emphasis. Moreover, the initial expectations were also taken into account, and a relatively small number of mentions can still be important, if these refer to an unanticipated area. This anticipation is largely based on the cleantech discourse with Chinese characteristics explored in the literature review. Finally, while the author has sought to distil a vast data amount into a more reviewable piece (for example, smog, air quality and air pollution are all listed as air pollution), it has been important to minimise the assumptions around how this summation has been conducted, and several elaborations on these assumptions follow in chapter four.

2.3.1 Categorisation of cleantech sub-sectors

In order to provide a structure for interview question two, a few examples of how the different cleantech sub-sectors can be categorised are illustrated on the next page, in *Table 1*. It compares two political categorisations with two equivalents from the private sector. The Seven Emerging Industries from 12th FYP is used as a baseline, which the other categorisations are grouped according to. As the number of categories varies, multiple categories within the same box are separated by a semicolon. The categories that do not match any of those in the 12th FYP are listed in italics in the lowest row. The main difference of the categorisation used by Burtis et al. (2004) compared to Parker et al. (2007) is that it looks at energy as one category (albeit with subcategories) instead of four, while it also includes *Consumer Products*, *Enabling Technologies and Services*, and *Environmental Information Technologies*. Moreover, the difference compared to the 12th FYP is that it includes a specific focus on vehicles (compared to the more general "transportation") and biotechnology, while it, compared to the other categorisations, lacks the focus on recycling and waste management, water management, air quality, agriculture, and consumer products, although the category *Energy savings and environmental protection* could be considered all-encompassing.

While the 12th FYP focuses on more recent, emerging industries, the lack of focus on particularly waste and water is evident. However, the International Labour Organization (2013) claims that recycling and reutilisation are in fact key economic areas invested into in the 12th FYP, although they are not part of the emerging industries; this categorisation simply provides a template for categorising the many sub-sectors, and inferences around what the inclusion into these means are avoided. Also, Yao (2012) asserts that three of the seven emerging industries are cleantech-related (new energy, new energy vehicles and energy savings and environmental protection), although all seven, one could argue, could be connected to cleantech. Finally, it should be mentioned that none of the categorisations below are exhaustive. For example, some categories not listed in the table include two mentioned by Landry (2007), namely green buildings and green chemistry.

Table 1. China's focus industries compared to conventional cleantech categorisations

The Seven Emerging Industries from the 12th FYP (2011–2015)	**The Six Emerging Industries from the 13th FYP (2016–2020)**	**The eleven categories used by Burtis et al. (2004)**	**The eleven categories used Parker et al. (2007)**
Advanced manufacturing	–	Manufacturing/Industrial technologies	Manufacturing/Industrial technologies
Bio-technology	Development of the biotech industry	–	–
Energy savings & environmental protection	–	Air quality; materials recovering & recycling; waste /water purification/manage-ment; consumer products	Air & environment; recycling & waste; water & wastewater
New energy	Energy storage and distributed Energy	Energy generation, storage, and infrastructure	Energy: efficiency; genera-tion; infrastructure; storage
New energy vehicles	New energy vehicles	Transportation and logistics	Transportation
Next generation IT	Innovation in next generation information technology industries; intelligent percep-tion of spatial information	Environmental information technology	–
New materials	Advanced materials	Advanced materials and nanotechnology	Materials
–	–	*Agriculture and nutrition; enabling technologies/services*	*Agriculture*

To categorise the cleantech sectors accordingly, the two questions below were asked, the first one to provide a background to which the preferences in some cases could be linked. The first question first considered the environmental problems with the interviewee's business in mind at first, but a follow-up question ensued to map out the interviewees' own perception, to make the distinction clear. While the two interview questions below are linked, the intention of having them separate was to avoid nudging in regard to viewing sub-sectors as promising based on environmental problems that had just been mentioned.

1) *Linked to your business, what environmental problems in China are you most concerned about? 就您的业务而言，您最关心中国哪些环境问题？*
2) *Are there certain cleantech sub-sectors that you see as particularly interesting for investing in today and in the future? Why? 在清洁科技领域，您有没有对特定的方面特别感兴趣呢？这些方面是如何吸引您的呢？*

2.3.2 Categorisation of external factors

As seen in the third research question, three aspects were considered to constitute the foundation upon which cleantech is built, namely environmental, social and political. However, to understand the underlying reasons behind cleantech investments, there are other external factors which influence the selection process. The goal of this sub-section is to provide a structure for capturing these in the study. Firms' internal aspects are also important, but they are briefly explored in question six (Sub-section 2.3.3).

A *PESTEL* analysis divides external factors into political, economic, social, technological, environmental and legal (Professional Academy, n.d.). This could be applied to China's cleantech sector. However, as this study puts a lot of emphasis on the interaction between policy and the market, the *political economy framework* is combined with *PESTEL* to guide question four, and to a lesser extent question three. As mentioned, the *political economy* perspective focuses on the relationship between the state and the market (Gamble et al., 1996). It examines the interplay of a range of institutional, political, and economic factors in technology-related decision-making processes, both involving the private sector and government actors; the *political economy* perspective seeks to situate itself somewhere between the macro-level, where broader structural trends predominate, and the micro-level, where focus is directed more towards the project-level organisational and technological characteristics (Kern et al., 2016). In this sense, *PESTEL* lies closer to hand, as the focus of the cleantech firms in this study is more externally oriented. However, with the political dimension in mind, the *political economy* perspective is important. First of all, it divides politics into more parts, both actual policies and political-institutional structure. Also, the environmental dimension is too essential for cleantech to be reduced to one of six factors. It underpins everything else.

In the *political economy* framework applied by Kern et al. (2016), the landscape is grouped into six categories that influence if a certain technology is adapted or not, namely: 1: *Project characteristics*; 2: *Government policy, objectives, frameworks and measures*; 3: *Economic factors*; 4: *Political-institutional factors*; 5: *Public and political opposition or receptivity*; and 6: *International dimensions*. These categories together with those in *PESTEL* form the basis of the categorisation presented below, according to which the responses are coded. The selection of sub-categories also builds upon the application of *strategic niche management* by Kemp et al. (1998) in their categorisation of barriers for sustainable technologies, to consider the specifics of cleantech innovations.

1. Technology The ability to access, develop and imitate pertinent technology. Availability of complementary technologies, and technical stability.

2. Policy Government (national and regional) policy objectives and measures, ranging from subsidies and tax cuts, to legislation and liability, quotas, and fines.

3. Economic aspects The general economic climate, access to resources, infrastructure, market demand, competition from conventional equivalents, and expected revenues.

4. Political structure How the political institutions are structured, power balance, political culture and paradigms, red tape, corruption, and actual enforcement.

5. Social aspects Demographics, public perception, media influence, NGOs and other actors and their views, related to culture, psychology, social paradigms, and finally, business culture.

6. International competition and access Global markets, trade aspects, and also international agreements and conventions.

With reference to the third research question—which includes environmental problems, public discourse and policy—the six categories above capture the last two categories of the research question through *Policy*, and *Social aspects*, although *Social aspects* covers one additional aspects that is not considered part of public discourse here, namely business culture. Also, *Environmental problems* is a category not included among the six listed above, and it is treated separately as an underlying theme that is the foundation of cleantech. Moreover, *Technology* is used instead of *Project characteristics*—as used by Kern et al. (2016)—to have more of an external focus.

Regardless of categorisation, some degree of overlap is inevitable due to the high level of interconnectivity between the different aspects. Also, depending on the point of view, all the aspects may act as both support and barriers, depending on the specifics of each aspect, and if the target is cleantech or a competing sector. Ideally, to avoid bias when mapping out the importance of the categories, the questions ought to be posed as entirely open-ended, so as to avoid bias. However, considering the difficulties of recollecting several different abstract categories, they are all mentioned as examples in the questions, and policy is treated as a separate category, considering its importance.

The corresponding interview questions to map out the external factors which influence investment decisions are:

3) *Could you describe the role of policy for supporting cleantech? What policies do you find particularly interesting or problematic? 您可以描述政策在支持清洁科技中扮演的角色么？有什么政策您觉得特别重要？也有政策的问题吗？*
4) *Besides policy, are there other essential factors which impact investment decisions (e.g. political structure, international competition and access, social, technological or economic)?*
除了政策，还有别的决定因素影响清洁科技投资吗 （例如政治结构的、国际竞争和准入的、社会的、技术性的、经济的） ？能仔细谈谈么？
5) *Who mostly drives the demand for cleantech (e.g. consumers, politics, investors, media)?*
您认为谁在推动中国的清洁科技的需求与发展呢 （例如消费者/政治家/投资人/媒体） ？

2.3.3 Categorisation of internal factors

Although firms' internal factors are not given the same weight as the external in this study, they are still briefly introduced in this sub-section. The framework of Bjornali & Ellingsen (2014) looks at the cleantech sector as a subset of *new technology-based firms*, for which there is more research available. This framework identifies which factors make for a successful cleantech start-up—internal as well as external. The internal factors in turn are divided into individual (e.g. personalities, skills and competences) and firm-specific factors (e.g. HR and financial resources, strategic choices and networks). Huber (2008) describes cleantech innovation as expressing similar features compared to Schumpeter's concept of technological innovation. Although the internal aspects constitute a small part of this study, they contribute to understanding what features the interviewees deem important besides the sub-sectors themselves. To assess these features, the interviewees were asked to describe which aspects are most important consider for Nordic start-up companies with their mind set on China. This focus on Scandinavia and on start-ups does not directly relate to the research questions. However, since a large part of the interviewees were aware that this study was conducted in collaboration with *Cleantech Scandinavia*, it was an easy reference point, which the interviewees

could connect to. Although this question was presumed to generate some information that would fall outside the scope of the research questions, it was also presumed that a large part of the information obtained would be applicable to Chinese cleantech firms as well. As the intention of this question was also to illustrate what characterises the Chinese investment landscape, the idea was that this is best done by approaching with reference to foreign companies, in order to provide a contrast. Finally, this was the question that was posed:

6) *Could you think of two or three aspects that are essential for a start-up to succeed in China? What kind of support do you think Nordic start-up companies need in the Chinese market? 对想要在中国取得成功的初创企业，您认为哪几方面是最重要的？能给一些建议么。您认为北欧的初创公司需要哪种支持在中国的市场里？*

2.4 Data analysis and discussion

After the data had been coded, it was analysed and discussed in order to answer research questions two and three. To some extent, the answer to the second research question on underlying reasons had already been provided by the interviewees' own reasoning. However, besides the 20 interviews, ten additional interviews were conducted for data triangulation and to provide a commentary of the findings and the underlying reasons. This group targeted non-Chinese actors with knowledge of and work experience from China, in order to include a different perspective to complement those of the Chinese actors. Besides these interviews, further (secondary) reviews of literature were conducted to help explain phenomena brought up in the interviews—besides the primary reviews that had already been undertaken.

For the last research question that sought to explore how well the preferred cleantech sub-sectors and features match the environmental problems, public discourse and policy focus in China, comparisons between the information laid out in the literature review for these three areas and the findings from the 20 interviews were carried out. How well the preferred sub-sectors and features reflect the three areas in the last research question helps answer if they constitute important underlying reasons. Accordingly, the second research question is to some extent fed from the processes of both the first and third research questions.

Moreover, to illustrate the interviewees' perspectives more clearly, examples of sub-sectors that they do not address are also mentioned. The selection of these and the underlying reasons for their absence are primarily based on the literature review, which led the author to anticipate mentions of certain sub-sectors. Finally—to reiterate—the ten follow-up interviews were also conducted as a measure to ensure that as few underlying reasons as possible were missed by the author.

3. Literature Review

This chapter introduces the reader to cleantech investments in China, by first exploring the characteristics of cleantech and investments into this sector in general, after which the Chinese business landscape is presented. Thereafter, these two areas are combined to map out the landscape of Chinese cleantech investments. After these three sections, the environmental trends which constitute the basis of cleantech investments in China are brought up. As energy is a keyword in cleantech, two of the sub-sections (3.4.3 & 3.4.4) are dedicated to addressing the relevant sub-sectors based on their connection to energy. In the last two sections, the public discourse and policy—both with reference to cleantech—are introduced. While this chapter does not fully answer the research questions, it constitutes the background on which the findings are built, and against which they are compared to answer the last two research questions; allusions to underlying reasons are also made throughout this chapter, and the last three sections are structured around the three areas in the final research question.

3.1 An introduction to cleantech

3.1.1 Definition

First of all, it is important to understand what cleantech is, how it works, and what the global trends look like. Gosens et al. (2015, p. 379) describe cleantech as:

"Technologies that have a reduced environmental impact, i.e., have reduced environmental emissions or natural resource use, when compared with conventional technologies in providing similar products or services."

Cooke (2008) and Georgeson et al. (2014) provide more extensive overviews of different definitions of cleantech, although the essence for most definitions is—similar to the previous definition—distilled into any product, process or service that delivers value by causing less pollution and by using fewer resources than current standards stipulate. However, while this is the essence of cleantech, and the definition the most relevant for this study, a few more points from Cooke's literature review deserve mention, such as the common focus on energy, and the economic rationale over sustainability aspects. Also, while *services* may not be technology as such, many services connect to and rely on technology. These should not be forgotten. Georgeson et al. (2014) also highlight that it is possible to think of cleantech as an investment theme, or as a discursive sphere rather than a clearly delineated sector. Besides these points, the author has decided to include one more, namely technologies which directly address an environmental problem, rather than having a reduced impact. Other terms that are sometimes used include *green tech* and *environmentally sound technology*, which here will be used under the cleantech umbrella. Additionally, although the spellings "clean tech", "clean-tech" and "cleantech" are all common, the latter is used consistently in this report.

3.1.2 History

Cleantech first occurred in a published setting already in the 1990 annual report by the *Economic and Social Council of the United Nations Economic and Social Commission for Asia and the Pacific*, but initially, the concept was more a portmanteau than a clearly defined concept. Toward the end of the decade, the term was used by over 100 research papers per annum, and in 2010, by over 500, by which time the concept had become more extensive. Between 2004 and 2005, cleantech experienced a large breakthrough, and the number of mentions in blog entries skyrocketed (Caprotti, 2016). Originally, renewable energy was the dominant area within cleantech. However, a gradual diversification started to occur during the second decade (Caprotti, 2009). As mentioned, more attention has been shifted toward energy efficiency, water and waste.

One important event in cleantech history is the "cleantech boom and bust". Between 2006 and 2011, VC firms spent over $25 billion to fund cleantech start-ups, losing over half of it, and impacting investments for many years afterwards, suggesting that the VC model is flawed for cleantech, especially due to the lack of large corporations willing to invest in innovation (Gaddy et al., 2016). Moreover, since the 2008 global financial crisis, fiscal stimulus packages with green measures have been rare (Eyraud et al., 2013), and the institutional support for cleantech is uncertain in most jurisdictions (Sarazen, 2012). Fortunately, the 2015 Paris Agreement may result in new capital through a more diverse set of actors, which hopefully will avoid the mistakes of the VC boom and bust (Gaddy et al., 2016).

3.1.3 Geography

Most of the world's cleantech firms around the world are found in clusters, and for the most part, cleantech innovation takes place in young R&D-oriented firms without large tangible assets, that require substantial capital, have negative cash flows and considerable technological uncertainty (Marra et al., 2015). In terms of actual locations, cleantech innovation takes place all over the world, but Scandinavia is one of the hotspots. Sweden, Finland and Denmark are in the top three of cleantech competitiveness (Cleantech Group, 2017). Another important hotspot that ought to be mentioned is the Bay Area in California. This area accounted for 38% of American cleantech VC investments between 2011 and 2016 (Saha & Muro, 2017).

3.1.4 Job aspects

Besides offering solutions to environmental issues, cleantech also holds promise when it comes to job creation. The International Labour Organization (2013) claims that a greener economy could lead to as many as 60 million new jobs globally. There are already at least 8.2 million *green jobs* (although this is more general than cleantech) in Europe, and it turns out that during the recession, cleantech in particular performed better than the rest of the economy. Part of this can be connected to the lower risks that renewables—as compared to fossil fuels—would become stranded assets (Gray, 2016). Moreover, although cleantech innovation takes place in companies of all sizes, start-ups are an important part. In Sweden for instance, 95% of the country's cleantech firms have fewer than 50 employees (Liu & Fu, 2011).

