GREEN BUILDING DEVELOPMENT IN CHINA

A Policy-Oriented Research with a Case Study of Shanghai

Yujun Liu

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ABSTRACT

Rapid urbanization and economic growth in China are increasing the pressure on limited natural resources and policy options to deal with sustainability problems. Within this context, several policy instruments have been implemented to encourage the development of green building. However, no evaluations about related impacts and outcomes have been done until today. To fill this knowledge gap, this research aims to assess the performance of green building policies in terms of market transformation. Using Shanghai as a study case along with an example of Chenghuaxinyuan project, the research offers an intensive and systematic analysis of the research topic. The method for analysis is based on market transformation theory. Key findings show that green building development in Shanghai is at a crossed stage of both market formation and expansion; but there is still a lack of proper designed standards and incentive mechanism to stimulate developers' green motivation, increase customers' demand, and help innovations on green building design and technology to break through into the building market. In the last part, some corresponding suggestions on policies for green building development in Shanghai are put forward.

Key Words: green building; policy; market transformation; Shanghai

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ABBREVIATIONS

AIJ: Architectural Institute of Japan

BIPV: Building Integrated Photovoltaic

BREEAM: the Building Research Establishment Environmental Assessment Method

CASBEE: Comprehensive Assessment System for Built Environment Efficiency

CLD: Causal Loop Diagram

CSR: Corporate Social Responsibility

EPA: Environmental Protection Agency, United States

FYP: Five-Year Plan

IBS: Industrialized Building System

IEA: International Energy Agency

LEED: Leadership in Energy and Environmental Design

LEED-ND: LEED for Neighborhood Development

MoC: Ministry of Construction [1]

MoHURD: Ministry of Housing and Urban-Rural Development

MoF: Ministry of Finance

OECD: Organization for Economic Co-operation Development

PRC: People's Republic of China

PV: Photovoltaic

R&D: Research and Development

SMAPLR: Shanghai Municipal Administration of Planning and Land Resources

SMCEI: Shanghai Municipal Commission of Economy and Information

SMDRC: Shanghai Municipal Development & Reform Commission

SMFB: Shanghai Municipal Finance Bureau

[1] Renamed to the Ministry of Housing and Urban-Rural Development in 2008

SRDC: Shanghai Residential Development Council

STCSM: Science and Technology Commission of Shanghai Municipality

SUCCC: Shanghai Urban Construction and Communications Commission

UN: United Nations

UNEP: United Nations Environment Programme

UNFCCC: United Nations Framework Convention on Climate Change

US: United States

WBCSD: World Business Council for Sustainable Development

The average exchange rate in 2011 is USD 100 = RMB 645.88 (State Administration of Foreign Exchange, n.d.), that is to say RMB 1= USD 0.15483

1 INTRODUCTION

1.1 BACKGROUND AND JUSTIFICATION OF RESEARCH

Growing world population and rapid urbanization go hand in hand with a greater exploitation of the world's limited resources (Mostafavi and Doherty, 2010). China is no exception. As UN's prediction (UN, 2011), such trend will remain in China and the annual growth rate would also keep high. This leads to a large demand and consumption in energy, land, water, and other resources.

Buildings worldwide, according to WBCSD, account for 40% of global energy consumption; and the resulting carbon footprint (consisting of 40% CO_2 emissions) significantly exceeds those of all transportation combined (WBCSD, 2009, Udyavar, 2006, Yin and Gong, 2007). In China, the proportion of building energy consumption took nearly 25% around 2008 (Chinese Society for Urban Studies, 2008) and 30% around 2010 (Wu, 2010). The level of energy consumption of current residential buildings in China is much lower than that in developed nations (Zhu, 2007); however, this is based on relatively lower degree of comfort of indoor environment, especially in the regions with cold winter and scorching summer (Chinese Society for Urban Studies, 2008, Zhu, 2007), like Shanghai. Thus, it is very likely that under a "business-as-usual" scenario, the requirement for improving living conditions would lead to a continuous growth in energy consumption and CO_2 emissions per unit building area (Chinese Society for Urban Studies, 2008). Moreover, the migration caused by urbanization would lead to much more demand of energy as well as buildings: the energy consumption per capita in urban area is already 3.5 times of that in rural area (ibid.); and it is estimated that in the next few years, the urban newly-built floor area would be around 1 billion m^2 per year (Chinese Society for Urban Studies, 2008).

At the same time, the increasing urbanization would be associated with loss of arable land, material and water crisis, and serious environmental problems like air pollution, light pollution, noise pollution and waste generated from buildings (Wu, 2010, Chinese Society for Urban Studies, 2008). All these indicate a must for China to improve the environmental

performance of its current and future building stock (Chinese Society for Urban Studies, 2008, Zhu, 2007). And in particular, there is a huge potential in China to develop green buildings (Chinese Society for Urban Studies, 2008, Qiu, 2010, China Greentech Initiative, 2009). Studies suggest that only by adopting green construction method (referring to IBS), there could be a saving of 20% energy, 63% water, 87% wooden mould, and a reduction of 91% construction garbage, comparing to the conventional construction way (Wang, 2010, Qiu, 2010).

To address the challenges mentioned above, China has adopted green building policies and strategies in the last few years. Such policy instruments related to green building put much emphasis on energy saving which is regarded as the first priority. Relevant policies regarding energy conservation started from 1980s, aiming at improving the energy efficiency of heating residential building in Northern China. Later during 2001-2005, such policies covered 3 other climate zones. From 1998, Construction Law of PRC became effective; related laws include Energy Conservation Law, Environmental Protection Law, etc. (Table 1.1).

Table 1.1 Chinese National Laws regarding Green Building

Principal Law	Related Laws	Adopted Date
Construction Law of PRC (National People's Congress; Promulgate Agency: State Council; Adopted Date: Nov 1, 1998)	Urban and Rural Planning Law of PRC	Oct 28, 2008
	Energy Law of PRC	Nov 1, 1997
	Energy Conservation Law of PRC	Nov 1, 1997
	Renewable Energy Law of PRC	Feb 28, 2005
	Environmental Protection Law of PRC	Dec 26, 1989
	Environmental Impact Assessment Law of PRC	Oct 28, 2002
	Urban Real Estate Management Law of PRC	Jul 5, 1994
	Law of PRC on the Prevention and Control of Environmental Pollution by Solid Waste	Oct 30, 1995
	Water Law of PRC	Jan 21, 1988
	Law of PRC on Protecting Against and Mitigating Earthquake Disasters	Dec 29, 1997

Translated and adapted from (Chinese Society for Urban Studies, 2008, Wu, 2010, The Central People's Government of the People's Republic of China, 2012)

However, aspects other than energy conservation haven't been considered systematically in terms of green building until 1996. That year, "Researches on Green Building System" was

listed as one of the main funding projects in the Chinese 9th national Five-Year Plan (FYP) by National Natural Science Foundation of China (Wei, 2006). There then came the establishment of National Innovation Award on Green Building in 2004, annually organized International Conference on Green and Energy-Efficient Building & New Technologies and Products Expo since 2005, Evaluation Standard for Green Building (GB/T 50378-2006) along with the definition of green building in 2006, and Three-star Green Building Certification Program in 2008, etc. Policies regarding green building in China cover mandatory regulations, financial incentives, and evaluation of local government's achievement. Besides, in 2011, the 12th FYP for the first time included green building as well as its related issues (e.g. formalized reduction targets for both energy and climate change) in the national FYP and ranked it among top priorities. The *Green Building Action Plan* will be released soon; one of its ambitious aims is to have more than 1 billion m^2 newly-built green buildings in the urban area during the following 5 years; and around RMB 1 trillion (USD 155 billion) will be invested to promote this action plan (Deng, 2011) and develop a green economy in terms of, for example, green building material, renewable energy, etc. Up till April 2012, in China, there were 435 certified star projects by Ministry of Housing and Urban-Rural Development (MoHURD), along with 630 LEED certified ones (among which 19 projects were LEED-ND certified) (Green Building Map, n.d.). Furthermore, the speed of growth in the number of such certified projects has been rather high during the past years (Green Building Map, n.d., Wang, 2011).

Despite the rapid development of green building in China and the relevant policy instruments being continuously carried out and improved, there is a lack of knowledge regarding the actual performance of these relevant policies. For instance, on the building market/project side, the number of certified star project is sharply increasing every year, but still remains a fraction of its potential size; it is estimated that certified "green" floor space constituted less than 1% of the new built environment in 2009 (China Greentech Initiative, 2011, China Greentech Initiative, 2009). And most of the projects are certified for design, while few gain certifications for their operation stage (Green Building Map, n.d.). Based on

the existing literature, it is hard to find the explanation as well as how these buildings actually perform. Take the aspect of energy efficiency for instance, which is addressed as the top priority in green building strategy. The literature suggests that for the newly-built buildings, the compliance rate of energy conservation standard at the design stage was just 53% in 2005; though the number increased to 99.5% in 2010, it was only a sampling result from several large cities (Qiu, 2011, Zhou et al., 2010). Compliance rate at the construction stage was even lower: 21% in 2005 and 95.4% in 2010 (ibid.). Thus it can be inferred that from a broader perspective, the realization rate of green building in the real estate market is still low.

In addition to this lack of knowledge, one can also recognize a lack of research as such. A preliminary literature review carried out by the author of this thesis shows that current researches regarding green building policies in China put much emphasis on the general policy design. Some of them analyzed the green building related policies abroad and then raised some suggestions for China (see e.g. (Shi and Chai, 2006, Yao et al., 2006)); some studies started from an externality angle to analyze green building, then looked into related policies based on the framework of institutional analysis and public policy (see e.g.(Chai, 2006, Li, 2006, Zhang et al., 2008)); and in the last few years, there came more researches with a focus on the design of green building assessment system (see e.g. (Qin et al., 2007, Duan, 2007, Ma et al., 2005, Xia et al., 2010, Yu, 2008, Cao and Dong, 2010, Li, 2008)). However, there are few researches on how relevant policies actually perform, especially in promoting the green building development in the current building market.

1.2 Research Objective and Research Question

The aim of the research is to improve our knowledge about the performance of green building policies in China. In particular, the thesis aims to assess these policies, with a focus on their impacts in terms of market transformation. This is a policy-oriented research and it seeks to evaluate whether current policy instruments are suitably designed, implemented and enforced. Based on the purpose of this thesis, the main research question is: *How do*

current policies in China contribute to green building development? And the sub research questions have been formulated as follow:

i. How do existing policy actions taken by the Chinese government facilitate the process of green building development?
ii. How do current policies make use of the key stakeholders in the green building system to encourage the development?

1.3 SCOPE

From the building point of view, the scope of this thesis is within newly-built multi-family buildings in the urban area. Rural-urban migration along with rapid urbanization spurs rapid construction in urban areas. In order to permit high population densities to make the best use of limited spaces, multi-family buildings mainly serve cities (WBCSD, 2009). Over 90% of the housing in many cities of China is in multi-family apartment buildings, ranging from indemnificatory housing to luxury apartments (ibid.). Since the urban population in China is expected to remain high growth rate to 2050 (UN, 2011), the scarcity of land for residential buildings will definitely keep encouraging the multi-family blocks wherever possible. Also, with living standards improving, the per capita living area would go up. All these make the multi-family residential sector an interesting research focus for the thesis at hand.

2 KEY CONCEPTS AND THEORETICAL FRAMEWORK

In this section, some key concepts would be clarified and theoretical tools would be introduced with regard to green building and the analyses on its relevant policies. This is critical for having a better understanding of the research object and also helps to better structure the research and frame the analysis.

