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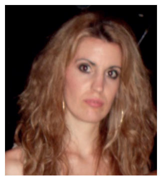

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Towards an Integrated Framework for Coastal Eco-Cities:
EU-Asia perspectives

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Towards an Integrated Framework for Coastal Eco-Cities

Coastal Eco-cities LRF Collegium 2013 Series, Volume 5

Towards an Integrated Framework for Coastal Eco-Cities

EU-Asia perspectives

Authors: **P Divakaran, V Kapnopoulou, E McMurtry, M Seo, L Yu**

Series Editors: **R A Shenoi, P A Wilson, S S Bennett**

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Foreword

The Lloyd's Register Foundation (LRF) in collaboration with the University of Southampton instituted a research collegium in Southampton between 18 July and 11 September 2013.

The aim of the research collegium has been to provide an environment where people in their formative post-graduate years can learn and work in a small, mixed discipline group drawn from a global community to develop their skills whilst completing a project on a topic that represents a grand challenge to humankind. The project brief that initiates each project set challenging user requirements to encourage each team to develop an imaginative solution, using individual knowledge and experience, together with learning derived from teaching to form a common element of the early part of the programme.

The collegium format provided adequate time for the participants to enhance their knowledge through a structured programme of taught modules which focussed on the advanced technologies, emerging technologies and novel solutions, regulatory and commercial issues, design challenges (such as environmental performance and climate change mitigation and adaptation) and engineering systems integration. Lecturers were drawn from academic research and industry communities to provide a mind-broadening opportunity for participants, whatever their original specialisation.

The subject of the 2013 research collegium has been systems underpinning coastal eco-cities.

The project brief included: (a) quantification of the environmental challenge; (b) understanding of the geo-political legal-social context; (c) one integrated engineering system for a coastal eco-city; (d) economics and logistics challenges.

This volume presents the findings of one of the five groups.

R A Shenoi, P A Wilson, S S Bennett (University of Southampton)
M C Franklin, E Kinghan (Lloyd's Register Foundation)
2 September 2013

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We would like to express our sincere gratitude to Mr Michael Franklin, Grants Director of Lloyd's Register Foundation (LRF) and Eileen Kinghan, Grants Manager, for facilitating this unique opportunity and recognising the potential of the scholars.

Throughout the research process, Professor Ajit Shenoi, Professor Phillip Wilson and Dr Sally Bennet have guided us with practical and constructive advice for which we are extremely grateful. Also, we extend equal gratitude to Professor Vaughan Pomeroy, who took considerable time to discuss with us our ideas and the direction of the project from the very beginning.

For their dialogue, and contributions of key documents, we would like to thank Mr Gang Wei from Tianjin Eco-City Project, Ms. Charlotte Schlicke, Senior Project Manager at Steinbeis-Europa-Zentrum, Mr Reto Michael Hummelshøj, Local co-cordinator for the Helsinggor/Helsingborg Project, Mr Ulf-Thore Kroher, University of Karlsruhe, Germany, Professor Simon Joss from the University of Westminster and Ms. Marilouise Berg, Environmental Co-ordinator, City of Helsingborg.

We found all of the guest lecturer's contributions interesting and informative, and each inspired us to explore various options for our project. Therefore we would like to express our thanks to each of the professionals and academics from within and outside of the University of Southampton whom took their time to deliver their lectures with enthusiasm and openness.

On a personal note, we speak on behalf of all the collegium scholars when we say that the warm welcome and continued support from Mirjam Furth and Bjorn Winden played a key role in making the collegium a pleasant and rewarding experience. Furthermore, our time at the Collegium would not have been nearly as positive without the invaluable contributions of Mrs Aparna Subaiah-Varma, who facilitated the majority of the administrative and organisational elements of this collegium.

Lastly, to all our colleagues in the collegium, thank you to each of you for each bringing a unique element to the dynamics of the group, and being part of what has been a fantastic experience.

Prasanth Divarakan · Vaso Kapnopoulou · Erin McMurtry · Min-Guk Seo · Liwei Yu

Southampton, September 2013

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List of Abbreviations

AWG-LCA Ad-Hoc Working Group on Long-Term Co-Operative Action

CA Consortium Agreement

CDM Clean Development Mechanism

CORDIS Community Research and Development Information Service

EU-ETS European Emissions Trading System

FIDIC [contract] International Federation of Consulting Engineers (Translation from French language)

GBES Evaluation Standard for Green Building

GEF Global Environment Facility

HDB Housing and Development Board

IPCC Intergovernmental Panel on Climate Change

IPR Intellectual Property Rights

JI Joint Implementation

KPI Key Performance Indicator

LA21 Local Agenda 21

LEDC Less Economically Developed Country

LEED Leadership in Energy and Environmental Design

LOU Public Procurement Act (Swedish Translation)

LTA Land Transport Authority

LUF Public Procurement Law

MBM Market Based Mechanism

MDG Millennium Development Goals

NAP National Allocation Plan

NEA National Energy Association of China/National Environment Agency

NGVAE Natural & bio Gas Vehicle Association Europe

NOU National Board for Public Procurement (Swedish translation)

PUB	Public Utilities Board
RES	Renewable Energy Sources
RTD	Research and Technological Development
SME	Small to Medium Enterprises
TWEA	Tianjin Wind Energy Association
SLR	Sea Level Rise
SSTEC	Sino-Singapore Tianjin Eco City
SVF	National Property Board (Swedish Translation)
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCC	United nations Framework Convention on Climate Change
URA	Urban Redevelopment Authority
WEEE	Waste Electrical and Electronic Equipment

Summary

This report presents a structured and informative analysis of two poignant European and Asian Coastal Eco-City projects. The scholars have recognised the diverse pathways Eco-City developments take within the duration their development; therefore we work towards a framework that draws upon influences from two, polarised developments in Eco-City design.

Available data for both cities was not equally distributed for all aspects of the development process; however we present a comprehensive analysis throughout various stages, from initial project drivers, through to project outcomes.

The environmental, social, and legal/political aspects of both developments are clearly outlined in order to reveal transferrable elements of Eco-City developments across EU-Asia borders. Equally, the pivotal role of contract arrangement and stakeholder engagement across two juxtaposed cultures are compared in context.

We then give recommendations for an integrated framework for Eco-City design. We address green building standards, energy supply, waste management, transportation, and coastal infrastructures, as well as the integral role of Key Performance Indicators.

We conclude the text with an analysis of transferability and the feasibility of combining EU-Asia Eco-City concepts towards the common goal of sustainable development.

1 INTRODUCTION

1.1 Background

1.1.1 Coastal cities

Marine coasts, with their boundless economic opportunities and plentiful natural resources, have been long viewed as preferred place to live, work, play and retire. Historic patterns of economic development during the industrial revolution transformed coastal cities into centres of trade and commerce. The financial opportunities augmented by the economic difficulties brought on by the second world war, resulted in a sudden population increase in coastal cities (Hinrichsen, 1998). Currently more than 50% of the world's population lives along the coastline, on 10% of the earth's land area (Hinrichsen, 1998). Migration is continuing, and according to the Population Reference Bureau of China, an estimated one thousand people migrate to coastal cities daily. This phenomenon of large human migration leads to the creation of coastal-mega-cities. These are defined as cities located within 100m elevation of the coastline, 100km distance from the coastline and exceeding 10 million inhabitants (Sekovski et al., 2012). According to these parameters there were 14 coastal mega-cities in the world by the year 2007, most of them in the developing countries (Sekovski, et al., 2012). The positive trends in population growth, along with an increase in the rural-to-urban and urban-to-urban migration, we could expect more coastal-mega-cities begin to emerge in near future. Population growth is not the only problem threating urban coastal areas. Climate change and predicted 50cm sea level rise by the end of the century would make coastal population especially vulnerable to climate and weather related phenomenon and also under greater flood risk (IPCC, 2007).

1.1.2 Population growth

Human population increased drastically from 1 billion in 1804 to 7 billion in 2011 (Livescience, 2011). Much of the population explosion during this period is down to the economic and food production boom due to the industrial revolution, and achievements in medical fields that increased human longevity and reduced infant mortality rate. Notable changes are found in least developed countries, where the United Nations report mentioned an increase in life expectancy from an average of 35 in 1950 to over 60 years in 2010. Furthermore, the infant mortality rate (child death under the age of 5 per 1000) down from 300 in 1950 to less than 100 in 2010 (United Nations, 2013) (Figure 1.1). With the current population growth rate, we have an increase in population of approximately 1 billion in every 13 years. According to the United Nations population forecasts, the world population will eventually hit the 10.9 billion mark by 2100 before it starts to show any sign of decline (United Nations, 2013). Majority of those projected increases will happen in developing countries. A larger population will put increased need for greater food production and higher demand for energy. However, the current demographic difference in consumption of food and energy per capita is greatly in favour of western developed countries and is unsustainable. The conventional way to meet these higher demands will eventually put more pressure on ecology and increase CO_2 emissions into the atmosphere. Hence, we need a collaborative strategy for the long term future of our species, involving a reduction in population growth by family planning and empowerment of women, lower consumption of goods, sustainable solutions for food, water and energy, and moreover, novel intelligent design of urban space to accommodate more people by maximizing land use and minimizing human imprints on nature.

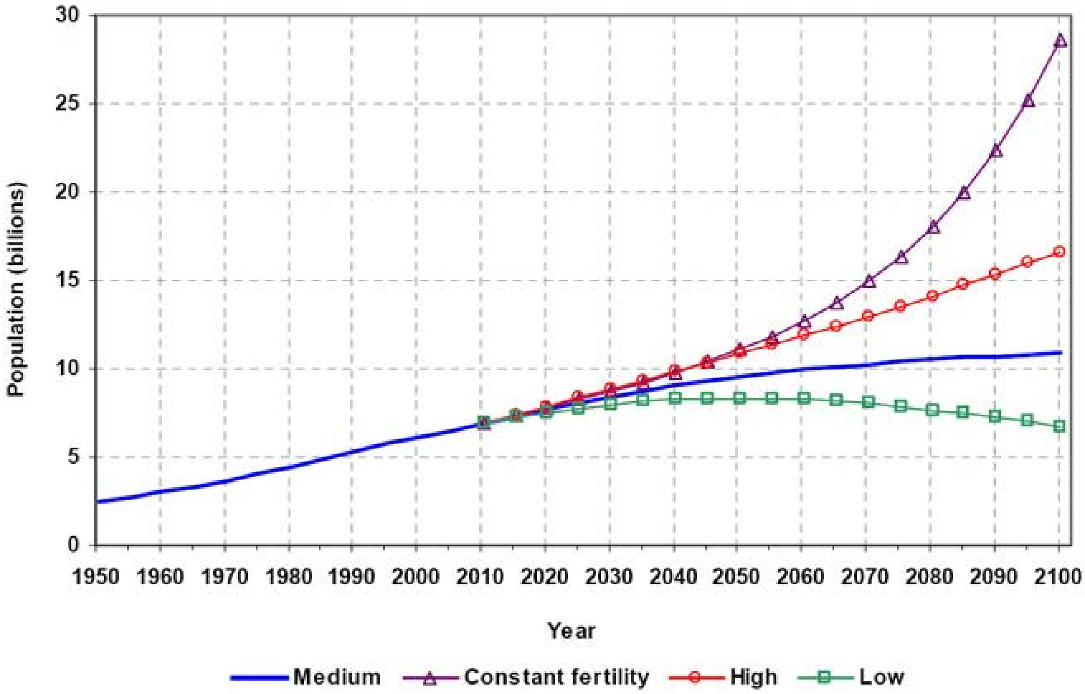


Figure 1.1: Population of the world 1950-2100, taken from United Nations (2013).

1.1.3 Climate change/SLR scenario

Climate change simply means a long-term statistical change (trend) in global weather patterns. However, recent observed rise in global surface temperature show increased correlation towards high CO_2 levels in the atmosphere. The higher concentrations of CO_2 are primarily a result of burning of fossil fuels; hence the present change in earth climate is commonly referred as 'Anthropogenic Global Warming'. IPCC fourth assessment report pointed out that the warming of the climate system is unequivocal. Eleven of the twelve years between 1995 and 2006 rank amongst twelve warmest years on record since scientists started collecting instrumental data (IPCC, 2007). Fifth assessment report from IPCC is due in 2014, and is widely expected to include more detailed analysis of the present warming trend. Meanwhile, the state of the climate report published by the American Meteorological Society concluded that the United States and Argentina had their warmest year on record in 2012 (Blunden and Arndt, 2013). The global surface temperature linear trend calculated using data from 1906-2005 is found to be 0.74°C, which is higher than 0.6°C noted in the third IPCC report. The report also mentioned that the warming trends are greater in the northern hemisphere compared to the south, possibly due to the greater land area (IPCC, 2007).

The observed sea level rise is consistent with global warming trends (see Figure 1.2b). Increases in sea level are primarily due to thermal expansion of sea water, and melting of polar ice caps and glaciers. Observed decrease in ice-cover extend (Figure 1.2c) is also consistent with sea level rise and global warming. The global sea level has risen since 1961 with an average rate of 1.8 mm/year; however, since 1993 that rate has increased to 3.1 mm/year (IPCC, 2007). Global climate prediction models used by the IPCC have forecasted an increase of about 50 cm rise in sea level by the end of the century. Many of the pacific island countries and low lying countries in the tropics (e.g. Bangladesh) are under greater threat from flooding and salt water intrusion. There is a general consensus among research community that the IPCC sea level forecasts are on optimistic grounds, and IPCC models lack rapid dynamics of ice-flow. Recent studies in this regard shows that with good ice-melting schemes sea level rise can be from 0.8m to 2.8m by the end of the century (Pfeffer et al.,2008).

Global warming also increase the strength of tropical cyclones, studies have shown that the intensity of tropical cyclones are significantly higher in the last 30 years over the Atlantic Ocean (Elsner et al.,2008). There is also literature on the global precipitation and water cycle changes in recent times (Huntington, 2006; Smith et al., 2006). Bush fires and extreme flooding also been linked to climate change (Cary, 2004). The mitigation efforts are important in slowing down climate change impacts; however, as the climate system is already disturbed we should also look to adapt from the possible consequences. Hence, it is especially important to manage our coastlines, protect our environments and have healthy futuristic life style and urban planning.

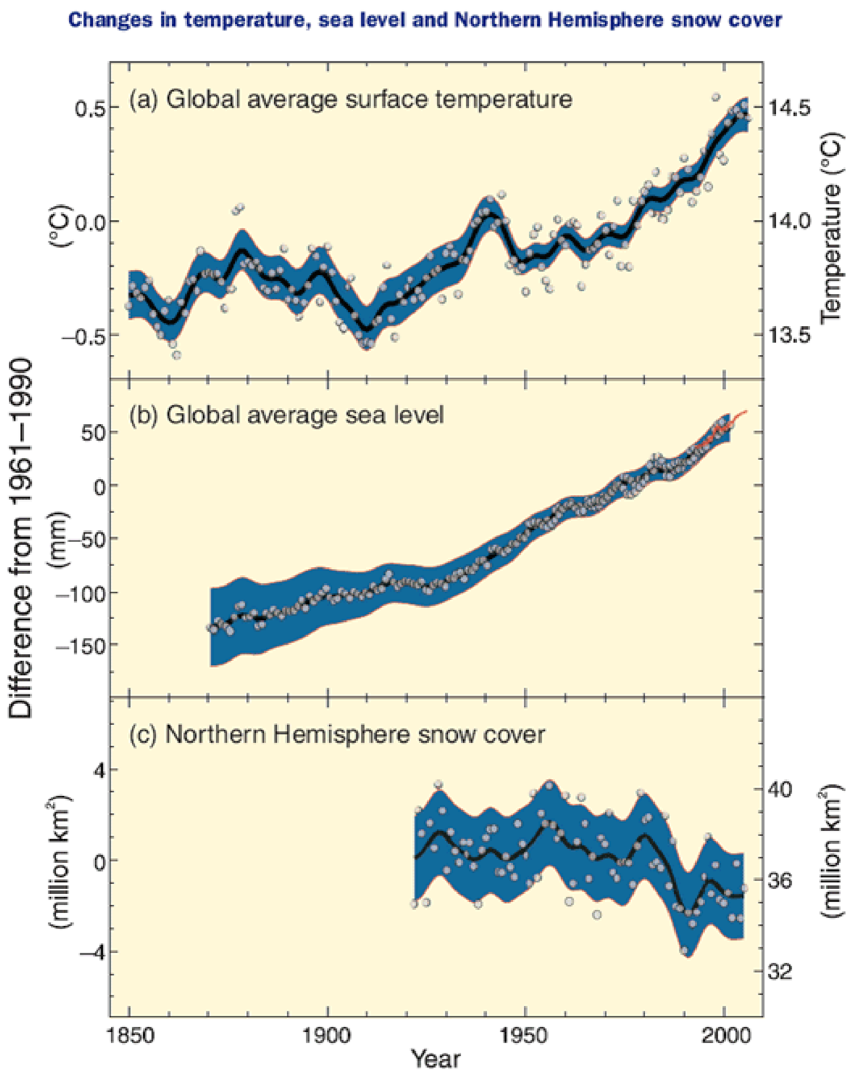


Figure 1.2: Observed changes in (a) global average surface temperature; (b) global average surface temperature and (c) northern hemisphere snow cover, taken from IPCC (2007).