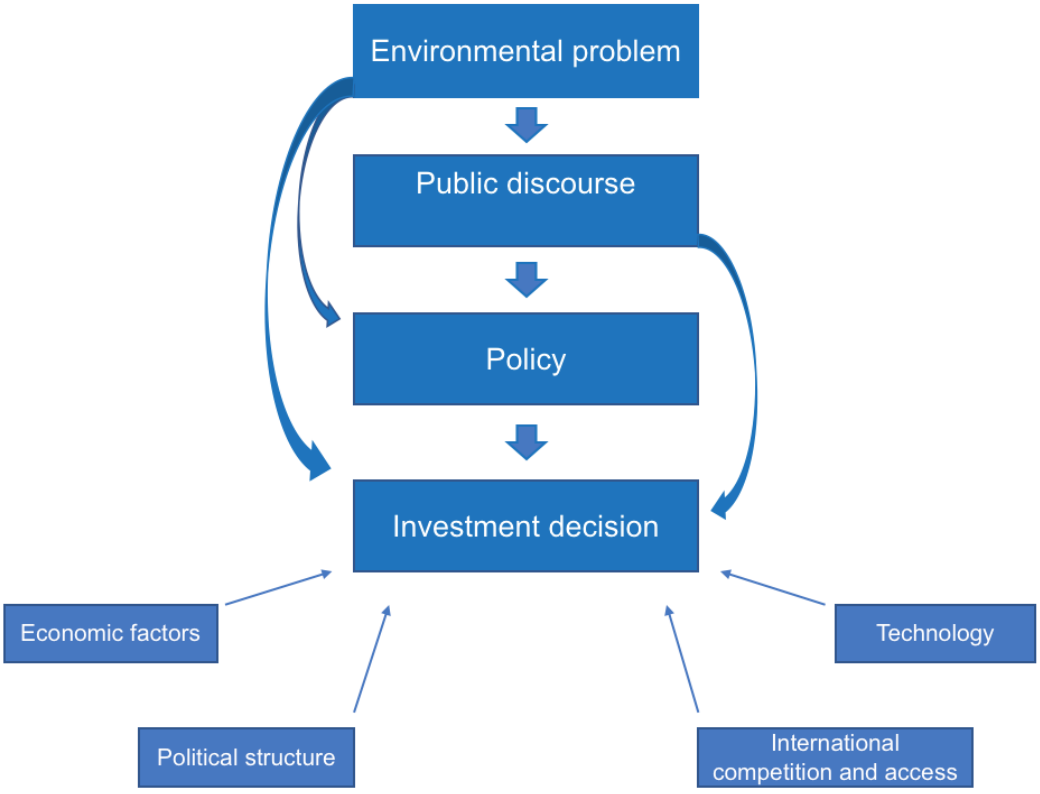
3.1.5 Investments

Baker (2010) asserts that cleantech in 2010 accounted for 25% of global VC investments. The majority of investments today are private (Georgeson et al., 2014). Max Jerneck at the *Stockholm School of Economics* brings attention to the difficulties of VC in facilitating cleantech development; as VC usually has time frames of three to five years—insufficient for many cleantech sectors—and VC usually comes into play when a technology is approaching the mainstream: one example is the solar power sector which the US used to dominate, but today, they produce only 3% of the world's solar panels (Meyer, 2017). The lack of interest from VC, together with a withdrawal of larger conglomerates in the '80s (by which time they started to financialise and become more concerned with consistent short-term profits) and lack of synchronised state support largely led to this decline (Jerneck, 2017). China—the leader in solar energy today—has, which will be explored later, quite different circumstances, with its strong, persevering state support and large corporations.

On a more structural level, it is important to ask what drives the decision to invest in a certain type of cleantech. Below, *Figure 2* is intended to illustrate this. The factors included in this figure—in particular the top three—are important for answering the last two research questions. Together with these top three, the remainder captures the categories of external factors introduced in sub-section 2.3.2. The latter parts of this literature review are also

structured around these categories. One factor not introduced in 2.3.2 is added in *Figure 2*: the environmental dimension, on which everything else rests. The bent arrows are intended to illustrate that besides the direct step-wise influence from environmental problem to cleantech investment, the investment decision is also affected directly by care and concern for both the environment itself and what people direct their attention towards. However, intrinsic values attributed to the environment are dismal in most cases, and it is usually not until an environmental problem has been recognised as important by the public and addressed by policy-makers that it can translate into an investment opportunity.

Figure 2. Factors that influence investment decisions



Finally, one factor that might skew the understanding of which cleantech sub-sectors hold most promise is whether the attention is directed toward the total number of deals or the total amount invested; certain sectors, such as renewables, make up a higher portion of total investments compared to the share of total deals, while the opposite is true for emerging IT-based investments, for which there are more but smaller deals (Day, 2015). When one is discussing investments, it is important to differentiate between these two ways of measuring.

3.1.6 Promising sub-sectors for cleantech investments

Despite the decrease of VC in recent years, most cleantech sub-sectors are booming (Day, 2015). Although renewable energy is still considered the most popular sub-sector, investments into it fluctuated considerably between 2012 and 2016, and VC investments decreased considerably (CBI, 2017). Solar has attracted the most interest of the renewable energy sources for a long time (Marra et al., 2015). However, as a result of this interest, oversupply has made profitability challenging both for wind and solar generating equipment (Sarazen, 2012). Also, within renewable energy, biomass and waste-to-energy have shown a more promising growth trend than other renewables (ibid). Heat pumps also deserve mention, as do different

geothermal energy solutions, contingent on local geology (REN21, 2017), with immense untapped energy globally (International Renewable Energy Agency, 2014). Certain renewables have attained much interest, but without large commercial dispersion yet to see the day, especially as is the case for wave and tidal energy (REN21, 2010; REN21, 2017).

Besides renewables, energy efficiency has gained increasing attention and reached new records in terms of investments (Baker, 2010). Energy efficiency solutions are not only less capital-intense, but also more predictable (Day, 2015). Some of these solutions include energy-conserving monitoring systems, better materials and energy-efficient lighting devices, all which have performed well, likely offering significant future gains (Marra et al., 2015). Energy storage and electric vehicles also deserve mention. They have received considerable investment sums, and they are the only two sub-sectors—besides solar and onshore wind—which are expected to meet their required contributions to the interim 2°C scenario targets in 2025 (International Energy Agency, 2017). Cleantech solutions which connect to chemicals, transportation and water management also hold promise (Marra et al., 2015). As further explored in sub-section 3.4.3, food- and agritech—although largely overlooked today—is an area of future potential.

In general, sub-sectors less dependent on subsidies are more attractive options in that they offer stability, as subsidies are often temporary, and they may also threaten firms' motivation to reduce costs (Interviewee Y, pers. comm., August 23, 2017). State involvement is of course an important component in most scenarios. However, the misguided notion that all cleantech is capital-intensive continues to hold back private actors active in the sector. Contrarily, while there is still a potential for the more traditional capital-intensive commodities manufacturing, a "next wave" of more capital-efficient downstream-oriented business models of for example IT-based efficiency-related solutions are closer to the evident market growth (Day, 2015). Although not a cleantech sub-sector per se, IT—and other computer-related features—will continue to play an increasingly important part in most cleantech sub-sectors. However, the cleantech sector's image has not quite caught up with its actual structure today, with the large growth of sensor platforms and other software designed for homes, cars and grids, following the trends in big data and automation. That being said, these new "cleantech" companies have successfully managed to attract investors—VCs and industrial giants alike—usually "allergic" to traditional cleantech, in some—but not all—cases by avoiding the cleantech tag (CBI, 2014).

3.1.7 What is important for facilitating cleantech innovation?

Since cleantech, as a nascent sector, largely involves new solutions, the following sub-section highlights the importance of innovation—a precursor for investments. Firstly, entrepreneurs are a vital part of innovation. "*An entrepreneur is a person who perceives an opportunity and creates an organization to pursue that opportunity*" (Selig, 2014, p. 1). Such an *opportunity* with reference to cleantech depends on the circumstances presented by both the firm-related and individual factors presented in 2.3.3, and the various external factors summarised in *Figure 2*.

Seen from another point of view, cleantech innovation depends on two factors, the eco-sophistication (i.e. the quality of innovation) and demand (Walsh, 2012). The latter is largely driven by policy, which plays an important part in making technologies cost-competitive. However, a common dilemma relates to directing available funds to researching ever-better options in R&D labs or helping disperse the solutions already available (Suurs & Hekkert, 2009), something that in turn could trigger further improvements—especially through customer feedback. Finally, besides economics, two factors that are often overlooked are the aesthetic design, and failures to convey the ecological claims which drive the price premium (Walsh, 2012); a solution may be useless unless the advantages are clearly communicated. Georgeson et al. (2014) also highlight the importance of networks for influencing success in

cleantech businesses. This relates, on one hand, to technical expertise and, on the other hand, to professional service and advisory firms in assisting the management in firms and in mediating relational connections. A common network strategy is to participate in an incubator.

There are several ways of nurturing innovation, for example accelerators, incubators, innovation centres and launch pads. There are differences, but some common features include financial support, mentorship, training and networking opportunities, as well as a limited timeframe of a few months to a few years (Grifantini, 2015). With reference to accelerators, McHugh et al. (2013) highlight the small investment sums in early-stage companies (with typical equity stakes of ca. 4–10%), as well as mentoring and networking support for three to four months—a more aggressive timeframe compared to incubators (Grifantini, 2015). These types of institutions have to a large extent come to act as mediators between entrepreneurs and business angels, academia, VC and more experienced entrepreneurs (Cheng, 2016). While participation can be a boon, it is not a panacea, and participants of incubator programmes tend to grow faster, but also die off sooner, and businesses with some nominal experience as stand-alone businesses before incubation tended to fare better during it (Grifantini, 2015). Moreover, it has been difficult to find causalities between funding levels and firm survival (McHugh et al., 2013). Studies for both cleantech accelerators (Ladd et al., 2015) and incubators (Selig, 2014) have shown customer interaction and feedback to be key for improving performance. Finally, one key to success is flexibility, which in this instance favours start-ups over larger companies (Steinz et al., 2016), as the latter is generally more risk-averse and inclined to focus continual improvement instead of disruptive innovation (Walsh, 2012). Finally, as stated by Max Jerneck, for true cleantech innovation to succeed, a corporate restructuring needs to occur, one where mindsets are not solely governed by quarterly earnings prevails and private VC (Meyer, 2017).

3.2 The Chinese context

The aim of this section is to introduce the Chinese context, not with reference to cleantech, but in general. After a brief history of China's development since the 1978 market reforms, the investment landscape is mapped out, and special attention is given to the concept of *guanxi*.

3.2.1 China's direction since the 1978 market reforms

To understand how anything is run in China, it is important to first understand the importance of the state. Before Deng Xiaoping's market reforms following the death of Mao Zedong, there was no private sector, but since the introduction of the market reforms, the importance of private businesses has gradually increased (The Economist, 2017a). The objective of the market reforms was to scrap the collectivisation reforms, turn China into a more market-based economy, and make the country more open to foreign investments (BBC, 2006). Since 1978, private firms have been much more profitable and fast-growing than state equivalents. However, in the last few years, this trend has stalled, and since 2015, SOEs' investments have outpaced private firms', a trend thought to continue due to Xi Jinping's measures to merge firms to spawn national champions, as well as the support for *state capital investment and operation* companies which function as state-run private-equity funds. This would, allegedly, allow the state to extend its reach from transport, heavy industries and energy, and into technology-related sectors, jeopardising the efficiency (The Economist, 2017a). Be that as it may, but one of China's main strengths besides being able to go big, is the perseverance and long-term thinking (Hansson, L., pers. comm., July 31, 2017; 2030-sekretariatet, 2016). As mentioned, this thinking has allowed the country to dominate the solar sector despite large inefficiencies.

Since 1978, China has experienced an impressive economic growth. Wages have also grown considerably, many times higher than in most developed countries, although the country risks

facing the "middle-income trap", by which it will find it difficult to continue growing. China has long been dependent on exports to fuel its economic growth, recent years' economic slowdown and a shift toward domestic consumption could make the country a less favourable market for foreign investments (The International Labour Organization, 2014). Between 2011 and 2016, China's fixed-asset investment (e.g. infrastructure, property and machinery) as a portion of total GDP growth, grew from 62% to over 80% (News China, 2017), an important growth, although businesses will need a new focus and mindset.

3.2.2 The Chinese investment landscape

Ding et al. (2014) have compared angel investors' selection criteria in China and Denmark, and they found that angel investors in China depend more on friends and family in the management team. Another difference is that the Chinese angel investors are more risk-prone than their Danish equivalents, which operate within a more rule-based institutional context (Ding et al., 2014); China's judicial system is still relatively weak (Ramirez, 2014), although it is expected to gradually become more like that of Denmark. The pressure from the more *social contracts*-like agreements have advantages with appreciating social qualities, having a different social pressure to perform, and also an informal safety net in case of imminent catastrophes (Ding et al., 2014). This is contrasted by the disadvantages, namely a weaker rule of law, nepotism and reciprocal favours, and the amount of time and effort required to establish strong ties (ibid).

However, despite these ties and the fact that angel investors are almost five times as common in China, Chinese entrepreneurs are more sceptical of interference from investors. Chinese investors are also much less likely to trust strangers than Danish equivalents, which operate in a more rule-based setting, where optimal contracts can be made, with minority investors considered (Ding et al., 2014). Related to this, IP (intellectual property) protection is a large challenge, particularly for cleantech (Steinz et al., 2016), and The Chinese Communist Party has successfully managed to extract superior technology from foreign competitors for a long time. One example includes high-speed trains (Wong, 2017). To mitigate the risks, it is important not to innovate continuously and not rely on IP, to keep IP-sensitive parts outside of China and work with larger companies with assets abroad (Steinz et al., 2016). However, IP rights have become increasingly important in China, as noted in chapter 12 of the 13th FYP.

In China, there are traditionally "safe" career paths, mostly connected to government jobs, but today younger Chinese are more willing to pursue other tracks, such as entrepreneurship. That being said, it is still difficult to attract talent in China, as the school system fosters diligent students rather than innovative employees (Steinz et al., 2016). Compared to Sweden, which is ranked as more innovative, a smaller portion of Chinese sees good opportunities to start a business where they live, although more Chinese people intend to start a business, and failure is less feared, possibly due to Chinese entrepreneurs' higher status; fewer Chinese businesses were profitable and sold, and a higher number were discontinued for financial or bureaucracy-related reasons (Herrington & Kew, 2017). Still, things are beginning to change. Chinese businesses are improving their innovativeness, largely as a result of huge amounts of money, energy and people, which compensate for a political system which misplaces and squanders resources (Wong, 2017). While China has traditionally been known to focus mostly on traditional safe businesses, like wind power, there seems to be an emergence of less risk-averse investor behaviour in China, with diversification into new ventures and non-traditional start-ups without proven success records (Agerström, M., pers. comm., May 3, 2017).

Furthermore, it is also important to understand the power structures in China. For instance, Brent (2007) claims that the aspirations of local governments often clash with the goals of the central government. Additionally, regarding power structures on more of a micro level, it

should be noted that Chinese culture is largely influenced by Confucianism, which attributes considerable value to hierarchy and age. Moreover, as it has become "fashionable" to invest among the newly rich, these actors' expectations—which differ from those of traditional investors—can be difficult to manage and often have suboptimal implications from a business point of view (Steinz et al., 2016). Whenever difficulties emerge, it is important to remember the Chinese concept of *face*, i.e. the fear of admitting failure, and knowing how to save partners from embarrassing situations can be a valuable skill (Fang, 2005, p. 227).

3.2.3 Guanxi

Few concepts are more important to the Chinese context than *guanxi*—social capital—and ample research has been dedicated to understanding the concept and its importance for successful business interactions in China (e.g. Wang et al., 2014; Shou et al., 2011; Barnes et al., 2011; Wang, 2007, & Chung, 2011). In a Chinese context doing business is as much a matter of doing it with a person as doing it with a company, why it is important to both have a presence on the ground and to consistently work with the same people (Fang, 2005, p. 226).

Guanxi can be divided into many different categories. Liu & Fu (2011) divide it into *guanxi* connected to kin, locality (including sharing a dialect), sharing common experiences, and friendship relationships—which can develop from initial acquaintance- and business-based relationships. These categories are not necessarily mutually exclusive and often overlap. Today, the kinship or family category is becoming weaker due to the One-Child-Policy, with smaller families and fewer people eligible for this part of *guanxi*. Accordingly, friends and acquaintances will play an increasingly important part in the future, although kin will remain as the core. Today, IoT is also bound to change the practices of *guanxi*. One way to think of it is as a "small-circle culture" with different layers. In the inner one there is family, then there are friends, whereas for example foreign investors are farther out. Becoming friends is important to do business, as friends help each other and do not only think about economic aspects (Zhu, D., pers. comm., July 31, 2017).

Two other concepts connected to *guanxi* mentioned by Liu & Fu (2011) are those of *huibao* and *renqing*, which relate to reciprocity and expectations to repay favours or gains resulting from the other party's actions. It is important to note that *guanxi* is largely long-term-oriented. While formal contracts are seen more as temporary and as guidelines in the Chinese context, personal contracts and agreements, contrarily, are worth more. Accordingly, investing in *guanxi*, and by extension building trust, is essential (Steinz et al., 2016). Ultimately, personal connections decide whether deals are made. There is no public procurement available to ensure fair competition, few audits to ensure economic efficiency and avoid overcapacity, and few constraints posed by shareholders' values (Hallding, K., pers. comm., August 11, 2017).

3.3 Cleantech in China

The following section builds upon the previous two sections to explore cleantech in China. After an initial overview, this section is divided into six parts based on the categories introduced in 2.3.2. Specific sub-sectors are introduced in the next section, 3.4., where they are connected to the environmental problems they address. The first section of this chapter (3.1) explored the general definitions of cleantech. However, in truth there is no all-encompassing definition that takes the local and temporal context into account. Originally, the definition in China focused more on renewable energy, but it later came to include environmentally related fields such as wastewater treatment, waste-to-energy and the circular economy (Lin, N., pers. comm., August 07, 2017). Today, the Cleantech Group for instance even extends the definition applicable in China to also include "clean coal" and first-generation biofuel (Caprotti, 2016).