2.1 POLICY INSTRUMENT

Policy instrument is the object of this research. It refers to the tools or measures used by the governments to exercise their power through public policy (Vedung, 1998). Here, based on the classification system from UNEP (2007), UNFCCC (1999), IEA (2005) and Klinckenberg and Sunikka (2006), the policy instruments are classified in the following categories:

- *Regulatory instruments* refer to laws and implementation regulations that are mandatory to fulfill by targeted participants. Regulatory instruments applicable to the case of green building include building codes, appliance standards, mandatory audits, etc.
- *Market-based instruments* are usually based on market mechanisms and contain elements of voluntary action or participation, though usually initiated or promoted by regulatory instruments (UNEP, 2007). Energy performance contracting and tradable certificates for energy efficiency improvements (e.g. LEED) are two examples of such instruments potentially applicable to the case of green building.
- *Fiscal instruments* provide financial incentives or disincentives to alter the economic conditions of targeted participants (Mundaca, 2008). For instance, taxation, tax exemptions/reductions, subsidies, soft loans, so on and so forth. They are often mandated and/or implemented through legal means (ibid.).
- *Informative instruments* aim at providing information, knowledge and examples of successful implementation in order to achieve social change, such as customers' behavior. This is based on the rationale that asymmetric information makes it difficult for market agents to make rational choices (ibid.). Such instruments include certificate

programs, labeling schemes, public demonstration programs, education, information campaigns, training programs, etc.

2.2 GREEN BUILDING

Green building is one of the most important concepts in this research. Without a clear and concrete definition of green building, it would be difficult to identify the policy instruments related to it and guide and scope the research.

The development of green building practice can be traced back to 1970s, along with energy crisis (Wilson, 2006, EPA, 2010); while the term of "green building" and its concept came later. The definition varies by the green building evaluation system or program (Yoshida and Sugiura, 2010).

In some evaluation systems or programs, the term of green building is merely defined by one single factor, such as energy efficiency. For example, the European Commission initiates the Green Building Program in 2004. No definition of this term was given; yet we can interpret from the program's aim that it regards green building the same as energy-efficient building (which will be mentioned later within this section): the program aims at "improving the energy efficiency and expanding the integration of renewable energies in non-residential buildings in Europe on a voluntary basis" (European Commission, n.d.). It is even narrower than the Chinese official definition of green building. Thus in light of the research background and scope, such definition is unsuitable for this thesis.

The official definition of green building in China came in 2006 with the *Evaluation Standard for Green Building* (GB/T 50378-2006). MoHURD defines green building as "*buildings that, throughout their lifecycle, maximize the resource savings (including energy, land, water, and materials saving), protect the environment, reduce pollution, provide people with healthy, comfortable and high efficient space, and exist harmoniously with nature*" (MoC, 2006, Li and Currie, 2011).

Likewise, there are other evaluation systems or related organizations address a combination of various sustainability factors in the green building definition (Yoshida and Sugiura, 2010).

Usually in this circumstance, green building is regarded the same as "Sustainable Building" (see e.g. (EPA, 2010, BREEAM, n.d., AIJ, 2005)). For example, according to US EPA, green, or sustainable, building refers to "*the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction; [t]his practice expands and complements the classical building design concerns of economy, utility, durability, and comfort*" (EPA, 2010). In Japan, CASBEE[2] uses the term "Sustainable Building" defined by the Architectural Institute of Japan-AIJ (Sunikka‐Blank and Iwafune, 2011) as a building "*which is designed: (i) to save energy and resources, recycle materials and minimize the emission of toxic substances throughout its life cycle, (ii) to harmonize with the local climate, traditions, culture and the surrounding environment, and (iii) to be able to sustain and improve the quality of human life while maintaining the capacity of the ecosystem at the local and global levels*" (AIJ, 2005).

By comparing the last three definitions, they all address the environmental aspect and more or less mentioned about the other two pillars of sustainability – economic and social. They especially emphasize a building's life cycle. Besides, Japanese and Chinese version also highlight tailoring measures to suit the local conditions: MoHURD just mentions the nature, while AIJ covers from nature to culture.

As for the cultural aspect, the traditional residential housing forms, like Anhui local-style dwelling house, are fine example of passive design (Xia, 2010), though they could not totally satisfy, for instance, current population density any more, their design ideas and principles are the things should be considered; besides, other cultures lying in living habits, for example, are of great significance as well (see e.g. (Shi, 2010, Xu and Wang, 2008, Yu, 2010, Mei and Chen, 2008)).

[2] CASBEE (Comprehensive Assessment System for Built Environment Efficiency) is originated from Japan. It is a tool for assessing and rating the environmental performance of buildings and built environment. Official website: http://www.ibec.or.jp/CASBEE/english/

Considering the three pillars of sustainability (environmental, social and economic) and the research site – Shanghai, the term "green building" applied to this research is adapted from MoHURD's definition, referring to

> *a building that saves a maximum amount of resources (including energy, land, water, and materials), protect the environment, and minimize pollution throughout its life cycle; provides people with healthy, comfortable and high efficient space, and exist harmoniously with local environment and culture.*

It is worth to mention that during the development of green building worldwide, there exist several relevant terms. Some of them address one single factor of green building; while some highlight the technical aspects to achieve green building. There are two representative ones listed as follows:

- *Energy-efficient building*: energy-efficient building is part of the origin of green building. An energy-efficient building retains the best environment while minimizing the consumption and waste of energy (Crook, 2006). Similar ones are low-energy building, zero-energy home, energy plus house, passive house, zero-carbon house, 3-litre house, etc. (European Commission, 2009). They all stress the factor of energy in building, regardless of life cycle.
- *Eco-architecture*: it is "in harmony with nature, including its immediate environs"; it "makes every effort to minimize the use of energy at each stage of the building's life cycle, including that embodied in the extraction and transportation of materials, their fabrication, their assembly into the building and ultimately the ease and value of their recycling when the building's life is over" (Broadbent and Brebbia, 2006). This term addresses more on the harmony with nature and considers energy, material as well as life cycle aspects.

2.3 MARKET TRANSFORMATION AND TRANSITION THEORY

Market transformation has different particular meanings under different contexts (see e.g. (IEA, 2003, Lukashenko, 2004, Wallace et al., 2011)). There is no single and widely accepted

definition for it. A general "Market Transformation" refers to the process of "*changing the types of products or services that are offered in the market, the basis on which purchase and behavioral decisions are made, the type or number of actors in a market, or in some other way altering this set of interactions in a self-sustaining way. … Any program that has a lasting effect on the structure or operation of a market could be called a market transformation program*." ((Synergic Resources Corporation, 1996)cited in (York, 1999)).

Also, there is a lack of unified theory for market transformation (York, 1999). However, as seen in the literature, the analyses can be divided into two perspectives: dynamic approaches to / strategic intervention in market transformation and interactions among market actors (see e.g. (Nilsson, 1995, Neij, 2001, Sunikka‐Blank and Iwafune, 2011, Klinckenberg and Sunikka, 2006, Jacobsson and Bergek, 2004)). Since transformation is identified as one pathway of sociotechnical transition by Geels and Schot (2007), the terms of "Multi-phase" and "Multi-level" from transition theory can be introduced here to represent these two analytical perspectives. More about the transition theory will be discussed later in the multi-level section.

2.3.1 MULTI-PHASE

In market transformation theory, different mechanisms of intervene have different effects and are therefore appropriate in different transformation phases divided by market maturity levels (Neij, 2001, Northwest Energy Efficiency Alliance, n.d.).

Considering the similarities within the building system, this research adopted the Klinckenberg and Sunnika's (2006) division method of market transformation process for energy-efficient building. They underline a combination of two requirements as basis for market transformation. The first one is standardized measurement procedures to determine the quality of (an aspect of) a building (e.g. measurement of insulation thickness) (ibid.). The second one is to classify the performance of products, building designs, or building operations, for all aspects deemed related to green building (ibid.). Performance classification can be based on efficiency or absolute performance; examples for the former one can be the maximum heating energy demand per square meter or minimum noise

reduction of a wall; and the maximum indoor air pollution level is a sample for the latter one (ibid.).

With these two requirements, three performance levels can be determined: *a minimum performance level*, which is the bottom line for all newly-built residential buildings; *a best practice level*, describing the level with good design and building practice; and *a state-of-art level*, indicating the maximum level can be achieved in the current context , which is usually as a target setting by a government (Klinckenberg and Sunikka, 2006). They are illustrated in the figure provided by the Eurima Blueprint Project (Figure 2.1), indicating the relationship between building performance and the policy applied to improve the performance. Also, three main phases of the market transformation process can be identified: *market formative phase*, *market expansion phase* and the *market maturity phase* (Jacobsson and Bergek, 2004, Hawaii Clean Energy Initiative, 2010).

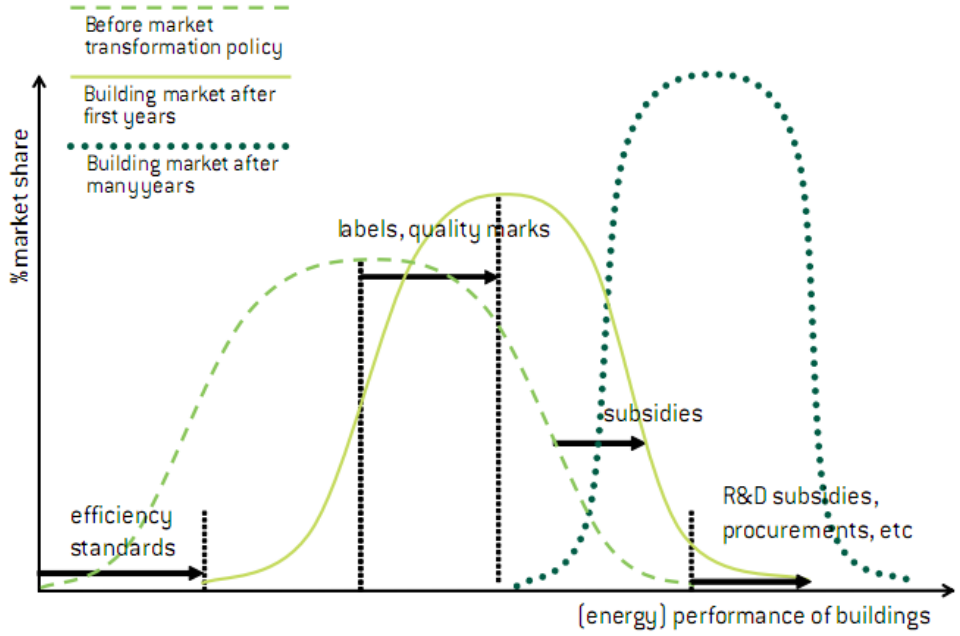

Figure 2.1 Market Transformation Process

Source: (Klinckenberg and Sunikka, 2006)

- *Market Formative Phase*: this period aims to meet a minimum performance level. Standards and other regulatory policy instruments are being applied during this phase

(Klinckenberg and Sunikka, 2006). And this phase is characterized by market formation, the entry of firms and other organizations, institutional change and the formation of technology-specific advocacy coalitions (Jacobsson and Bergek, 2004). During this phase, market transformation normally involves the exploration of niche markets and building bridge to the mass markets (ibid.).

- *Market Expansion Phase*: it is a period from the minimum performance level to the reach of a best practice level. Economic incentives can trigger such expansion (Klinckenberg and Sunikka, 2006, Neij, 2001, Jacobsson and Bergek, 2004). During this phase, a chain reaction of positive feedback loops will form, involving all the constituent components and functions of the (green building) system (Jacobsson and Bergek, 2004).
- *Market Maturity Phase*: this period starts from the best practice level to achieve a state-of-art level. The virtuous circles continue running with "outside pushes and pulls and the momentum of [the system's] own internal processes" in a self-sustaining way ((Mydral, 1957)cited in (Klinckenberg and Sunikka, 2006)) to reach a new dynamic equilibrium.

2.3.2 MULTI-LEVEL

Market transformation requires collaboration among a diverse set of market actors (York, 1999, Neij, 2001, Klinckenberg and Sunikka, 2006). However, the simple demand-supply model is not enough to address the complexity of building market actors; there is a lack of a systematic tool within market transformation theory to analyze the complex relationships and interactions among these actors (see e.g. (Neij, 2001, Jacobsson and Bergek, 2004, Klinckenberg and Sunikka, 2006, Sunikka‐Blank and Iwafune, 2011)). Thus a multi-level perspective from transition theory is introduced here. It is capable to handle complex issues (Geels, 2002) and there are previous studies applying multi-level to analyze transformation (see e.g. (Geels, 2006, Geels, 2007, Geels and Schot, 2007)).