1.1.4 Global carbon reduction targets

KYOTO PROTOCOL

Since the United Nations Conference on Environment and Development (UNCED), referred to as the Rio Summit (1992), it has been evident that there is a global drive to curb the rapidly increasing volume of greenhouse gases emitted from a growing global population. 192 countries ratify the Kyoto Protocol, signed in 1997, and is an international attempt to meet the carbon reduction targets recommended by the United Nations Framework Convention on Climate Change (UNFCC), formed in 1988. The IPCC undergoes continuous research into the anthropogenic contribution to climate change through the release of greenhouse gases. It recommended a global reduction of 20% in greenhouse gas emissions from 1990s levels by 2012 in order to avoid 'disastrous climate change', or the equivalent of a 2°c rise in global average temperatures. The first commitment period was from 1998-2002, and include the gases Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydroflourocarbons (HFCs), Perflourocarbons (PFCs) and Sulphur hexafluoride (SF_6), otherwise referred to as the 'Kyoto Basket'. The Kyoto Protocol separates the countries party to the Protocol into Annex I and Annex II countries, representing the policy of 'common but differentiated responsibility' reflecting the diminished responsibility perceived to be held by Less Economically Developed Countries (LEDCs).

Notably, the majority of EU member states, as well as Australia remain bound under the protocol as of 2013. However, significant global contributors including Canada and the USA have removed themselves from the collective signatory. Likewise, debate continues regarding the sharp differentiation between Annex I and Annex II nations. For example, China is a significant global contributor to the overall global carbon budget at over 25% (Table 1.1), but is included under Annex II. The continued population and industrial growth of China is a significant setback for the emissions reduction targets met in Europe. India has received similar criticism, having emitted 2, 008, 823 ktCO_2e in 2010, or 6.4% or the global total.

Table 1.1: Top five global CO_2 contributors 1990-2010 in thousands of metric tonnes of CO_2 (United Nations Statistics Division, Millennium Goal Development Indicators, 2013).

Rank	Nation/Economic Union	1990	2010	% change from baseline	% of global total (2010)
1	China	2460744	8286892	336.8	26.4
2	U.S.A	4768138	5433057	114.0	17.3
3	India	690577	2008823	290.9	6.4
4	Russia	N/A	1740776	N/A	5.6
5	Japan	1094834	1170715	106.9	3.7
Global Total*		**16603201**	**31350448**	189.0	100

*Excluding Democratic Yemen, Union of Soviet Socialist Republics, Yemen Arab Republic and Yugoslavia

Annex I countries can meet their carbon reduction commitments through flexibility mechanisms. These flexibility mechanisms are a collaborative effort with Annex II nations, and are described as Joint Implementation (JI) and the Clean Development Mechanism (CDM) in order to earn certified carbon credits. However, as stated, the measurable value of the objectives met by JI or more poignantly the CDM, are questionable. The objectives include helping communities towards achieving sustainable development and through this, promote both knowledge and technology transfer. However, the tangible carbon reductions achieved by these, as well as the knowledge and technology transferred is equally bought into question. The global distribution of CDM projects indicates a disproportionately large number of them attributable to Asia, and most significantly, China (Figure 1.3).

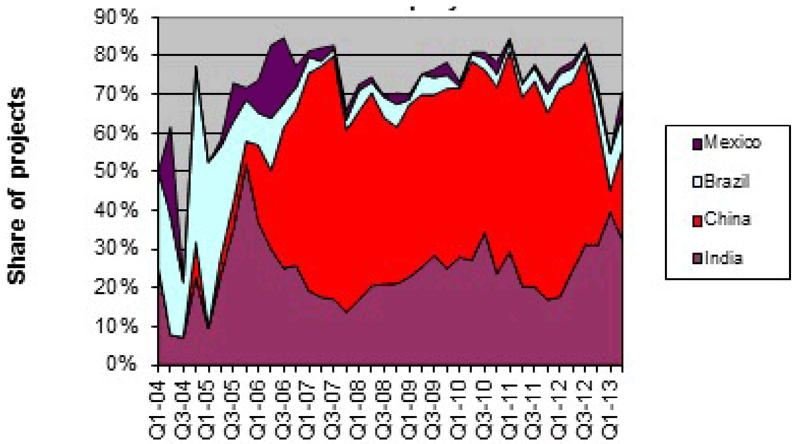


Figure 1.3: All CDM projects from Mexico, Brazil, India and China as a fraction of the global total, taken from UNEP (2013).

The second commitment period for the Kyoto Carbon Reduction targets began on the 1st January 2013 and will run until 2020. The countries that are under the protocol include 38 of the original 39 Annex I countries having ratified the protocol, which are committed to binding CO_2 reduction targets (DPCEU, 2012).

The Ad-Hoc Working Group on Long-Term Co-operative Action (AWG-LCA) was developed under Conference of the Parties [to the Kyoto Protocol] 17 (COP-17) in Durban, South Africa. This has been put in place to further increase the measures and penalties taken in order to bridge the gap between the aggregate of global emissions targets, and the actual likelihood of meeting a 1.5-2°c global average temperature increase from pre-industrial levels (UNFCC, 2012). It also strives to achieve the objectives set out in the Bali Action Plan outlined at COP-13 in 2007. That includes integrating the aspects of economic and social development and the eradication of poverty as a global priority within emissions reduction commitments (UNFCC 2008).

European Union Emissions Trading System (EU-ETS)

The EU-ETS is a Market Based Mechanism (MBM) put in place by the European Union in order to meet the carbon reduction obligations set forth by the Kyoto Protocol (EU, 2003). It uses a 'cap and trade' method in order to gradually reduce the number of emissions 'credits' over time. An emissions credit is equivalent to one ton of carbon dioxide and has a market value.

The EU-ETS has defined 'trading periods'. The first trading period was from January 2005 to December 2007, followed up January 2008 to December 2012, and currently the third period from January 2013 to December 2020. On reaching December 2020 the cap on emissions is expected to have achieved a 21% drop in CO_2 emissions from 1990s levels (CCC, 2008).

The success of the EU-ETS in aiding investment in low carbon technologies depends on a stable carbon price. However, of late the price of carbon has dropped significantly, partly due to the economic recession in Europe (Figure 1.4).

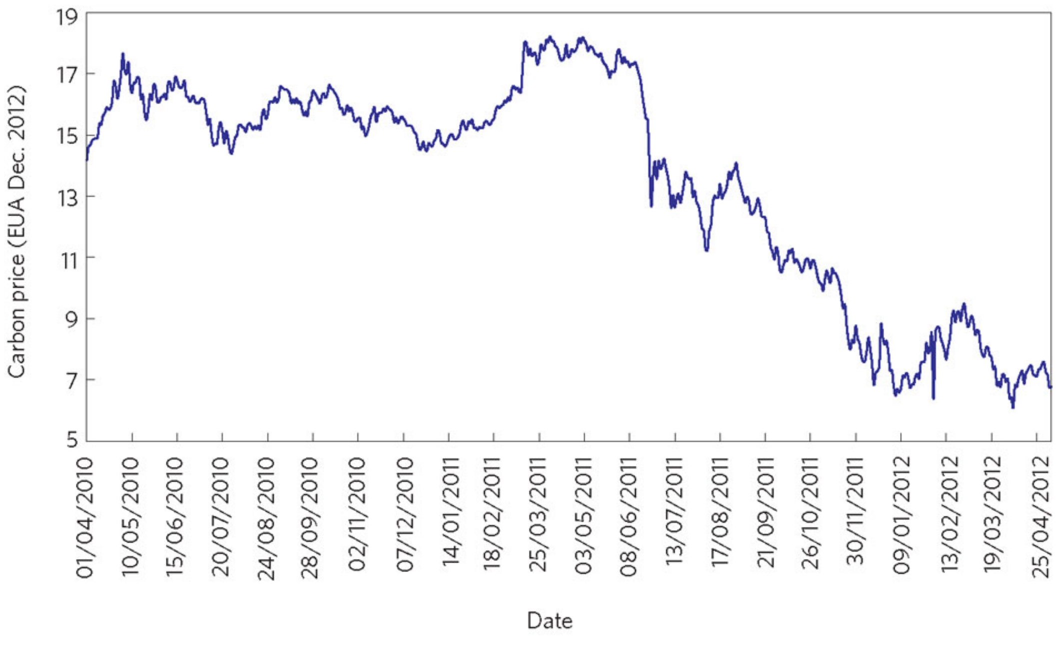


Figure 1.4: Carbon price fluctuations between April 2010 and April 2012, taken from Van Renssen (2012).

In order to improve the operation and effectiveness of the EU-ETS, it is proposed that the third phase incorporates a number of changes. Currently, the allocated emission for each country obliged to the Kyoto Protocol is decided by the National Allocation Plan (NAP), and is relative to their Kyoto protocol carbon reduction targets. Once decided the allocated emissions are then distributed throughout industry. It is proposed that the emissions are allocated through an auction process from an overall EU cap. The EU-ETS accepts Certified Emissions Reduction credits (CERs) from JI and CDM projects; however it is also proposed that the usage of offset mechanisms is more strictly controlled in order to ensure that the offsets are tangible and reliable.

1.2 Pressure

1.2.1 Global energy requirements

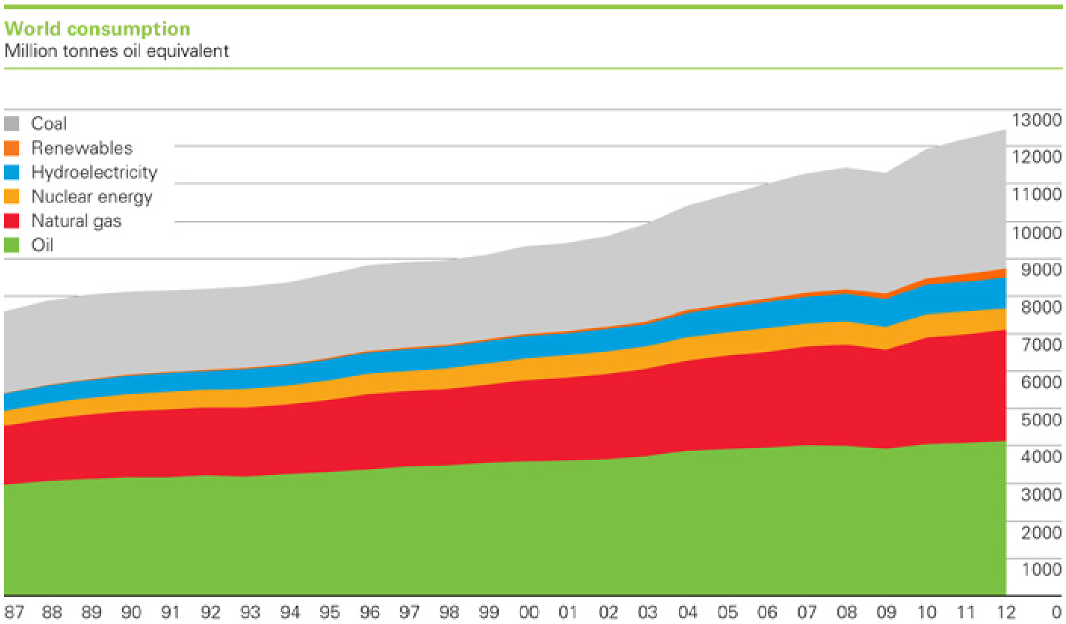


Figure 1.5: World Energy Consumption, taken from BP (2013).

Accelerated growth in human population coupled with the rapid industrialisation over the last few decades pushed the global energy consumption into record levels. During 1990 to 2008, the population of the world increased by 28%, and more importantly the world energy use per person surged 10% (IEA, 2013). We need energy for all most everything. Except nuclear energy, all other forms store energy by converting the potential of sun rays. World energy consumption has grown from an average of 50 exajoules (50×10^{18} Joule) per year at the start of the last century to almost 550 exajoules by the year 2010 (IRA, 2013). Most recent energy statistics shows that the global energy consumption increased by 1.8% in 2012, with China and India alone contributed 90% of that rise (BP, 2013). Large chunk of the energy comes from the burning of fossil fuel, with oil remains the leading fossil fuel at 33% of global energy consumption. In 2012, global oil consumption grew by 890,000 barrels per day (BP, 2013). The production of fossil fuel is also on the rise in the last few years. In 2012, United States has recorded the largest gain in oil production in its history (BP, 2013). Saudi Arabia, UAE, Qatar and Libya also produced oil in record levels. However despite these increases in oil production oil prices reached record high. The trade and consumption of coal increased rapidly over the last decade, and in 2012, China alone consumed more than half of the total coal production of the world. Along with these increased consumption of fossil fuel, global CO_2 emissions continue with an upward trend. China's interests in wind and solar energy saw the renewable energy production in 2012 grow by 15% compared to that of 2011(BP, 2013). However, renewable forms of energy accounted only 2.4% of global energy consumption in 2012, which is slightly better than the 0.8% recorded in 2002 (BP, 2013).

1.2.2 Global freshwater requirements

Freshwater is a human right; and is an important determining factor on the quality of life. Only 2.5% of the total water content of earth is made by freshwater, and even lesser (0.5%) is accessible to humans. Estimates show that around 9-14 thousand cubic kilometres of fresh water available each year (Falkenmark, 1994). Out of the total available freshwater, 54% is being used currently. If consumption per person remains steady we would be using 70% of that by 2025, based on calculations of population increase only (Bernstein, 2002). However, the outlook of the forecast worsens as we already have witnessed a six fold increase in water usage in the last 70 years in line with a tripling in population number (Bernstein, 2002). The majority of this increase in water usage is not just down to the rise in domestic use of water, much is due to higher industrial output and increase use of agriculture for food production. Water is used as a main industrial input. As much as 1000 cubic meters of water are required to produce 1 cubic meter of cereal in moderate conditions, even more is needed for drier regions. A similar story can be found in meat production, for each kilo calorie of meat requires approximately ten-kilo calorie of grain (Cohen, 1995). At the current level this trend of increased water usage in agriculture and meat production is unsustainable. Changes are already happening to increase the efficiency of water usage in industries and agriculture. Increasing usage of drip irrigation instead of the conventional flood irrigation method in developing countries is one such positive measure. There are also studies, which show that relatively low cost technologies could double the agriculture production with less amount of water (Postel, 2001).

Countries can be classified according to the amount of renewable fresh water available per person. Water stressed countries have fewer than 1700 m^3 fresh water available per person per year, whereas water scarce countries fresh water availability is less than 1000 m^3 (United Nations, 2012). Insufficiency of water impacts adequate food and agriculture supply, create serious environmental problems and deter the economic development of the region. Estimates show that in 2000, 508 million people lived in 31 water stressed or water scarce counties (Bernstein, 2002). It is expected that the figure will grow to more than 3 billion by the end of 2025 (Gardner-Outlaw and Engelman, 2007). Desalination is expensive economically and environmentally damaging. Freshwater from desalination plants are currently less than 1% of world freshwater usage (Bernstein, 2002), and are not a useful alternative for landlocked countries. As noted earlier in this chapter, Climate change is forecasted to affect the rainfall patterns, evaporation rates and even timing of storms. These uncertainties in weather patterns along with increased urbanization and population growth will severely test the sustainability of the current pattern of human settlement, in terms of its water usage. Water problems are already severe, and many national and international conflicts exist over fresh water sources that run across borders. In order for these problems not to escalate into major economic or military war like situations over water resources, and to increase and maintain the quality of life, we need a concerted action on many fronts.