Overall, investments into cleantech have increased dramatically in recent years, making China the world's largest cleantech investor today (Steinz et al., 2016), with the second highest number of cleantech firms after the US (Sarazen, 2012), with most investments having been directed toward wind and solar energy (Steinz et al., 2016). In general, the average deal size for cleantech investments in China has been rather large, higher than in Europe, although not as high as in the US (Chen, 2009). While renewable energy in China started with massive hydropower projects decades ago, this continued with wind, and today solar has taken over this position (Forslund, 2016). In recent years, Chinese cleantech investments have followed global trends, by diversifying into more sectors than renewables (Azure International & Cleantech Scandinavia, n.d.). Within cleantech in China, renewables made up 30% of these investments in the previous decade, and in the years to come, China is expected to be a leading cleantech market, especially in renewable energy technology, manufacturing and project infrastructure (Caprotti, 2009). However, the cleantech VC boom has had repercussions in China as well. Section 3.4 goes more in depth into different sub-sectors and how these connect to different trends.

In terms of geography, the Yangtze Delta area (around Shanghai) topped the list for regional breakdowns in 2006, both for the number of deals and amount of investments. The Jingjinji region around Beijing followed, with the area around the Pearl River Delta in the south close behind. Generally, western and central China have a long way to go to catch up with the East (Parker et al., 2007). A decade later, this make-up had changed little (EU Gateway, 2016).

3.3.1 Technology

China has experienced an unprecedented development in recent years, and today it possesses much advanced technology. The country also spearheads technology innovation in some fields. However, it still lags behind in others, in which technology has to be imported from other countries. Fortunately, China has more and more home-grown innovation (Mialaret, J., pers. comm., July 31, 2017), and the importance of cleantech has become increasingly recognised. Castellacci & Natera (2013) compare two ways of catching up in technology levels, namely by imitating foreign advanced technologies or by innovating and producing new advanced knowledge. There is a close interdependence between these two (United Nations Conference on Trade and Development, 2013). To stimulate innovation, there is a multitude of policies dedicated to this purpose, as explored in section 3.6. With regard to imitation, there are also several Sino-foreign partnerships, ranging from renewable energy to energy efficiency, green buildings, and water and waste management (Chen, 2009). Apropos of imitation, the limitations around IP rights are—as mentioned—notorious in China, although patent systems are vital for stimulating innovation (Rodrik, 2013).

Besides imitation, producing own innovation is also an important part. One of the advantages provided is to not have to purchase foreign licenses (Gosens et al., 2015). Incubation plays an important in China, and only the US has more technology-based incubators (TBIs) than China, and the number is growing. The government has encouraged these establishments since the Torch Programme was launched in 1988, in order to tackle the vast regional disparity. In general, state-owned and diversified technology-based incubators are more common, but not as successful as the non-state-owned and specialised TBIs, as the latter two are more concerned with financial returns than job creation and government image (Hong et al., 2017). Unfortunately, there is a dearth of research on incubators in China (Xiao & North, 2016), but some of the factors that have positively influenced the success of firms in technology-based incubators early on include technical and financial support, entrepreneurial mentoring, geographical clustering—especially in economically and socially more advanced cities with

more support infrastructure for entrepreneurs (Xiao & North, 2016)—experience, size, the number of mentors and the amount of venture capital (Hong et al., 2017), although graduation records may not be the most accurate proxy for success.

Besides innovation, supportive infrastructure is also key for technology. As an example, the infrastructure for intermittent energy is a challenge, both in terms of energy distribution and storage. Currently, China is wasting 17% of the wind energy it produces, compared to 4% in Germany (Bergen, 2017). Considering that coal is still dominant, it is erroneous to refer to this as overcapacity as it is often done in the discourse. Rather, the flawed distribution and storage constitutes a bottleneck which should be addressed. Finally, one important factor that holds Chinese firms and cleantech innovation back, besides technology itself, is the lack of professional technical personnel (Feng & Wang, 2011). If one of the goals is to bring in foreign firms and personnel, a relevant point brought up by Steinz et al. (2016) is that these ought to be mixed with and into Chinese businesses to best manage the large inherent differences.

3.3.2 Policy

As this aspect is attributed a special weight in this study, it is addressed in more depth in section 3.6—*Cleantech-related policies in China*. In short, little support in terms of policy-making, excessive subsidies for natural resources and energy, along with lax enforcement, insufficient fines and preferential treatment to domestic firms are all barriers for cleantech development difficult.

3.3.3 Economic aspects

The economic circumstances are largely shaped by policy, both when it comes to the expected revenues of the new technology and the competition of incumbents. As mentioned, access to cheap coal has been a major barrier to direct funds toward cleantech. However, beyond policy, there are other economic determinants, including the global conjuncture. Moreover, the Chinese economy is experiencing a major—and inadvertent—shift by which exports will contribute less to the overall economy (PwC, 2016). Also, the relative economic slowdown in China is causing repercussions across multiple sectors (The International Labour Organization, 2014). As mentioned, government spending on cleantech has increased dramatically in recent years, and in 2015, it was about three times higher than in Europe (Mathews, 2016), and China is the largest cleantech investor in the world (Steinz et al., 2016), although it still lags behind when it comes to supporting innovation. Limited domestic market demand is often a challenge too (Feng & Wang, 2011). Connected to this, one challenge has been to make cleantech solutions more affordable for lower-income Chinese consumers (Chen, 2009). Additionally, as a mean to achieve better profit margins, more and more Chinese cleantech companies have looked towards vertical integration (Azure International & Cleantech Scandinavia, n.d.).

3.3.4 Political structure

In China, the state is more important than in few other places, and the country has been run by the same party, The Communist Party of China, since 1949. Its importance for making policies and directing funds is evident, but it extends to the way it is embedded into many parts of businesses, in SOEs and joint ventures, especially, as mentioned, when it comes to more conventional categories of cleantech, such as wind and solar energy. That being said, private investors have come to play an increasingly important part over time. However, a break in—and even reversal of—the decade-long trend of fewer SOEs has been observed since 2015 (The Economist, 2017c), and progress in opening this sector will probably take a long time, and it requires overcoming powerful interest groups (EU Gateway, 2016).

Regardless of the country, collaboration between national and regional governments is important. Experience from Sweden has highlighted this importance across multiple sub-sectors, be it wood-chip boilers or organic food (Cooke et al., 2008). In China, entrepreneurs consider both levels, but they usually look toward the top first (Zheng, L., pers. comm., August 04, 2017). For industrial policy to be successful, it is not so much a matter of a list of specific policies, as the right state of mind—one where the climate of collaboration is more important than simply providing financial incentives. This state collaboration is vital to elicit investment opportunities from private actors and to identify bottlenecks; this requires "*a government that is 'embedded' in the private sector, but not in bed with it*" (Rodrik, 2013). President Xi Jinping implemented several anticorruption measures in 2013, including the austerity measures. Besides strengthening the power of Xi Jinping and the surrounding top tier of Chinese politics, these measures have also changed the way in which businesses and industries operate (EU Gateway, 2016).

Unfortunately, in China, the aspirations of local governments often clash with the goals of the central government (Brent, 2007), and the setting of very ambitious targets has often resulted in regional officials publishing statistics with limited bearing on reality (EU Gateway, 2016). Also, the opaque investment processes and regulations (Brent, 2007), and the lax enforcement of environmental rules and regulations (Feng & Wang, 2011), including *the Chinese Environmental Protection Agency*, has rendered the development of cleantech difficult (Brent, 2007). Also, implementation (e.g. of subsidy applications) is still rather weak. Also, an important characteristic of the Chinese market connected to its structure is that it develops extremely quickly, but also gets saturated extremely quickly (Lin, N., pers. comm., August 07, 2017).

3.3.5 Social aspects

Like the corresponding sub-section on policy is covered in section 3.6, the content of this sub-section is covered in section 3.5—*Public discourse and cleantech in China*. However, in line with the definition laid out in 2.3.2, social aspects include more aspects than public discourse; it also includes business culture. As explored in sub-section 3.2.3, *guanxi* is really important for investing, and Liu & Fu (2011) highlight the importance of business networks for cleantech in particular, as most cleantech firms are relatively small, in effect meaning more difficulties of establishing trust, and a weaker bargaining power in market situations with big projects. Attention to hierarchy is also important, as is the focus on traditional markets.

3.3.6 International competition and access

Competition is an essential aspect. It both relates to the number and quality of competitors within the same business, but also across different alternatives. This applies to cleantech as well. For example, a study by Haase et al. (2013) found that—unsurprisingly—the existence of few alternatives to liquid transportation fuels has positively influenced its market share in the US. Besides competition, access is an important factor for driving cleantech development. It includes Chinese companies' prospects of accessing foreign markets, and for foreign firms to diffuse their technologies in the Chinese market. Although there are a multitude of restrictions that apply to the later, China has in fact signed 13 free trade agreements with a wide range of countries and one regional intergovernmental organisation, ASEAN (EU Gateway, 2016).

Bjornali & Ellingsen (2014) assert that while the step-wise internationalisation applies to existing old industries, such as hydropower, more nascent sectors behave differently by regarding the entire world as its potential market from an early stage. This global mindset is important to keep in mind when considering the cleantech market and prospects of success. However, trade barriers can inhibit cleantech growth. For foreign firms to be able to enter China, there are several barriers besides the cultural, including quota for local manufacturers,

obscure investment regulations, restrictions on foreign capital, and fears of IP infringement, which in reality means that fewer investors are interested in investing in China (Chen, 2009).

Finally, one aspect that may influence the prospects of cleantech in China is adherence to international environmental agreements and conventions. For example, where there are many signatories to a protocol which restricts certain substances or practices, this may lead China to have to change parts of its trade to conform to these stipulations even if it is not a signatory itself. The Montreal Protocol has influenced the development of chillers, and, more recently, the Paris agreement in particular has changed the playing field for any type of cleantech that can help meet this target (Zhang, X., pers. comm., July 31, 2017). Conversely, an underlying factor that could also positively impact Chinese competitiveness in this sector could be Trump's recent move with opting to leave the Paris agreement. It has left the door open for China to lead and push forward (Hansson, L., pers. comm., July 31, 2017). Rather than saving the environment, the driving factor for signing this agreement was more connected to an opportunity to, first of all, solve the pollution issues connected to coal and thermal generation, and secondly, with the whole world signing up, tremendous new export and job creation opportunities, especially as China is already the biggest manufacturer of PV cells and wind turbines. Lastly, it is also about energy security and not having to rely on imported fuel (Sahu, 2017). China holds 14% of global coal reserves, but only 1.5% of the world's proven crude oil reserves (Miller & Spoolman, 2012). Finally, another international aspect worthy of mention is that of cross-boundary pollution, which could serve as another driver. In fact, 77% of the black carbon (soot), 25% of the particulate matter, and 33% of the toxic mercury in the air above Los Angeles can be traced back to China and its coal-fired power (ibid).

3.4 The environmental trends behind China's cleantech sub-sectors

The previous three sections have introduced the cleantech sector, important Chinese business characteristics and the intersection of these two areas. Based on this background, the following three sections (3.4–3.6) are intended to lay out how environmental problems, public discourse and policy influence the different cleantech sub-sectors. This section focuses on the environmental trends. First, however, it introduces the major megatrends in China, followed by a brief synthesis of China's pollution problems. Thereafter, as energy is the dominant theme in the cleantech sector, relevant cleantech sub-sectors are categorised according to supply and demand factors in the next two sub-sections. Then the sub-sectors and features which are not connected to energy are listed.

3.4.1 Megatrends

Megatrends are large geostrategic and macroeconomic forces which are shaping the world, and form some of society's largest challenges and opportunities. For firms intent on remaining relevant in the long run rather than merely being driven by quarterly earnings, anticipating and adapting to these trends is a matter of survival (PwC, 2016). Also, as it is often difficult to study the impact of one specific policy separately you have to study megatrends and how they are echoed in the national and provincial plans, as these are important for guiding cleantech (Lin, N., pers. comm., August 07, 2017). The five listed trends (PwC, 2016) are:

A shift in global economic power: Although China's economic growth is slowing down, it will still continue to grow relative to the west for many years still. In 2016, China had 225 million middle-class households compared to 5 million in 2000 (The Economist, 2016).

Accelerating urbanisation: Over the next 15–20 years, China will have to fully urbanise another 400 million people while addressing the growing inequality and disparities in quality of life, particularly between the eastern and western parts of the country (Brubaker, 2011).

Demographic shifts: While closely related to the previous category, there is another aspect of shifting demographics, namely that of an aging population. The 13th FYP is also addressing the reformation of the One-Child Policy. In 2007, Su Wei—an official of China's foreign ministry—claimed that the One-Child Policy had reduced greenhouse gas emissions by 1.3 billion tonnes in 2005, by reducing the number of births that otherwise would have taken place during the previous three decades by 300 million (The Economist, 2014a).

Climate change and resource scarcity: The temperature increase in China in the last century was 1.5 times higher than the global average (National Intelligence Council, 2009). The consequences of climate change will be particularly severe in China, considering the country's already stressed water resources, sinking cities in the delta regions, rising sea levels and the increased frequency of natural disasters. Also, the danger that biodiversity and many biomes face is considerable (Lai, 2011). Brubaker (2011) also mentions the importance of policy here to put pressure on the most damaging industries and practices. In 2007, five sectors accounted for 81% of all greenhouse gas emissions, namely *Electric Power/Steam & Hot Water Production and Supply*, *Coal Mining and Dressing*, *Non-metal Mineral Products*, *Smelting and Pressing of Metals*, and *Agriculture* (Chen & Zhang, 2010), all categories which also have implications on resource depletion. Moreover, with reference to resource scarcity, China is today the world's largest consumer of fossil fuels, minerals and other primary materials; its use of these materials increased over 13 times between 1980 and 2008 (West et al., 2013).

Rise of technology: Technology may seem most pertinent for cleantech solutions. However, the underlying trends that have contributed to the country's environmental problems are essential. Therefore, the other megatrends ought not to be disregarded.

3.4.2 Pollution

Besides the five megatrends listed above, pollution is another theme must be mentioned. Pollution—air, water and soil—is the most tangible environmental issue in China. Despite the country's growing demand for food, China's total arable land has decreased from just over 13% in 1990 to approximately 11% today, a large part of the drop caused by pollution. Gao Shengda, secretary of the China Environmental Remediation Industry Association, admits that China lacks the technical skills and experience to stabilise its polluted soils. Also, if China were to clean all its soils to the same standards as London did for the Olympic Games, it would cost $1,000 trillion (The Economist, 2017b). Technologies that can make remediation more effective and efficient are much sought after. Chen (2009) mentions water pollution as well as scarcity as severe issues in China, particularly in the north. According to one survey by the Ministry of Water Resources, 80% of the wells tested in China had water too polluted to drink (Piao, 2016). Remediation technology for both soil and water is much needed.

Besides soil and water, air is for many Chinese the most tangible issue, especially in and around urban areas. Air pollution might be responsible for as many as 4,000 deaths a day in China, or almost 1.5 million people annually. This would account for about one sixth of all deaths in the

country (Lu, 2015). Polls have also shown that people care more about air pollution than global warming (Magistad, 2015). Be it in terms of micro-oriented solutions for indoor air purifiers, filters and masks, or more macro-oriented solutions which target the causes both in preventing and addressing pollution sources with end-of-pipe technology, the market potential is undeniable. Air pollution, or rather, people's sentiments towards it, is a major driver behind most of the areas addressed in the following two sub-sections.

3.4.3 Energy: supply factors

A few years ago, 63% of total greenhouse gas emissions were caused by energy-related carbon dioxide (Chen & Zhang, 2010). One category alone accounted for 37%: electric power and hot water production and supply (ibid). It is difficult to imagine any future scenario where non-renewable energy will not continue to play a substantial part in China's energy sector. However, renewables are on the march, and China installed almost half of global renewable energy in 2009 (REN21, 2010), and it has been the single largest renewable energy developer in the last eight years, and it accounted for 32% of global financings of renewable energy (REN21, 2017). When it comes to hydropower, wind and solar PV capacity, in 2016, China both had the highest installed total capacity and annual net capacity addition, although the country is not near the top for either of these categories on a per capita basis (REN21, 2017).

Solar

Accounting for 46% of global addition (ibid), the addition of solar capacity in China is astonishing, and the goal of 560 GW by 2020 in the 13th Five-Year Plan for Solar Applications does not appear unfeasible (International Energy Agency, 2017). Also, it is important to note that solar power comes in many forms for both heating and electricity. When it comes to solar hot water collectors—a low-tech solution in no need of grids—China is a world leader with 70% of the market (REN21, 2010), accounting for 75% of the global addition in 2016. 60% of these systems were large domestic hot water-based for multi-family houses and the public sector, and close to 40% were for single-family houses (REN21, 2017). It is estimated that half of all Chinese households will have their water heated by solar power, in one way or another (Miller & Spoolman, 2012). Also, as the use of solar space heating has increased, new opportunities for solar cooling have emerged, and in 2016 an office building in Shanghai demonstrated the potential of using solar heat for both heating and cooling (REN21, 2017).