Three levels in the multi-level perspective analysis are distinguished as follows (Geels, 2002, Geels, 2006, Geels and Schot, 2007, Jacobsson and Bergek, 2004):

- *Landscape level*: a sociotechnical landscape is an external structure or context for interactions of actors; it contains a set of heterogeneous factors, such as oil prices, economic grows, wars, environmental problems; and changes at the landscape level usually take place slowly.
- *Regime level*: sociotechnical regimes refer to cognitive routines shared by a community of different sociotechnical groups and explained patterned development along sociotechnical trajectories; contributors to such development can include engineers, scientists, policy makers, users and special-interest groups.
- *Niche level*: the micro-level where radical novelties emerge; such novelties are initially unstable sociotechnical configurations and are of relatively low performance; niches act as "incubation rooms" shielding novelties against mainstream market selection in the regime.

Geels and Schot (2007) define transition as changes from one sociotechnical regime to another. And transformation path is taken under the situation that moderate landscape create pressure on the regime, while niche-innovations have not been sufficient developed yet. This situation leads to reorientations by regime actors (ibid.). Such pathway is called transformation. In the market transformation context, it is the government authorities that respond to such pressure from landscape level and "modify the direction of development paths and innovation activities" (ibid.).

3 METHODOLOGY

The methodology of this research was guided by the research questions, driven and framed by policy-oriented research. An in-depth case study would be conducted with a focus on green building related policies, seeking answers to the research questions and potential improvements. Both qualitative and quantitative data would be collected via multiple methods and would be analyzed under the market transformation theory framework.

3.1 A CASE STUDY STRATEGY

What kind of research design to employ is guided by the established research questions (Bryman, 2012). The research questions for this thesis are mainly "how" questions about a contemporary event – green building development in China, this phenomenon has just been addressed in recent years, and I as a researcher have little control over it; thus a case study was chosen as the research strategy (Yin, 2003) for a better and deeper understanding of the certain problem.

Via using purposive sampling (Silverman, 2009), Shanghai was selected as the single case for this study. It is a highly urbanized city and a representative city in the climate zone with both cold winter and scorching summer where there has seen a significant growth in heating demand; at the same time, it is also a top city in terms of green building in China (detailed information would be introduced in Section 4). It is worth to choose a case of such "successful" city to check how it performs in the context of local as well as national policies and to see how these policies work. Besides, within this case, the project of Chenghuaxinyuan, Vanke would be used as an example to provide and verify some arguments. It was selected for its representativeness: (i) it is one of the earliest and representative projects developed by a top green building company - Vanke[3] in Shanghai, (ii)

[3] Vanke is the top real estate developer all over China. It invested the most in gaining land, and at the same time achieved the largest sales amount and area in the year of 2010, which is more than 1.5 times the amount of the second one (CRERA et al., 2011). Moreover, based on the search on Green Building Map (n.d.), it is a leading building company in the green building area, owning the most certified green building projects. It only focuses on developing residential building projects, no commercial ones, which fits the scope very well. According to Vanke's CSR report (2011), in 2010, 750 000 m^2 three-star certified green residential buildings were constructed by Vanke, comprising 54% of that throughout the whole nation. Till now, it has 21 projects in Shanghai.

buildings in it achieved three-star rating for design, and (iii) it is awarded as a "four-high" community[4] by Shanghai government (SRDC, 2000, China Green Real Estate, 2011, MoHURD, 2010).

3.2 METHODS FOR DATA COLLECTION

Both quantitative and qualitative methods were applied in this research to collect data, including literature review, interviews, workshops and observations.

3.2.1 LITERATURE REVIEW

An extensive literature review was conducted through the field of green building, via peer reviewed journal articles, government official documents, books, grey literature (i.e. workshop/seminar presentations, institutional publications, etc.), and mass media. This process went throughout the entire research. First, the background information (incl. pressure and driving forces) on green building development in China was gathered. This helped to understand the current situation in China, and played a significant role in narrowing down the research scope as well as selecting the case of this study. Then there came an intensive literature review aiming to build the theoretical context relating to green building and market transformation. In order to achieve a comprehensive view of the whole system and the market transformation process, the literature review were mainly focusing on policy statements and peer-reviewed articles. Additionally, company documents along with other grey literatures were widely used while giving examples.

3.2.2 OBSERVATIONS

Direct observation by getting access to projects and visiting some green buildings can help to gain a sensitive understanding, and is often helpful in discovering additional information, like problems, that other resources won't offer (Yin, 2003). Such observations were conducted by visiting Shanghai Scientific Energy Conservation Museum, two Landsea (another top green residential building developer in China) Green Habitation Exhibition Centers and attending two forums during IE Expo (International Trade Fair for Water, Sewage, Refuse,

[4] A "four-high" community refers to a community with a planning of high starting point, high level design, high construction quality and high standard management.

Recycling and Energy Conservation) in March, 2012 (see Appendix I). It helped to gain a better understanding of current policy as well as market trend regarding green residential building. Meanwhile the observations offered the chance to conduct some on-site interviews with key stakeholders within the system, like engineers, scholars and government officers.

3.2.3 INTERVIEWS

Interview is deemed as one of the most important sources of case study information (Yin, 2003, Tellis, 1997). It is a useful tool for understanding complex phenomena and gaining insights from the interviewees into a certain matter (Yin, 2003, Hastings and Perry, 2000). Also interviewees can sometimes help to get access to some other resources, e.g. grey literatures and special chances for observation. Semi-structured interview offers the opportunity to ask questions that are not included in the guide but are important when the interviewer catches something significant said by interviewees (Bryman, 2012). Hence, given a nature of flexibility, different levels of semi-structured interviews were conducted. Meanwhile, focused interviews were also employed in this research because of limited time for example (Yin, 2003). Usually the latter one was conducted with the main attempt to get supplementary information or figure out specific problems; while the former addressed topics related to (i) the life cycle of constructing a green building; (ii) the relationships between stakeholders; (iii) problems, from interviewees' point of view, lying in the green building development; and (iv) the current market trends as well as policy trends, etc.. The interviewees (see Appendix II) were selected based on a purposive sampling principle; it was conducted with the reference to the goal of the research, allowing the research questions to be answered (Bryman, 2012). They are all key stakeholders within the system, varying from engineers to government officers. Interviews were conducted based on the designed interview guide respectively (see Appendix III). It is worth to point out that there was a snowball sample when it came to interviewee #9 and #10; that is to say interviewee #9 was proposed occasionally by someone and then interviewee #9 suggested interviewee #10. Without an arrangement or appointment, the strategy of nearly unstructured interview was adopted.

3.3 METHODS FOR DATA ANALYSIS

Yin (2003) suggested that the first and most preferred analysis strategy is to follow the theoretical propositions that led the case study. Thus by returning to such propositions as well as the reflected research questions, the following analytic strategy of market transformation was given priority. Within this strategy, there would be a combination of both quantitative and qualitative analysis for the data gathered.

3.3.1 MARKET TRANSFORMATION

Market transformation strategy was developed internationally in the 1980s and 1990s, mainly to effect a change in the market for appliance towards greater energy efficiency (Klinckenberg and Sunikka, 2006). Over the last decade, many countries implemented sets of policies to shift the market towards better-performing building in line with the market transformation strategy, though not many of them have formally adopted such tactic (ibid.). Chinese government has been intervening the market by adopting relevant policies to encourage the development and wide-spread of green building, which is an adaptation and improvement from existing buildings. Then based on the definition of "market transformation" (see Section 2.3), it can be identified that a transformation of "well-established" housing market is undergoing. Further, it is believed that market transformation would not take place unless managed by some leader, and a government usually plays the role to encourage or induce such change (Nilsson, 1995, IEA, 2003, Blumstein et al., 2000), which is exactly the situation in China now and at the same time leads to a focus on policy, matching this policy-oriented research. Therefore the market transformation framework was applied in this research to describe and analyze current green building policy system in Shanghai, China, and to put forward several suggestions about how it can be further improved. Additionally, qualitative data gained mainly from interviews and documents would be applied here.

Market transformation assumes a government should intervene to make the market works better, and its important objective is to change consumers' behavior (IEA, 2003). However, in the green building system, there are dual demand-supply relationships: customer of green

building – developer, developer – architect/engineer/supplier (and so on). A developer plays the role of both supply side and demand side. The (market) barriers perspective can be employed as complementation, which takes the customer preference as given, so that the customer won't be the primary target of policy (ibid.). Thus the market transformation analyses would be combined with an identification of the barriers to green building development. And during the analyses, policies to solve such barriers would also be identified and discussed.

The analysis will start from a multi-phase perspective for an understanding in depth of the history of green building development in Shanghai over time and what makes the market for green building to take off.

After that, a multi-level analysis will be conducted. Since building market is equipped with a fragmented character (IEA and OECD, 2003). In order to achieve a broad picture of the whole system including the relationships between stakeholders, and different roles of them at different transition levels, the system analysis tool of causal loop diagram (CLD) will be employed. Then, based on the above understanding, aspects of market structure would be identified, and so would be behaviors that affect product acceptance and also happen to be determined or affected by government actions (ibid.)

Analyses from these two perspectives would help to check issues like present broad strategies and policy coverage, discovering what has been covered and what is missing in current policy system, and whether existing policies can play a driving role in the transformation, etc.

4 THE CASE OF SHANGHAI

The study site of Shanghai is one of the four municipalities under the direct control of the national government. It had a population of 23 million till the end of 2010 (National Bureau of Statistics of China, 2012), and it has the highest urbanization ratio among all the provinces and the municipalities in China, which was 88.70% in 2006 (Chinese Society for Urban Studies, 2008). During the 11th five-year period, the area of newly-built residential building was 154.66 million m^2, accounting for 75.40% of the total newly-built building area (SUCCC, 2012).

Shanghai is located in the Yangtze River Delta in eastern China, with a clear climate characteristic of cold winter and hot summer (Figure 4.1). This climate zone didn't belong to the Chinese designated building heating region in the 1950s. Thus with the economic development and the improvement of people's living standard, this region has witnessed a rapid growth in energy consumption especially in heating (Chinese Society for Urban Studies, 2008). It is estimated that the total energy consumption (in both construction and operation phase) of residential building in 2010 was 55% more than that in 2005 (SUCCC, 2012).

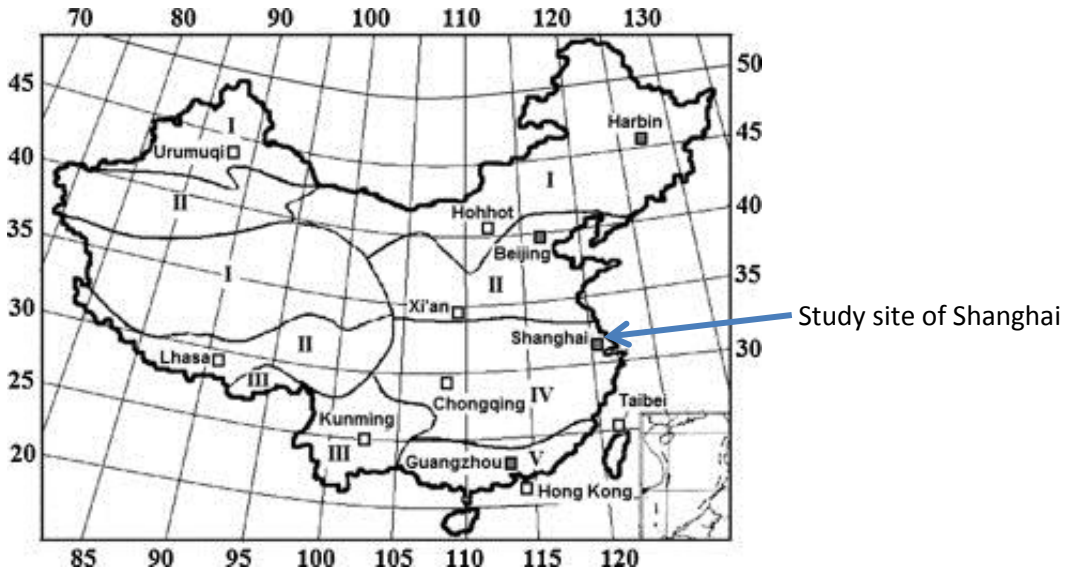

Figure 4.1 Architectural Climate Zone Map of China (I: severe cold zone; II: cold zone; III: mild zone; IV: hot summer and cold winter zone; V: hot summer and warm winter zone)

Source: Adapted from (Yanming Kang, 2010)

Shanghai is one of the earliest cities to start green building development. Till March 1, 2012, Shanghai owns the most certified green building projects among all the cities and provinces all over China; that is 208 projects, 23 out of which are residential projects (Green Building Map, n.d.).