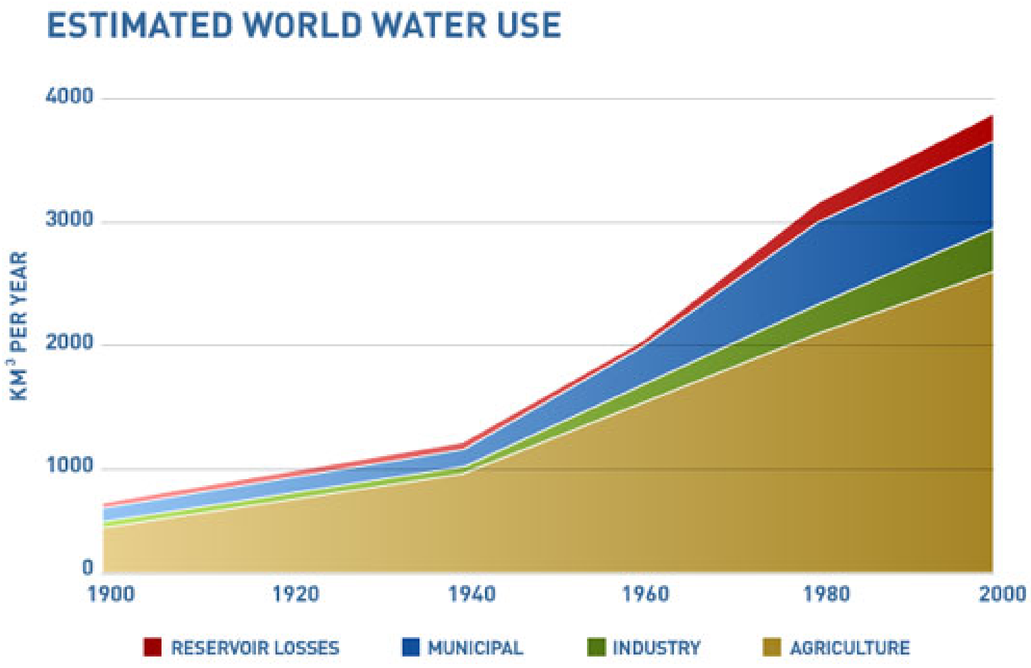


Figure 1.6: World water use, taken from Chenoweth (2008).

1.2.3 Peak oil

Peak Oil is based on the idea that 'if we continue to use a finite resource at an increasing rate, at some point the rate will reach a maximum value and decrease afterword'. The concept is mathematically formulated by the geologist M. King Hubbert, and the finite symmetric distribution curve is known as 'The Hubbert Curve'. Though the Hubbert

Curve is used for most resources in current times, none got more attention than the successful prediction of the American Oil production peak of the early 1970's.

Modern human society is very much dependent on fossil fuel, and especially on the production and consumption of Oil. Though the percentage of oil in the total world energy production is 33%, its contribution in transportation is more than 55% (Hirsch et al., 2005). As a finite resource, increasing consumption rate and stable amount in discovery of new oil fields (Johnson, 2010), it can be reasonably assumed that the global oil production will peak sometime in future. Prediction of peak oil is currently of high uncertainty, mainly due to the poor quality and political bias in world oil reserves data (Hirsch et al., 2005). Even though, it has been noted that a peaking in Oil will bring unprecedented risk management problem to the world. Without adequate mitigation measures, this can range from increase in liquid fuel prices to unprecedented economic, social and political cost.

The first modern oil well is drilled in Azerbaijan in 1848. Soon after that, oil wells were installed in Europe, Canada and the United States. In 1960 total crude oil production in the world reached around 20 million barrels per day (mbpd). During 1970 peak US oil time, world total crude oil production was approximately 45 mbpd (Gebbis, 2011). According to the United States energy administration, in 2012, world production reached 74.644 mbpd. Though the production is increasing, it needs to be noted that out of the 21 major oil fields, 9 have already reached its peak and are in decline (e.g. Alaska and Texas oil fields) (Workers Solidarity Movement, 2006). ERoEI (Energy returned on energy invested) on oil has increased from 1:50 to approximately 1:10 barrels currently (Oil drum, 2006). Majority of rise in ERoEI is down to the increase in cost of production from new oil resources through unconventional methods, and oil drilling in technologically challenging areas such as deep in the ocean. These surges in production cost eventually push the oil price further.

Peak oil crises will be a huge undertaking for human civilization. Mitigation efforts will need large amount of time; replacing such vast dependency on oil is a monumental challenge. Increasing the efficiency of machines and automobiles are neither sufficient nor a permanent fix to the problem. Modern human life style and idea of suburbia, driving for everything need to be changed. We require a novel way of life based urban planning and sustainability. Influence of oil is everywhere in our society from plastic carrying bags to intercontinental flights, replacing every by-product of oil though innovation and future technology is doubtful even in the most optimistic sense.

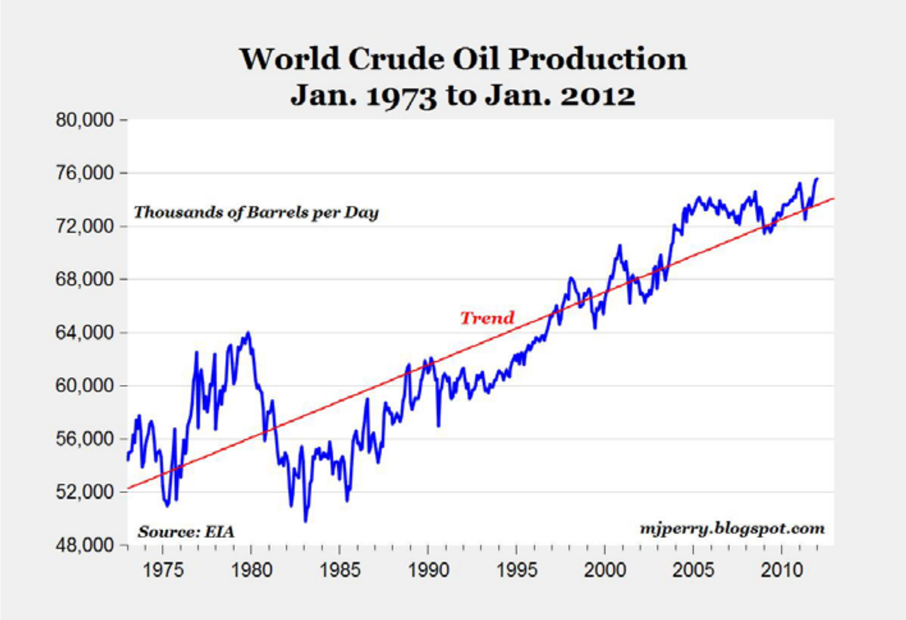


Figure 1.7: World Crude Oil Production (Courtesy: Prof. Mark J. Perry, University of Michigan).

1.3 International development goals

1.3.1 Millennium Development Goals

Since 1990, the United Nations have implemented the globally accepted Millennium Development Goals (MDGs) in order to meet targets in tackling world poverty by 2015. In the 2013 MDG Report, One of the aspects that fell short was Environmental sustainability, misses it target goals of reducing CO_2 emissions and slowing the rate of biodiversity loss. Sometimes referred to as the most successful anti-poverty push in history, some of the MDGs have achieved more tangible success than others. Considering this the interim goals post 2015 will have increased poignancy with regards to less successful aspects.

Millennium Development Goals

1) Eradicate poverty and hunger
2) Achieve universal primary education
3) Promote gender equality and empower women
4) Reduce child mortality
5) Improve maternal health
6) Combat HIV/AIDS, malaria and other diseases
7) Ensure environmental sustainability
8) Develop a global partnership for development

Within the main goals is target 7a: “to integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources”. The UN is in talks with government and civil society to create a post-2015 MDG agenda, and within this, attempt to meet the sustainability goals in order to avoid the ever increasing threat of climate change and over-exploitation of the natural environment. Each target has its own measurable indicator, which is used to measure progress towards targets (Table 1.2).

Table 1.2: Indicators used within the Millennium Development Goals (Recommended to be disaggregated by sex and urban/rural) (Millennium Declaration 2008).

Target for Goal 7	Indicator
Target 7.A: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources	7.1 Proportion of land area covered by forest 7.2 CO_2 emissions, total, per capita and per $1 GDP (PPP) 7.3 Consumption of ozone-depleting substances 7.4 Proportion of fish stocks within safe biological limits 7.5 Proportion of total water resources used
Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	7.6 Proportion of terrestrial and marine areas protected 7.7 Proportion of species threatened with extinction
Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	7.8 Proportion of population using an improved drinking water source 7.9 Proportion of population using an improved sanitation facility
Target 7.D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	Proportion of urban population living in slums

Post 2015, the integration of economic growth, social justice and environmental stewardship is the ‘global guiding principle’ (United Nations, 2013). The Millennium Development Goals do, undoubtedly focus on the world’s most vulnerable, however the exploitation of resources by the privileged few in the ‘Developed world’ is inadvertently a focus of this aspect. In order to meet these goals, developed nations and the cities within must also avoid over exploitation of resources and attempt to curb biodiversity loss.

However, most importantly join the global effort to reduce CO_2 production per capita. This is also an objective that is rife within existing Eco-City guidance.

1.3.2 World Bank

The World Bank is the leading global financial institution that works towards tackling poverty and improving the standard of living globally, most notably in heavily indebted developing nations. Research by the World Bank recognised the poignancy of targeting cities due to the sheer volume of the global populace that this would reach through these development programs.

The World Bank put forward the Eco^2 Cities Initiative, which is based on four core principles that is aimed to apply to any city wishing to merge into what can be described as an Eco-City (Table 1.3).

Table 1.3: Synopsis of the main objectives of the ECO cities initiative, World Bank (2010).

Principle	Detail
A city based approach	Enables local governments to lead a development process that takes into account their specific circumstances , including their local ecology
An expanded platform for collaborative design and decision making	Accomplishes sustained synergy by coordinating and aligning the actions of key stakeholders
A one system approach	Enables cities to realise the benefits of integration by planning, designing and managing the whole urban system
An investment Framework that values sustainability and resiliency	Incorporates and accounts for life cycle analysis, the value of all capital assets (manufactured, natural, human and social) and a broader scope of risk assessments in decision making.

The Word Bank can also provide funding for such schemes that work towards an integrated approach, for example technical assistance in the form of assessment. This could take the form of diagnostics and analysis, scenario planning, sustainability indicators (tailored for a specific city) and the role of new technologies. Capacity building aims to enhance integrated sustainable urban development, policy changes, independent planning, training and finally, partnerships between what are referred to as ‘Global best practice cities’.

The over-riding theme within the Eco^2 Cities Initiative is that of an integrated approach, and on which, one does not rely solely on the volume of financial backing a project may have. It must be internally led, with guidance from other international experiences, and as well as the Eco^2 cities initiative itself. A second key element is the emphasis that every project will be different and will need to be dealt with on an ad hoc basis. Aspects from the planning stage will depend entirely on the context of that nation and city.

The 'City Based Approach' put forward by the World Bank support this notion that because of the disparity between cities globally within many factors, successful projects will need to be city-led. Most importantly, local level decision making must work towards self-reliance, while top-down governance only plays a supporting role (Figure 1.8).

Figure 1.8: The city-based approach, taken from World Bank (2010).

This 'city-centric' view is a predominantly western concept; however this initiative is developed to have global applications. A 'one system approach' is the phrase used to describe this holistic method of developing an Eco-City. Planning, designing and management of the whole urban system are achieved by optimizing all the subsystems in synergy. To look at systems separately is ignoring the obvious inter-reliance of one system upon other(s).

1.3.3 UN Habitat Sustainable Cities Program

The UN Habitat Sustainable Cities Programme is a joint venture with the United Nations Environment Programme (UNEP) for urban environmental planning and management. It brings together key concepts from global environmental movements such as Agenda 21, the Habitat Agenda, the declaration of cities and other human settlements, and the Millennium Declaration.

Localising Agenda 21 (LA21) aims to aid cities operating above capacity to deal with their rapid population growth, and deliver higher standards of living to its inhabitants. Such aspects include clean water and sanitation, waste disposal, pollution control. The LA21 project attempts to meet these goals in order to tackle the seventh Millennium Development Goal 7 regarding drastically reducing the number of urban slum dwellers (UN Habitat, 2013).

The predominant focus of LA21 spans a range of city aspects:

- Community-based solid waste management
- Urban mobility
- Cultural heritage management and promotion of tourism
- Sustainable water management
- Access to urban services and social integration
- Revision of master plans
- Establishment of municipal environmental management system
- Strengthening of citizen participation in urban environment planning and management

LA21 recognises the importance of attempting to achieve these goals at the micro scale, which is often the most effective way of improving quality of life for residents of secondary towns.

The UN Habitat Agenda also pledges numerous key factors essential to improving a number of aspects of city living (UN Habitat, 2003). The UN Sustainable cities programme particularly works towards meeting the environmental targets of the agenda, and working towards sustainable development. The remaining element, ‘The declaration of cities and other human settlements’ focuses on an anthropocentric view of improving the lives of the ever-increasing global urban population, whilst attempting to meet environmental standards and economic improvements.

1.4 Definition of an Eco-City

According to Oxford Dictionary, a 'city' is defined as a large town. Other definition of a city includes "a relatively permanent and highly organized centre of population, of greater size or importance than a town or village" (Merriam-Webster, 2013). However, there are no clear boundaries and characteristics to differentiate a city from town. Historically, in Europe an urban settlement with a cathedral was used to distinguish a city from town. In United States on legal terms, city is an incorporated municipality whose boundaries and powers of self-government are defined by a charter from the state in which it is located. In other words, a city is a town of significant size or an urban area with self-government (Merriam-Webster, 2013).

Coast usually refers to the land next to the sea or seashore. However, coast in legal terms is defined as "The margin of a country bounded by the sea. This term includes the natural appendages of the territory that rise out of the water, although they are not of sufficient firmness to be inhabited or fortified. Shoals perpetually covered with water are not, however, comprehended under the name of "coast" (A Law Dictionary, 1856). For the purpose of this project we adopt Coastal city as a city in the near-coastal-zone, where near-coastal-zone is defined as areas within 100 km from the coast and 100 m elevation (Klein et al., 2003). According to this definition, for example, Sao Paulo is not considered coastal, as its elevation is 800 m above sea level. On the other hand, cities like Dhaka, Calcutta and Cairo are considered coastal even though they are farther from the sea. A main criterion for this definition is whether a city has economic and geomorphic characteristics that are typically and exclusively coastal (e.g. sea port, deltaic, or estuarine setting) (Klein et al., 2003).

Eco-City is also another loosely defined term, and often been used interchangeably with names such as sustainable city or smart city (Alusi, et al., 2011). However, the World Eco-City Summit held in San Francisco in 2008, declared "An Eco-City is an ecologically healthy city. Into the deep future, the cities in which we live must enable people to thrive in harmony with nature and achieve sustainable development. People oriented, Eco-City development requires the comprehensive understanding of complex interactions between environmental, economic, political and socio-cultural factors based on ecological principles. Cities, towns and villages should be designed to enhance the health and quality of life of their inhabitants and maintain the ecosystems on which they depend" (San Francisco Eco-City Declaration, 2008). San Francisco declaration also states that "Eco-City development integrates vision, citizen initiative, public administration, ecologically efficient industry, people's needs and aspirations, harmonious culture, and landscapes where nature, agriculture and the built environment are functionally integrated in a healthy way" (San Francisco Eco-City Declaration, 2008)

Another similar definition of Eco-Cities can be found in the World Bank report on Eco-Cities. "Ecological cities enhance the well-being of citizens and society through integrated urban planning and management that harness the benefits of ecological systems and protect and nurture these assets for future generations" (Suzuki, et al., 2010). Eco-Cities can also be defined as Economical-Cities. "Economic cities create value and opportunities for citizens, businesses, and society by efficiently using the tangible and intangible assets of cities and enabling productive, inclusive, and sustainable economic activity" (Suzuki, et al., 2010). Hence, an Eco-City brings together environmental, social and economic factors, along with comprehensive urban planning and management, for the long-term sustainability of human society.

1.5 Notable existing coastal Eco-City projects

Below given are three examples of Eco-City (sustainable city) constructions. Though they are not based any particular criteria, they represent a wide variety of practices in eco-initiatives around the world. For example, In Curitiba Eco-City, every policy is based on people as its centre. Reykjavik gives slightly more importance to energy and emissions. Both these cities are retrofitted and are not built from scratch, from South America and Europe respectively. On the other hand, Tangshan Caofeidian is completely newly built, and a good representation of Asian top-down approach.