Wind

In 2013, wind passed nuclear as the third largest source of electricity in China, and the country's installed wind power corresponded to 83% of the wind power installed in the European Union (Shukman, 2014). China still has the highest installed capacity in the world, but the growth of installation is much slower than that of solar, and the country had to postpone its 2015 capacity target to 2020 (REN21, 2017). However, it is still expected to continue to grow from making up 2% of all renewable energy sources in 2010 to 17% in 2030, or 4.4% of the total primary energy production (The International Renewable Energy Agency, 2014). The biggest potential for wind energy on land is found in the north-western and north-eastern parts of China, while the biggest potential for offshore wind power is found in the Taiwan Strait (Wang et al., 2011)

Hydropower

Hydropower is generally given little attention in the policy discourse. However, considering its importance as a green non-intermittent energy source in China—and as all applications are not mega-scale—it is briefly introduced here. In 2012, hydropower accounted for 8% of the total

primary energy consumption in China (The US Energy Information Administration, 2015), and although the country already has 28% of the installed capacity of hydropower (REN21, 2017), the output is projected to increase by almost 150% between 2010 and 2030 (The International Renewable Energy Agency, 2014), 80% of which would be located in the southwest, to a large extent in ecologically fragile and earthquake-prone areas, not to mention the implications dams could cause on cross-country river flows (Li, 2011). In 2016, China installed 3.7 GW of *pumped storage* capacity, giving the country a total of 27 GW (REN21, 2017). This energy (storage) form is also not as dependent on geography as large dams.

Bioenergy

Although bioenergy holds promise for future cleantech applications in China, there is some confusion about what it actually means. Sometimes waste-to-energy is included. Bioenergy is often ranked as having a small contribution to the overall energy output, but if one were to include households' energy, one third which still rely on traditional biomass for cooking (REN21, 2017), biomass reached 58% of the total renewable energy output in 2010 (The International Renewable Energy Agency, 2014), and in fact, there were 25 million small-scale biogas systems installed in China in 2009 (REN21, 2010). However, this huge part of the total energy output is often not addressed, with larger and more technologically advanced bioenergy solutions often overshadowing it. Regardless, the growth trajectory is clear, as China plans to increase its biomass power capacity from 3.2 GW in 2009 to 30 GW in 2020 (REN21, 2010).

Geothermal energy

Another sub-sector that the discourse mostly overlooks is geothermal. At a capacity of 30 MW (2015), China is far behind the world leader—the US—at 3.6 GW (REN21, 2017). While it makes up ca. 0.6% of the energy output today, the potential is huge, as China holds one sixth of the world's geothermal resources. Unfortunately, hot dry rock accounts for the largest share by far, a form that is currently not as developed as other geothermal energy sources (Wu, 2014). However, while most high temperature resources are located in remote areas of Yunnan and Tibet, the regions adjacent to where most cleantech VC circulates—Jingjinji, The Pearl River and Yangtze Delta—have considerable medium-temperature resources (Li, 1997).

Wave and tidal energy

Some more uncertain energy sources include wave and tidal power, which have not yet experienced any major development. By combining data from Guo (2010) and Huodong Jia (2016), one can infer that the tidal energy that could be extracted from the country's coastline would correspond to approximately 12.6% of its renewable electricity in 2010, or 2.0% of its total electricity output. Similarly, the wave energy that could be extracted from China's coastline would correspond to 40.3% of its current renewable electricity, or 6.5% of its total electricity output. However, these are nascent energy sources, and although they are promising, they are shrouded by uncertainty. Also, with reference to wave energy, Wan et al. (2014) bring attention to the drawbacks posed by the seasonal fluctuations; along most of the eastern coastline, this energy source is mainly an option during the fall and winter. Finally, another nascent energy form is ocean thermal energy conversion, which use the temperature difference between warmer surface water and cooler deep water to produce energy, and China has a target of an installed capacity of 50 MW by 2020 in its 13th Five-Year Plan for Ocean Energy (State Oceanic Administration, 2017).

Fossil fuels

In spite of the potential for renewables in China, it is important to remember that they only accounted for approximately 13% of the total energy output in 2010 (International Renewable Energy Agency, 2014). Coal is still the backbone of the energy system, and it will remain important for many years to come. Coal makes up 60–70% of not only the electricity consumption, but also of total energy consumption, and many researchers expect it to remain around 60% by 2020 (National Energy Administration, 2013). That being said, a large part of China's coal industry risks becoming stranded assets (Gray, 2016). As mentioned, "clean coal" is often considered cleantech in China, and solutions that relate to this ought not to be disregarded considering the dominance of coal. Similarly, the potential of carbon capture and storage (CCS) should also not be forgotten. Any major Chinese assessment model—with a less than 2˚C increase under the Paris agreement—includes a significant component of carbon capture and storage, introduced before 2020 at the latest (ibid). Currently, this technology is off the targets set for its contribution to meeting the 2025 interim 2°C scenario targets (International Energy Agency, 2017). Another part of carbon capture and storage relates to agriculture and deforestation (Eyraud et al., 2013), although the link to cleantech is less evident.

Moreover, besides coal, oil accounted for 18% and natural gas for 7% of the total 2014 primary energy consumption in China (Lawrence Berkeley National Laboratory, 2016). It is hard to project the future shares (Forslund, 2016), but natural gas will likely play an increasingly important role, as it is considered to be less bad than both coal and oil; some studies have found its environmental benefits to be 26 times better than coal-generated electricity (National Energy Administration, 2014). Furthermore, nuclear, sometimes included under the Chinese cleantech umbrella, as it is an attractive solution as there are no direct noxious or greenhouse gas emissions. Although the government plans to expand the share of nuclear, it only accounted for 1% of total primary energy in 2012 (The US Energy Information Administration, 2015).

3.4.4 Energy: demand factors

Supply factors are certainly important, but demand factors may be even more important for driving cleantech, as the demand does to a large extent determine supply. Electricity generation in China makes up almost half of the total energy output, higher than in many other countries (Lawrence Berkeley National Laboratory, 2012). When heating is defined to include both space heating, water heating and cooking, it accounts for close to 90% of the energy use in the buildings sector, or almost 28% of the total energy in China (The US Department of Energy, 2012). Fuels account for most of what is neither electricity nor heat. In particular, oil has increased its share of the total energy consumption considerably (Lawrence Berkeley National Laboratory, 2016), and it had a share of 20% of the total energy consumption in China (The US Energy Information Administration, 2015).

Energy efficiency

Energy efficiency has a considerable potential to save energy across multiple sectors in China ranging from housing and construction to industry and transportation. These last two consumed almost 70% and 15%, respectively, of China's total energy consumption (Lawrence Berkeley National Laboratory, 2012), and they are addressed separately below. According to Walker & Liu (2015), the current waste from electricity (resulting from poor planning, power grids and infrastructure) could power all of Germany. Sometimes as much as 25% of the renewable electricity is wasted, and grid development is receiving a lot of support from the government (Sahu, 2017). Reliability is an important element for reducing overproduction.

Also, "energy intensity" has been addressed in several of the previous FYPs, and in the 13th edition, the goal is to reach a 15% improvement by 2020, based on 2015 levels, with opportunities ranging from buildings to transport, industry and changes of a more structural kind (International Energy Agency, 2016a). Buildings are currently off the targets for their part as a sub-category in meeting the 2025 interim 2°C scenario targets (International Energy Agency, 2017). Besides the already mentioned energy efficiency, water efficiency technology is also expected to take off, for example on an industrial level with water reuse methods (Brent, 2007). The focus on the Beijing-Tianjin-Hebei region for environmental governance in the 13th FYP also calls for water management solutions, as this is a hotspot for water scarcity.

Apropos of energy efficiency, heat pumps hold considerable potential for the Chinese market, as heat pumps have only recently started to gain attention in China, with sales tripling between 2014 and 2015, and local governments supporting heat pumps with subsidies (REN21, 2017). District heating could also be implemented more in China to cut net energy losses, by utilising waste heat (a major issue in China), optimising insulation during delivery, and by economies of scale. District heating also presents an opportunity to add in more renewable energy, as much as 24% by 2030, from 1% today, according to a roadmap presented by International Renewable Energy Agency (2017). The country has already constructed many district heating systems in its recently urbanised areas, but a major challenge is its reliance on coal in these systems, at about 90%. Solar thermal is also gaining ground, and Denmark is in the lead here; in 2016, it commissioned the largest solar thermal plant in the world (REN21, 2017). As much as 32% of district heating and cooling in China could be met by solar energy (International Renewable Energy Agency, 2017).

Industry

When addressing China's environmental impact, it is impossible to overlook industry, as it consumed almost 70% of the country's energy and accounted for 72% of the country's greenhouse gas emissions in 2010 (Lawrence Berkeley National Laboratory, 2012). The industry sub-sectors which contribute most to China's total greenhouse gas emissions in 2007 were smelting and pressing of metals (14.7%), production of non-metal mineral products (in particular cement and glass) (13.8%), and chemical products (4.9%) (Chen & Zhang, 2010).

However, moving away from energy-intensive manufacturing poses considerable challenges (Brubaker, 2011), and besides specific the multitude of energy-efficient technologies that could be applied across many of the industries, processes should also be considered more broadly. One part of the solution that deserves mention is industrial symbiosis. Harvey (2012) mentions the company *LanzaTech*, which is making ethanol for aviation from carbon monoxide waste streams, from steel manufacturing and other heavy industrial facilities. The value of such solutions is particularly valuable in China, not only as it is largely unexplored, but also as controversies around water and land use, and competition with food are avoided Harvey, 2012), as compared to convention biofuels. However, ethanol production is actually growing in China (REN21, 2017). Connected to this, second-generation biofuels focusing on biorefineries ought to be considered, as the potential is still largely unexplored (REN21, 2010).

Extraction & mining

This category is comprised of areas which to some extent are not traditionally thought of as cleantech. However, as mentioned, greening conventional sectors is an important part of cleantech, especially in the Chinese context. In line with the findings of Chen & Zhang (2010), coal mining and dressing made up 6.7% of the greenhouse gas emissions in 2007. As these

emissions are attributed to a process which generates more energy—the production of coal—it could also be categorised under supply. Unsurprisingly, clean coal is an area that is encouraged by the National Development and Reform Commission (EU Gateway, 2016), Besides coal, extraction, processing and dressing of petroleum, natural gas, ferrous and nonferrous metals and other minerals accounted for another percent (Chen & Zhang, 2010).

Transportation

One sector that is difficult to disregard is transportation. Already in 2003, it accounted for ca. 17% of total energy use, and between 2005 and 2030, the sector's energy use is expected to increase between three and four times, more than the overall energy use (Knorr & Dünnebeil, 2008). Accordingly, addressing this sector is inescapable. Recently, Chinese-owned *Volvo*, announced that they will phase out convention engines by 2019; today China is one of the fastest growing markets for electric vehicles (Ewing, 2017). Indeed, when it comes to electrification, China is a world leader (Wong, 2017). By the end of 2015, China had 98% of the world's fully electric buses according to *Cleantechnica*, and the country might be fully electric in this category already in ten years (Ayre, 2017). For sales of electric cars and two-wheelers, China is also a global leader (International Energy Agency, 2016b), and sales increased from 11,600 vehicles in 2012 to approximately 350,000 in 2016 (REN21, 2017). Besides solar and onshore wind, electric vehicles (EVs) and energy storage are in fact the only sub-categories—used by the International Energy Agency—which are currently meeting the 2025 interim 2°C scenario targets (International Energy Agency, 2017). China's contribution here is considerable. As China is leading this boom, EVs are a very interesting field for investing in (Interviewee Y, pers. comm., August 23, 2017).

With regard to transportation, it is also important to consider other means than motor-related vehicles, but also alternatives, such as bikes. While bikes may not bring cleantech to mind themselves, the sharing system under which they are provided does. China is a world leader here, and one of the giants in this field, *Ofo*, has grown from 2,000 bicycles in 2015 to hundreds of thousands across China, and the growth is expected to continue. One of the key differences compared to other systems is that there are no bicycle stands. (2030-sekretariatet, 2016). It is hard to make predictions regarding the sharing economy, but the potential is undeniable.

Remainder

As mentioned, industry and transportation consume the bulk of China's energy. The remainder—less than one sixth—is comprised of construction, commercial energy, residential energy, agriculture and "others" (Lawrence Berkeley National Laboratory, 2012). With reference to the commercial and residential energy, heating is dominant in the northern half of the country, while the electricity consumption plays a relatively more important part in the southern half during the winter. Additionally, services are listed by Eyraud et al. (2013) as one important component of demand, and it will likely become increasingly important as the Chinese economy is shifting from export-related industries to domestic consumption.

3.4.5 Non-energy-related environmental problems and sub-sectors

Energy is the key theme behind cleantech, and it has been covered in the previous two sub-sections. However, cleantech comprises more areas than energy, and these are covered in this sub-section. First of all, the solutions which cover water and soil pollution come to mind. Wastewater treatment and water purification and soil remediation technologies come to mind based on the previous sub-section on pollution in China.

Water scarcity

An immediate threat besides pollution is water scarcity, especially in northern China. 300 of China's 662 cities have insufficient water supplies. Of these, 110 experience severe water shortages, while 30 out of 32 metropolitan areas (more than 1 million people) are struggling to meet water demands (Zhou et al., 2014). Besides measures to prevent and remediate the pollution and excessive extraction of the country's water resources, other solutions relate to desalinisation, rainwater recycling, water storage (EU Gateway, 2016), as well as drip irrigation, and—perhaps most importantly—minimisation of leakage. Although it is difficult to estimate, the rate of leakage could be as high as 30-60% in urban areas (Miller & Spoolman, 2012).

Food and agriculture

Furthermore, agriculture and food is a sector with a huge impact. Globally, they it accounts for as much as 29% of global greenhouse gas emissions (Science News, 2012). Considering that power generation and industry still account for the majority of the emissions in China, the contribution of the agricultural sector is lower, relatively speaking, as low as 10% according to one estimate of data from 2007 (Chen & Zhang, 2010). Also, unlike many high-income countries, fertiliser manufacturing (besides meat) has the largest impact of greenhouse gases in the agriculture sector in China (Gilbert, 2013). In fact, nitrogenous fertilisers in China account for as much as 7% of the country's total greenhouse gas emissions (Zhang et al., 2013). Also, one study with a really ominous message has found that the impact of the agriculture and food sector in Sweden will have the largest greenhouse gas emissions by far in 2050 (Swedish Environmental Protection Agency, 2012). While the relative share of the different sectors will be different in China, the message is the same: The impact the processes of food cause will be difficult to address, even after all other parts of our society have been addressed—unless drastic changes occur. In line with thinking, one study found that it is possible to achieve emission reductions by 20–40%, but beyond that, more transformative changes are needed (Bordoff, 2016). Moreover, China has to feed 22% of the world's population on only 7% of the world's total arable land (Yin, 2017).

Unfortunately, food- and agritech are given little attention in the cleantech discourse. Still, much could be done, be it technologies and solutions that address food waste, inefficiencies across the supply chains, or how and what kind of food is consumed. According to some estimates, livestock account for four-fifths of the total emissions of food (Friel et al., 2009). There are both technologies for plant-based protein, artificial meat, and for increasing the muscles of cattle, and changing what they eat—for instance insects raised on biogas. Moreover, data-intensive farming techniques are improving the yields of crops like soyabeans by careful monitoring of how much water and fertiliser are used (The Economist, 2017d). Higher yields, less impact. This is particularly important as China's cereal yields dropped for the first time in 12 years in 2016 (Yin, 2017). Another study found that when a supplement was added to cow feed, it reduced methane emissions by 30%. (Hristov et al., 2015). Finally, another perspective that deserves mention is aquaculture, as China raises 70% of the world's farmed fish, and consumes two thirds of all fish and shellfish globally (Miller & Spoolman, 2012).

Consumption-related areas

The impact of human consumption reaches from resource depletion, to energy use, and to many other areas. Based on the categorisations of greenhouse gas emissions for 26 different sectors applied by Chen & Zhang (2010), most are connected to industry, although this means

that they relate to consumption indirectly. The delineation between the two is tentative at best. However, the following were found to relate to consumption more directly:

1. Garments and other fibre products, e.g. leather, furs, down and related products
2. Processed food, tobacco and beverages
3. Paper products and printing
4. Electronics
5. Wholesale, retail trade, hotels, and catering services
6. Furniture manufacturing and other applications of wood and wood-like materials

Apropos of consumption, the sharing economy deserves mention. China has favourable conditions for sharing: a huge population, dense cities, a large group of people with relatively small incomes, and cutting-edge, smartphone-based mobile payment systems (Qin, 2017). China is already ahead of many other countries when it comes to the sharing economy (Wong, 2017). Some examples include the Chinese ride-hailing app *Didi Chuxing*, the country's bike-sharing systems already discussed in the previous sub-section under *Transportation*, and the most recent hotspot for VC investors in this area during the first half of 2017: portable phone-charging business (Qin, 2017). However, while a lot of money has been spent in this area, some critics bring attention to the lack of good ideas, even though the government approves of it and has projected that the sharing economy will constitute 10% of the economy in 2020 (ibid).