5 Findings and Analysis

Within this section, research findings (i.e. data collected via documents, interviews and observations) are presented and analyzed in accordance to research questions and the theoretical framework of market transformation.

5.1 Development and Current State of the Policy System regarding Green Building in Shanghai

In order to improve the eco-environment quality of new communities and construction quality of new residential buildings, Shanghai, in 2003, issued *Shanghai Ecological Community Construction Management Approach* and *Detailed Rules for the Implementation of Ecological Community Technology*, which started green building development in this city and has promoted it a lot (Chinese Society for Urban Studies, 2008). However, sectoral policies started much earlier than that. For example, at the national level, the mandatory minimum energy-saving rate (30%) was adopted in 1986 and the requirement keeps increasing with the development and now reached 65% in advanced cities like Beijing and Shanghai.

While reviewing the literature, the following policies related to newly-built green residential building were found for the specific case of Shanghai (Table 5.1). These policies were summarized in accordance with the instrument category system in Section 2.1.

Table 5.1 Current Policies regarding Newly-built Green Residential Building in Shanghai

Type of Policies	Policies
Regulatory Instruments	- Regulations on wall material production (1991, latest revision in 1997) - Mandatory minimum designing energy saving rate for newly-built buildings (50% in 2005 and 65% in 2009) - Mandatory labeling and certification programs for electrical appliances (National level 2005) - Standards on building envelope design, construction material and appliance (around 2002) - Acceptance standards on indoor decoration (2003) - Regulations on project inspection of energy-efficient building envelope (2005)

	- Regulations on construction supervision especially of energy-efficient projects (2006) - Mandatory use of water-saving appliances in fully-furnished apartments (2011)
Fiscal Instruments	- Local special fund and soft loans for energy conservation and renewable energy programs (2008) - Local subsidies on renewable energy and energy efficient products (around 2009) - Tax reduction for companies conducting energy/water conservation and environmental protection projects (National level 2007) - "Four-high" community award (2007) - Tax reduction on new green construction material (2003)
Informative Instruments	- Local FYP (since 10th 2001) - Local green building certification system (2008) (*no subsidies now*) - National green building innovation award (National level 2004) - Demonstration program on garbage classification, renewable energy application, green building, etc. - Awareness raising, education, information campaigns about green building

Source: Adapted from (Chinese Society for Urban Studies, 2008, Kang, 2008, Qiu, n.d., UNEP, 2006, PRC State Council, 2007, SUCCC et al., 2011, Zhang, 2011, SMDRC and SMFB, 2008)

5. 2 Analysis from A Multi-phase Perspective

Shanghai has been undergoing a transformation in the building sector in the past decade. A multi–phase perspective analysis aims to identify the development periods and examine different policy instruments adopted by Shanghai municipal government along the process over time.

Different market transformation phases would be identified according to their respective characteristics described in Section 2.3.1, especially the differences between the leading policy instruments at each phase. In order to simplify the huge and fragmented policy system of green building, only the policies focused on building itself are considered as the basis for the identification of the phases (Table 5.2).

Table 5.2 Brief Overview on Shanghai Market Transformation Phases in Green Residential Building Development

Market Transformation Phases	Period	Key Policy
Market Formative Phase	2001-	- 2001 10th FYP related to energy-efficient building - 2002 Standards on building envelope design, construction material and appliance - 2005 Mandatory minimum designing energy saving rate set at 50%
Market Expansion Phase	2007-	- 2007 "Four-high" community award - 2008 Green building certification system

5.2.1 Market Formative Phase

From Table 5.1, it is clear that most policy instruments on building per se are regulatory ones, especially in the early years. During the 10th Five-Year period (2001-2005), the administrative regulation system of building energy efficiency was basically established (MoC, 2007b). Local building codes and standards were set in this phase, covering building envelope, construction material, appliance, as well as construction supervision and project inspection. These official regulations and standards set crucial minimum performance level for different aspects of green building at the beginning of market formative phase, aiming to improve the basic level of quality assurance for buildings going to the market.

Along with these regulatory instruments, there were fiscal ones in energy efficiency, renewable energy and sustainable construction material sectors. As constituent components of green building system, energy efficient and renewable energy technologies as well as building materials are superior in some dimensions in the policy system. With energy and natural resources pressures at the landscape level, innovations have emerged in these sectors. Early in 2001, the national government introduced policies on tax reduction for renewable energy (e.g. biomass energy, wind and hydro power) and energy-efficient wall materials (Zou, 2007). Also at the local level, Shanghai has adopted tax reduction on new green construction materials since 2003. These fiscal instruments along with regulatory ones have largely accelerated the development of these sectors and provide "protected spaces"

from the existing mass market for them, forming the niche markets. Such markets are linked with the building market through “bridges” like mandatory minimum energy saving rate for newly-built buildings and green building certification system. The former one forces developers seeking ways and technologies to achieve energy saving goal, and avoid being abandoned by the market; the latter one can encourage and guide developers to adopt new approach to achieve better performance and fame. Such “bridges” have brought larger volumes of production. For example, during the 11th Five-Year period (2006-2010), Shanghai achieved 3.38 million m^2 new building area for solar-thermal application and 2.42 million m^2 for geothermal application (SUCCC, 2012).

During this phase, informative instruments were adopted as well to raise the awareness of green building issues, but remaining prime focus on the energy perspective. A scientific understanding of green building had been evolved and in 2006 an official definition was put forward by MoHURD. Before that, there are various understandings of this term and it is regarded the same as high green rate building, energy efficient building, low-carbon building, eco-building, so on and so forth. After that, in 2008, Shanghai Green Building Council was founded. Relevant exhibitions and expos have been hold as information campaigns as well as platforms for communication and trade of green building related technologies and products. The *2008 Shanghai International Green-Eco Building Technology Trade Fair* and *2011 China Green Building Expo* are two examples. Besides, Shanghai Scientific Energy Conservation Museum was established in 2009, providing a free space to the general public to learn energy-saving knowledge, experience energy-saving facilities and share relevant experiences (Shanghai Scientific Energy Conservation Museum, n.d.).

Besides, there are prime and first movers during this period, even before 2001. Vanke started the exploration of green residential building since 1999 (Vanke, n.d.); and Landsea began in 2001 (China Entrepreneur and Landsea, 2011). These two leading real estate companies in the field of green residential building are not driven by any standards or fiscal instruments at the very beginning, but pursing a differentiation advantage and farsighted to see the green trend in real estate industry (China Entrepreneur and Landsea, 2011, Wang,

2009). After several related policies issued, these two companies turned their strategy into an active action to become the leaders in green building, gaining more benefits and avoiding unnecessary loss for late decision (ibid.). Except a demonstration effect, first movers also play an important role in the process of policy-making in green building field (see Section 5.3).

Two problems lying in the market formative phase were identified as follows:

a. *Not enough coverage of bottom line*. There are four main segments in the green building related regulatory systems: Energy Efficiency, Sustainable Materials, Optimized Design and Water Efficiency; and as shown in Table 5.1, the first two obviously catch the primary focus. This is not just for Shanghai, but a common phenomenon all over China. Also, current standards are largely focus on the period from green building design to operation; it has not been found any regarding, for instance, demolishing stage especially for green building. Before the transforming process enters the next stage, there is a need of comprehensive and systematic bottom lines covering key aspects of a green building (at least, bottom lines for some aspects can form invisible bottom lines for others) as well as different stages (e.g. design, construction, operation, demolishment, etc.). Take current green building evaluation system in China as an example. According to The Climate Group (2011), this evaluation system puts much more emphasis on the application of technology and building sections (e.g. wall materials), while ignoring the integrated effect by design; this would cause a deviation from original green target and lead to a pile of green technologies and building sectors rather than a real sustainable building. Let alone the situation that developers are not willing to apply for certification of green building.

b. *Immature "bridge"*: one case of such immature "bridge" is the mandatory minimum energy saving rate for newly-built buildings. For the last decades, the building energy efficiency standards applied in China are all design standards, with no exception in Shanghai. The standard is not on the ground of actual building energy consumption data,

but based on an assumption of certain energy service level. According to Interviewee #2, #5 (2012) and Kang (2008), for Shanghai, the baseline is the energy consumption from air-conditioning in summer and heating in winter per square meter per year of a local representative residential building during 1980 to 1981 in the hot summer and cold winter climate zone. Thus reaching the 65% energy efficiency standard doesn't mean the actual building energy consumption is reduced by 65%. Another example is the green building certification system. Currently the system offers certifications on two stages: the design stage and the operation stage. And they are in terms of voluntary participation mechanism. Although the government realized that meeting design standard does not mean the operation would satisfy the requirement, there is no corresponding "carrot" or "stick"[5] to help it work effectively. This is also one main factor leading to the fact that the majority of the certified green residential buildings are design certified (as one approach to promote sale) while few of them achieved operation certification. In the 12th FYP, subsidies for star certified residential buildings are under consideration. Once it works, there is one thing Shanghai needs to think about, that is how to manage the overlap with four-high community award.

5.2.2 Market Expansion Phase

In Shanghai, bottom lines regarding green building did not come at the same time; some have not even arrived yet. On the other hand, some fiscal policy instruments on green building are already being adopted. Accordingly, Shanghai is now at a crossed stage: the formative phase still keeps going while a market expansion phase has already begun.

During the market expansion stage, the best practice level is often working for official government endorsement purposes to stimulate the market (Klinckenberg and Sunikka, 2006). Usually such purpose does not need to be enforced by law, but more on the other policy instruments, especially the fiscal ones, such as subsidies (ibid.). We can identify two

[5] Carrot and Stick: an idiom refers to an approach "characterized by the use of both reward and punishment to induce cooperation" (http://www.merriam-webster.com). "Carrot" is the reward here and "stick" means the punishment.

systems for best practice levels regarding green building in Shanghai: one is the four-high community, another one is the green building certification system.

As for the former one, it is grated during the operation stage of the residential buildings and the community. Thus it can guarantee the community's performance quality. However, it has not been found to what extent such award criteria related to the green building certification system. That is to say, we don't know, for example, whether reaching certain green level (according to the certification system) of a residential building is a necessary condition to achieve such four-high community award. Besides, the amount of subsidies is far from enough to cover the incremental costs of a green building project (e.g. in Chenghuaxinyuan project, the subsidies from four-high community award only accounts for 4.84% of the costs borne by Vanke (see Appendix IV)), while the reputation gained from such awards is high, yet difficult to quantify.

The latter one, green building certificate system, is not equipped with any "carrot" or "stick" thus it has little incentive contribution in this phase till now[6] except the fame gained after certification on the design stage (this could not guarantee the performance during operation), which is often used for marketing. Such marketing is necessary for two reasons identified. First, the incremental costs borne by green building developers, based on the current situation, could not be covered by related financial incentives; hence these costs will no doubt pass through housing price on to customers. Second, till now, at the beginning of the market expansion phase or the mixed stage, differentiation advantage of green residential building is still of great significance due to its low proportion in the residential building market; thus developers (eg. Vanke and Landsea) take the advantage to target the group of well-heeled customers, further pushing the housing price up much higher. However, such reputation incentive is rather weak for the most developers who don't view green building as a differentiation advantage. They can still earn a lot of money by building non-green ones because of a short supply in Shanghai real estate market. And this is the

[6] On April 27th, 2012, MoF and MoHURD (2012) issued an announcement showing the 2012 award criteria for certified green buildings: RMB 45/m^2 for two-star certified projects and RMB 80 /m^2 for three-star certified ones.

same for many other cities in China. Thus proper “carrot” along with “stick”, that is stronger incentives, can play an important role in wide-spreading green building.