1.5.1 Curitiba, Brazil

Curitiba is the capital city of Parana State in Brazil. It has a population of approximately 1.8 million, with women account for 52.05% of the total. Population growth rate decreased from 5.3% in the 1970's to 1.7% currently (Curitiba, 2013). The city is situated at a high altitude of 932 metres on the southeast of Brazil. Curitiba has a longstanding, international reputation as one of the first Eco-Cities, initiated in the 1970s (Joss et al., 2011). Curitiba is also renowned for green urban planning, which put people at the centre of strategy. Around 30 parks and urban-forested areas, the city provides each inhabitant with 52 m^2 of green space (Terra, 2013). The main objective of the Curitiba master plan was to reduce the traffic of the downtown area. The city came up with novel ideas like an integrated bus public transportation system and streets designed only for walking with no motor vehicles. Though the city has the highest ownership of cars in Brazil, because of the efficiently of its public transport system, Curitiba also has the highest public ridership of any Brazilian city (about 2.14 million passengers a day). It registers country’s lowest rates of ambient pollution and per capita gas consumption (ICLEI, 2002). New social initiatives such as “garbage that’s not garbage” and food-for-recyclable exchange scheme, saw the city recycle 70% of its trash (ICLEI, 2002). The money raised from selling recyclable materials goes to social schemes and city employ the homeless and people recovering from drugs in its garbage separation plants. The city has its own Open University and university buses to reach out to local communities. Cities per capita income is 66% greater than rest of the country; economic growth is 7.1%, higher than the national average of 4.2% (ICLEI, 2002). In 2010, the city received the Globe sustainable city award from Globe forum, given to cities and municipalities excel in sustainable urban development (Joss, Tomozeiu and Cowley, 2011). Curitiba also has the highest Human Development Index in Brazil with 0.856 (Curitiba, 2013).

1.5.2 Reykjavik, Iceland

Reykjavik is the capital and the largest city of Iceland. Sitting on the southwestern side of the country at a latitude of 64°08'N, Reykjavik has a population of around 12000 inhabitants (Joss et al., 2011). The city is very multi-cultural with people from more than 100 different countries call it home (Icelandic Statistical Bureau, 2013). The city and Iceland plans to be 100% free of fossil fuel by 2050. Almost all of the country’s electricity is already produced by renewable sources such as geothermal and hydroelectric (Joss, et al., 2011). Reykjavik has the world’s largest geothermal heating system; all buildings are heated with geothermal water. Public buses are already running on hydrogen fuel and local government encourage people to use hydrogen fuelled cars and private vehicles. Since 2003, the city has installed a network of hydrogen stations towards this cause (Joss et al., 2011). Reykjavik also uses methane gas derived from landfill as fuel. Ninety per cent of the city’s waste collection vehicles are run by methane gas. In 2009, Reykjavik Climate and Air Quality Policy were approved, according to this, the city aimed to reduce greenhouse gas emission to 35% by 2020 and 73% by 2050, compared to an emission baseline of 2007 (European Green Capital Application 2012-2013, 2013). The city has a good system of measuring CO_2 emission from vehicles. Reykjavik implemented a free parking scheme for eco-friendly vehicles. In order to better manage the urban dwellings, the city initiated programs to increase the density of residential buildings in well-established suburbs and city centres, rather than broadening the city borders with new developments. Waste management bins are provided at every household, a fee is charged relative to the amount of non-renewable waste produced. Under this scheme city has seen a reduction of 36% in household waste. About 40% of the municipal waste and 53% of household waste is recycled (European Green Capital Application 2012-2013, 2013). As part of improving the green space and carbon capture, community has planted 20, 000 trees in city borders. Reykjavik already have 28% of its total urban area is converted into green space. About 92% of inhabitants live within 300m or 5 minutes walking distance from recreational or public green space (European Green Capital Application 2012-2013, 2013). There are different school programs and short projects intended at better resource management and sustainability. Iceland has a very high Human Development Index of 0.906, and Reykjavik was shortlisted for the European green capital award in the years 2012 and 2013 (European green capital award 2012&2013, 2013).

1.5.3 Tangshan Caofeidian, China

Tangshan Caofeidian Eco-City (Tangshan Bay Eco-City) is situated on the northeast of china, around 220km away from Beijing. Development began in 2009 as one of the new Eco-City developments currently under construction in Asia. Built from scratch on 74 km^2, the city plan to inhabit around 800,000 people by 2020 (Joss and Molella, 2013). The project is planned and designed with the help of Swedish engineering group Sweco. The design consists of, a 12 km^2 high-rise at the city centre, an 18 km^2 mixed-use area to the north (incorporating multifunctional resource management centre, waste/water/material recycling facility and district energy system) and a 44 km^2 district to the east to be built as part of phase two of the project development (Joss and Molella, 2013). A wetland park, of about 45 km^2, will surround the city. This will act as a natural barrier for seawater intrusion into the freshwater ecosystems seen south of the city. The public transport system will include monorail and buses. It needs to be noted that 90% of residential areas and official building are designed such as way that they are within 500 m from the public transport system (Joss and Molella, 2013). Renewable energy generated onsite from wind, solar and geothermal will account for 95% of the cities energy use. Planning is based on elaborate and specially designed 141 key indicators for Tangshan Caofeidian. Developments are happening in all regions, keeping a proposed initial completion of 2020 (Joss and Molella, 2013). Though 800,000 inhabitants are planned for the initial phase, the city will have the capacity to increase its population to 1.5 million when it is full completed (Lin, et al., 2010). The overall cost of the project is expected to be around $15 billion USD. The local Tangshan city government provided an initial investment of approximately $3 billion USD upfront for infrastructure developments (Joss and Molella, 2013).

1.6 The projects

1.6.1 Overview

The aforementioned aspects lead us towards a conclusion that there is an unmistakable disparity between the approaches taken globally, but most significantly between Eastern and Western communities. There are indeed, existing frameworks available for 'Eco-Cities' as a generality, but it is questionable whether these are practically applicable to communities outside of what is assumed to be the correct 'western-centric' viewpoint.

By bringing together a number of aspects, this project hopes to result in a framework that brings together aspects that we gather from looking at eco-cites as a wider context, coastal elements, global, political and social pressures, and the lessons learned from the case studies.

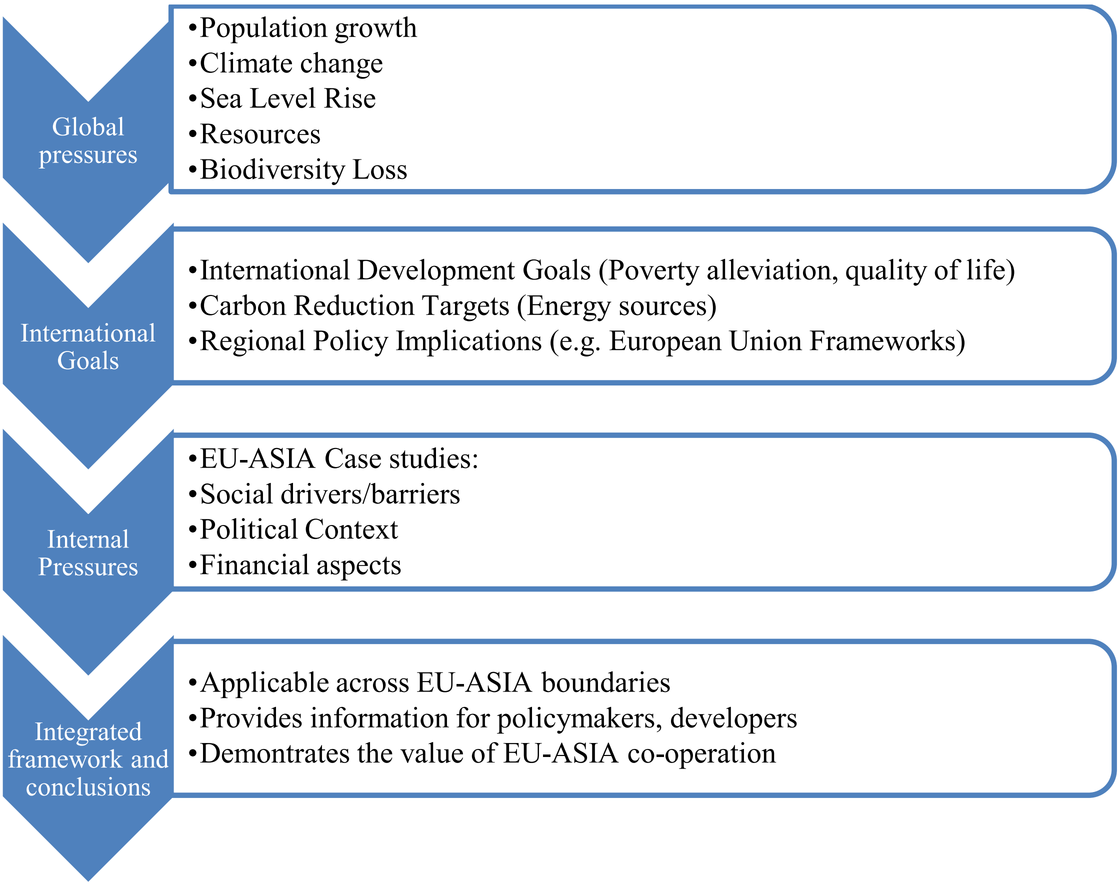


Figure 1.9: Schematic of formation of framework.

The project will not make generalisations about each case study being wholly 'representative' of an entire nation or culture. However, it is undeniable that the juxtaposition between the types of coastal Eco-City projects they represent, and the extent of socio-political-environmental aspects makes for an interesting concept. When all these external factors are considered, we question the fundamental lessons to be learned from one project to another. Secondly, we question whether any of these can be transferred onto future projects.

1.6.2 Aims and objectives

The aims and objectives of such a task can be broken down into a number of key elements.

- *To explore the meaning and drivers towards coastal eco-cites in a wider context:*

Look at shared global pressures (Climate change, sea level rise, population growth, future population resource demands)

Look at shared international goals (Development goals, CO_2 reduction targets, and examples of existing 'successful' Eco-City projects, to question: what defines a coastal Eco-City?)

- *To analyse case studies of coastal Eco-City projects in a national context:*

Look at financial, environmental and legal and policy aspects, stakeholder engagement and policies. Look into engineering aspects i.e. green building, energy supply, waste management, transportation and coastal infrastructures.

Question: How were the projects implemented? (Look at successes and failures at each development stage)

Where existing Eco-City frameworks were not followed, what attribute to the success of each project? Are there aspects we can out forward as an improved framework?

- *To propose a new framework for coastal Eco-Cities [across EU-ASIA borders]*

To use lessons earned to focus on the transferrable aspects

To recommend change(s) in approach for policymakers, developers and the public

To demonstrate the potential value of EU-ASIA co-operation

2 CASE STUDIES OVERVIEW

2.1 Background

2.1.1 Discussion Current EU-Asia Projects

The value of sharing experiences between EU and Asia is not an unknown concept; "EU-Asia Dialogue- Shaping a Common Future for Europe and Asia" (EU, 2012a) is the most prominent example applicable particularly to Eco-Cities. Predominantly, discussions revolved around practices in planning and performance of Eco-Cities globally, however, some emphasis was given to national practices, policy choices, obstacles, challenges and prospects.

The project duration spans from 1st January 2012 to 31st December 2014 and is mainly led by Konrad-Adenauer-Stiftung (Konrad-Adenauer Foundation). The foundation is based in Germany, and led by the former leader of the European Union, Hans-Gert Pottering.

"The overall objective is to contribute to the formulation of relevant sustainable development policies for framing a comprehensive and constructive partnership between Asia and the EU as well as its member states. The stakeholders shall become aware of the regional and cross-regional developments in order to identify both short- and long-term challenges, to prevent their emergence and solve them at an early stage." –EU-Asia Dialogue

The research topics discussions focus on seven key aspects, this highlights what is perceived as the most important aspects to share experiences across EU-Asia borders (Table 2.1).

Table 2.1: The main topics of discussion within the 'EU-Asia Dialogue' (EU, 2012a).

Topic	Details
Climate change diplomacy	- Opportunities for breakthrough in climate change talks - Research and working papers for policy recommendations - Share knowledge between policy makers and researchers - Localised policy recommendations - Recommendations for future institutionalization of further policy dialogues

Eco-Cities	- Practical information and policy combining best practice in both regions - Policy discussion at 'World City Summit' (Singapore, 2012) - Keep policy makers abreast of new developments
Migration/integration	- Best practice in governing inflow of migrants - Study of activities in the cluster of migration and integration - Researchers disseminate findings to policymakers
Social Cohesion	- Study of factors threatening social cohesion and fostering societal division - Emerging policy recommendations - Best practice of programmes and policies across EU-Asia nations
Human trafficking	- Closed-door dialogue between researchers and policymakers - Concrete recommendations for future policy dialogue
Maritime Piracy and security	- Establish a currently non-existent link between EU and Asia on Maritime piracy - Study of maritime security: coastal guards and illegal fishing
Food security	- Study of meaning of food security across EU/Asia nations - Discussion of common approaches across nations - Building contact points and linkages across nations

The EU-Asia Dialogue Eco-Cites Workshop in Singapore 2012, attendees included representatives of UN Habitat Programme, the Tainjin Eco-City project, and the Swedish Helsingborg/Helsingor project (EU, 2012b). The main theme of the discussion pointed towards a mutual goal in gaining the strengths from one to another, mentioned was the dynamism of Asia, and the high standard of living in Europe being a quality the other desires to develop.

The intelligence of cities and mobility, ecological sustainability, social participation, cohesion and integration were the four areas of governance identified as essential to Eco-City development. The removal of political barriers was also identified as essential for allowing sustainable schemes to develop.

The overall bottom-up/top-down approaches taken by the EU and Asia respectively were discussed along with their associated merits. However, it was acknowledged that there is definitely a need for a much stronger involvement of the existing population in Asian developments; this was detailed by using Singapore as an example.

2.1.2 Drivers for this type of research

There is an undeniable disparity between the approaches taken by EU and Asian developers; however there are merits of both that may be of benefit to the other. Furthermore, the subject of Eco-Cities overlaps with innumerable other key issues of economic, social and environmental factors that need to be looked at as a whole.

Asia is currently leading the global push towards developing Eco-Cities as it is the global leader in both city and Eco-City developments. In Europe around 80% of the population live in small to medium sized towns and cities. In Asia, predominantly China and India, the sheer speed and scale of urbanisation has led to the development of huge population pressures on urban areas on an unprecedented scale (Fook & Gang, 2010).

Western ideals of development may not be applicable directly to Asian developments, as they have limited perspective on the history of Asian development in context, especially the Chinese civilisation (Hald, 2009). However, knowledge transfer between EU-Asia boundaries not only shares technical knowhow but can possibly helps to overcome or at least start dialogue regarding a wider range of social, political and economic trans-national issues.

2.2 Case studies introductions

2.2.1 Introduction

Two cities from EU and Asia were selected for the case study. The one from EU is Helsingborg of Sweden, supported by the CONCERTO Initiative launched by the EU. The Asian city is Tianjin Eco-City of China. The Tianjin Eco-City is established as a flagship project for the cooperation between the governments of China and Singapore. The general information of these two cities are outlined in table 2.2.

Table 2.2: General information on Helsingborg and Tianjin Eco-City.

	Helsingborg (2010)	Tianjin Eco-City (by 2020)
Country	Sweden	China
Area	38.42 km^2	34 km^2
Population	97,122	350,000
Density	2,529/ km^2	10,294/ km^2
GDP per capita*	49,662 US dollars	13,322 US dollars

* The GDP per capita in Helsingborg is in 2010, and the GDP per capita of Tianjin main city in 2011 is used. Because Tianjin Eco-City is under construction, and its citizens are mainly from Tianjin main city.

2.2.2 Helsingborg

The Eco-City project

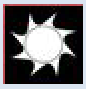
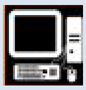
The Eco-City project is supported by the CONCERTO Initiative launched by the EU. The objective of the Eco-City project is to demonstrate innovative integration of energy concepts in both the supply and demand side. In this project, three other EU-countries were also included; the cross border community of Helsingør (Denmark) and Helsingborg (Sweden), the community of Tudela (Spain) and the community of Trondheim (Norway). The project started up in October 2005 and ended in December 2012. However, many of the activities and the transformation of the three communities extend beyond the boundaries of this project.

The cities of Helsingør and Helsingborg are both ancient cities separated by a 4 km strait of Oresund and a 20 minutes ferry ride. Today cooperation between the two cities is extensive in many fields.

Figure 2.1: Aerial view of Helsingør and Helsingborg, taken from Helsingborg and VisitNordsjaelland (2011).