Waste and recycling

Connected to consumption, waste and recycling deserve mention. While it connects to energy efficiency, there are additional dimensions, such as the resource and waste aspects. Waste is indeed a large problem, and it is expected that the municipal solid waste will increase by 200% between 2009 and 2030 (The Economist, 2009). Recycling is largely carried out by the informal sector, and the rapidly increasing municipal solid waste mostly ends up in the country's landfills, although more and more is being incinerated. In 2003, 85% of the municipal solid waste ended up in landfills, while only 5% was incinerated; in 2013, these shares had changed to 68% and 30% respectively, and over 300 waste-to-energy plants have been planned between 2016 and 2019 (EU Gateway, 2016). Still, there are vast landfilled areas in China, creating considerable pollution problems. However, one opportunity relates to extracting landfill gas, as it both generates energy and reduces emissions. Besides municipal solid waste, there are many other categories of waste, such as electronic waste. In fact, 70% of the world's e-waste ends up in China (Miller & Spoolman, 2012). However, despite the development of the waste sector in China, the technological know-how is still largely absent (EU Gateway, 2016). Finally, the circular economy is gaining increasing attention in China among policy-makers, with multi-sectoral productivity- and reuse-related targets laid out in the last three FYPs. The country's resource use is still inefficient, the amounts of waste are increasing, and both landfill-related incidents and incineration-related protests have increased (Mathews & Tan, 2016).

Further areas of environmental impact

Besides the mentioned cleantech sub-sectors, there are many more environmental problems for which there are few direct cleantech solutions addressed in the cleantech discourse—although there are few areas, which do not experience positive spillover effects of technologies which address pollution and climate change in one way or another. While there are interesting technologies which capture these, any elaboration around these would be a digression, with reference to the research questions. These additional environmental problems that were not

covered were identified by looking at the Swedish 16 environmental quality objectives, as well as China's own environmental quality targets from the FYPs, and a few areas not covered were identified, such as:

Biodiversity & protection of different biomes: China holds 14% of the world's animals and 10% of its plants species (UNDP China, n.d.). Unfortunately, biodiversity is declining sharply, and almost 20% of the country's plant species are endangered (Zheng & Cao, 2014). In 2016, there were 446 nature reserves in China, covering 10% of the country's surface (China Council for International Cooperation on Environment and Development, 2017).

Toxicity: People's exposure to toxicity—be it chemical toxicants, disease-causing microorganisms, carcinogens or radiation—is higher than in many other countries. However, recognition of the risks is gradually growing, and in 2010, a Chinese equivalent to REACH was released (Chemical Inspection & Regulation Service, 2014), largely as a response to growing public demand for chemical safety (Tracy, 2011).

Eutrophication: Although this is a type of water pollution, it ought to be mentioned separately, as it is mainly caused by China's agricultural methods. Since the 1980s, gradual accumulation has made the eutrophication increasingly severe (CCTV, 2013). China's water bodies today have some of the world's highest phosphorus loadings, and the problem continues to worsen, despite large resources spent to address the problem (Ni et al., 2016).

Acidification: This is largely caused by sulphuric emissions from various sources, and the deposition is most severe along the eastern coast (Zhao et al., 2013). Excess deposition of sulphuric compounds in China has implications on both humans and the environment; it caused reductions in crop yields of up to 25% already in the 1980s (Larssen et al., 1999).

The depletion of atmospheric ozone: The Montreal Protocol has been ratified by most countries, including China, which recently stepped up its efforts to reduce emissions of ozone-depleting gases, by announcing to close several hydrochlorofluorocarbon production lines in just one year, thereby meeting one sixth of its 2030 target (The World Bank, 2014).

Noise pollution: 92% of daytime but only 26% of nighttime monitoring sites in the 309 largest cities attained levels within the national standard (China Council for International Cooperation on Environment and Development, 2017). There were 354,000 noise-related complaints documented in 2015. This accounts for 35% of all pollution-related complaints—second only to air pollution (China News Service, 2016).

3.4.6 Important features of Chinese cleantech firms

Besides addressing the various cleantech sub-sectors, a few words should also be said about some of the overarching features of the sector. In line with one of the main suppositions of this study, the capacity to understand the contribution of the various aspects introduced in *Figure 2* is pivotal, regardless of which sub-sector is ultimately selected. As mentioned, social connections and access to the right networks are particularly important for Chinese cleantech companies (Liu & Fu, 2011), as is a strategy for protecting IP (Steinz et al., 2016). As mentioned in sub-section 3.1.6, the "next wave" of capital-efficient downstream-oriented business models with IT-based efficiency-related solutions holds considerable promise (Day, 2015), and it is difficult to see why this would not apply to China. In fact, computer-based solutions (e.g. IoT, big data, AI, etc.) in general are certainly up-and-coming in China, and the country is already ahead of most countries in e-commerce and fintech (Wong, 2017). Computer-based solution,

in general, apply to all areas of society, but in particular to cleantech. Finally, the fact that China is the world's largest market implies that cost-effectiveness is essential. Also, as China is a very policy-driven economy, policy is a factor that cannot be overlooked.

3.5 Public discourse and cleantech in China

Public discourse can be defined as discussions that focus on national issues which large sections of a population follow or are affected by. In a very broad sense, it is how we arrive at a public opinion around a topic (White, n.d.) In line with the categorisation in 2.3.2, it is here used to refer to all aspects included under *Social aspects*, except business culture.

The cultural revolution (1966–1976) all but wiped out autonomous civil society in China. However, although not on a par with civil society in many western countries, a gradual recovery has occurred. *Chinadialogue*—a bilingual Chinese–English online publication on environmental issues and climate change started in 2006—has met with some success, and around this time, it was no longer unthinkable for people in China to share information and ideas on environmental crises (Hilton, 2013). By 2011, there were ca. 449,000 registered civil society organisations—including NGOs—in China and there may be as many as three million (Geall, 2013). Although the state has been ambivalent in approaching this emergence, there has also been a recognition that the transition to a more market-oriented economy would bring with it a civil-society revival (Hilton, 2013). In spite of more state control recently (The Economist, 2017a), the public has become an increasingly important actor in China. Still, Confucianism is an ideal which permeates Chinese society (Steinz et al., 2016), and deference to authorities limits open dissent, and public protests against breaching environmental rules and regulations are rare, which means that businesses are not, in a way, forced to look at cleantech innovation (Feng & Wang, 2011). However, the public voice with demands of safe food and clean air is becoming increasingly important (Lin, N., pers. comm., August 07, 2017). Consumers are also important, as consumer acceptance levels are high in China, which facilitates for new technologies to be accepted (ibid). Unfortunately, besides tangible health-related issues, Chinese consumers still have a relatively low environmental awareness (Hui & Zhang, 2015).

Besides backlashes connected to pollution, social backlashes to the growing inequality have also increased (EU Gateway, 2016). Jobs constitute a vital part of this inequality. *Green jobs* are an important part of this, and in terms of actual jobs, there were approximately four million *green jobs* in China in 2013. The target industries laid out in the country's 12th FYP are expected to grow from 2% of domestic GDP in 2013 to 15% in 2020, by then having created a net gain of 10 million jobs (The International Labour Organization, 2013). Also, while the quantity of jobs is important, the quality of jobs ought not to be disregarded. One study has found that wind power workers' contentment is considerably higher than that of thermal power plant workers: 77% compared to 18% considered their work environment to be "very good" (Institute for Labor Studies, 2010). Finally, Tan et al. (2014) highlight the role of universities in stimulating both technological innovation and sustainable societies. Fortunately, universities in China have undergone a considerable greening with several initiatives in the last 25 years, including initial green campus plans to more recent holistic sustainability initiatives encompassing more aspects of sustainability throughout both campuses and curricula.

3.6 Cleantech-related policies in China

3.6.1 Conceptual introduction to policy

Eyraud et al. (2013) divide policy instruments into three categories, namely subsidies, regulations and indirect support. For subsidies, which can both be directed towards producers

and consumers, premiums for greener options are considered as well. Tax breaks and preferential financial schemes (for instance lower interest rates) also fall into this category. When it comes to regulations, there are both mandates (for example for a percentage of the fuel mix), feed-in-tariffs, cap and trade schemes, and green certificates. Finally, indirect support includes a variety of forms, from upstream support to R&D. For government incentives to be effective, they need to be based on performance, and they need to be temporary (Rodrik, 2013).

3.6.2 General policy characteristics in China

In China, policy is more important than in most other countries. For Chinese entrepreneurs, market demand is not enough for them to set up a business. Instead they consider both market demand and policy push (Zheng, L., pers. comm., August 04, 2017). First of all, the National Development and Reform Commission is the main policymaking, planning and regulatory government authority of the energy sector, but there are multiple other government agencies involved in cleantech (The US Energy Information Administration, 2015), in particular, the ministries of Environmental Protection and Science & Technology (EU Gateway, 2016).

Of the policy instruments categorised in the previous sub-section, all apply to the Chinese context to a varying extent. Funding programmes exist to support cleantech R&D, as do incentives for the private sector to take a leading a role, and for public-private synergies to continue to bring together expertise from multiple sectors (Tan, 2010). This is important as the sales revenues for start-ups are usually unsatisfactory in their early development stage, and without this support, many companies would not survive (Interviewee Y, pers. comm., August 23, 2017). Besides the emphasis on financial support, China has traditionally focused more on regulatory approaches than market-based instruments, although the international community has highlighted the importance of the latter (Zhang, X., pers. comm., July 31, 2017).

While the government has emphasised sustainability in recent years, doing business with it is difficult. There are few regulations for public procurement (Steinz et al., 2016), and another important aspect of the market in China—and the cleantech market in particular (especially renewables)—has, as mentioned, been the dominance of large SOEs. However, a reform plan was issued in 2015, intended to encourage competition by allowing private and foreign actors to join the market (The Climate Group, 2015). Also, one of the major focus areas of reform for the 2017 National People's Congress was the restructuring of the country's investment-driven growth model toward a more investment-driven one (Yu, 2017). The 13th FYP is also putting more emphasis on a more market-oriented allocation of resources (Yin, 2017).

3.6.3 The Chinese policy landscape around cleantech specifically

There is much debate over whether the Chinese government is doing enough to support the transition to a greener economy. The Chinese central government is the world's largest consumer of renewable energy (EU Gateway, 2016), and although recognised as increasingly important, sustainability is still second to maintaining economic growth and, allegedly, poverty reduction (Brubaker, 2011). In 2014, goals to increase the country's share of renewable energy to 20% by 2030 were announced (The Climate Group, 2015), which is a massive increase in renewable energy output, but considerably lower than the projection of 26% that the International Renewable Energy Agency (2014) offers as a feasible goal in their roadmap. Also, seen globally, the taxation of fossil fuel-based energy in China is still close to the bottom (OECD, 2015). That being said, renewables supply about 15–20% of global energy consumption (Eyraud et al., 2013). After the 2008 financial crisis, the Chinese government committed 10% of its stimulus funds to cleantech (Fung, 2011). Initially, most of this support targeted wind power, although, more recently, the push toward energy efficiency has been relentless, and both large companies, building codes, appliances and vehicles have been

targeted (Brent, 2007), as has the financial support for EVs (International Energy Agency, 2016b). Regarding BREF documents (for *best available technology*, i.e. BAT) in Europe, the European environmental movement now wants the Chinese cleaner production requirements of BAT to constitute the basis for these documents (Hansson, L., pers. comm., July 31, 2017).

Moreover, although the government has introduced policies to encourage more sustainable businesses, national policies which support cleantech are in many ways insufficient, supportive capital is not guaranteed, and many enterprises are hesitant when it comes to engaging in this sector (Feng & Wang, 2011). Also, fines on pollution are insufficient (Chen, 2009). Insufficient energy conservation support (Caprotti, 2009); energy prices that are too low (Olczak, 2014; Caprotti, 2009); and the low prices of natural resources in China (Brent, 2007) are all aspects of Chinese policy which impede cleantech development. Also, high quotas for locally manufactured parts, along with restrictions on foreign investment and mergers and acquisitions add to this (ibid), and finally, connected to the previous point, the preferential treatment given to Chinese businesses (US-China Business Council, 2013). In 2008, China increased its taxation rate of foreign investment enterprises from 15% to 25%. However, while the Chinese government is known to discourage foreign companies, this applies to a lesser extent when it comes to cleantech, for which the 15% rate continued to apply. However, in order to be eligible for this, the cleantech company must hold a core proprietary IP, something that many foreign companies are hesitant to own in China for fear of infringement (Zhang, 2011).

The 2015 reform plans which addresses the dominance of SOEs could potentially facilitate the development of smarter grids, and incentivise smaller actors to invest in renewables (The Climate Group, 2015), although the development of the SOEs seems to have been going in the opposite direction recently (The Economist, 2017c). Even though regulatory approaches have been more dominant in China historically, the Chinese government is in fact moving more and more towards market-based instruments today. One example is FITs, which they have had since 2011, and now they are introducing green certificates, and they are just about to introduce carbon credits, and there are evens plans for a carbon tax (Hansson, L., pers. comm., July 31, 2017). However, it is difficult to understand what impact this shift will actually have as there are so many different vested interests and little transparency, especially in strategic sectors such as energy (Interviewee X, pers. comm., August 15, 2017). With reference to carbon taxation and trading, for which there are pilot projects in some cities, the limited transparency indeed makes it difficult to assess its impact (EU Gateway, 2016). There are multiple important policy documents worthy of mention, in particular the *2005 Renewable Energy Law*, as well as the upcoming 2018 *environmental tax*. However, the goal of this study is not to study the effectiveness of specific policies, but rather to understand the general direction of Chinese policy-makers, which is why the focus is directed toward the country's FYP.

3.6.4 The Five-Year Plans

One of the most important set of policy documents in China is its FYPs, which have been used since 1953. The main cleantech-related changes in the last few FYPs are largely influenced by growing concerns around air pollution (Hansson, L., pers. comm., July 31, 2017). The twelfth plan (2011–2015) as a large part of its focus lays out the shift from investments to consumption, and from development in the coastal regions to those inland. The 13th FYP (2016–2020) continues to build upon this, putting more emphasis on innovation and coordinated development. More weight is also given to address waste and pollution. In fact, the environmental quality targets have increased from three in the 10th FYP (2001–2005) to 16 in the 13th FYP (Kennedy & Johnson, 2016). Due to their central importance, aligning any entrepreneurial undertaking with the objectives of the FYP was listed by Steinz et al. (2016) as one important success factor. Many of the areas mentioned in the 13th FYP hint at a yet

untapped potential and business opportunity. The areas which China is leading in today, such as solar, have been paved through the FYPs. It did not happen like wildfire; it was guided and intentionally invested (Lin, N., pers. comm., August 07, 2017). Finally, it is important to note that the FYP here is the general national overview plan, and there are numerous sub-plans, some very specific, such as the *13th Five-Year Plan for Ocean Energy*, or the *13th Five-Year Plan for Solar Applications*. Also, China has a three-layer government structure (except for the tier-1 cities which answer directly to the national level). The key level to get things done is the local. At this level, they mostly already know what will be accepted by the higher levels, although they can only proceed after getting the green light from the provincial levels, which in turn need a green light from the top level, and this is why the FYP is so important (Berbon, P., pers. comm., August 14). The 13th FYP is dissected below, with all sectors found by the author to connect to cleantech listed according to the chapter in which they were found:

Part I: Guiding Thinking, Major Objectives, and Development: Effective control of energy and water consumption, waste levels, land use, carbon and other emissions, more renewable energy, forest cover, cleaner surface water, and more days with good air quality.

Part II: Innovation-Driven Development: Smart grids, clean coal, big data, robotics

Part IV: Agricultural modernization: Lower environmental impact with high yields (e.g. new varieties), safe products, resource conservation, smarter irrigation and water conservancy, land remediation, internet-based solutions and mechanisation.

Part V: An Optimized Modern Industrial System: Clean production with low-carbon industry systems. Energy storage, new/advanced materials, and new-energy vehicles (including battery recovery/disposal) are three of the six strategic emerging industries in this FYP. Others include advanced rail transit equipment and (industrial) wastewater treatment.

Part VII: Modern Infrastructure Networks: Urban and intercity transportation. Digitalisation, automation, and smart operations are important, as is renewable energy and cleaner conventional energy, with smart grids, storage and transmission, and water allocation and diversion, flood control and mitigation systems.

Part VIII: New Urbanization: Green and forest cities: including eco-friendly buildings and green coverage with urban forests, electrified transportation, and bicycling (Part X), shallow geothermal energy and distributed energy, drainage, rainwater control and storage.

Part IX: Development Coordinated between Regions: Ecological restoration of areas devastated by ecological degradation, e.g. mining areas, wetlands and shorelines.

Part X: Ecosystems and the Environment: GIS surveying, energy efficiency, circular economy (incl. extended producer responsibility), systems for disposal of kitchen waste, textiles and construction refuse, food waste, frugal packaging, water-saving equipment, air pollution, sewage treatment facilities, soil pollution treatment, and storage of nuclear waste.

Part XI – XIX explore social and political aspects with little relevance for cleantech

3.6.5 Regional policy – Shanghai

Steinz et al. (2016) assert that the cleantech market in China is rather fragmented, with large regional differences. Most cleantech innovation occurs in the more developed first-tier cities, especially in Shanghai—mentioned in the 13th FYP as a focus area for scientific and technological innovation together with Beijing. However, Shanghai still faces considerable challenges. 85% of its surface water was deemed unfit to drink in 2015 (Boren, 2017). Also, the higher expectations of environmental quality and the higher energy use along with higher expectations of economic growth are difficult to reconcile. Reflective of China's regional disparities, there are regional targets, and cooperation between the central government and local governments is essential for developing the cleantech sector (Chen, 2009). Certain regional support may also reflect varying budget capabilities. For instance, Beijing has introduced generous support for household heat pump installations (REN21, 2017). Similar to the dissection above, Shanghai's 13th FYP is listed below:

17: An accessible and convenient integrated transport network: An increased share of new-energy bus and rail-transit, and an increased construction of new energy vehicles.