In short, preconditions to achieve fine effect of such strategy include well-designed best practice level, and proper amount of incentives. Nevertheless, these two are all absent in current green building system.

5. 3 Analysis from A Multi-level Perspective

The aim of the multi-level analysis is to give a big picture of the green building system, highlighting the transformation dynamics at different levels and their interactions, especially the role of policy instruments.

Based on the characteristics of three levels mentioned in Section 2.3.2, the key factors or stakeholders of green building market transformation in Shanghai, China were identified as follows:

- *Landscape Level Factors*: pressure from national great energy & natural resources consumption, international and national urges to reduce CO_2 emissions, etc.
- *Regime Level Actors*: government authorities, developers, customers (occupiers is the preferred terminology in WBCSD, 2009);
- *Niche Level Actors*: suppliers & manufactures, planners, architects & engineers.

Landscape factors in light of market transformation towards green building in China are primarily lying in sustainability dimensions. As mentioned in Section 1, these factors include greater consumptions of energy and natural resources as a result of rapid urbanization and development, and increasing stress from home and abroad on carbon emission reduction. Such changes at the landscape level exert pressures especially on the political regime, forcing both national and local governments to turn to the development of green building and put much more emphasis on it in the policy agenda, e.g. FYPs since 2001. Also corresponding efforts have been made on the legislation framework, such as relevant laws, acts, regulations and standards shown in the previous sections. Meanwhile, niche-innovations have already taken place, like the emergence and development of energy

efficient appliance, green construction materials, water efficient equipment, etc. These novelties respond to the landscape pressures, take the advantage of governments' support, and make use of the existing regime tensions. Through good sustainability performance, these niche-innovations have the potential to build up the internal momentum for the transformation towards green building. Such interactions between processes push the market transformation of green building forward.

Below, Figure 5.1 presented a simplified version of the key stakeholders' relationship together with current green building policy system in CLD (full version see Appendix V). And the following analysis as well as discussion would characterize different market actors and start from policy regime to see its present effect on other regimes and niches.

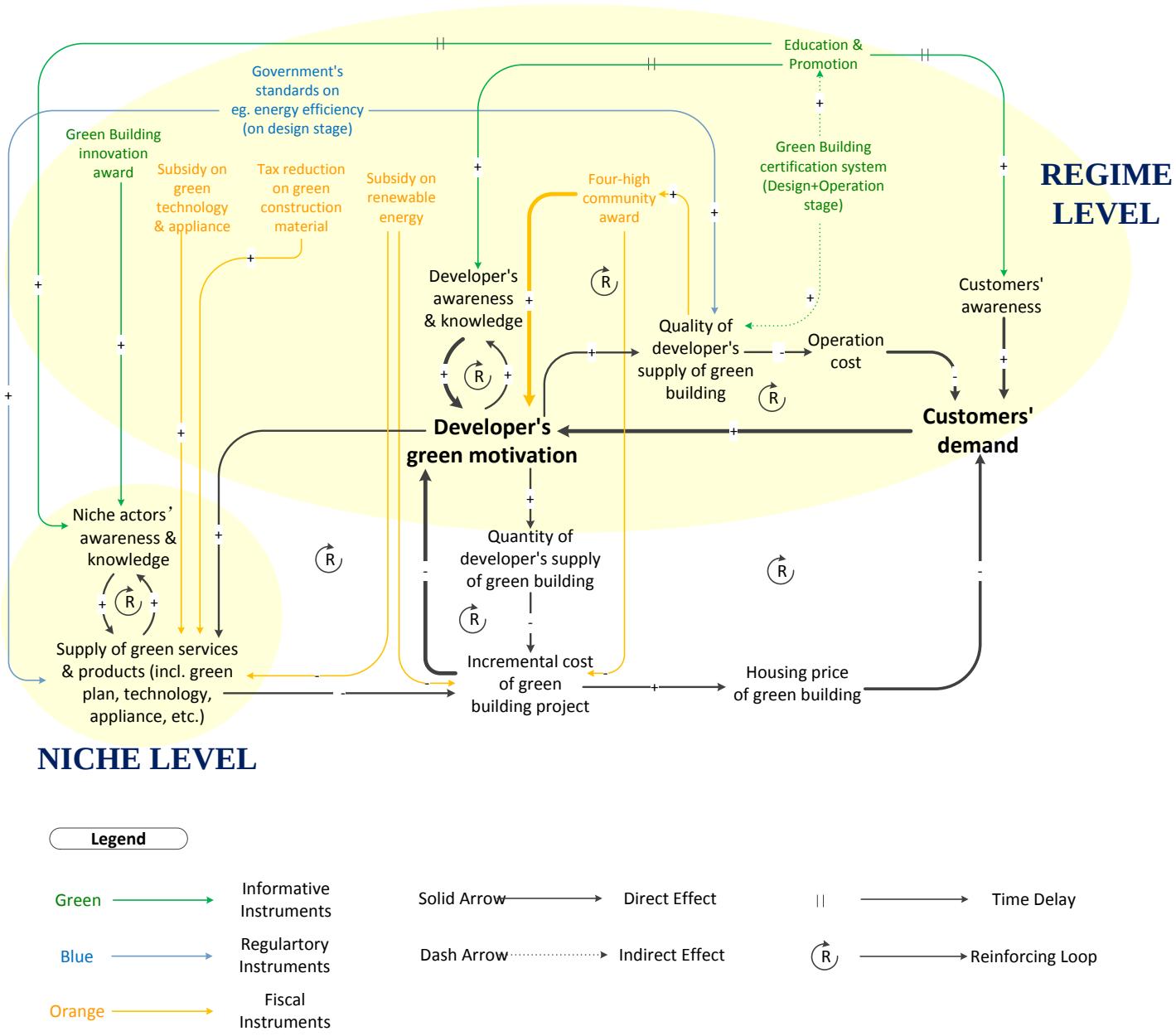

Figure 5.1 Simplified CLD of Relationship between Stakeholders and Current Policy Instruments in Shanghai, China

5.3.1 Regime Level and Related Policies

The most direct related stakeholders in the mass market are green building supplier and green building buyer, in other words, developers and customers/occupiers. Plus local government authorities, these are the three main actors identified in the regime level, where the market transformation is taking place.

As analyzed before, local government is the one leading the reorientations at the regime level in this case. In Figure 5.1, the policies it issued have effect on the other regime actors (i.e. developers and customers) as well as niches development.

Besides the mass market regulator, developers' green motivation plays a key role in the system. On the one hand, it acts as a link to the niche level. According to Interviewee #1 and #2, it is the developer that chooses the final architectural design scheme and decides the materials to use, the appliances to buy, the construction company to employ, etc. Developers make decision of almost every aspect related to the residential buildings they are going to build. They are at the demand side of green building related downstream industry. Thus their green motivation, as the "window of opportunity", could drive the development of niche markets and let the innovations break through.

On the other hand, stimulating the developers' green motivation is a pivotal way to promote green building development. In the residential building market, developers and customers are the supply and demand side of the green building per se respectively. The loops of their relationship are the key in the diagram. The higher customers' demand for green building, the greater green motivation can be gained by developers. And the greater green motivation can stimulate developers to build more green residential buildings, thus the incremental costs of the projects would decrease, theoretically leading to a relatively lower housing price (but still higher than conventional buildings). However, currently in Shanghai, such customer demand for green building is inadequate to trigger developers' green motivation. There is a high demand for basic housing in Shanghai. Till 2009, only 20% of the residents in Shanghai were renting an apartments (Shanghai Municipal Statistics Bureau, 2010); and according to Shanghai municipal government officer Changrong Jin (Liu, 2010), among those who hadn't had their own property right till 2010, 62.7% were unwilling to rent, which can be interpreted that they preferred to have their own apartments. This increases the short supply in current Shanghai residential housing market, pushes the housing prices even

higher[7]. Since traditionally, a developer's aim is to gain maximum return on minimum investment in shortest time (Lam, 2007), with the existing high profits from conventional buildings, the developers are reluctant to pursue green ones. This situation is exacerbated by two market barriers: a 'split incentive' and misperceptions on the incremental costs borne by developers. A 'split incentive' is a common barrier to no direct-owned green buildings; the benefit of greenness does not go into the developer who makes the investment: the developer makes the investment to green building projects, but it is the customers/occupiers that receive benefits of better indoor air quality and lower energy bills, etc. (WBCSD, 2009, UNEP, 2007, Yin and Gong, 2007, Jacobsson and Bergek, 2004, The Climate Group, 2011). This means the developer has no direct incentive to invest though they may benefit from higher housing price. The misperceptions lie in the incremental costs borne by developer. A green residential building nowadays is still perceived in the marketplace to be much more expensive to build than traditional construction, despite the evidence to the contrary (The Climate Group, 2011). According to Li and Sun (2008), technological incremental costs of green building are in the range of RMB 24.1/m^2 (USD 3.71/m^2) to RMB 319.16/m^2 (USD 49.42/m^2) for one-star and three-star certified green building projects respectively. As for Chenghuaxinyuan, the costs borne by the developer as well as the authority were USD 41.37/m^2 (see Appendix IV). These two barriers even lessen the developers' green motivation.

As presented in Figure 5.1, customers' demand for green building was identified to be affected mainly by their own awareness, housing price and operation costs. Generally, there is a lack of comprehensive awareness about green residential building among customers (The Climate Group, 2011). People who have no/little access to a green building have difficulties to experience the direct benefits brought by increased "greenness". Additionally, for those who are equipped with green awareness, the willingness to buy is hindered by financial constraints in Shanghai. The acceptable amount of incremental costs generated

[7] According to Savills (2012), Shanghai average housing price in the 1st quarter of 2012 was RMB 20 700/m^2 (USD 3 204.98/m^2); while the average income per capita in the same period was RMB 3 767 per month (USD 583.24).

from increased "greenness" and borne by customers mainly remains in the range of RMB 100 – 1000/m^2 (USD 15.48 – 154.83/m^2) (China Green Building Council and Landsea, 2010); while the actual amount in the market has reached USD 1021.88 /m^2 (see Appendix IV), taking Chenghuaxinyuan as an example, which is far beyond major customers' acceptable range. Considering the majority of residents in China have to spend decades of income to buy an apartment and most young people have to borrow their parents' money for the down payment, they are likely to have great difficulty buying a green apartment of a much higher price (first cost/up-front cost). Facing such financial constraints, customers would tend to choose conventional apartments given the first price advantage. In a nutshell, customers' demand for green building is quite weak nowadays. At present, there is no policy with a focus to enhance customers' demand, except the relevant education and promotion aiming to increase their green awareness.

Besides the customers' demand, a developer's green motivation was identified to be at least now affected by three other factors in the context of Shanghai (see Figure 5.1): its own awareness, incremental cost of a green building project, and local "Four-high" Community Award. Developers' awareness is now increased via informative instruments like relevant promotion and governmental demonstration projects. These measures also aim to remove misperceptions on incremental building costs and spread some professional knowledge about green building. The local "Four-high" Community Award could bring developers with reputation and subsidy, which can cover limited part of the incremental costs.

5.3.2 Niche Level and Related Policies

Two main actor groups were identified at the niche level: supplier niche and architect, engineer & planner niche.

Supplier niche includes suppliers of energy-efficient and renewable energy technologies and appliances, sustainable materials, water efficient technologies and appliances, etc. Here solar PV was used as an example to illustrate the development of this niche. In response to the landscape changes, solar energy as renewable power caught great focus worldwide, aiming to ease energy pressures and provide clean energy. PV is one method to make use of

solar energy. The terrestrial solar PV industry started in 1970s in China (Li et al., 2007). And China now is a leading country in the manufacturing of PV cells and panels; in 2008, over 95% of the manufactured cells were exported (China Greentech Initiative, 2009, China Greentech Initiative, 2011). At the same time, the domestic solar PV capacity remains low, representing only 1% of the world total in contrast (ibid.), although there are various possible markets for solar PV, like large scale power station, street lamp lighting, satellite, etc.