Objectives of Helsingør and Helsingborg communities are to establish new eco-dwellings and eco-rehabilitation with energy saving using the eco-technologies i.e. extra insulation, and an optimized window and demand-controlled system. In addition, office, school and cultural institution are included. The project will set a reference for new standards in energy supply, energy efficiency in building and use of polygeneration. The following table outlines the overall objectives.

Table 2.3: Overall objectives of Eco-City project Helsingør and Helsingborg community, (Eco-City, 2013c).

	Objectives
 Renewable energy supply	• 2MW wind turbines • Photo Voltaic plants • 5.5MW biomass boiler • 228m2 solar collectors for domestic hot water
 Energy efficiency in buildings	• 543 new ECO-dwellings • 259 dwellings ECO-refurbished • 37,884m^2 tertiary buildings refurbished
 Polygeneration	• Extension of an existing biogas plant producing gas for public transport
 Integration of energy demand and supply	• Extra renewable energy covers need of included ECO-buildings after improving their energy efficiency • Improving energy efficiency of tertiary buildings covering administration office, schools and institution
 Specific innovations	• New type of comport metering and control system • Potential of geo-exchange and energy storage

City of Helsingborg

In the present study, we focus on the city of Helsingborg. The city of Helsingborg has about 130,000 inhabitants and it is 9th largest city in Sweden. Helsingborg is located in right at the strait of Oresund, facing Denmark. Closest point to Denmark is Danish city Helsingør, clearly visible on the other side of the Oresund. Due to this good coastal location, Helsingborg has developed one of the biggest ports in Sweden. The ferry traffic between Helsingborg and Helsingør is also intensive; now it is one of the world's busiest ferry ports, and the busiest in Sweden.

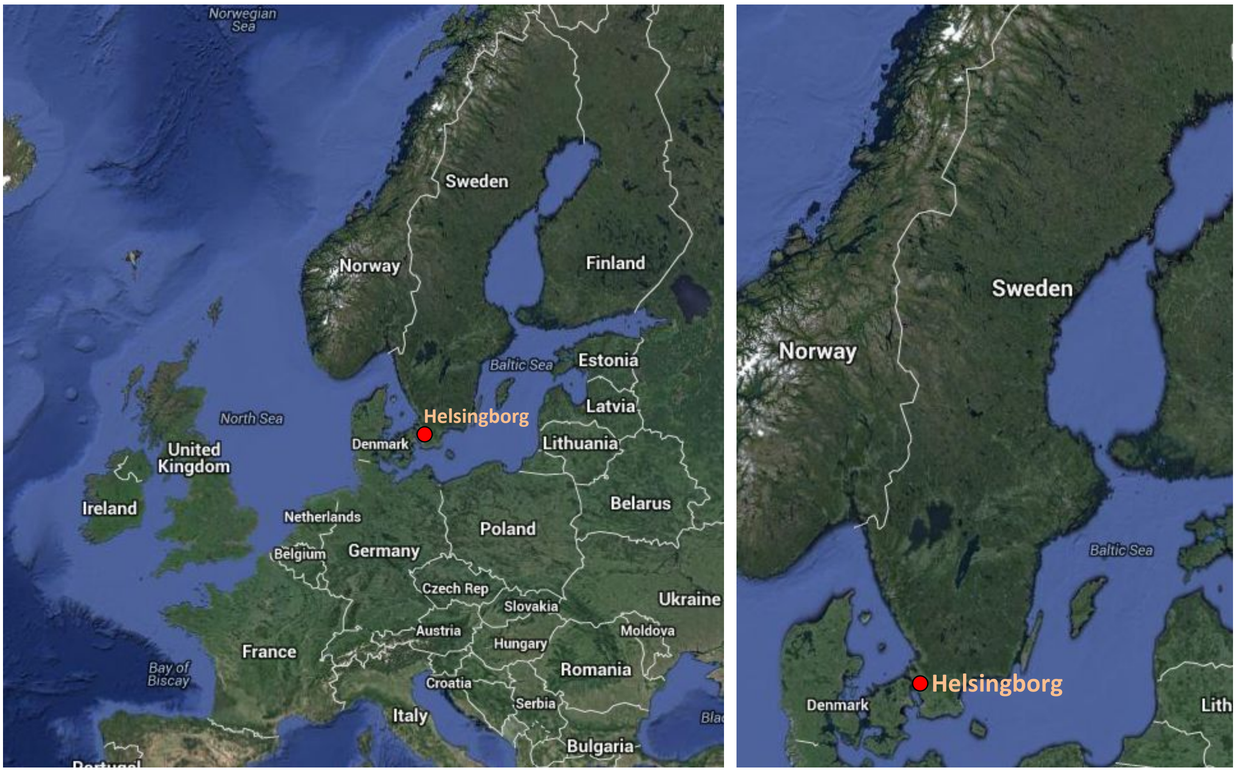


Figure 2.2: Location of Helsingborg, taken from Google maps.

Figure 2.3: Aerial view of Helsingborg, taken from Helsingborg (2010).

2.2.3 Tianjin Eco-City

The Sino-Singapore Tianjin Eco-City project is located in Tianjin Binhai New Area – one of the fastest growing regions in China, which is entirely newly built. It has a total area of 34 sq. km. When the project is fully completed in around 2020, it is expected to have the capacity to hold 350,000 residents. It is 10km from the centre area of Tianjin Binhai New District, 45km from the Tianjin main city and 150 km from Beijing. Figure 2.4 shows the locations of Tianjin Municipality and the Tianjin Eco-City.

Figure 2.4: Location of Tianjin Eco-City (Apple Maps).

The planning principle of the Sino-Singapore Tianjin Eco-City is to balance the social, economic and environmental needs of the Eco-City. It was jointly developed by the China Academy of Urban Planning and Design, the Tianjin Urban Planning and Design Institute, and the Singapore planning team led by the Urban Redevelopment Authority. It includes the planning of land usage, transportation and green (vegetation) and blue (water) networks.

The overall spatial layout of the city can be summarized as "1 Axis – 3 Centres – 4 Districts".

- 1 Axis: the Eco-valley as the green ribbon that links the whole Eco-City.
- 3 Centres: the main city centre and two sub-centres in the south and north.
- 4 Districts: the four fully functional residential districts.

The ecological layout the city can be generalized as "1 Core – 3 Rivers– 6 Eco-corridors".

- 1 Core: the eco-island surrounded by green (vegetation) and blue (water) networks.
- 3 Rivers: the three rivers in the Eco-City.
- 6 Eco-corridors: the 6 eco-corridors spanning out from the eco-island.

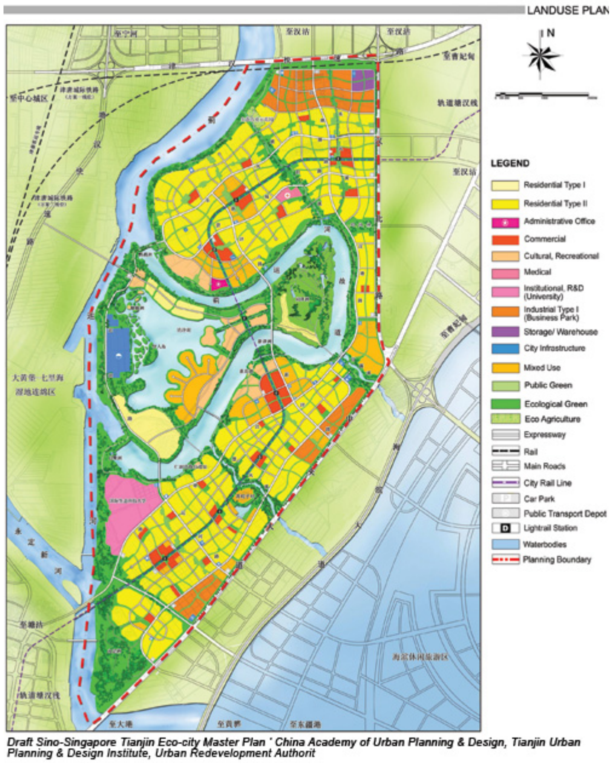


Figure 2.5: Master Plan of Tianjin Eco-City (Source: Website of Tianjin Eco-City, http://www.tianjinecocity.gov.sg/bg_masterplan.htm).

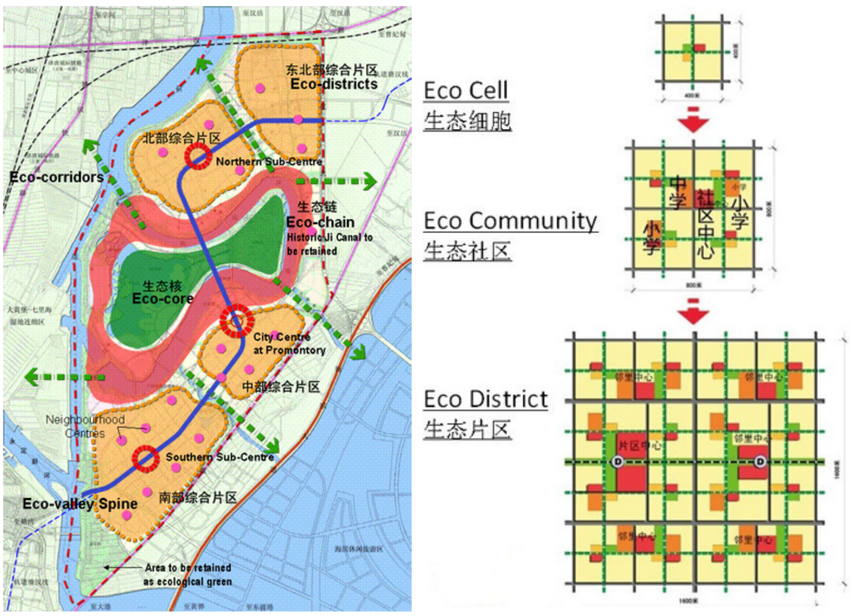


Figure 2.6: Layout of Tianjin Eco-City, taken from Website of Tianjin Eco-City, http://www.tianjinecocity.gov.sg/bg_masterplan.htm.

The Master Plan of the Eco-City has 4 Districts, an eco-core and an eco-valley connecting them. Each district consists of several Eco-communities. In each eco-community, a community centre will be established with local shops and schools to provide living necessities and public education. Eco-communities can then be divided into several Eco-cells, which are basic building blocks of the Eco-City. According to the master plan of Tianjin Eco-City, the Eco-cell is approximately 400m by 400m in size, which is generally accepted as a comfortable walking distance.

Figure 2.7: Start-up area of Tianjin Eco-City (*Google Maps*).

Figure 2.8: Comparison of the overview in the Start-Up area (Left: 2010 Google earth, Right, 2013 Baidu Maps).

The total area of the Tianjin Eco-City is approximately 34 km^2. In 2007, more than five years ago, this area on Tianjin's outskirts was a deserted salt farm that was virtually uninhabitable. Currently an 8 km^2 Start-Up Area of the Tianjin Eco-City is almost completed. The Start-Up area includes an industrial district for animation, public buildings and residential communities.

3 PROJECT DRIVERS

3.1 Financial drivers

3.1.1 Funding scheme of the project "Helsingborg"

The project of Helsingborg/Helsingor Eco-City is part of the Sixth Framework Programme under the thematic priority: "Sustainable development, global change and ecosystems".

The following table depicts the RTD (Research and Technological Development) figures and European Union financing for Integrated Projects. (European Commission, 2004b)

Table 3.1: RTD figures and EU financing for integrated projects.

Type of Instrument	RTD Activities	Community Contribution
Integrated Projects	- Priority thematic areas - Policy support and anticipating scientific and technological needs	Community Grant up to a maximum of: - 50% for research - 35% for demonstration - 100% for certain other activities such as training of researchers and consortium management

The community contribution in table 3.1, illustrates the financial plan estimating all the resources and expenditure needed to carry out the action. Furthermore, the EU's financial contribution cannot cover 100% of the expenditure of an indirect action. Exceptions to this rule occurs only for proposals covering a purchase price governed by the terms applicable to public procurement procedures, or taking the form of a pre-defined lump sum pre-set by the Commission. However, the EU's financial contribution can actually bear up to 100% of the expenditure of an indirect action if they complement those otherwise borne by the participants. Also, in the specific case of coordination actions, this covers up to 100% of the budget necessary to coordinate activities funded by the participants themselves (European Commission, 2004a).

The community grant can be differentiated according to the rules of EU framework for state aid for research and development. They are based on whether activities are related to research (maximum 50%) or demonstration (maximum 35%) or to other activities implemented, such as training of researchers (maximum 100%) or the management of the consortium (maximum 100%). It should be noted that the community distribution for integrated projects is subject to conditions and specific legal entities. This is particularly the case for public bodies that will receive funding of up to 100% of their marginal/additional cost (European Commission, 2004a).

3.1.2 Funding scheme of the project "Tianjin Eco-City"

Regarding the project's financing, SSTEC's total investment costs are not yet available and, consequently, its financing strategy is only emerging. Until 2009 (when the World Bank's technical report was published), TECID (Tianjin Eco City Investment and Development Company) had mobilized total funds of RMB 2.45 billion, however this financing is short-term, and matures over one to three years. The development of a solid, long-term financing strategy is paramount to ensure the sustainable implementation of SSTEC. Therefore, TECID investigated options to finance its investment requirements, including additional commercial loans, insurance loans, and corporate bonds. Based on indicative cost estimates, TECID is estimated to require total financing of up to RMB 13 billion (World Bank, 2009).

It is worth noting that the costs and benefits of investments do not necessarily result in the same outcomes. For instance, while higher investment costs connected with a green building are initially assumed by the building developer; the lower energy, water, and gas costs fall to the building owner and/or tenants. The developers, on the other hand, should be able to reimburse higher investment costs through higher property prices. In these terms, the Green Building Standards (including the proposed silver, gold, and platinum standards) could be used as signals to help achieve differentiated pricing according to environmental benefits (World Bank, 2009).

Resolving this potential difference of interests is less obvious in other cases, as demonstrated by an example within SSTEC's wastewater sector. The Joint Venture Company is assuming the investment costs of wastewater and sewerage system at fixed and agreed prices, however the operational and maintenance savings due to the optimized but more costly designs will benefit the operator. The question is whether the JV Company has the appropriate incentives to invest in more energy efficient pumping stations, even though the benefits will not come into the possession of the company. This was an example of interrelationships between financial and institutional issues that had to be fully addressed (World Bank, 2009).

Taking into consideration significant investments and financing needs, SSTECAC (Sino Singapore Tianjin Eco City Administrative Committee) and related project implementing companies, including those under TECID, need to establish convincing investment and financing strategies. This is of the essence for numerous reasons, not least of which is to ascertain that the project stays within a defined budget and remains affordable to a socially diverse community (World Bank, 2009).

The constructed assets are looking into a long lifecycle; therefore it is important that TECID will form its finance investment strategies on a long-term basis. Until the World Bank report was published (2009) only short-term financing strategies were established. Additionally, SSTEC has the potential to tackle innovative financing solutions besides matching long-term assets to long-term liabilities. Furthermore, it should be noted that the financing dimensions of SSTEC should not be limited to TECID, but should include schemes that create incentives to residents to install environmentally friendly appliances (World Bank, 2009).

3.2 Environmental drivers

CHINA: Tianjin

Tianjin is environmentally significant for a number of ecological and anthropocentric aspects. Due to the unprecedented population growth over the last few decades, as with many large settlements in China, population pressure has led to severe environmental degradation. This in turn affected both the quality of life of the human population as well as the physical and ecological resources of the surrounding natural environment.

There are particularly high levels of sulphur oxides, nitrogen oxides and particulate matter in the atmosphere, which are products of fuel combustion. The levels of these air pollutants in Tianjin have been found to lie above the secondary ambient air quality standard in China, and this has been found to have significant links with Cardio-vascular disease within the local population (Guo, *et. al.,* 2010).

The Tianjin Eco-City project is approximately 30km from North Dagang Wetland Nature Reserve. The reserve itself is used as a water source for the city. It possesses four distinct types of wetland; lakes, rivers, seashore and marsh. Many protected species reside within this area, including 23 state protected bird species. The area is also a significant migration route for birds travelling from East-Asia to Australia. Some research has identified a number of insect species including 90 moth species that are integral to the local ecology (Ping and Houhun, 2006).

The reserve is awarded a score of 9.996 out of 10 (10 denoting excellent condition) according to the international wetlands standard; however some studies have indicated that insect species are becoming unstable due to human activities degeneration of the wetland habitat (Victoria Department of Sustainability and Environment, 2006).