21: Significantly improve the water quality: Sewage treatment plant expansion.

22: Effectively improve air quality: Addressing industry and power generation (e.g. desulfurisation in coal-fired power plants) & vehicle and ship emissions.

23: Increase the green ecological space: Urban green belts, & wetland restoration.

24: Advance energy conservation and low-carbon solutions to respond to climate change: Wind, solar & natural gas, green buildings & green consumption.

25: Focus on intensive use of resources and promoting circular economy: Waste reduction and recycling, and water-efficient technologies.

26: Strengthen environmental remediation: monitoring, risk assessment & remediation.

27: Strengthening the environmental governance

4. Results

This chapter maps out the interviewees' investment preferences and perspectives around these. This is the key data, and it directly answers the first research question, while it adds to the second. Chapter 5 analyses and discusses the findings from this chapter—as well as the material from the previous two sections (3.4–3.6)—in order to answer the second and third research questions. 20 interviews (listed under personal communications) have been conducted to answer the interview questions introduced in the second chapter (See Appendix I). The six ensuing sections are aligned with these six interview questions. The number of mentions in the following sections refer to a part of this total, unless expressed otherwise. It is important to underline that whenever something is *mentioned* in this chapter, it means that it has been mentioned spontaneously—without prompting—by the interviewee, unless otherwise stated. Finally, each section is introduced by the corresponding interview question and a text box containing the initial suppositions based on the information gained in the literature review; in other words, the expected answers are presented at the start of each of the six interview questions. After these text boxes, the answers are synthesised.

4.1 The most concerning environmental problems

Linked to your business, what environmental problems in China are you most concerned about?

Pollution—in particular air-based—was presumed to bring forth most mentions, followed by solid waste and climate change, and scattered mentions of other problems.

Most (13) of the interviewees mentioned three environmental problems. Five interviewees mentioned two, while two mentioned only one environmental problem. 13 of the interviewees also indicated an order of importance. *Firstly*, air pollution was the one environmental problem that was mentioned in *all* of the interviews. 12 of the interviewees viewed it as the most worrying of all environmental problems in China. An explanatory recurring theme among these 12 was the tangible implications on health. The only interviewee (#4) who instead of air considered water quality as more concerning attributed this to the business in which they were active. *Secondly*, after air pollution, water pollution was the most mentioned environmental problem, as 18 interviewees brought up this issue. Besides the one interviewee who thought water quality most concerning, four thought it the second most important, and one the third most important. Apropos of water, water scarcity was also mentioned by five interviewees. *Thirdly*, soil pollution was mentioned by 12 interviewees. No one ranked this as the most or second most concerning problem, although five of the interviewees ranked it third. Two interviewees also connected the problem of soil with food safety.

It is striking that these three areas attracted such a high number of mentions. However, it is perhaps even more striking that there are so few areas mentioned besides these. Climate change was mentioned once (#7), although as a result of the interviewee's work experience. Although not stating climate change explicitly, higher temperatures were also mentioned (#17). Solid waste also came up (#13), but beyond these, there were no mentions of other environmental problems, as for example biodiversity, depletion of natural resources, or chemical exposure. It is true that pollution is in a sense all-encompassing, but besides food from polluted soils, there were no other categories of exposure to human health, such as toxins and carcinogens.

4.2 Preferred cleantech sub-sectors

Are there certain cleantech sub-sectors that you see as particularly interesting for investing in today and in the future? Why?

Renewable—in particular solar and wind, but also geothermal and waste-to-energy—was expected to constitute the most popular sub-sector, followed—in turn—by energy efficiency (especially in industry), wastewater treatment, and electric mobility.

Air, water and soil

Similar to the previous question, the sub-sectors brought up are focused on relatively few areas. Firstly, three interviewees mentioned technologies broadly connected to solving air, water and soil pollution as interesting investment areas. Seven interviewees (#4; #5; #7; #12; #8; #13; #16) mentioned wastewater treatment. There were also two mentions (#7; #8) of water-saving devices. Moreover, in reference to soil, soil remediation recurred (#9; #12; #20), especially considering China's sky-high property prices (#20), which lead to a higher acceptance of costly solutions (For example, chemical oxidation over the relatively slower and cheaper bioremediation process). However, two interviewees (#8; #18) drew attention to the lack of competitive remediation technologies, and the intangible results offered by these. Three more brought up technologies specifically connected to air, with coal burners as the main target, but also the greening of industry broadly more generally (#2). Two more (#3; #9) mentioned technologies for emission control and monitoring, in both manufacturing, chemical plants and vehicles (#3). Air purification applications for the consumer market were seen as both promising (#6; #14), and as an overly competitive market segment, except for niched air purification applications in healthcare (#8). The largest—indirect—applications, however, were found in renewable energy, energy efficiency, energy storage and transportation.

Energy efficiency, storage & renewables

Energy efficiency was seen as a particularly interesting sub-sector, largely because of increased policy support and quick returns on investment. This sub-sector was brought up by 11 of the interviewees, and alluded to by another (#2) (in describing a cleaner industry). It was mentioned in relation to buildings (#3; #7; #9; #13; #15; #18), transportation (#7), industry (#14), and lighting (#13), and making traditional energy (e.g. diesel) more efficient (#9).

Besides energy efficiency, energy itself—unsurprisingly—was brought up, in particular renewables (#5; #7; #11; #12; #15; #18; #19). Specifically, solar (#7; #11; #12; #15; #18) and wind (#5; #12; #15; #17; #18; #19) came up, as did geothermal (#18), but also nuclear (#15). Solar was mentioned as the most promising of these renewables by three out of the four who indicated an order of importance (#7; #11; #12). Surprisingly, no one mentioned solar thermal specifically. Wind was mentioned as the most important energy source by one interviewee active in the industry. Bioenergy was only mentioned once (#9), although waste-to-energy also came up twice (#9; #12). Hydro-, tidal and wave energy were overlooked.

Energy storage also caught considerable attention (#5; #9; #10; #13; #16; #17; #18). One interviewee (#11), however, recognised energy storage as promising, but pointed out that it will only be competitive in ca. five years. Connected to this, microgrids and systems through

which consumers can produce and sell their own renewable energy were also mentioned (#7; #10; #11), as were grid infrastructure and smart grids (#12; #18) Apropos of grids, district heating systems were mentioned once (#15).

Transportation and electric mobility

In regard to transportation, seven mentions (#3; #5; #7; #9; #13; #14; #17) were made. Five of these (#3; #5; #9; #14; #17) covered electric mobility. Within these, there was one mention of quick-charging (#14). Besides these five, one interviewee also pointed out that even though electric mobility will be an interesting area of investment in a few years, energy storage today is not yet competitive. Also, besides electric mobility, autonomous vehicles were also brought up once (#13), as were bikes (#5), and last mile logistics (#5).

Miscellaneous

Based on the categorisation in sub-section 2.3.1, almost all the cleantech areas were mentioned, albeit scarcely. New materials were mentioned twice (#3; #15), as was the connection to biotechnology (#5; #7). Besides soil remediation, solutions connected to food safety (#5; #9; #18), and chillers as a mean to avoid spoilage (#7), there was no mention of technologies connected to agriculture or food. With regard to waste and recycling, remanufacturing was mentioned (#12; #15), as was solid waste management (#13), and treatment and monitoring of hazardous waste and VOCs (#20), due to stricter policies. With reference to services, this area was overlooked in the interviews, as were consumer products. Also, beyond the categorisation in 2.3.1, carbon capture and storage was also mentioned once (#5).

The most surprising finding of this question was the interest in various computer-based solutions (Big data, AI, IoT, digital platforms, blockchain, software and e-commerce were mentioned). Eight interviewees highlighted the importance of this development in China—significant considering that this is not cleantech per se. However, as this was not an anticipated category, these were not categorised in detail, why they are listed here under this umbrella. These solutions were seen as valuable in themselves, for example by holding user data (#11), using blockchain technology (#9), and capitalising on e-commerce (#17). However, they were emphasised as most promising when connected to different areas of cleantech, for example data management-related demand-side management for water use (#7), solar (#11), energy-related cost-savings in buildings (#9), the sharing economy (#9), transportation (#5), and industry 4.0 (#13). There were two mentions (#9; #13) of digital platforms for transportation, and two mentions of energy management and efficiency (#6; #9; #16). A recurring theme was the belief that China will pioneer the development of computer-based solutions.

4.3 The role of policy

Could you describe the role of policy for supporting cleantech? What policies do you find particularly interesting or problematic?

Policy was presumed to be important—especially the FYP—with successful examples mainly centred around renewable energy, and policy constraints centred around favourable conditions for incumbent energy sources.

Everyone recognised policy as important, although three interviewees (#5; #8; #9) thought other aspects more important for investments. In spite of the recognised importance, few specific policies emerged. In terms of international policies, the Paris Agreement was described as important (#7; #12). Domestically, the focus was directed toward national policies, although local policy was also included (#8; #9; #11; #12; #15; #20). Some of the mentions (#1; #11; #12; #15) highlighted the difficulties and time required for implementing and enforcing national policies on a local level, as the interests are often conflicting on different levels. The local level was described as key, since although approval from the provincial level—and in turn from the national level—is needed, local officials generally know what will align with the FYP and pass through (#16). The FYP is—in a sense—the mother document which all other policies must align with at both national, provincial and municipal levels (#20), and it sets the tone for the next five years (#17), and between the 12th and the 13th FYP there has been a shift from viewing the cleantech sector as "strategically important" to viewing it as a "pillar industry", turning it into a competitive advantage for China (#15). Thus, it came as no surprise that all interviewees recognised the FYP as important for making macro-based decisions with reference to selecting specific sub-sectors to invest in—when asked. However, only four interviewees (#5; #7; #12; #18) brought it up without prompting.

Policy support entails many aspects; it can both restrict incumbents with rules or taxation, or favour new technologies through favourable rules and economic incentives. When it comes to taxes and subsidies in China, the latter is clearly favoured. 15 of the interviewees mentioned subsidies, while only six alluded to environmental taxation. Of these, only four explicitly mentioned the word tax, and of these four, only one (#7) mentioned taxation of carbon. One interviewee (#4) mentioned that environmental taxation is not a common policy instrument, while two more (#3; #18) highlighted that there are more efficient methods of tackling the use of fossil fuels, such as emissions trading and stricter safety rules in coal mines. Besides taxes, subsidies and rules, facilitation of access to funds and risk reduction for the public to invest was brought up (#2). Industry was the area that most interviewees (#2; #11; #12) considered most important for policy support, likely related to the growing attention around air pollution.

Successful facilitatory policies

In reference to examples of specific policies that have been successful in supporting cleantech, most mentions related to renewable energy—nine in total. One did not specify which (#11), three mentioned wind energy (#12; #13; 19), and four solar energy (#3; #4; #13; #16). Two more (#17; #18) which highlighted FITs as successful could also be connected to solar. Surprisingly, the 2005 *Renewable Energy Law* was only mentioned once (#12), with reference to its impact on wind energy. Also, the deregulation of the electricity market, which allowed consumers to sell electricity on the market in 2014, was mentioned once (#7), as was the upcoming environmental tax in 2018 (#18). Besides renewables, EVs were mentioned three times as an example of an area which has profited from successful policies, with the Chinese government as one of few actors to invest a lot into larger fuel cells, and infrastructure for EVs (#9), and also by stipulating that manufacturers produce a set minimum of vehicles (#3). Besides these three mentions, tougher vehicle standards were also mentioned (#14).

Other areas covered included strong incentives for low-emission power generation (#13), minimum requirements and emission subsidies for industry (#14), and the opening up of the supply side, allowing for more actors to produce energy. Also, public-private partnerships have been mentioned (#7; #15) as important initiatives for having facilitated cleantech development. Specifically, The Jing-jin-ji regional economic strategy was mentioned twice (#7;

#20) as a successful project, although it has to a large extent shifted the problem from one part of the area to another, in particular from Beijing to the surrounding Hebei province (#20).

Policy constraints

When it comes to policies that were perceived as less successful, some of the interviewees struggled to offer any mentions, although some were made. Firstly, on a general level, there was a recognition of the need for pollution (#2; #6) and climate change (#7) to bear the environmental costs. To achieve this effectively, cost-benefit analysis was mentioned (#6), as was the need for more market-driven policies (#7; #20), support for making alternative technologies available and affordable (#2), tougher enforcement (#12; #15), monitoring (#11), and local implementation (#1; #4), although it can sometimes also be rushed (#17).

Few specific areas were thought of as in need of more support, but eco-construction (#5) and energy-conserving materials in buildings (#3) were, as was tougher legislation for wastewater pollutants (#4), and air pollution broadly (#20), for example by reducing the number of cars and making them more efficient (#7). Some interviewees also thought that EVs need more support (#5), and that the environmental costs of conventional vehicles ought to be included to favour EVs (#2). Cheating around the rebate offered by the government was also seen as a problem (#20). Conversely another interviewee (#6) thought that the subsidies for EVs are already set too high. With regard to intermittent energy sources, mentioned constraints include overcapacity (#12; #16), the lengthy and complicated approval process (#10), little support for peer-to-peer trading and necessary infrastructure (#7), policy execution (#10), the hasty move to change FITs into green certificates (#17), and the low price set for FITs (#18).

4.4 Investment drivers besides policy

Besides policy, are there other essential factors which impact investment decisions (e.g. political structure, international competition and access, social, technological or economic)?

Considering the competitiveness of the Chinese market, the economic reasons were thought to be most important for making investments.

Besides policy, the interviewees were asked what other factors are important behind investment decisions, and examples were given in line with the six categories introduced in sub-section 2.3.2. 18 of the interviewees ranked these in order of importance. Firstly, few direct mentions to the international dimension was made, although the Paris Agreement (#7; #12), and Montreal Protocol (#7) were mentioned. At the opposite end, technology was mentioned by 13 of the interviewees, 12 of which indicated an order of importance; six (#10; #11; #13; #14; #18; 20) of these ranked it as the most important factor, three (#5; #15; #17) as one of the two most important, while three (#3; #4; #12) ranked it as the second most important.

Secondly, eight interviewees pointed at the social aspect, seven of which indicated an order of importance. Five (#2; #3; #4; #6; #12) of these thought it the most important, one as one of the two most important aspects (#5), and one as the second most important (#18). One (#6) even thought it more important than policy. Some saw public opinion as the key driver behind policies which make cleantech economically viable, while others thought this influence dismal

(cf. #3; #4; & #13). Not surprisingly, the importance of networks was also a recurring theme, although one interviewee (#18) asserted that this was more important ten years ago. Customer behaviour and habits were also mentioned as important (#2).

Thirdly, economic aspects were mentioned by seven interviewees. Four of these (#7; #8; #9; #16) thought it the most important factor, two (#15; #17) considered it one of the two most important factors, and one (#11) thought it the second most important factor. More specifically, returns on investment were described as a key consideration (#7; #16), as were market opportunities (#8), and capital (#9; #17).

Finally, in reference to the political structure, it is difficult to say what is policy and what is political structure, and it has been the most difficult category to code. No one explicitly mentioned political structure as a factor, although it was alluded to by half of the interviewees. Transparency and enforcement came up, as did cheating (#6; #8; #18). Conflicting interests between different levels were also brought up (#15; #20), for example how provincial environmental bureaus have largely not had to take the directives from the Ministry of Environmental Protection into consideration (#20). Another recurring theme (e.g. #12; #13; #14; #16) was the way in which the government manages to quickly develop, but also quickly oversaturate market segments. Another recurring characteristic was China's powerful SOEs and their impact on cleantech development (#2; #3; #11; #12), for example their tendency to favour local suppliers (#11).

4.5 Drivers behind the demand

Who mostly drives the demand for cleantech (e.g. the public, politics, investors, media)?

The political sphere was presumed to be most important for driving demand.

Most interviewees (13) pointed towards the government as the most important actor for creating demand for cleantech. Four (#5; #10; #15; #19) thought the public and government equally important for driving demand—depending on the area. Three interviewees (#4; #9; #20) thought the influence from the public more important. Also, many (#3; #4; #8; #9; #12; #13; #14; #15; #20) mentioned that the public to be the key driver behind policy. Moreover, some of these (#12; #13; #20) shared the notion that public opinion is becoming an increasingly important factor. Some of the interviewees (#6; #16; #18; #19) highlighted that policy is less important for areas which relate to health, such as air purification and food, for which consumers are willing to pay a premium. Also, on a similar note, policy is more important when it comes to substitution, as compared to new technologies with no incumbent, where politics is less important for driving demand (#5). No one considered neither the media nor the investors themselves as particularly important. In fact, had these two categories not been given as examples in brackets in the questions, it is possible that they would not have been mentioned. Moreover, no other actors besides these four were introduced by the interviewees.

4.6 Success factors for Nordic companies

Could you think of two or three aspects that are essential for a start-up to succeed in China? What kind of support do you think Nordic start-up companies need in the Chinese market?