Both national and local governments have been trying to encourage the application of solar PV via renewable energy law, policy documents and demonstration projects. As for Shanghai, a plan to install solar PV on 100 000 household roofs was carried out in 2005 by Shanghai Jiaotong University, with the support from Shanghai municipal government and World Wildlife Fund (WWF) (NDRC, 2005). The plan aimed to make full use of the existing solar PV technology and the roof area to alleviate pressure of short power supply in Shanghai. However, till now, there is only one household installed the PV equipment; that is one researcher of that plan. According to Interviewee #5 (2012), there are two main reasons for the failure. First, the up-front cost was too high. Installing one set of such PV equipment would need more than RMB 140 000 (USD 21 676), equal to that of using the electricity from the municipal grids for 81 years[8] by one household (Li and Hong, 2007). Though the electricity generated is more than one household can consume, people are not willing to pay such high up-front cost. Second, current one-way electricity meters could not match the PV system. Such meters are not able to recognize the electricity goes into the municipal grids, thus the excess electricity generated by PV would be charged as well. Although Shanghai government has solved the electricity meter problem for this special household as well as some demonstration programs conducted by the government (e.g. government conducted renewal projects for the poor) (Interviewee #8, 2012), no measures have been taken for the wider public.

[8] Based on current electricity fee in Shanghai RMB 0.617 / kWh, and assume that one household use 3 000 kWh electricity every year.

Besides the plan, there are other innovations linking PV and residential buildings together, that is the research on Building Integrated PV (BIPV). According to Interviewee #5 and #8 (2012), currently BIPV are mainly applied in government projects, such as government buildings, Shanghai Hongqiao Railway Station and Shanghai Scientific Energy Conservation Museum. There have been subsidies on solar PV power generation system since 2009, however, they are restricted to those with over 50 kW install capacity (the PV system in the "100 000 roofs plan" has only 3 kW), meaning these subsidies are mainly for large public buildings rather than residential ones (MoF, 2009, SMCEI, 2009). That is to say, the largest barriers to apply solar PV to green residential building remain the high up-front costs and the problematic way to charge electricity.

All in all, in Shanghai, there are relatively mature solar PV technologies and there are informative policies to promote and demonstrate the application of them, however, there is a lack of proper regulatory or fiscal policies to remove the barriers when linking PV technologies up to the regime level of green residential building market.

As for **architect, planner & engineer niche**, some private research centers play an important role in leading the innovation, for example, Vanke Architecture Research Center founded in 1999. It started researches on Industrialized Building System (IBS) since 2002. As it stated, there are three driving forces for such innovation. First, Vanke believes that the traditional extensive construction mode is restricting the development of building industry (Vanke, 2010). It aggravates the landscape pressures (e.g. increasing energy consumptions and environmental pollutions), causes longer construction period as well as low enterprise operation efficiency, and could not help to solve some quality flaws (e.g. the leakage of external walls) (Vanke, 2007). Second, Vanke regards IBS for housing as a trend in China since Chinese government issued *Several Suggestions on Promoting IBS for Housing and Improving Residential Quality* in 1999, though received rare response from the market (Vanke, 2010, MoC et al., 1999). Third, there are successful experiences abroad (Vanke, 2010). Since this research center belongs to the developer - Vanke, it is well-connected with the building market and the IBS mode has been successfully applied in many Vanke projects

including Chenghuaxinyuan. Moreover, in 2007, it became part of the national base of IBS for housing (MoC, 2007a). In the same year, Shanghai municipal government set the floor area goals of new residential IBS construction projects (SUCCC et al., 2011). Such informative and/or regulatory policies open “windows of opportunity” and would let the innovation widely break through into the regime level.

Except the construction mode, there is in general a lack of professional knowledge regarding green building design and construction in this niche. A lack of specialized knowledge about the possibilities, techniques, and potentials of green building solutions is a major barrier in China as well (Yin and Gong, 2007, The Climate Group, 2011). Many architects do not know and do not learn about how to construct green building during their studies. This is also one of the main reasons why some “green” buildings are just collection of high-tech and high-cost green technologies rather than starting from a design perspective (The Climate Group, 2011).

On the whole, perceptions of niche actors and the size of networks are influenced by broader landscape development and requirements & incentives from the regime level (Geels and Schot, 2007). As shown in Figure 5.1, better plan & design and large amount of green technologies & appliances supplied by niche markets help to reduce the incremental cost of green building projects, which facilitate developers’ green motivation and the market transformation process. In turn, developers’ green motivation will encourage or even force the niche actors to provide better services and products. Hence policies successfully implemented at the regime level will influence the niche actors via increasing demand.

Some standards and incentive policies at the niche level are already put into effect, such as standards on building envelop, tax reduction on green material, labeling system on electricity appliance, etc. Some of them have certain influence on the regime transformation; while some are not suitable for residential building sector, like subsidies on solar PV application. There has been Green Building Innovation Award since 2004 for green building design and technology. But without any direct fiscal incentives, it largely acts as an

informative instrument to niche actors. Other informative policy measures at the niche level include education, promotion, and demonstration projects. On the other hand, informative policies are also the primary instrument used at the regime level currently, which is not strong enough to arouse developers' green motivation and drive the niche development or even secondary innovation.

6 DISCUSSION

According to Elzen et al. (2002), it is the alignment of developments that determines whether a shift in the existing regime will occur; such alignment refers to successful niche development, with the reinforce by the changes at regime level as well as the sociotechnical landscape level.

In the case of Shanghai, policies applied on the supplier niche are somewhat mature now in terms of encouraging green technologies and products development. Supplier niche is equipped with both standards and incentive policies; while the latter one is quite weak for architect, planner and engineer niche. When bridging these niche innovations with the green building regime level, some problems occur, such as the mismatched infrastructure and high up-front costs. Thus it is necessary to strengthen the "bridge" via better standards and incentives compatible with green building requirements. Take renewable energy use as an example. If the equipment (e.g. solar PV panels and geothermal heat pump units) is installed on site, there should be financial incentives direct to individual households or the project. And suitable infrastructure (e.g. electricity meter) as well as charging methods is also necessary. Generally, efforts from outsiders and interactions among regime and niche actors can help to set better "bridge". The former one can translate landscape pressures and draw attention to negative externalities, which is often neglected by regime insiders (Geels and Schot, 2007). Currently, such outsiders principally remain to be research institutes (e.g. Shanghai Research Institutes of Building Sciences) and international & national organizations (e.g. Johnson Controls Institute for Building Efficiency and China Greentech Initiative). Societal pressure groups, such as NGOs, are lack in terms of newly-built green residential building research or promotion. Also there is a need to make full use of the public media, not only for spreading green building ideas, but also collecting local wisdoms and public's opinions for better design and application of green technologies that fits the local natural condition and culture. As for the latter one, communication between market parties and policy-makers is a vital element in any market transformation strategy (Klinckenberg and Sunikka, 2006). Experiences and feedbacks from other regime actors (i.e. developers and

customers) and niche level are of high reference value in improving standards and green building certification system. Furthermore, sharing common beliefs among these actors, especially the first mover developers, may gain enough strength to compete and influence the rest and the majority of market actors (e.g. non-green building developers). Hence, in order to achieve better "bridge" between niche innovations and green building market, there is a need for government to make full use of the outsiders and enhance the communications with other regime actor as well as niche ones.

As for the regime level, it was identified in Section 5.2 that Shanghai is now at a crossed stage of market formation and expansion; it is in urgent need to solve the problems remaining in formative phase. First is to better current standard system aimed at newly-built green residential building with more comprehensive coverage on two dimensions: (i) different aspects of green building and its component products, not only restrict to energy efficiency and sustainable materials, but also optimized design, water efficiency, etc.; (ii) different stages along the green building lifecycle (examples are given in Appendix V). So that it can enhance the overall quality of green building as well as down-stream products, and exert more pressure upon developers to turn it into motivation.

Then since the market expansion phase has already begun, fiscal instruments on the regime level need to develop to keep up with the pace and to the largest extent trigger developers' green motivation. Current fiscal instruments are mainly in the form of subsidy to encourage green action in Shanghai. Except enhancing such subsidies, a combination with taxation and/or punishment can be considered to strengthen the incentive (this would be illustrated later). Furthermore, since the premise of well setting and implementing these fiscal policies is a proper-designed best practice level, as for Shanghai, there is a need to better combine "four-high" community criteria with local green building evaluation system. Besides a focus on developers, there could be some fiscal measures for customers as well.

Here some suggestions are listed aiming to increase the adoption of products and services from the niche level, encourage their development, and form or enhance some positive

feedback loops to create a chain reaction for a “change in gear” (Jacobsson and Bergek, 2004); and the chain involves all the constituent components in the green building system. Below some detailed partial CLDs are applied for better understanding (full version see Appendix VI). The roles of better standards, proper subsidies for supplier niche, and outsiders have been discussed earlier. And “Subsidy on certified green building project” in the diagrams is used to represent the well-combination of “four-high” community award and green building certification system.

- *Taxation on fossil fuel energy* (Figure 6.1): it boosts customers’ demand, developer’s green motivation as well as niche level actors’ motivation; once developers’ motivation increases, the demand for green design, technologies and products would all increase. The tax can be used as the main source of subsidies on renewable energy, promoting the niche development and enhancing the regime demand.

- *Tax reduction on green building developers* (Figure 6.2): it increases developers’ motivation, encouraging them to build more and high-qualified green buildings; the more high qualified green buildings they build, the more they get on tax reduction. Also, part of the high taxation on worse performed projects can be added to subsidies for star certified ones, which reduce the incremental costs also leading to an increase in developers’ green motivation.