Coastal wetland is a valuable habitat for a number of key species and aquatic organisms. Plant species include:

- *Phragmites australis* (Common Reed) (60%),
- *Scirpus validus* (Soft-stemmed bulrush) (2%),
- *Pragmytes autralis-Typha angustifolia* (Lesser Bulrush) community (5%).
- *Miriophyllum spicatum* (Eurasian Watermilfoil) -*Vallisneria asiatica* (Eelgrass) -*Potamogeton Suaeda corniculata malaianus* (Longleaf Pondweed) community (5%).
- *Miriophyllum spicatum- Certophyllum demersum* (Hornwort) -*Hydrilla verticillata* (Esthwaite Waterweed) community (3%)
- *Suaeda glauca* (Seepweed)- community (5%)
- *Pragmites australis- Suadea glauca* community (15%)
- *Tamarix chinensis* (Chinese Tamarix) community (3%)

Surrounding Forest:

- *Ulmus pumila L.*
- *Sophora japonica L.*

Natural wetland is 3.8% of China's territory, provides 54.9% of ecosystem services. Due to anthropogenic activity, dry seasons have been lengthened, and ground water levels have been altered. Wetland has decreased over last 50 years due to wetland reclamation, population pressure, water diversion, dam construction, resource over excavation, biological invasion, desertification, climate change and misguiding policies.

The nature reserve itself is in the west of Bohai Bay in East Tianjin (Figure 3.1) and is home to 196 Species of 46 taxonomic families. The population density in the surrounding area is 316 people per km^2, and the terrain lies between 0-30m above sea level. The area is undergoing fast economic development including aspect of commercial, industrial and fishing activities. The ecological environment is under pressure from industrial activity and dense population; it is also vulnerable to SLR (Xie, *et. al*., 2010).

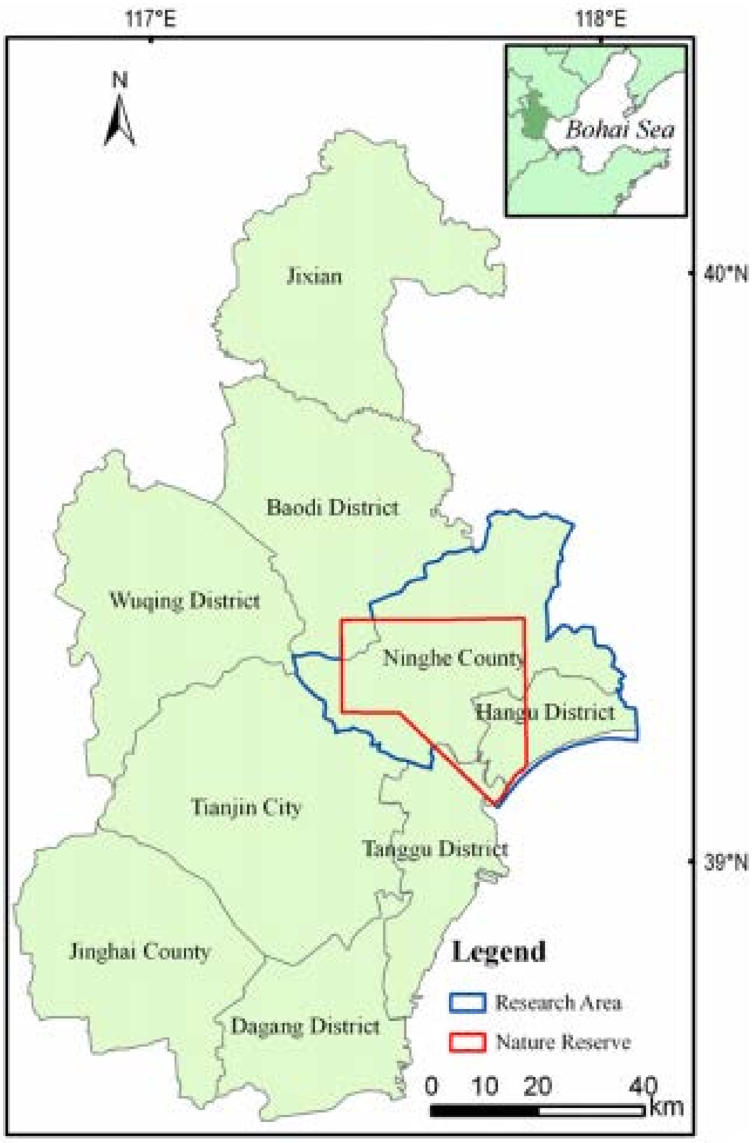


Fig. 1. Location of the study area.

Figure 3.1: The nature reserve in relation to Tianjin and the surrounding area (Xie, *et. al.*, 2010).

The water quality in the area is measured against The Class V of Surface Water Environment Quality Standard, which measures pH, DO, COD_{Mn}, BOD_5, CR^{6+}, Cd, As, Pb, TP, Hg and TN. The groundwater is measured using the Groundwater Quality Standard GB/T14848-1993, and is classed as class IV Groundwater.

The quality as well as falling levels of groundwater is an increasing cause for concern in this region of China. Over exploitation of water resources has led to significant fall in the water table as well as salinization of the groundwater. Falling water table and soil degradation led to a reduction in agricultural output. This problem is affecting a significant area of the North China Plain. Agriculture has also encountered similar problems with pollution from using sewage for irrigation over several decades. An example is Polycyclic Aromatic Hydrocarbon (PAH) concentration in soils, and consequentially in cultivated vegetables, is a major problem near the urban areas that have had an insufficient wastewater treatment protocol previously (Tao, *et. al.,* 2004).

3.3 Legal/Policy aspects

3.3.1 Introduction

The procurement of construction projects has undergone significant reforms in both China and Sweden. In China it is due to changes in the economic environment of the country, and in Sweden owing to its alignments with the European directives.

Since 1980s, China has enforced many national economic reform policies in order to accelerate its economic growth. One of the government's strategies was to change its planned economic market into a market-oriented economy system within a social context. The reform aims to promote competition amongst different economic sectors. This alteration has significantly affected the operation of the construction industry, to which a workforce of approximately 50 million is employed. Consequently, the way in which the procurement of construction projects was performed has been modified from government assignment to competitive tendering (Zou, 2007).

Regarding the European countries who are members of the European Union, common market rules have been formulated by the EU, to which the member-states have to comply with. In the area of public procurement, they established a EU Directive concerning public works in 1993 (93/37/ECC), along with those involving public supply and public service (Ohno and Harada, 2006). In 2004, these directives were merged into "The European public contracts Directive" (2004/18/EC) (Ojec, 2013).

3.3.2 The current framework in procurement of construction projects in Sweden

Sweden is considered as world leading country in decentralizing its administrative issues, which have led the municipalities in following their own system of procuring. Thus it currently faces the challenge of standardizing the management of public procurement methods at national level. The local governments in Sweden have a relatively strong authority as such that they can be considered as separate entities. In Sweden, all public procurement procedures have to be implemented based on the Public Procurement Act (Lagen om offentlig upphandling: LOU). Even in small-scale project such as the repair of a road (project conducted by a municipality) it is imperative to be conducted according to the LOU as long as it utilizes public subsidies (Ohno and Harada, 2006).

The National Board for Public Procurement (NOU) suggests that the local municipalities should manage their funds in such way that it complies with the EU Directives. However, the municipalities that have been conducting procurement according to their own rules intensely object to this recommendation, mainly because it enforces them to alter their procurement methods. The national governments ministries have generally aligned their procurement methods with the LOU, nonetheless, the Swedish National Audit Office have identified certain governmental agencies not to have yet understood the details of the public procurement act (Ohno and Harada, 2006).

As aforementioned, the LOU has to be employed in all cases where public funds are utilized no matter what kind of organization makes use of these subsidies (public corporations, organizations, associations, national and local bureaus for example). Nevertheless, Sweden as part of the European Union is obliged to align its regulatory framework with the EU Directives. The LOU complies with the EU Directive regarding procurement at or above the threshold. Below the threshold, the EU Directive is not applied. In these cases LOU has its own regulations.

The following Table illustrates the threshold set by the EU through the Public Contracts Regulations 2006 applying from 1 January 2012.

Table 3.2: EU Procurement Thresholds. (Source: http://www.ojec.com/Threshholds.aspx).

	Supplies	Services	Works
Entities listed in Schedule 1[1]	£113,057 (€130,000)	£113,057 (€130,000)	£4,348,350 (€5,000,000)
Other public sector contracting authorities	£173,934 (€200,000)	£173,934 (€200,000)	£4,348,350 (€5,000,000)

[1] Schedule 1 of the Public Contracts Regulations 2006 lists central government bodies subject to the World Trade Organisation's (WTO) Government Procurement Agreement (GPA). These thresholds will also apply to any successor bodies.

Indicative notices	£652,253 (€750,000)	£652,253 (€750,000)	£4,348,350 (€5,000,000)
Small lots	£69,574 (€80,000)	£69,574 (€80,000)	£869,670 (€1,000,000)

Tendering systems

The EU Directive provides its member countries with the following four tendering systems:

- Open procedure: There is no pre-qualification for bidders (anyone can apply) as it is employed for simple procurements.
- Restricted procedure: Requirement for pre-qualified suppliers based on their financial standing and technical/professional capability.
- Negotiated procedure: The process is formed based on the Public Contracts Regulation 2006 and it is used in extremely limited circumstances. It is employed in cases where a unique type of solution is sought, the funding model is yet untested and the contracting authority is not aware of any other contracts using the same model.
- Competitive dialogue: A process with limited scope. It can be employed when the contracting authority is unable to develop the requirements specification for the project without prior discussion with the suppliers, and when the solution is likely to be complex and it is necessary to interact with bidders to conclude (Mills and Reeve, 2013).

The EU Directive recommends the open and restricted procedure to be of high use and the negotiated tendering system to be applied for exceptional cases that are clearly described in the directive.

In Sweden, the open and restricted procedures are mostly utilized for the procurement of public works at or above the threshold. For contracts below the threshold the EU Directive is not applied and Swedish authorities make use of their own procurement methods (Ohno and Harada, 2006).

When the procurement process has to be conducted urgently or special techniques are required, the government will most likely use the negotiated procedure (for cases at or above the threshold). Even though there is no national data available it is recorded by the National Property Board (SVF) that the route used for tendering system of public works at or above the threshold is the open or restricted procedure (Ohno and Harada, 2006).

For contracts below the threshold set by the EU Directive, the Public Procurement Law (LOU) applies to the classical sector and the Public Procurement Law (LUF) for the utilities sector. In these cases there are no national thresholds for the application of specific procurement methods. Direct purchasing is allowed for low value contracts at the discretion of the contracting authority. The method to be used is either a simplified open or a restricted, tendering procedure with prior publication of contract notices in generally accepted databases (OECD, 2010). When the simplified procedure is employed, the contracting authority invites tenders from candidates of its choice. At the end of the process the contracting authority will award the contract to the bidder who offered the best value for money (European Commission, 2004b).

The criteria for awarding the contract are described at the LOU and suggest that the bidder who proposed the lowest bid price or the most economical advantageous tender shall be awarded the contract. The evaluation procedure as well as the weighting factors will be denoted in advance. The party, which ordered the contract will assess the bids by itself and will rarely employ external experts to aid. Regarding the level of negotiability, the contract authorities will negotiate with the bidders only within the negotiated procurement procedure to clarify issues concerning the bids and not to make them change their proposed bills of quantities. For the simplified procedure, the government can negotiate with bidders to standardize the specifications among them, but must not negotiate with only one of them and the details of their negotiation must be disclosed to the public (Ohno and Harada, 2006).

3.3.3 The current framework in procurement of construction projects in China

Tendering Process

In China, the process of tendering and procurement of construction projects is conducted based on the Article 33 of the "Tendering and Bidding Law" combined with further provisions. The most notable of them are:

1) Article 26 regarding the capacity of the bidder to undertake the project.

2) Article 27, which involve the profiles and business performance of the people in charge of the project, the appointed technical personnel and the machinery, equipment employed, in the contents of the bid documents.
3) Article 28 that trigger the cancelling of the tender process if the number of bidders is less than three (Chen, *et. al.,* 2005).

The concept of Article 33 is to prevent problems related to "buying work" by contractors; however that clause can be translated in different ways. The term in question is the meaning of cost, which can be total, average, marginal, direct, indirect; prime, variable, semi-variable, fixed, sunk, incremental, etc. Therefore, the mere reference of cost is considered as insufficient (Chen, *et. al.,* 2005). The issue of pricing and cost is one of the main problems in the Chinese construction industry, and will be addressed further later in this chapter.

The process of the current procurement of construction projects follows the principles of competitive tendering. For every construction project with an overall value of $500,000 a tender evaluation committee must be formed. Its responsibilities involve the call for the tender, the decision of the eligible companies, the selection of the companies who can proceed on bid submission, the release of tender documents and project drawings, the arrangements of site visits, the response to any questions, the establishment of evaluation criteria, the opening of tenders, the evaluation of bid submissions and finally, the decision of the company to which the contract will be awarded (Zou, 2007).

At the "call for tender" procedure, the companies will be qualified as Grade 1, Grade 2 or Grade 3 by the Ministry of Construction based on their technical capability, financial capacity, past performance (reputation) and company assets. Regarding each company who has expressed interest in bidding, their qualification and past performance will be examined against the selection criteria. In the case of an excess number of companies having expressed interest in submitting bids, two methods are utilized to decide on the winning bid. Either it will be by random selection using a computer software or by scoring (Zou, 2007). The evaluation of the tenders is performed on the basis of multi-criteria including price, time, quality, construction plan, company's profile, past performance and the proposed project team, and not merely on the lowest price (Zou, 2007).

Contract Arrangement

Regarding the contract arrangement, it can be categorized into lump sum contract, measurement contract and cost reimbursement contract, based upon the means of arriving the contract sum (Zou, *et. al.,* 2007).

In the late 1970s, several Chinese state-owned construction enterprises aided by Hong-Kong businessmen, decided to participate in international projects, exposing the Chinese construction industry to international contract conditions for building and civil engineering construction, including the FIDIC conditions of contract for works of civil engineering construction.

Since then, the FIDIC contract has gained popularity and is widely used in China. Experience indicates that most of the civil engineering works procured under the FIDIC conditions had successful outcome (Zou, *et al.,* 2007).

Issues and possible improvements of the tendering process

The process of procurement and tendering of construction projects in China has undergone significant changes. Construction companies also gained significant experience by participating in international projects and practices from various regions. However, there are a number of problems still affects the success of the projects and the function of the construction industry itself.

It has been recorded that the current tendering system in China provides certain barriers to bidders that restrain them from submitting tenders that represent their capabilities. Reviews have revealed that the issue of price is not related to providing value for money and the construction plans do not promote any technological innovation. Furthermore, the process of tender evaluation is considered more as a formality and not an in-depth procedure specifically related to the project. The time allowed for tender evaluation, especially for construction plans, is deemed to be insufficient. Last but not least, the tender evaluation process as well as the contract award decisions have never been audited or reviewed (Zou, 2007).

Improvements of the tendering procedure have been suggested by Zou (2007), which predominantly focused on achieving value for money by collecting and analyzing accurate data from past projects. The utilization of information technologies to carefully identify and collect key project data was considered as critical at the process.

In the short term, it is of the essence to collect and compare the tender prices, the contract price at contract award and the final contract price at contract completion. This data can provide evidence in cost growth, possible signs of corrupted behavior from unusual cost increases, and also allows the Chinese government to identify whether value for money is yielded from the contracts. Another step that will help establish the level of value for money provided is the collection of number, type, (client changes, unforeseen site changes, etc.) and value of contract variations (Zou, 2007).

An equally important factor is the measurement of time and cost overruns on contracts. In case of them exceeding a predetermined value, the projects should be further reviewed. The data should be assembled locally (municipal level) and analyzed at a provincial and national level so that they can be compared with other projects in different municipalities and provinces. This will allow the detection of a trend across China. All relevant data should also be utilized for benchmark purposes, provide reference for tender price, value for money and construction time for future projects (Zou, 2007).

In the long term, it is substantial to establish a secure e-tendering system. The system will imperatively meet certain security and functional requirements such as non-repudiation and authentication, secure time and secure record keeping. The implementation of the e-tendering system will significantly prohibit subjective influence on tender decision and will assist in improving the tender evaluation process (Zou, 2007).

3.3.4 The case of Tianjin Eco-City

The Sino-Singapore Tianjin Eco-City was designed to 34.2 square kilometers. The project was implemented by both the Chinese and Singapore governments, by joining a collaborative agreement in order to develop a socially harmonious, environmentally friendly and resource-conserving city in China. The city was designed as such, that it can be practical, replicable and scalable (Ma, 2009).