This was the question with the fewest initial suppositions. However, a focus on business models, business partners, and local characteristics was expected.

The most important factor—mentioned 13 times—was having a presence on the ground with a local business partner. Seven (#1; #2; #7; #11; #15; #18; #20) even saw it as the single most important factor. For the most part, the rationale was the considerable cultural and institutional differences between China and Scandinavia. Moreover, making use of the knowledge of Chinese expats in Scandinavia was also suggested once (#19), and the importance of government backup was also highlighted (#2; #8; #17). Six interviewees (#2; #4; #5; #11; #14; #17; #20) emphasised that the technology itself has to be good; two (#4; #14) highlighted this as the most important factor. One interviewee (#1), however, pointed out that technology ultimately matters less than the ability to make deals happen—why the right connections are key. Moreover, other themes included differentiated solutions with profit potential (#16; #17), and cost-effectiveness (#4; #8; #11). Additionally, another aspect that was highlighted repeatedly (#2; #3; #4; #5; #8; #10; #15) was that the technology ought to already be mature, commercialised and proven successful in the home market, and also that it can be scaled and grow fast (#5); it must also be possible to demonstrate the solutions (#2; #3; #4; #15), although issues around IP protection were recognised (#3; #13; #14; #18), which is why continuous innovation is important (#18).

Unsurprisingly, later-stage companies stand a better chance according to some (#5; #12; #13). Moreover, tweaking the solutions so as to better capture the local market was mentioned six times (#6; #7; #10; #13; #15; #16). To ensure this, it is important to have the right mindset (#7), keep an open mind (#15), and know the local market well (#7; #13), as well as being able to read and know local policies (#13; #18; #19), and which areas are restricted for foreigners (#5). Also, it is key—allegedly—to want to go to China (#5; #9), to clearly know the reasons for going there (#13), to avoid half measures; go—and give it all—or do not go (#12), although now is a good time to go before domestic innovation becomes more competitive (#18). Moreover, to see China as more than simply a market was underlined (#5), and preferably to have an interest in and knowledge of Chinese culture (#6; #17), and on this note, managing the in-China universal mobile app *WeChat* is important (#6). Finally, four interviewees (#1; #5; #16; #18) mentioned the importance of having the right team, although this is more difficult to build in China than in many other countries, as there is a culture of wanting to be number one, and to build a good team, it is important to have other supportive team players. Thus, a lot of resources have to be spent for building teams in China (#16).

When comparing the findings of the sixth interview question to the *environmentally sound technology innovation* framework introduced in sub-section 2.3.3, the division between firm-specific and individual aspects appears as expendable, considering that no individual aspects were highlighted—neither with reference to personalities, talents or experience. However, as seen by the findings above, the firm-specific sub-categories (Finance, technology, market solution, business culture and networks) were all brought up in the interviews.

5. Analysis and discussion of the findings

The goal of this chapter is to finalise the answers to the second and third research questions, in sections 5.1 and 5.2 respectively. Thereafter, various limitations of the study and their impact on the results are discussed. Areas of further research are suggested throughout this chapter.

5.1 The sub-sectors and features: underlying reasons

In order to answer the second research question, the focus of this section is directed toward the underlying reasons behind the preferred cleantech sub-sectors (5.1.1) and features (5.1.2). Overlooked opportunities (5.1.3) are also covered to provide a contrast to the previous two sub-sections. The point of departure for the underlying reasons is best summarised in *Figure 2*, while interview questions three to five in particular hold the interviewees' own reflections on the underlying reasons. These perspectives are also complemented by the discourse covered in the literature review, as well as by the perspectives of the ten additional interviewees.

Pollution—in particular air—was found to be the dominant environmental problem in the eyes of both the public and the policy-makers. This was largely reflected in the interviewees' most highlighted sub-sectors: energy efficiency first of all, followed by solar and wind energy, transportation and wastewater treatment, in turn followed by energy storage. One reason why the focus is so narrow might be because of how tangible air pollution in particular is today. China will certainly suffer from climate change, but more in the future; today it is not very tangible compared to pollution (Interviewee X, pers. comm., August 15, 2017). The realisation that there are huge costs associated with pollution-induced health problems and reduced lifespans are the main drivers to cut emissions, not climate change (Hagman, M., pers. comm., August 14, 2017), not to mention the fear of social unrest. Although there are multiple environmental problems in China, it is important to remember that China is still a developing country, preoccupied with other issues. In 2014, 200 million people were still living in poverty (The Economist, 2014b). Moreover, one aspect which none of the 20 interviews mentioned was the dimension of energy security, which is interesting considering it—and not the environment—has been the most important driver for investing in renewables. When this national strategy was initiated, there was little concern about air pollution (Hallding, K., pers. comm., August 11, 2017). Another contributing reason that was overlooked in the interviews relates to the persistence of meeting GDP growth targets, which could cause cleantech support to be neglected. However, in 2015, Shanghai became the first large region to "ditch" an official economic target. This has led many to believe that more regions could follow suit (Yu, 2017).

5.1.1 Cleantech sub-sectors

Unsurprisingly, pollution-related technologies were mentioned. However, although both soil remediation and wastewater treatment are highlighted in the last FYP, the interviewees took more interest in the latter, which could indicate that the policy support directed toward it has been more sufficient than for soil remediation, but it could also indicate that the technological challenges have not made it cost-effective. Finally, regarding air pollution, the associated technologies mostly addressed it indirectly, and they follow under the next headings.

Energy efficiency is a more nascent sub-sector—with more low-hanging fruits—which the interviewees expressed the most interest in. It is covered in the FYP, and besides this policy support, it offers fast returns on investment. It was mentioned in relation to buildings six times more than any other area of application, which is difficult to explain, considering the potential in industry, although the government influence in this sector could deter many private actors. Regarding renewables, solar and wind attracted the most attention by far, albeit less frequently

than expected, considering renewables' dominance in cleantech, but as both the interviewees and the discourse pointed out, this market segment is saturated. Moreover, the (scant) mentions of nuclear and "cleaner" incumbent fossil fuels were indicative of the Chinese cleantech definition and the continued reliance on fossil fuels. Finally, current challenges around the cost-effectiveness of energy storage technologies may have limited the interest in it. However, the fact that it was still seen as promising may be explained by the technology's large potential, the increased market space it can create for renewable generation, and the connection to electric mobility, which was also an area of interest for investments, helped by more and more infrastructure and a belief that it is a field that China will (continue to) pioneer.

5.1.2 Company features

The unanimous recognition of policy as a key factor influencing cleantech investments was expected, as was the perceived increasing importance of public opinion. Perplexingly, however, the interviewees did not consider the economic factors less important than the technological. What could be more important than returns on investment? China is the world's most competitive market (PwC, 2017), and cost-effectiveness ought to be essential. There are of course trade-offs between technology and a low price. In China, the "cheapest" is still the largest part of the market, but there is a trend in China with a growing understanding of quality, as more and more consumers in China care about the price-quality ratio of the product instead of just price (Interviewee Y, pers. comm., August 23, 2017). One example where this has been demonstrated is the wind energy sub-sector where China spent large resources on cheap wind turbines, which soon malfunctioned (Interviewee X, pers. comm., August 15, 2017). Also, even though China has a lot of domestic innovation, there is often still an interest in foreign niche solutions, which companies can use as a stamp of quality for their whole business (Lindgren, A., pers. comm., September 06, 2017). Also, no interviews mentioned export opportunities for Chinese firms; most of the focus was directed toward the domestic market.

Based on the responses of interview question six found, some characteristics of the Chinese cleantech market were found which could explain the investors' preferences (in particular the narrow range): more measures must be taken to protect new ideas, while there is—at the same time—high expectations to see demonstrations of these new ideas, and there is little patience for peripheral technologies which fail to offer a quick return on investments. In spite of this, China is becoming more innovative, although this is largely a result of the large resources allocated (Wong, 2017). Another characteristic of the Chinese market is that it both develops and reaches saturation extremely quickly; supply can often outpace demand. This means that investors often focus on one sector one year, and then shift to another the next (Lin, N., pers. comm., August 07, 2017). Accordingly, companies in China must be more attentive to timing. If the market reaches maturity, then there will be enough local financial and investor support, making it difficult to compete; and—paradoxically—higher-risk areas can sometimes be more stable and promising (Sahu, 2017). Moreover, a theme that recurred in both the literature review and interviews was the social factor of business; the right network can prove at least as important as the actual business solution for many companies. Also, because of cultural reasons, more time and resources must be spent to build the right team in China.

Computer-based solutions

The large focus on these solutions exceeded the author's expectations, considering that they were mentioned in a question that asked the interviewee to mention promising cleantech sub-sectors, which computer-based solutions are not per se. This hints at its importance. Also, because of the author's expectations, the concept was not defined before the interviews, but instead created as an umbrella for the interviewees' examples listed in the last paragraph of 4.2.

Due to both the late discovery of this area, and also due to the dearth of research surrounding computer-based solutions connected to cleantech, this interface is one of the main areas of further research recommended by the author—particularly in the Chinese context.

Sinologist Ola Wong points out that China has a population that is very interested in technology, and the Communist Party of China has set very ambitious targets to be the leader in these areas, and it has spent large sums on R&D. Moreover, with reference to private investments, one advantage of IT is that there have not been many state-owned enterprises active in this sector, which is why few restrictions were imposed on private Chinese actors as they emerged. Also, these actors have to a large extent been shielded from foreign competition due to China's censorship and discrimination against foreign competition, which could perhaps explain the emergence of successful domestic equivalents to American search engines and social media. (Wong, O. pers. comm., September 08, 2017). Moreover, one interesting aspect is that when more of the sensitive information comes as software rather than a physical product it is easier to protect IP (Lindgren, A., pers. comm., September 06, 2017). The seemingly imminent ubiquity of computer-based solutions represents a major technical paradigm shift, and companies that can utilise such solutions to leverage effectiveness have a clear advantage.

5.1.3 Forgotten cleantech sub-sectors and features

To best understand where the focus of the interviewees was directed, it can help to illustrate where it was not, so as to provide a contrast. The narrow focus on a few sub-sectors and feature—influenced by policy push, the tangibility of air pollution and investor behaviour—occurs at the expense of several areas. When comparing the findings to the categorisations in 2.3.1, these areas were found to relate to waste, water scarcity, chemical exposure, industry, and geothermal and bioenergy. New materials and chemical products could also be mentioned. Gaddy et al. (2016) claims that these two areas have largely struggled to develop scale and provide sufficient returns globally. There may be similar explanations to why additional sub-sectors were not included among the interviewees' perspectives, in particular fringe technologies like tidal and wave energy. Moreover, apropos of economics, as energy has been cheap and lightly taxed and as a few areas, such as EVs, have been heavily subsidised, the incentives for cleantech solutions to develop more broadly have been limited (Hagman, M., pers. comm., August 14, 2017). While subsidies are important, they are not enough by themselves, and taxation of fossil fuels is overdue, especially as a green tax shift could both help catalyse and diversify the development in the cleantech sector.

For some sub-sectors—like bioenergy—the absence was likely influenced by missing policy support—perhaps surprising considering the dominance of coal in the electricity mix (Ekengren, Ö., pers. comm., September 10, 2017). As the government selects winners in certain sub-sectors in lieu of green public procurement, competition is not arranged to favour the greenest candidate. For example, Swedish biogas buses would struggle to compete with the favoured EVs in such a situation in spite of lower emissions (Hagman, M., pers. comm., August 14, 2017). The competition with food is one reason for the exclusion of bioenergy, but it is somewhat perplexing as not all bioenergy relies on food crops.

The same could not be said for geothermal, which receives policy support. Instead, it could be partially explained by geographical (geological) limitations to developing this energy source. For water scarcity, chemical exposure and waste however, the absence was more difficult to explain, although one factor connected to the waste sector specifically is that it—for a long time—was not open to private investments. Partially connected to waste, the sharing economy also deserves mention as an area with considerable untapped potential for entrepreneurs., as it is both something that the government has taken to—and it is projected to constitute one-

tenth of the Chinese economy in 2020—while there, at the same time, allegedly, has been a dearth of good ideas (Qin, 2017). One factor that is important to consider is that—despite the national perseverance which has enabled the development of solar energy—there is a certain "silo thinking" in China with much focus on consistent growth in the short term. Thus, collaboration between different actors is sometimes difficult to establish. To sell electricity as a consumer, and also to trade electricity between different regions, is very difficult. Moreover, industrial symbiosis—an area that has not been developed very far in China—illustrates these difficulties. The solutions here are not technical, but rather connected to mindsets and collaboration, which is why more immediate tangible results, such as installing another boiler are often favoured (Hagman, M., pers. comm., August 14, 2017). However, that being said, there are some successful pilot projects, such as the *Suzhou New District*, from 2005, where focus has been aimed at the circular economy and industrial symbiosis (Mathews & Tan, 2016). That being said, industrial symbiosis is unfortunately often disregarded in the cleantech discourse, and more research ought to be directed to applications in China, both connected to barriers of dissemination and good examples of measures taken to overcome these. Connected to this, the role of pilot projects for actually disseminating technologies and solutions also ought to be explored further, as should the already mentioned cleantech incubators.

The just mentioned factors connected to industrial symbiosis could perhaps help explain why so little attention was directed toward industry. It should be mentioned that this is possibly also due to semantics; solutions for electric mobility, renewables and energy efficiency all rely on industry to be delivered, but the key point is that a sector that both receives ample policy support, and is responsible for over two–thirds of both the carbon dioxide emission and energy consumption would generate more attention broadly, especially within power generation and the production and processing of minerals—the largest culprits.

Finally, one area with much potential that is not given much attention within the cleantech umbrella is food- and agritech, neither in the general cleantech discourse, nor by the interviewees (although there were three mentions of food safety). Considering the huge and growing environmental impact of food—in particular that of meat—it seems inevitable that these technologies will be given more attention. Two companies that have recently capitalised on this potential—albeit not in China—are *Karma* and *ResQ*, by selling leftover food from restaurants and cafés to consumers (Lindgren, A., pers. comm., September 06, 2017). However, the reasons for food waste are partially different in China, and food is largely wasted as "too much food" is ordered because of cultural reasons (Zhou, 2013), and a different approach is required for tackling this, something which the much needed further research (across all fronts of food- and agritech) ought to keep in mind. However, there are multiple areas besides food waste. For example, considering that lab-grown meat is bound to become cheaper than conventional in the next few years (Ghosh, 2015; Wang, 2017), the lack of coverage is difficult to understand.

5.2 Links to environmental trends, public discourse and policy

The following section answers the third research question in the three sub-sections. Firstly, however, it should be mentioned that none of the interviewees used the word *megatrend*. However, these trends were all alluded to, except resource scarcity as an environmental problem, and as mentioned, climate change was not considered a major concern.

5.2.1 Environmental problems

The preferred cleantech sub-sectors almost exclusively reflected one set of China's environmental problems, namely pollution, especially air pollution. China's pollution problems

are not unique. However, they are severe enough to overshadow many other environmental problems, which are given more attention in countries less afflicted by pollution. For example, Sweden adopted 16 environmental quality objectives in 1999 with, reduced climate impact as the first objective (Swedish Environmental Protection Agency, 2008). No mentions were made of areas which address resource depletion (except waste), biodiversity, protection of different biomes, eutrophication, acidification, the depletion of atmospheric ozone, or noise. The complex of problems connected to waste was alluded to less often than expected, even when all mentions of waste itself, recycling and circular economy were combined. Also, considering that the attention paid to air pollution is largely an expression of health concerns, exposure to various chemicals was also expected to be a bigger concern, although this could partially be explained by that it is seen as a subset of pollution.

This does not mean that cleantech solutions which address areas other than pollution do not have a market in China, the results of this analysis support the position that the interest for these is more limited. At the same time, China's recent commitment to address climate change is promising—albeit conflicting. The interviewees' scarce mentions of climate change do not mean that it is not possible to capitalise on climate change mitigation. One company where proven reductions turned out to be an important part of delivering the sale in China recently is *Enersize* (Lindgren, A., pers. comm., September 06, 2017). Also, as pollution gradually becomes less severe, it is likely that other environmental problems will gain more attention.

5.2.2 Public discourse

The public discourse in China is of course linked to its environmental problems. However, there are limitations as far as the overlap is concerned, and the most severe environmental problems are not always the ones around which the public worries the most. Moreover, public discourse is, as described by Professor Michael Schoenhals, a relatively "fuzzy" area, and therefore it is hard to identify, and even harder to describe it with any degree of accuracy. The late US president Nixon once famously implied that the majority is by definition silent, from which follows that the members of the public that actually share their opinions with outside observers may well represent but a minority (Schoenhals, M., pers. comm., September 08, 2017). Nonetheless, the growing middle class is becoming more vocal as a whole (The Economist, 2016). On this note, it should be said that the applications the interviewees mentioned were heavily weighted in favour of urban applications—perhaps not surprising, considering the income disparity and subsequent ability to offer returns on investment.