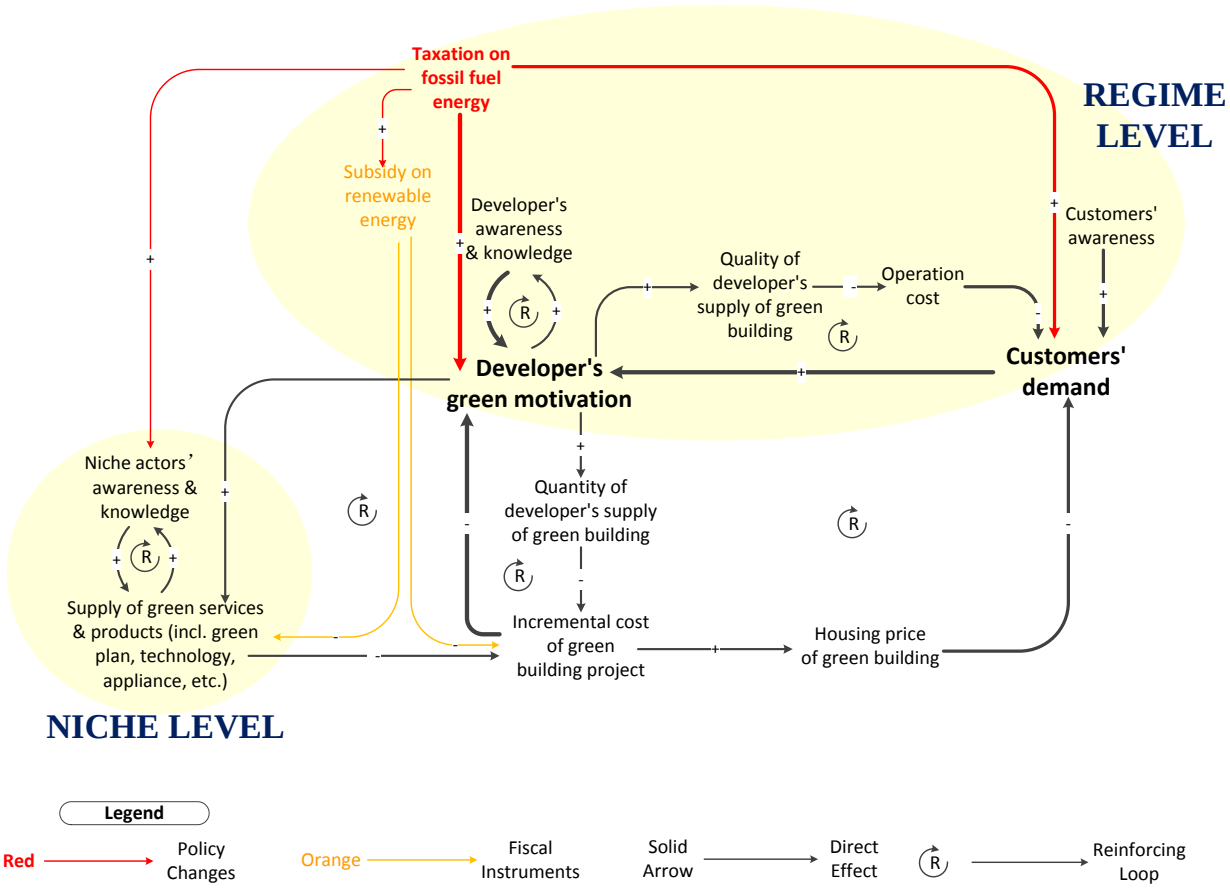

Figure 6.1 Partial Enlargement of CLD for *Taxation on Fossil Fuel Energy*

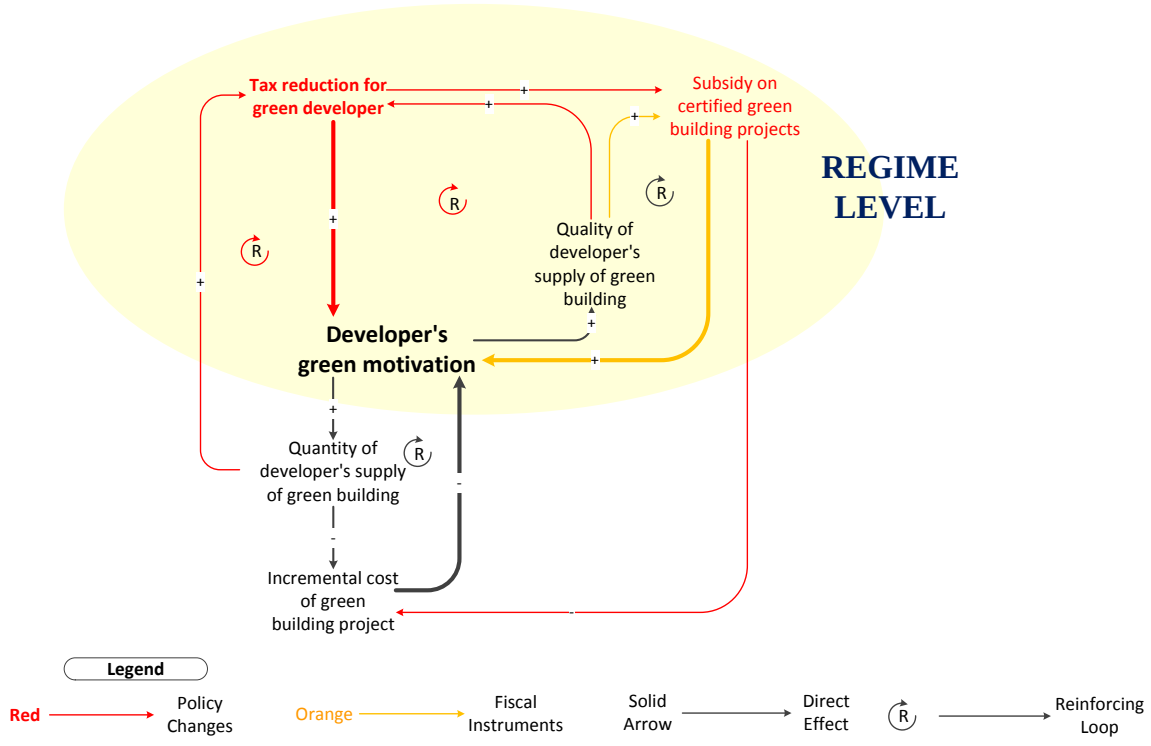

Figure 6.2 Partial Enlargement of CLD for *Tax Reduction for Green Developer*

- *Punishment of unqualified green building projects*: a bottom line should be set for green building as well. The punishment here does not need to be fiscal (if so, it can be directed as part of subsidies for star certified green building); it can remain the same as the current one for energy efficiency aspect: no allowance into the real estate market unless it reaches the bottom line after improvements. This measure could drive developers' green motivation as well.

- *Housing price control or tax reduction/subsidies on green building consumption*: this measure suggestion puts a focus on current high housing price, aiming to reduce the financial constraints for the customers in order to increase their demand, affecting the developers' motivation.

7 CONCLUSION

7.1 MAIN CONCLUSIONS REGARDING RESEARCH QUESTIONS

RQ1: *How do existing policy actions taken by the Chinese government facilitate the green building development process?*

Results show that green building development in Shanghai is at a crossed stage of both market formation and expansion. Regulatory and informative policy instruments are the predominant ones applied to the building per se on regime level during market formation phase while regulatory and fiscal instruments are employed on the niche level (eg. energy efficient appliances) to explore niche markets first. Two problems were identified during this crossed phase: (i) not enough coverage of bottom lines for green building to guarantee the basic quality, (ii) immature "bridge" between niche markets and mass market (i.e. green building). These will hinder the development of market expansion phase, where the fiscal instruments being applied. In regarding with newly-built residential green building, Shanghai has two best practice levels: four-high community and green building certification system while the latter one is yet equipped with neither "stick" nor "carrot".

RQ 2: *How do current policies make use of the key stakeholders in the green building system to encourage the development?*

This question can be interpreted from a multi-level perspective. Landscape changes beget pressures on the regime level (mainly for the government authorities) and niche innovations. Relevant policies (i.e. Policy Regime) play a key role in leading the niche market development as well as transformation in other regimes, especially building market. Stimulating developers' green motivation is identified to be a key to promote the green building development in present system. Developers' awareness, customers' demand, cost of green building projects, and local four-high community award are currently the major factors affect developers' green motivation. The first two are quite weak now though they are being enhanced via informative instruments. Subsidies from "four-high" community award are also very limited. Incremental cost of green building is one significant barrier to

market transformation. Besides related subsidies, such barrier can be cut down via largely breakthrough of niche markets. However, this is sometimes hindered by mismatches between regulatory or incentive policies at the niche level and green residential building requirements at regime level.

7.2 POLICY RECOMMENDATIONS

Market transformation analyses identify the policy solutions to widely develop newly-built green residential buildings. Here below is a summary of policy recommendations for green building development in Shanghai.

- Better standards and fiscal instruments for green building component products at the niche level to enhance the development of niche markets; and intensify communication and cooperation with outsiders and market parties (i.e. niche and other regime actors) to help strengthen the "bridge" for niche products go into the regime.
- Strengthen education and promotion regarding green building, especially to architects, planners, engineers, developers and customers.
- Develop a better and clear standard system with comprehensive coverage on different aspects of green building along its lifecycle. In consequence, it can exert more pressure upon developers to turn it into motivations, and enhance the quality of green building as well as down-stream products.
- After setting bottom lines, with existing green building certification system, there is a need for fiscal instrument to the largest extent trigger developers' green motivation. And it is not limited to the subsidies for star-certified projects but also could be, for instance, taxation on fossil fuel energy to influence the landscape level. Fiscal instruments on green/non-green building projects should be well-coordinated with current "four-high" community award system.
- Local green building development strategies should be compatible with local culture, cooperate with regional utility network development, and consider the middle- and low-income families.

7.3 LIMITATIONS AND FURTHER RESEARCH

This research focused on the performance of green building policies in Shanghai, China, attempting to provide a comprehensive and insightful picture of policy impacts in terms of market transformation; however, there exist limitations and many aspects still need to be investigated.

The political system as well as the green building system in reality is too complex in China; both the institutional structure and the green building system are quite fragmented and huge. This research tried to model these systems by proper simplification, selecting the key stakeholders and policies. However, there is always a risk of selection bias, like missing some important factors. This research tried to reduce such bias via multiple data collecting methods. There are more can be done to increase the validity and reliability for further studies. For example, do expanded interviews or questionnaires to developers and government officers if possible, to see their views on key stakeholders and their attitude towards different policy instruments and even put weight on them. Due to time constraints and other reasons, this research did not make it to interview more government officers or any developers/project managers.

From a theoretical point of view, market transformation theory could be better developed based on transition theory for green building development in future studies. Although Geels and Schot (2007) categorize transformation as one pathway of transition, they mainly analyzed from a multi-level perspective. Meanwhile, the market transformation theory puts more emphasis on technology innovation and starting from a multi-phase perspective (see e.g. (IEA and OECD, 2003, Jacobsson and Bergek, 2004, WBCSD, 2009, Klinckenberg and Sunikka, 2006)). This research tried to combine these two. However, a more systematic integration and a more solid model are needed to address the complex problem of green building along with its systemic nature.

Besides, the analysis could also start from other policy evaluation perspectives. Using criteria like environmental effectiveness, economic efficiency, transaction costs, political feasibility, etc. to evaluate and judge the actual outcomes or impacts of certain policy instruments. Also,

by doing sustainability assessment on some representative projects can help to check present certified green buildings' performance on sustainability. This would help to get a more comprehensive view of current policies to see whether they really lead to sustainable development before taking the next step in the market transformation.

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APPENDIX I LIST OF OBSERVATIONS

Time	Site	Form
Feb 29, 2012	Landsea Green Habitation Exhibition Center, Nanjing, China Sales office & construction site of Green Town, Zhongshan project, Nanjing, China	Without guide
Mar 7, 2012	Shanghai Scientific Energy Conservation Museum, China	Guided
Mar 7, 2012	Landsea Green Habitation Hall, Shanghai, China	Guided
Mar 7, 2012	Chenghuaxinyuan and its surroundings, Shanghai, China (without access into the community)	Without guide
Mar 8, 2012	IE expo (International Trade Fair for Water, Sewage, Refuse, Recycling and Energy Conservation), Shanghai, China - Storm water Section in Technical-Scientific Conference Program 10:00-12:30 - Energy saving, environmental protection and health Forum 13:00-16:30 (http://www.ie-expo.com/article.php?item=area&id=34)	Participating in seminars

APPENDIX II LIST OF INTERVIEWEES

No.	Position	Methods	Time
#1	Engineering director of one private company	Interview in person	Feb 24, 2012
		Interview via phone	Feb 29, 2012
#2	Engineer, Technical Director of one cultural organization	Interview via phone	Feb 27, 2012
#3	Sales Engineer of Landsea, Nanjing	Interview in person	Feb 29, 2012
#4	Deputy Secretary General of Shanghai Green Building Council	Interview via phone	Mar 6, 2012
#5	Senior Engineer of Shanghai Energy Conservation Supervision Center, Shanghai Scientific Energy Conservation Museum	Interview in person	Mar 7, 2012
#6	Sales Engineer of Landsea Green Habitation Hall, Shanghai	Interview in person	Mar 7, 2012
#7	Vice Director of Shanghai Water Planning and Design Research Institute	Interview in person	Mar 8, 2012
#8	Vice Director and Secretory-General of Housing Improvement Committee of China Commonweal General Association	Interview in Person	Mar 8, 2012
#9 & #10	Shijingshan Project Preparation Group of China Energy and Environmental Protection Group	Interview in Person	Mar 15, 2012

APPENDIX III INTERVIEW GUIDE

Questions for engineers #1 #2:

- What is your role in the system?
- Who makes the plan? And who decides the plan?
- Who chooses the construction materials, electricity appliances, and so on?
- Is there any third party to do the supervision work during the construction process? Is it a private company hired by the developer or a department belongs to the government?
- Is there any third party to monitor the consumption of energy during the operation phase? What is the difficulty to conduct this (cost, technique or others)?
- Is it possible for the developers to choose renewable energy sources, like solar PV, geothermal, biogas, etc.? What are the difficulties to apply these technologies?

Questions for sales engineers #3 #6:

- What are the differences between the 1st generation of green building and the 2nd generation in Landsea?
- Is it possible for the customers to re-decorate their home? What if they are not 100% satisfied with the decoration you offered?
- Do you use any renewable energy and reclaimed water?
- Is it possible for me to visit one of your communities?
- What does the irregular water use refer to in your designed certification? (This is for the Green Living District in Shanghai.)