Collaboration Areas

There were two levels of collaboration in the project; at the Government-to-Government (G-to-G) level and at the private sector level. At the Government-to-Government level, both China and Singapore, with 50% involvement each, have committed in contributing their experiences in subjects such as urban planning, environmental protection, resource conservation, water and waste management and sustainable development, as well as policies and programs to breed social harmony in the Tianjin Eco-City (Singapore Government, 2012).

The following diagram demonstrates the authorities responsible for the implementation of the project at the G-to-G level and their obligations.

Joint Steering Council

- Co-chaired at the Deputy Prime Minister-Vice Premier level, responsible for establishing the strategic directions of the project

Joint Working Committee

- Co-chaired by Singapore's Minister for National Development (MND) and China's Minister of Housing and Urban-Rural Development, and comprising senior representatives from agencies involved in the Eco-city project on both sides, supervise the implementation of the project and the achievement of its key milestones.

MND, PRC Central and Tianjin Governments

- Singapore's Minister for National Development (MND), officials from People'e Republic of China (PRC) in a National level and officials from the local Tianjin Government participated in the consortium.

Figure 3.2: Authorities responsible for Tianjin Eco-City at G-to-G level. (Source: http://www.tianjinecocity.gov.sg/col_overview.htm).

Furthermore, six working-level sub-committees comprising officials from various Singapore agencies and Chinese officials from the Tianjin Eco-City Administrative Committee (ECAC), were formulated to concentrate on developing public housing, water management, urban planning and transport, environmental management, economic promotion and social development in the Eco-City. Singapore agencies that are currently involved actively in the Tianjin Eco-City project include the Urban Redevelopment Authority (URA), Housing and Development Board (HDB), Building and Construction Authority (BCA), National Environment Agency (NEA), Public Utilities Board (PUB), Land Transport Authority (LTA) and IE Singapore. The following diagram illustrates the responsibilities of the Singapore working committees involved in the project (Singapore Government, 2012).

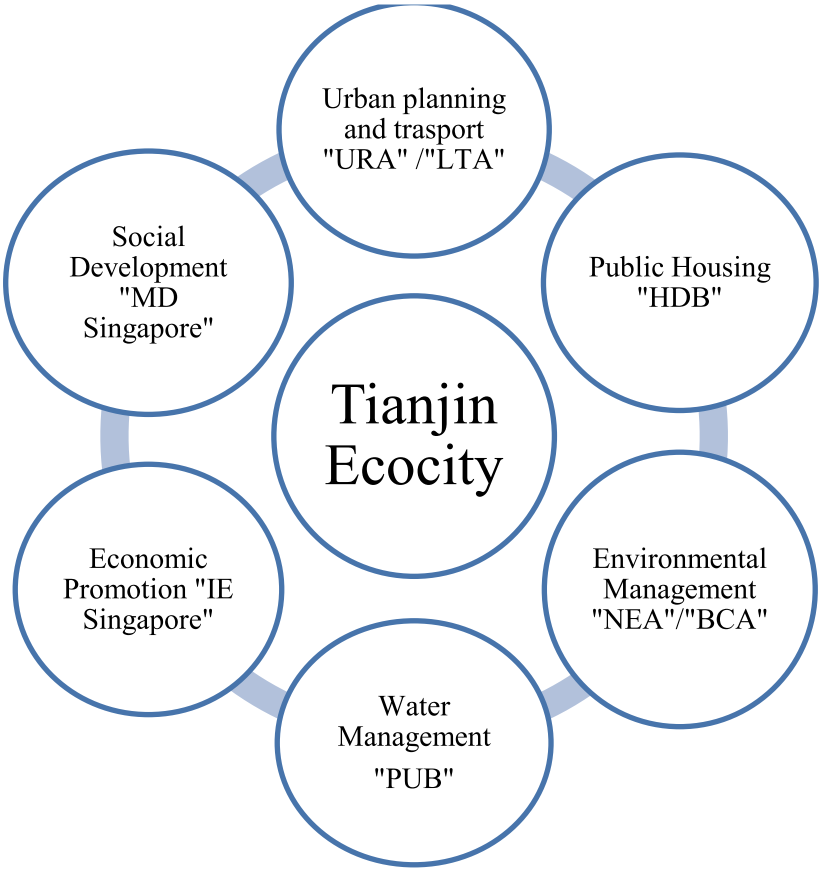


Figure 3.3: Singapore agencies involved in Tianjin Eco-City. (Source: http://www.tianjinecocity.gov.sg/col_overview.htm).

Certain tangible outcomes are expected from the G-to-G collaboration, including framework of Key Performance Indicators of the project (KPIs), city's master plan, formulation of green building evaluation standards, formulation of integrated guidelines in water management, public housing policy framework and planning of investment promotion activities (Singapore Government, 2012).

Regarding the private sector cooperation, the master developer joint venture company is the Sino-Singapore Tianjin Eco-City Investment and Development Co. Ltd (SSTEC). SSTEC is comprised of a Singapore and Chinese consortium each with 50% participation. Among others, SSTEC has taken over the economic promotion of the Eco-City. The involvement of the private sector in the project ascertains its commercial viability and it raises the possibilities of it being reproduced. The leader of the Singapore consortium of SSTEC is Keppel Corporation, while the leader of the Chinese consortium is Tianjin TEDA Investment and Holdings Co. Ltd. The following figure depicts the partners of both consortiums, as well as the participation rate of each company in the consortium (Singapore Government, 2012).

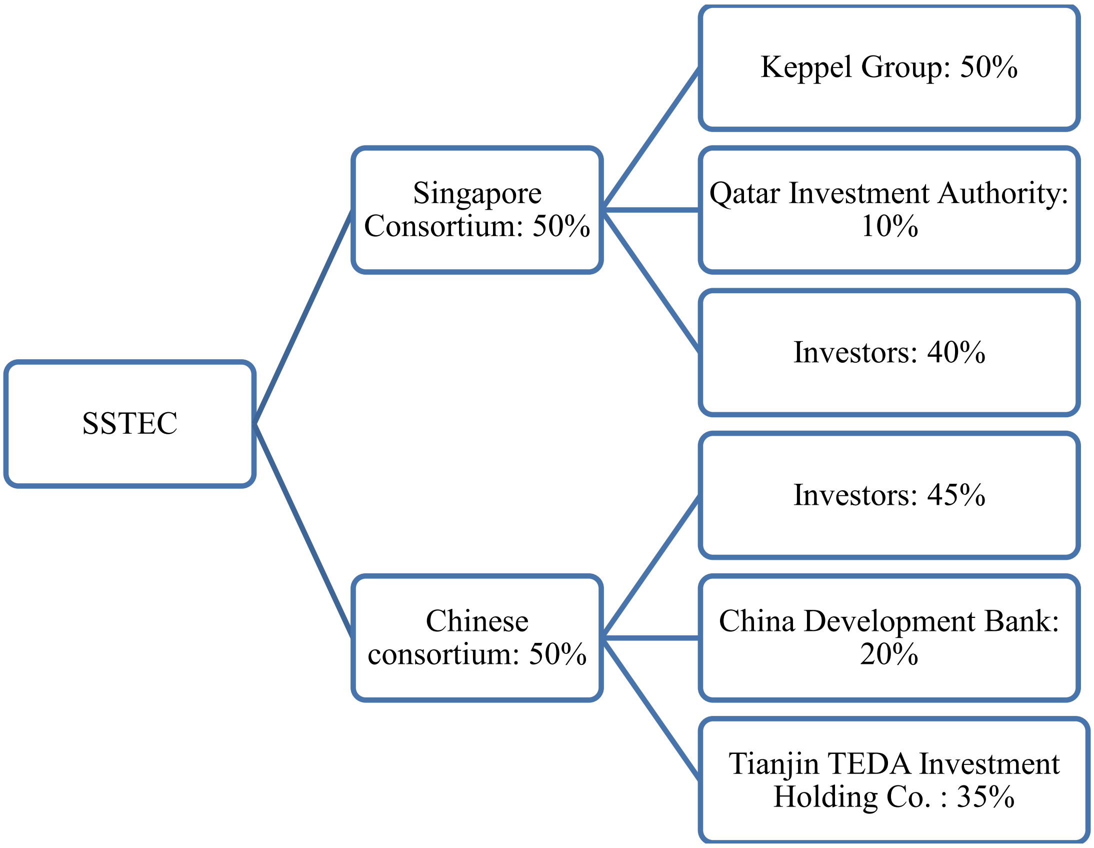


Figure 3.4: The structure of SSTEC. (Source: Boon, G.H., 2008, "Developing a City of the Future; Sino-Singapore Tianjin Eco City", Sino-Singapore Tianjin Eco City Investment & Development Co. Ltd).

4 ENGINEERING CONCEPTS

4.1 Planning

4.1.1 Decision making

Decision making is a daily process for every activity, however when it comes to business organizations, it is a very important parameter. This lies in the fact that effective and successful decisions turn out to be profitable for the companies, while unsuccessful ones make losses. In the decision making process a course of action is chosen over a few possible solutions. In order to choose the proper course of action, several tools and techniques are employed. Most of the times, the decision making process cause conflicts among the involved parties. Figure 4.1 shows important steps in decision making process. For each of the steps different tools and techniques can be employed (Tutorialspoint, 2013).

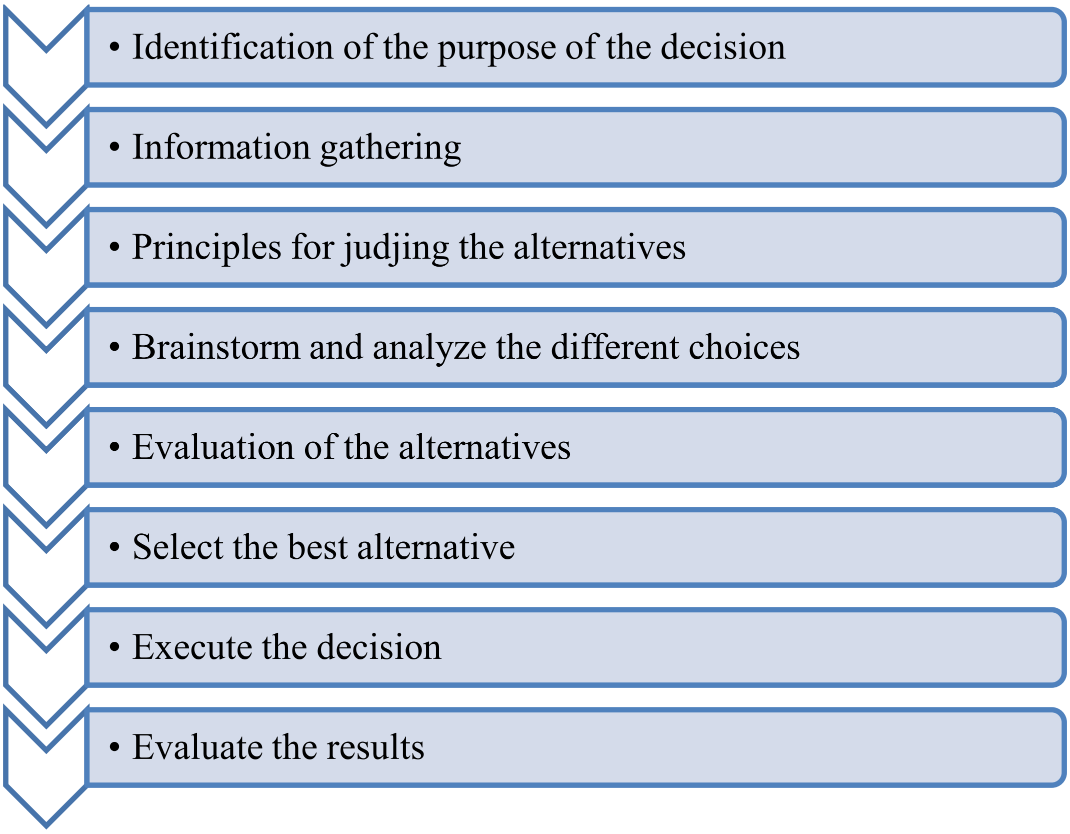


Figure 4.1: Important steps of a decision making process, taken from http://www.tutorialspoint.com/management_concepts/decision_making_process.htm.

Helsingborg

The decision making structure in the project was run through three closely interacting structures:

- The Trans-National coordinating is managed by the Project coordinator (COWI-DK) in close collaboration with the work package leaders and the Local coordinators of the three Communities.
- The Local coordination management integrates the detailed planning, execution and control of the technical tasks to meet the project scientific and technical objectives set within the communities.
- The Advisory management which through a Steering Committee keeps track of the project directions, looking for consultancy from the Community Advisory Boards in order to assure that the project meets its stated and implied goals.

The Steering Committee supervises all project management groups, including initiation, planning, execution, control, and closure; within the management structure framework. For the day-to-day communication in the "Helsingborg/Helsingor" part of the project a structure has been set, as illustrated in the following figure.

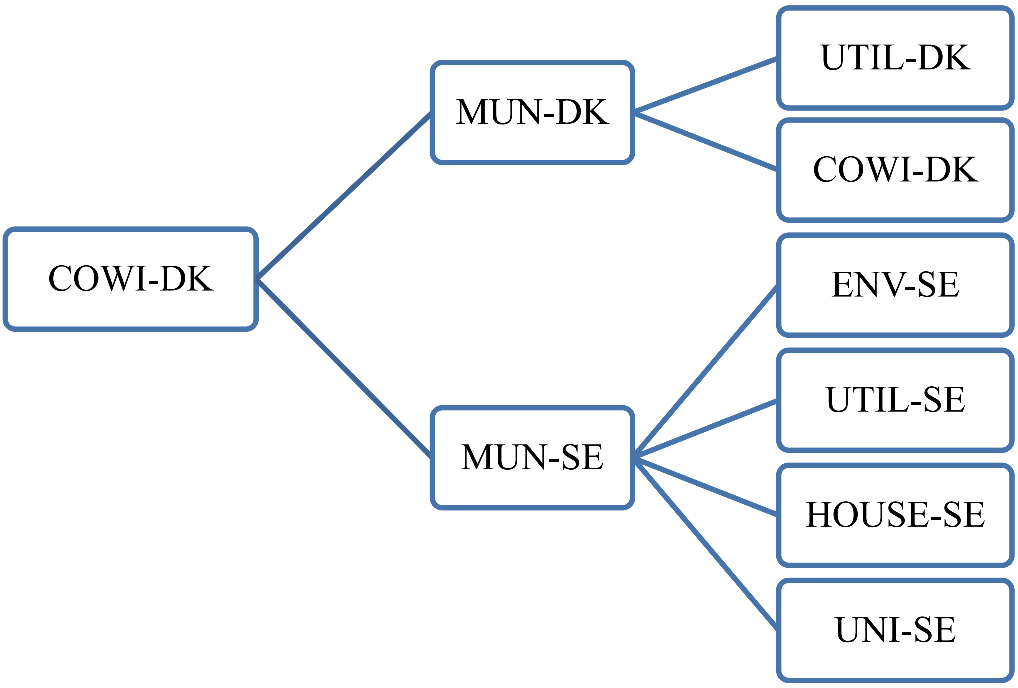


Figure 4.2: Communication day-to-day management (part of Helsingborg/Helsingor project), taken from Eco-City (2005).

Tianjin Eco-City

Mott MacDonald Company developed a unique methodology called INDUS. INDUS brings together sustainability into the design process alongside 'traditional' technical, financial, statutory planning, safety and regulatory decision making criteria. This approach has also been successfully demonstrated on large scale projects in other countries such as the Middle East, China and the UK. INDUS aims in bridging the gap that exists between the aspirations of the clients and the performance of their projects (Mott MacDonald, 2013a).

Objectives are set for each project considering economic, social and environmental sustainability over its whole life. The importance of each objective is weighted at the outset. This indicates the existence of a reference framework and scoring system for decision making. There is no limit set on the number of criteria for guiding and tracking the performance of the project. Key stages are identified over the course of project development where important decisions are to be taken and scored. Definition and weighting of objectives is achieved through consensus with the client and the project stakeholders (Mott MacDonald, 2013b).

It is a given fact that the decision to implement sustainability at any stage of project development can significantly improve performance; however, the clients are encouraged to set objectives at the outset so that maximum possible benefits can be achieved (Mott MacDonald, 2013b).