Air pollution has become undeniably tangible for most people, and it has replaced land disputes as the number one cause of social unrest (Bloomberg News, 2013). With this in mind, one could easily conclude that the preferred cleantech sub-sectors capture the social discourse, but this could be erroneous. First of all, although probable, there is no guarantee that air pollution actually is the issue most Chinese care most about. Secondly, the investment preferences could be a result of the government's recent recognition of the problem. In any event, one could venture to say that the interviewees' focus reflects either—or both—the public discourse and policy; the two have become more connected with reference to air pollution; Li Yan, of *Greenpeace China*, brings attention to China's first "Red alerts" in 2015, when schools and factories were closed due to this warning; they represent real progress in the government's understanding of how to respond to air pollution (BBC, 2016). Admitting the state of the air quality was significant, and—deliberately or not—an important recognition of the public voice. The risk of social unrest posed by the growing middle class has been increasingly recognised. Also, the realisation that the air quality has improved during large official events (blue sky days) has shown to the Chinese that it is possible to fix the issue, which ironically has put more pressure on the government to solve it (Hagman, M., pers. comm., August 14, 2017). In spite

of these indications of the growing importance of how the public views the air pollution problem, more research is needed to help answer how this actually translates into changes in how cleantech investments are carried out.

5.2.3 Links to government policy

As just discussed in the previous sub-section, the Chinese government's recognition of the pollution problem in recent years marks a paradigm shift with reference to the importance of cleantech in China. Moreover, it shifts the answer of the question if the preferred cleantech sub-sectors capture the country's policy more toward the affirmative. In light of this, it would be interesting to compare today's preferred cleantech sub-sectors today with those five years ago, to assess if air pollution would have been as dominant then. Further research is also needed to compare not just the preferred sub-sectors over the last lustrum, but also the policies as such in more depth—to assess if the political rhetoric around air pollution is mostly grandiloquence or if it represents a real shift for the cleantech sector. As expected, the preferred cleantech sub-sectors all reflected areas from the FYP, although all of the areas from the FYP were not mentioned, which could be expected, considering the length of the FYP. However, certain areas highlighted in the FYP that were expected to attract considerable attention among the interviewees did not. This includes water scarcity, solid waste, and also geothermal energy. Industry was also thought to generate more mentions, as was chemical exposure. Overall, the focus on sub-sectors was very narrow, and China is likely missing certain opportunities.

One of the advantages of the *political economy framework* is the separation of the political dimension into political structure and policy, and the coding of both made it possible to further educe the importance of the political dimension from the data; half of the interviewees alluded to the political structure as an important factor in the investment landscape. At the same time, however, the paucity of mentions of specific policies is somewhat perplexing as it hints at the opposite. The interviewees are not policy experts, but there still seems to be a disconnect between how the cleantech community in China perceives of policy as important on one hand, and how it does little to leverage information about it to its advantage on the other. One reason for this could be the sometimes weak implementation, which causes people to sometimes conclude that policy matters little to them (Lin, N., pers. comm., August 07, 2017). Besides, the flora of Chinese policies is like a dense thicket—untamed and sometimes contradictory—which makes it difficult to relate to as an investor (Hallding, K., pers. comm., August 11, 2017).

On a final note, another important aspect to remember when discussing policy is the difficulty of distinguishing between what is caused by policy and what is caused by social context. One example is the sloping land programme, which offered incentives for farmers not to cultivate on sloping areas, but what one as a citizen was expected to do was probably more important (Hansson, L., pers. comm., July 31, 2017). This perspective is important to keep in mind when it comes to the preferred cleantech areas as well; the preferences may sometimes reflect a social construct as much as the policy support. Chinese investors do to a large extent flock together and exhibit a similar behaviour (Ekengren, Ö., pers. comm., September 10, 2017).

5.3 Discussion of methodology

First of all, it is important to recall the scope of this study. It is only a snapshot of the Chinese cleantech sector and community. While the study has discerned the existence of multiple possible trends which could constitute the basis of further research, it is difficult to make far-reaching conclusions. The objective of this section is to demonstrate why.

5.3.1 Literature

One barrier has been the limited access to Chinese literature. This includes subscription services of journals, and documents that are difficult to open from outside of China. This means that the study has, to some extent, been restricted to English-language literature from outside of China. While a score of sources in Mandarin partially compensated for this, the inclusion of these reflects but a tiny fraction of the Chinese discourse on cleantech investments—presumed to hold considerably more information than what is available in English. Moreover, as both technology and investments are two information-sensitive areas—especially in China—a large part of the insight is not disclosed. While the access to a cleantech network allowed the author to partially bypass this obstacle in the interviews, the same could not be achieved in the literature review. Finally, as cleantech is a fast-changing sector, it is difficult to keep abreast of the latest development, and considering the dearth of information, it was not possible to exclusively rely on recent sources.

5.3.2 The interview questions

While the author sought to avoid nudging to the largest extent possible, a small degree of nudging was inevitable. For example, the order by which the questions were asked is one factor to take into consideration. As the first question on environmental problems was succeeded by another question on investments preferences, it is possible that the mentioned preferences reflect the environmental problems to a larger extent than had been the case without the first question. By swapping the order of these two questions, and adding a few questions in between, the risk of interference between these two questions could have been lowered, although this change would have resulted in a less logical flow. Moreover, the questions which were posed to clarify what the interviewee meant may also have conveyed certain implications. However, although it is important to take measures to minimise nudging, the decision to do so can also result in more meagre data than had more follow-up questions been permitted. It is true that the cleantech sector is largely policy-driven, but one possibility is that the narrow focus on a few areas could stem from the structure of interview questions; while the top recurring examples provide findings of a certain significance, it is possible that other valuable examples that could recur did not surface, as they were consistently overshadowed by the top recurring ones. Thus, follow-up questions asking the interviewees to mention more examples could have provided less meagre data—albeit it at the cost of more nudging.

Furthermore, the focus on policy as the most important factor in this study was to a certain extent contingent on an underlying supposition: that policy is indeed the most important factor. This supposition appears not to be erroneous, and limitations of the purview of policy have also been discussed to overcome this bias. However, despite the unanimous recognition of policy as important in the interviews, it is possible that contrary opinions failed to surface because of this supposition. In light of this, it would have been preferable if the third interview question (on policy) succeeded questions four and five—this time at little expense of the flow. Moreover, with reference to this set of questions, the categorisation based on the *political economy framework* was difficult to introduce in a few words, and it is unlikely that the interviewees could recall the definition of each when faced with assessing their importance. Moreover, the understanding of each may have differed. For example, some may have understood the economic aspect to refer to the firm's financial situation, while others may have understood it to refer to the conjuncture. Apropos of nudging, including the categories as examples in the question may have influenced the outcome, both in terms of the order in which they were listed, and in terms of other categories not surfacing. However, questions four and five were thought too difficult to answer had they not been provided with examples.

One important aspect which was difficult to address in the interviews was the division between the interviewees as individual entities and as representatives of a firm. As mentioned, there is no rigid dichotomy between them, and any individual perspectives are largely contingent on the experiences gained from their firms. Although the cases where a perspective was evidently that of the interviewee's firm have been listed in the results, it is possible that not all cases were identified. Another limitation is also connected to the fact that different forms of communication were used to conduct the interview. While the difference between telephone, *WeChat Call* and *Skype* is minimal, the inclusion of written interviewees via email and *WeChat* is suboptimal, although only three written interviews were included. Had the sample of interviewees been bigger, it would have been easier to omit these, in order to have one set of interviews conducted through the same medium. One factor that counterbalances this limitation is that the questions were sent out prior to the interviews and that summaries of the interviews were sent out after the interviews. Finally, no test sample was included for the interviews. Such a sample could have useful for fine-tuning the interview questions and process

5.3.4 Internal validity

The two previous sub-sections have covered various limitations of and suggestions of improvements with reference to the internal validity. However, a few points in support of it—with reference to the research questions—should also be expressed. For the first question, no inferences had to be made by the author, as the response depended on an open-ended question, which was summarised and answered already in the results section. The same could partially be said for the first part of the second research question, which depended on the interviewees' own perspectives, although these, as discussed, were more difficult to capture and code with accuracy. However, the additional interviews conducted helped solve this difficulty, by providing data triangulation and explaining the reasons behind the interviewees' perspectives, as did the follow-up literature review. Which underlying reasons were included was ultimately the author's own decision, but as both the perspectives of the 20 interviewees, the additional interviewees, and the wider discourse on cleantech have been taken into account, the likelihood that the inferences made are invalid is smaller.

Finally, with regard to the third research question, the validity of the inferences is contingent on three factors already discussed: how the perspectives of the interviewees have been captured, what these perspectives are compared against, and how the comparison is conducted. In conclusion, the process of capturing the preferred cleantech suffered from some, but little, nudging. The selection of both environmental problems and policy areas was straightforward and transparent, although public discourse was found to be inherently difficult to capture. For the comparison, the most valid inferences could be made for the sub-sectors which generated the most mentions, in particular energy efficiency. By assuming that it indirectly addresses air pollution, it was easier to compare it to the public discourse.

5.3.4 External validity

While there are advantages to including the perspectives of multiple stakeholders, there are also limitations to having a more heterogeneous sample; more experiences paint a broader, more holistic picture of the cleantech landscape, but on the other hand, as there are more sub-groups, each one is also smaller, which is suboptimal with reference to the external validity. Moreover, the interviewees' perspectives are—as mentioned—to a varying extent indicative of the respective businesses in which the different actors work. As an example, a wastewater treatment company would likely consider water pollution as one of the most important environmental issues. With reference to the sample at hand, it is intended to represent the Chinese cleantech community, but it is important to keep in mind that most of the

interviewees—13 out of the 20—are associated with venture capital, investment firms and platforms. SOEs, financial institutions and academia were under-represented in this sample, and they would likely present a different perspective around cleantech. There are several reasons why the sample was not sub-divided into different groups. First of all, as the inclusion of interviewees occurred gradually, it would have been difficult to prepare a categorisation at the outset of the study. Secondly, the small sample size would make it difficult to create such a categorisation. For example, for financial institutions, academia and business accelerators, there was just one representative of each in this sample. Thirdly, some of the interviewees could be categorised into different sectors, as they were associated with more than one business or institution, and as most have work experience from more than one sector. Ultimately, if external validity had been the most important objective, all but the 13 interviewees mentioned in this paragraph could have been omitted.

Ideally, future research on this topic should seek to create more niched samples, both across the kind of business, as well as the positions held; consultants might have different perspectives compared to managers and CEOs. Finally, in order to paint a broader picture, future research should not only seek to provide more niched samples, but also to expand the scope of actors which comprise the cleantech community; the perspectives of policy-makers, public officials at different levels, NGOs, and other stakeholders also constitute an important part if the intention is to better understand the cleantech sector.

6. Conclusion and outlook

Cleantech has become key for addressing many of China's environmental problems, especially air pollution—today both the main environmental and social driver for Chinese policy-makers to consider. As people's willingness to pay a premium a premium for cleantech has only been sufficient for a few health-related technologies, and not for environmental problems as a whole, market demand has been insufficient for driving the development. Instead, policy has played a very important supportive role. Largely because of this persevering support, China has come to dominate the wind and solar energy sub-sectors today, and the country appears set to lead in electric mobility and computer-based solutions as well.

The study found energy efficiency to be the most preferred cleantech sub-sector—especially in building applications—largely due to quick returns on investment. It was followed by three areas which generated an equal number of mentions, namely solar and wind, transportation and wastewater treatment, in turn followed by energy storage. These preferred areas are largely reflective of China's highlighted policy areas, air pollution problems, and the public discourse around these. The tangibility of the pollution problem is an important factor behind the focus on these areas, as is the importance of policy push in China. However, for certain cleantech sub-sectors, the study found a disconnect between how both policy and environmental problems are captured in the preferences. Solid waste (including waste-to-energy), and water scarcity are two such areas in particular, and geothermal also deserves mention. Also, the limited interest in the industrial sector broadly—but especially in power generation and the production and processing of minerals—and in chemical exposure are two corresponding features. The interest in computer-based solutions, on the other hand, was found to be a key feature, reflective of the culture, technological development and potential in the cleantech sector, and further research ought to focus on these solutions. Finally, bioenergy is largely neglected by both policy-makers and the cleantech community in China.

Furthermore, despite the remarkable achievements in China's cleantech sector during the last two decades, a veritable risk is that the targeted focus on a few sub-sectors which has prevailed thus far will leave the potential of many promising technologies untapped. From an outsider's point of view, some of these areas include niche technologies, heat pumps, district heating systems and industrial symbiosis—besides the already mentioned areas of disconnect. The challenges that China is facing are not only technological and financial, and many of the solutions have to do with changing mindsets, and encouraging multiple stakeholder involvement. Accordingly, consulting, managerial skills and capacity building must not be forgotten. Moreover, if the sector is to continue to develop, it is important that China addresses its many structural inefficiencies, starts viewing economic growth targets differently, embraces carbon pricing, market-based instruments, and makes it easier for foreign actors to enter the Chinese market. The risk that many promising sub-sectors are being forgotten is considerable, but if measures are taken to address the mentioned areas, and if air pollution becomes less dominant in the minds of the people, a gradual diversification which considers more environmental problems appears inevitable.

China may face many challenges, but the Chinese word for crisis (危机 Wēijī) consists of two components. The first is connected to danger. The second one, however, means machine. Also, it means opportunity. Cleantech may not be a panacea, but it is a vital part—and a large opportunity—when it comes to solving China's environmental problems.

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Personal communications

Main interviews with respondents for the six questions	
Interview 1	Principal at a multi-sectoral venture capital firm
Interview 2	Managing Director at a cleantech accelerator
Interview 3	Consultant at a professional services firm
Interview 4	MD at an electrical equipment manufacturing and power generation company
Interview 5	Partner at a multinational private equity firm
Interview 6	Investor and partner at a large financial institution
Interview 7	Investor active in several cleantech-related firms
Interview 8	Investor at a large industrial and cleantech company
Interview 9	Manager at a financial firm
Interview 10	CEO at an investment platform
Interview 11	Investor at a large investment firm
Interview 12	Investor at a large investment platform
Interview 13	Managing Director at a multinational VC firm
Interview 14	Investor at a state-owned investment institution
Interview 15	Senior Project Manager at a large investment platform
Interview 16	Partner at a large investment firm
Interview 17	Business Development Director at a large energy company
Interview 18	Cleantech investor, research director and financial advisor
Interview 19	Cleantech researcher
Interview 20	Consultant at a clean technology transfer agency

Additional interviews outside of the main questions

Agerström, M., Managing Director – Cleantech Scandinavia (2017, May 03). Personal interview.

Berbon, P., Managing Partner – China Materialia (2017, August 14). WeChat Call Interview

Ekengren, Ö., Vice General Manager – IVL (2017, September 10). Email interview.

Hagman, M., Counsellor Science & Technology – Office of Science and Innovation, Embassy of Sweden, Beijing, China (2017, August 14). Telephone interview.

Hallding, K., Senior Research Fellow – Stockholm Environment Institute (2017, August 11). Telephone interview.

Hansson, L., Senior lecturer – The International Institute for Industrial Environmental Economics (2017, July 31). Personal Interview.

Interviewee X, Senior Vice President of a large renewable energy firm (2017, August 15). Telephone Interview.

Interviewee Y, Assistant professor at the Beijing Institute of Technology (2017, August 23). Email Interview.

Lin, N., Cleantech investment advisor – Invest in Skåne (2017, August 11). WeChat Call interview.

Lindgren, A., CEO/Partner – Cleantech Invest OYJ (2017, September 06). Personal interview.

Mialaret, J., Operating Partner – Idinvest Partners (2017, July 31). Skype interview.

Schoenhals, M., Author, sinologist and professor of Chinese studies – Lund University. (2017, Septmber 08). Personal Interview.

Wong, O., Author, sinologist and journalist – Svenska Dagbladet (2017, September 08). Email interview.

Zhang, X., Founding Partner at New Development Ventures & Silicon Valley Frontier Labs. (2017, July 31). WeChat Call interview.

Zheng, L., General Manager, China – Conduit Ventures (2017, August 04). Telephone interview.

Zhu, D., Partner – China Eco Fund (2017, July 31). WeChat interview.

Appendix I – Compilation of Interview questions

1. Linked to your business, what environmental problems in China are you most concerned about? 就您的业务而言，您最关心中国哪些环境问题？

2. Are there certain cleantech sub-sectors that you see as particularly interesting for investing in today and in the future? Why? 在清洁科技领域，您有没有对特定的方面特别感兴趣呢？这些方面是如何吸引您的呢？

3. Could you describe the role of policy for supporting cleantech? What policies do you find particularly interesting or problematic? 您可以描述政策在支持清洁科技中扮演的角色么？有什么政策您觉得特别重要？也有政策的问题吗？

4. Besides policy, are there other essential factors which impact investment decisions (e.g. political structure, international competition and access, social, technological or economic)? 除了政策，还有别的决定因素影响清洁科技投资吗 （例如政治结构的、国际竞争和准入的、社会的、技术性的、经济的）？ 能仔细谈谈么？

5. Who mostly drives the demand for cleantech (e.g. the public, politics, investors, media)? 您认为谁在推动中国的清洁科技的需求与发展呢（例如消费者/政治家/投资人/媒体）？

6. Could you think of two or three aspects that are essential for a start-up to succeed in China? What kind of support do you think Nordic start-up companies need in the Chinese market? 对想要在中国取得成功的初创企业，您认为哪几方面是最重要的？能给一些建议么。您认为北欧的初创公司需要哪种支持在中国的市场里？