Questions for Green Building Council #4:

- What's the difference between certification system in the designing stage and the operation stage?
- Why there are so few projects owning the operation certification in Shanghai, and none of them are residential building projects?
- Is the 5-star green standard still working (which appears in one piece of news on your website in 2008)? If yes, is it for the public building project or the residential building project? Is there any relevant financial incentive policies? If yes, who is responsible for this, Shanghai government or the national government?

Questions for Senior Engineer in Shanghai Energy Conservation Supervision Center #5:

- How can you tell the energy saving rate in the designing stage reaches 65% or not? Computer modeling?
- Is there any monitoring system for the public buildings, residential buildings, etc.? If yes, who is responsible for this? If no, why? Especially for residential buildings.
- What kinds of renewable energy have been usually applied in common communities?
- During last decades, the solar water heater has been greatly promoted. These years, newly built residential buildings become higher and higher, what about the solar water heater? And how about the solar PV?
- (Other questions were asked during the guide and according to the content introduced.)

Given that some questions had been answered during the presentation by the Vice Director of Shanghai Water Planning and Design Research Institute, the supplementary questions are #7:

- Is there any consideration from your side to reuse the storm water or grey water in Shanghai?
  - If yes, is there any plan at a community level? What is that like?
  - If no, will you consider it and why? Or what are the main difficulties to do this, if applicable?

Given that some questions had been answered during the presentation by the Vice Director and Secretory-General of Housing Improvement Committee of China Commonweal General Association, the supplementary questions are #8:

- Who is responsible for or who is in charge of such projects? Who are going to pay for the costs?
- Is there any regulation on the energy saving rate for renovate existing residential buildings?
- Except for reforming the wall and window, what else have been done to achieve energy saving?
- Except for energy saving, what else have you been done to achieve sustainability, if it is one goal?
- How do you deal with the Solar PV you applied in these projects?

APPENDIX IV ESTIMATED COSTS FOR CHENGHUAXINYUAN PROJECT, VANKE, SHANGHAI

All figures are in dollars: the average exchange rate in 2011 was RMB 1= USD 0.15483 (State Administration of Foreign Exchange, n.d.)

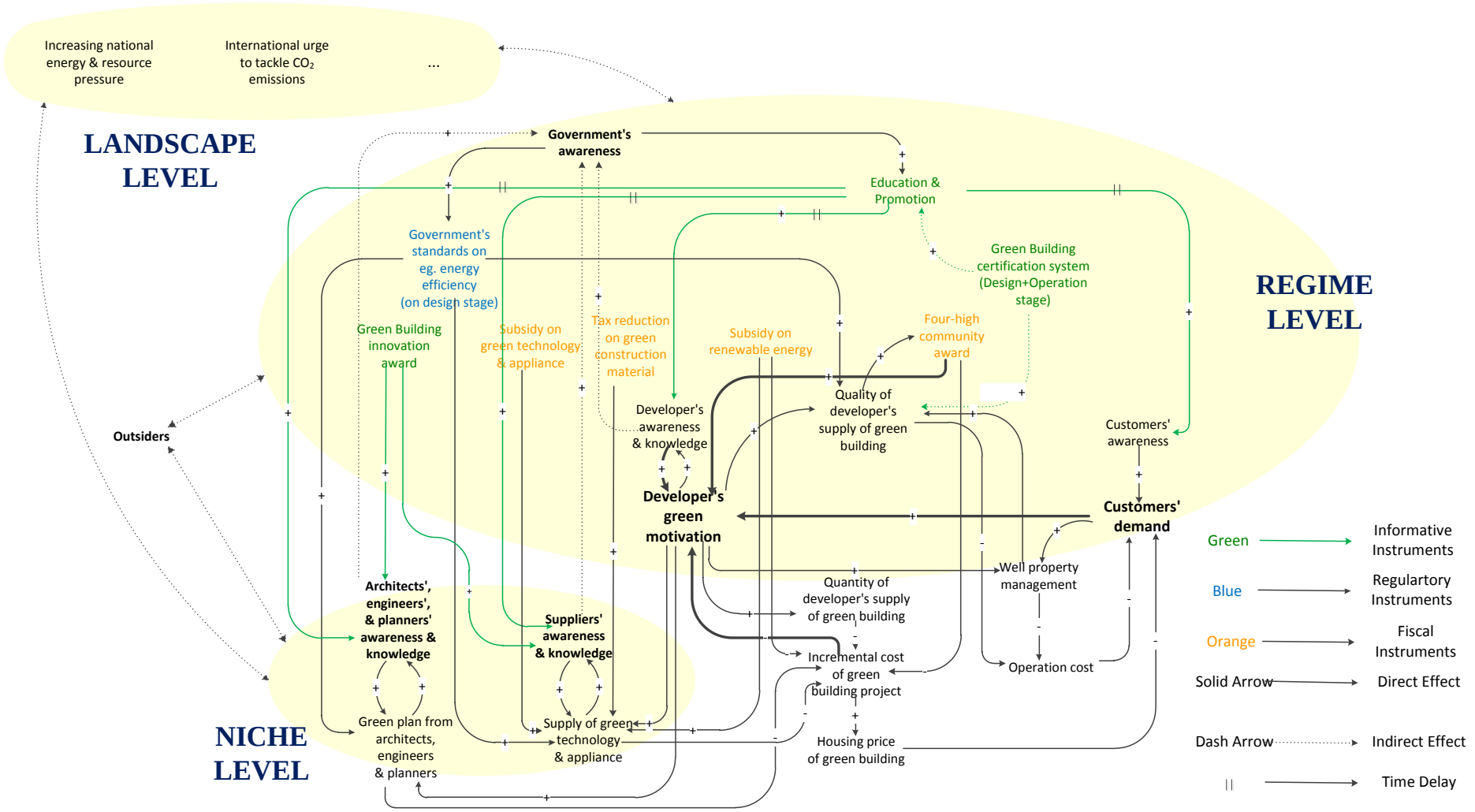
Estimated program costs (undiscounted)	
Investment incremental costs borne by project developer	$ 34.84/m^2 [a]
	R&D: $ 0.28/m^2 [b]
Administrative costs borne by project developer (certification)	$ 0.02/m^2 [c]
Transaction costs borne by project developer	$ 4.32/m^2 [d]
Investment incremental costs borne by customers	$ 1021.88/m^2 [e]
Administrative costs borne by the authority (Award & Subsidies)	$ 1.91/m^2 [f]
Total program costs	**$ 1063.25/m^2**

2009 Financial Report of Vanke (Vanke, 2009)

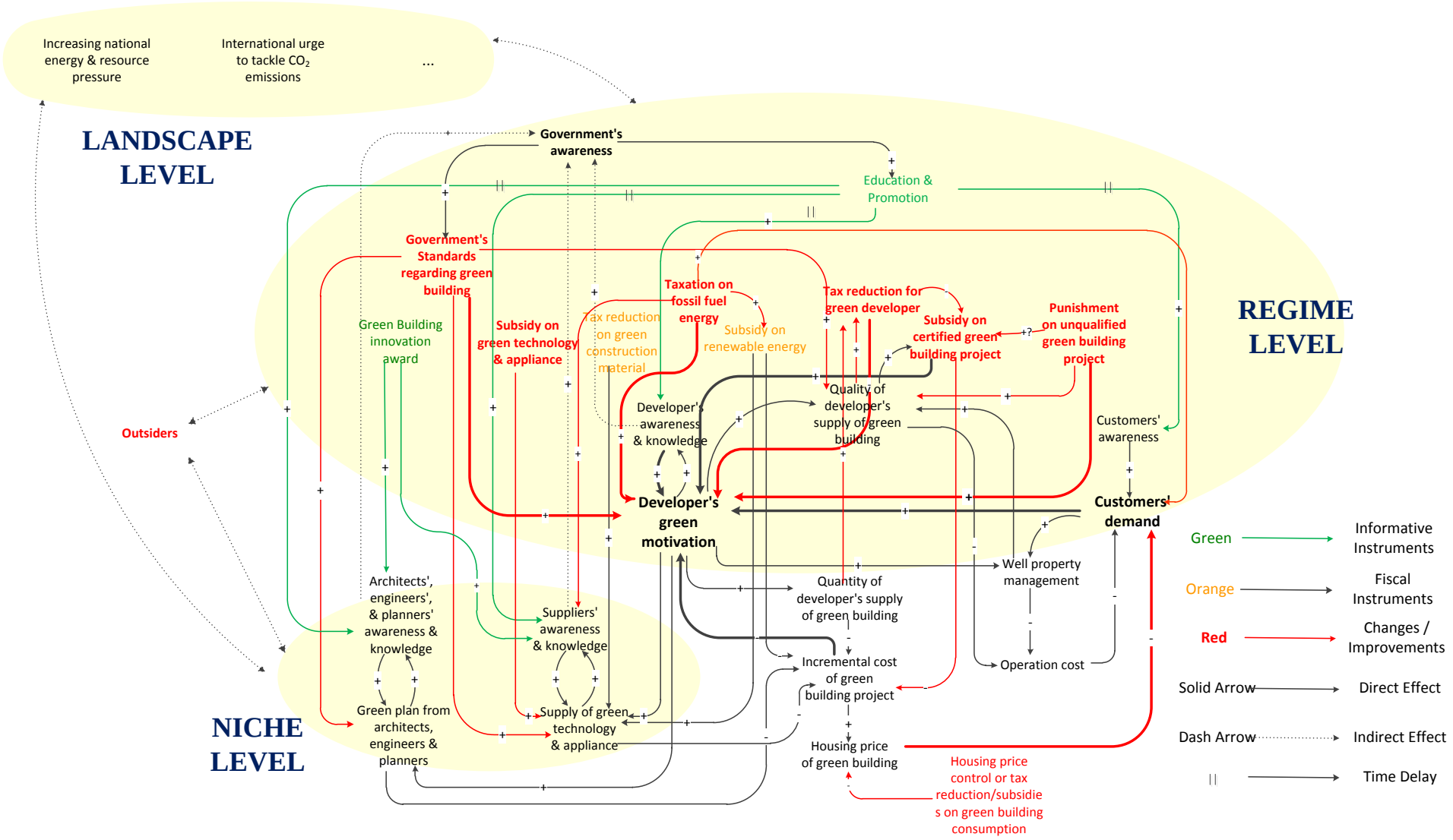
- Construction area of Chenghuaxinyuan Period I: 365 764m^2

a. The data of incremental costs are from a report from Green and Ecological Building Research Center, Chinese Academy of Architecture of Shanghai Branch (Li, n.d.)
b. According to 2009 Social Responsibility Report of Vanke, the total investment in R&D sector was RMB 100 million. Thus the national average would be RMB 100 million/54 319 883m^2=RMB 1.84/m^2.
c. Registration fee is RMB 1 000 and the evaluation fee for green building at the designing stage is RMB 50 000 (MA et al., 2010). (1 000+50 000)/ 365 764m^2= RMB 0.14/ m^2
d. Based on Vanke Financial Report 2009 (Vanke, 2009), the average promotion fee and sales agency fee in 2009 around China is RMB 1 513 716 869.35/54 319 883m^2=RMB 27.87/m^2.
e. According to the data from Sohu Focus (Sohu Focus, 2012), the housing price of Chenghuaxinyuan in July 2009 was RMB 19 300/m^2, and the average housing price for newly built residential buildings at the same time in Shanghai was RMB 12 700/m^2.
f. According to lvdichan.com (China Green Real Estate, 2011), Chenghuaxinyuan project was awarded RMB 4.52 million for its great design of green residential building, especially on the energy saving part, by the Shanghai government. RMB 4 520 000/365 764m^2=12.36/m^2

APPENDIX V CLD OF RELATIONSHIP BETWEEN STAKEHOLDERS AND CURRENT POLICY INSTRUMENTS IN SHANGHAI, CHINA



APPENDIX VI CLD OF RELATIONSHIP BETWEEN STAKEHOLDERS AND IMPROVED POLICY INSTRUMENTS IN SHANGHAI, CHINA



APPENDIX VII CURRENT AND POTENTIAL POLICIES ALONG A GREEN RESIDENTIAL BUILDING'S LIFECYCLE IN SHANGHAI