4.1.2 Stakeholder engagement (SE)

Helsingborg

It is paramount for the project's success to continuously interact with the different stakeholder groups so that they can accept the planned measures. The SE activities are targeted towards various stakeholders, such as residents, tenants or owners of the buildings redeveloped as well as their associations. Moreover, public and private housing associations and building developers are also aimed through this program. This is either done by a range of stakeholder engagement measures or by involving them in the measures that address the tenants and residents. Professionals were involved in the process as a targeted group or as a collaborator. The group of professionals involved is mainly installers, energy consultants, building professionals, caretakers, sales agents and municipal employees. This group is targeted by training activities and information events (Di Nucci and Spitzbart, 2010).

Groups in the education and academic level (schools, kindergartens and universities) were addressed by courses and lessons for pupils and students. Private companies especially the Small Medium Enterprises (SMEs) were either considered as collaborating stakeholders (e.g. on smart metering or campaigns to raise awareness) or target groups for guidance on energy usage (Di Nucci and Spitzbart, 2010).

The socio-economic activities that took place in all the cities of the Concerto initiative included five different categories and were tailored based on the community that was implemented. For example, in Helsingborg there was no socio-economic plan, however there were activities concerning environmental education and raising awareness. The range of activities regarding the stakeholder engagement involved is:

- Information and dissemination: Aiming at informing stakeholders, other interested people and organisations about CONCERTO related actions. Though, general communication material targets a general audience, in some cases more specific measures were taken. These involved providing specific information to residents of refurbished dwellings before and after the refurbishment such as guidelines on how to live in the refurbished flat.
- Surveys and studies: Regard all activities related to what is conceived as stakeholder engagement research. Surveys (making use of questionnaires distributed by post, email, or even electronically) or interviews conducted with closed and standardised questions by telephone or personally were employed to research the opinions and attitudes of stakeholders.
- Stakeholder involvement: It is a primary objective and is used for mapping inhabitants' engagement in CONCERTO area. It is noticeable that this group did not aim just in collecting opinions, level of satisfaction and perceptions, but also provided an intense exchange process among the stakeholders to contribute to the development of solutions. In some community activities other stakeholders such as SMEs, developers, owners of non-residential buildings, energy suppliers and municipal employees are also involved.
- Activities to change energy behavior: mainly involved the participation of households in providing feedback, through specific feedback systems, on energy consumption or Renewable Energy Sources (RES) generation and smart metering.

- ➢ Training and counseling: incorporating activities as school-related projects, personal energy advice or energy checks, energy consultancy for groups of stakeholders and training for professionals (Di Nucci & Spitzbart, 2010).

The following diagram demonstrates the specific activities that took place in Helsingborg :

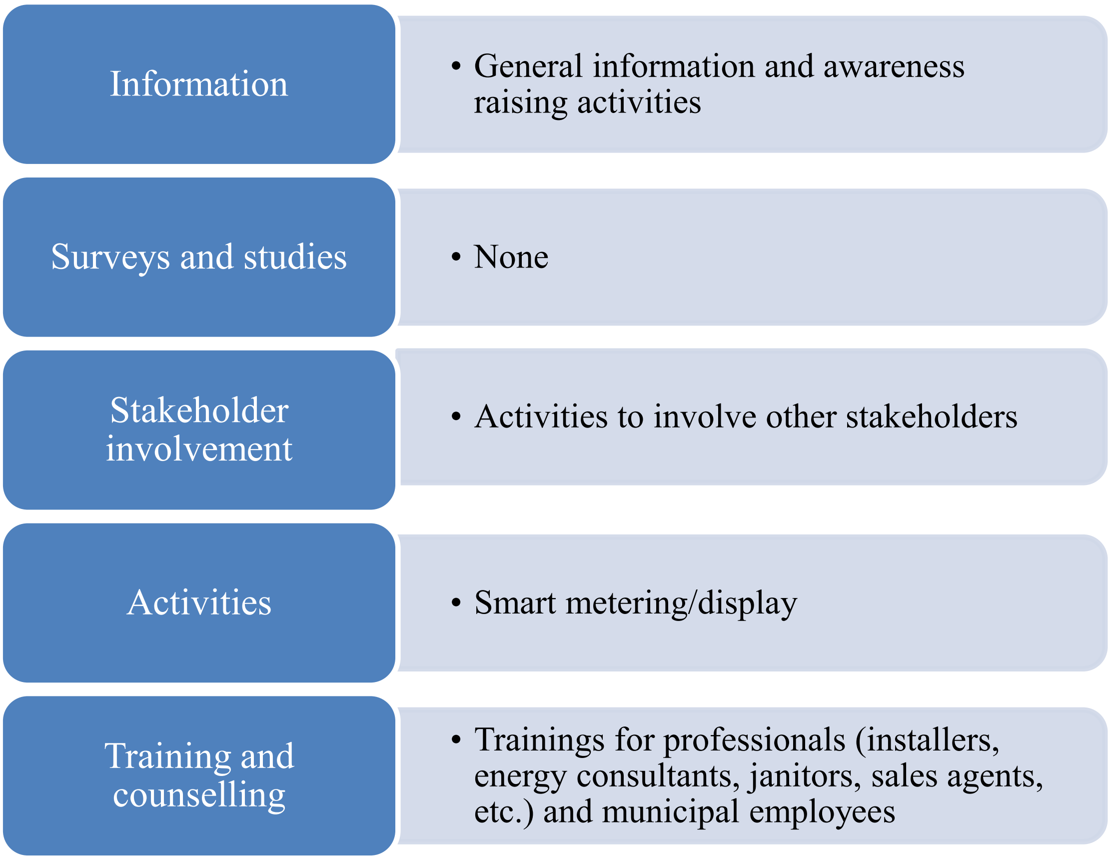


Figure 4.3: Activities for Stakeholder Engagement; taken from Di Nucci and Spitzbart (2010).

Involving the stakeholders in the process is the beginning towards making a commitment, and making a commitment gets people more likely to act. Interpreting the groups implicated, inhabitants and home owners is one key to successful refurbishment activities. The important fact is the involvement of those affected by the measures so as to ascertain acceptability of the project and bring social response. It is crucial that the participation of the people affected by the project is provided at every stage from planning through to implementation, and is of the essence to keep them informed about the development. (Di Nucci & Spitzbart, 2010)

Tianjin Eco-City

In the case of Tianjin Eco-City there were many different stakeholders involved; the Chinese and Singapore central government, local governments and municipalities, developers, architects, residents, organizations and participating companies. Varied stakeholder participation can create a difficult situation, owing to the increase in likelihood of difference in opinions and priorities on sustainable urban development among different stakeholders. Their many individual interests on different levels and failure to get to a consensus can be proven highly problematic for the success of the project. A good example on the conflict of interests among stakeholders comes from China. One of the goals of eco initiative by the Chinese government is to demonstrate to the world how far they have reached in terms of green technological development. However, local officials are often concerned about their status and promotion possibilities. Companies such as Arup are concerned about getting a portion from the Chinese Eco-City market and investors and private companies prioritize profitability. In some cases resident priorities also differ as some of them need a better living environment while others are more concerned about increased land value due to the continued development of the area (Hald, 2009).

During the planning process a specific team (by Mott MacDonald company) was appointed by Sino-Singapore Tianjin Eco-City Administrative Committee and Global Environment Facility (GEF) to provide technical assistance. Moreover to develop a strategy to educate and engage the stakeholders involved in order to encourage low energy living.

The team lead the design of two demonstration projects: a 20,000m^2 school and a 600-apartment residential complex. They will both show a 65% saving in annual energy compared with the previous national standard benchmark. The team of Mott MacDonald Company worked with local design teams on the demonstration projects to shape the sustainable design features and improvements that can be employed. They also come up with a relative cost, to define the final cost-effective designs (Mott MacDonald, 2013b).

4.1.3 Contract arrangement

The case of Helsingborg

The joint development of ecocities in Scandinavia and Spain was part of the programme: “Sustainable Development, Global Change and Ecosystems: thematic priority 6 under the

Focusing and Integrating Community Research Programme 2002-2006" by CORDIS (Community Research and Development Information Service) (CORDIS, 2013).

To all participants in the 6th framework programme a consortium agreement (CA) was made among the parties, as it was defined by the rules adopted by the *European Parliament and the Council for the participation of undertakings and for the dissemination of the research results* (known as the Rules of Participation, or the "Rules"). A consortium agreement was an imperative factor for all projects financed by the 6th framework programme, except it was declared otherwise in the calls for proposals. It is noteworthy that the EU community is not considered as a party to these agreements and has no active role in the choices made by the parties to the clauses they regard as appropriate to the purpose of their collaboration. However, the consortium agreement must always comply with the Rules and European Commission contract (CORDIS, 2003).

The contract types used for the projects under the 6th framework programme were (CORDIS, 2013):

- Networks of Excellence
- Integrated Project
- Specific Targeted Research Project
- Specific Targeted Innovation Project
- Coordination Action
- Specific Support Action

For the project of the joint development of Eco-Cities in Scandinavia and Spain, the contract type of "Integrated Project" was utilized (2020-horizon.com, 2011).

In the case of an integrated project specific provisions are described by CORDIS (2013). The provisions include are given below:

1) Sub-projects coordination.
2) Calls for extension by the Commission and its suggestions.
3) Special calls for extension of the consortium membership.
4) An annual update of the implementation plan.
5) An annual update of the financial plan.
6) Annual review and consequences of additional work or revisions.
7) Annual audit certificates / partner.
8) Cost sharing.
9) How to deal with 7% management activity (costs reimbursed at 100%).

10) The distribution of the community financial contribution. (CORDIS, 2013)

The implementation plan can also identify the pre-existing know-how and knowledge to which access rights are needed to achieve the objectives and deliverables of the project. In the update, the requests for new pre-existing know-how and knowledge should be described, taking into account any new participants that have joined the project. Further down the basic principles of a Consortium Agreement (CA) as well as of an Integrated Project are analyzed.

Consortium Agreements (CA)

A Consortium Agreement is commonly perceived as a single formal legal document which is agreed and signed by all the participants of a project that enforces a set of standard conditions to the parties involved. The conditions include agreements to the ownership and exploitation of the IPRs (Intellectual Property Rights), as well as a set of warranties and disclaimers to distribute the risks among the participants. This interpretation of the form of the "Consortium Agreement" is widely used across the research/development environment. Hence, a similar agreement is adopted under the 6^{th} Framework Programme which had research/development purposes (Charlesworth, 2013).

The main issues arising from CA templates are the tendency to focus project staff in the form of an agreement between the participants instead of focusing on the agreement's function. To elaborate this issue, in some cases it might be less important to have a multiparty "formal" CA than have a series of well documented agreements upon the administrative ones. The above mentioned arrangement can efficiently tackle issues regarding the project's aims and objectives, the management of the project and the allocation of resources and risks. Such well documented agreements or administrative arrangements can be of the essence to managers and project administrators. This enable them to identify, examine and cope with problems during the lifecycle of the project, as well as to assert appropriate solutions to disputes in the basis of the pre-agreed process or dispute management (Charlesworth, 2013).

In brief, it is important for the parties involved in the Agreement to tackle the following issues:

- The Agreement should be well documented.
- There should be provisions for an appropriate management framework.
- It should clearly define the responsibilities for resource distribution and risk allocation.

- Contemplate the understandings of the participants as to their roles, rights and responsibilities.
- Ascertain that the work for which the financing is apportioned is completed in the predetermined time frame (Charlesworth, 2013).

The type of consortium agreement utilized for the project was that of a formal consortium agreement. The following figure illustrates the legal and administrative arrangements for that type of CA.

Figure 4.4: Type of a Formal Consortium Agreement, taken from Charlesworth (2013).

Integrated Project (IP)

Integrated Projects are projects with multi-partners which are formed to support objective driven research, where the preference is to generate knowledge required to implement the thematic priorities. The IPs brings forth a large amount of critical resources in order to achieve ambitious goals to upgrade Europe's competitiveness and cope with major social issues. It is imperative to contain a research element, as they do normally have technological development, demonstration components and perhaps have training aspects. The factor that differentiates the integrated projects is that of the "integration" that may take several forms within a project (European Commission, 2002):

- Vertical integration of the whole "value-chain" of stakeholders reaching from those implicated in the knowledge production towards those involved in technological development and transfer.
- Horizontal integration of several multidisciplinary activities.
- Activity integration through integrating various research activities from fundamental to applied research in combination with different types of activities

such as take-up activities, protection and dissemination of knowledge, training, etc, as appropriate.

- Sectorial integration of participants from private and public sector organisations, particularly academia and industry, including small medium enterprises (SMEs).
- Financial integration of public and private funds along with the overall financial plans that can involve the European Investment Bank and co-operation with Eureka (organisation to raise competitiveness and technology in Europe) (European Commission, 2002).

Integrated Projects are knowledge and research driven. Therefore they are good model for efficient management of knowledge, its circulation and transfer. Integrated projects also exploit technologies developed with competitive analysis and assessment methods (European Commission, 2002).

For every IP there must be a minimum of three participants from three different member states or associated states of which at least two are from member states or associated candidate states. All issues regarding the number of participants will be clearly defined in the calls for proposals, however usually there are more than three participants (European Commission, 2002).

It is expected that the value of the activities integrating in a project will range up to many tens of millions of Euros. Nonetheless, there is no minimum threshold, provided that the ambition and critical mass of resources are there. Funding to an Integrated Project will take the form of a grant to the budget, as a contribution to costs arising, with specified maximum rates of support for the different types of activity within the project (European Commission, 2002).

The case of Tianjin Eco-City

The project was initiated by Premier Wen Jiabao (PRC) and Prime Minister Lee Hsien Loong (Singapore) signing the "Framework Agreement on the Development of an Eco-City in the PRC". At the outset it was established that Sino-Singapore Tianjin Eco-City will be a thriving city, socially harmonious, environmentally friendly and resource-efficient area. The city was developed to be a model for sustainable development (Singapore Government, 2012).

The Framework Agreement dictates that PRC and Singapore Government will cooperate and share their experiences in formulating policies and programs to bring forth social harmony. Furthermore, they will collaborate in areas of urban planning, environmental protection, resource conservation, recycling, ecological infrastructure development, use of renewable resources, reuse of wastewater, and sustainable development in the Sino-Singapore Tianjin Eco-City. Moreover, the supervision mechanism for the city was agreed upon the Framework Agreement (Singapore Government, 2012).

Along with the Framework Agreement, a Supplementary agreement was signed by Minister Mah Bow Tan (Singapore) and Minister Wang Guangtao (PRC), in order to incorporate and reinforce the joint development of the Sino-Singapore Tianjin Eco-City in accordance with the Framework Agreement (Singapore Government, 2012).Based upon the Supplementary Agreement, the key outcomes of the development of the Sino-Singapore Tianjin Eco-City are expected to be (a) a vibrant local economy with good environmental conditions, (b) a breeding on the formation of socially harmonious and inclusive communities, (c) the adoption of good environmental technologies and practices in order to stimulate an attractive quality living environment and (d) the project to act as reference for other cities in the PRC in the management, technological and policy aspects of the development and protection of their ecological environment (Singapore Government, 2012).

Framework Agreement

Framework agreement falls into the category of framework arrangements along with framework contracts. Framework arrangements have gained popularity as they comprise a "smarter way" to purchase works or supplies than placing "one-off" orders for repeated contracts. This way volume purchasing discounts are optimized and repetition on purchasing tasks is minimized, among other benefits (cips.org, 2013).

In a framework arrangement it is of the essence to establish a pricing structure, without implying a fixed price. Instead, a mechanism is launched and applied for pricing particular requirements and tasks during the period of the framework. Furthermore, it is tangible to establish the scope and types of services/works that will need to be called-off. Call-offs are individual contracts under the framework arrangements, in which the contracting authorities in the public and utilities sector do not need to repeat the process again as long as the rules for establishing the framework agreement in the first place were correctly observed. The option for call off arrangements can vary according to individual circumstances and specifically in the number of suppliers involved (cips.org, 2013).

In a framework agreement, each time a buyer uses the agreement, a separate contract is formed by paying the consideration for the order in question. The consideration can be a purely nominal sum, which in the case of a dispute, will be interpreted by the court as confirmation that the parties are happy to be bounded with. Basically, a framework agreement is an agreement between two parties for the supply of an unspecified amount of product/works for a specified time period (cips.org, 2013).

The benefits of a framework agreement include the reduction of costs and delays associated with the procurement process and the possibility of generating economies of scale, particularly if it is to be used by many authorities. The risks involve the time frame of the agreement which is normally limited to four years, in the case of multi-authority use the agreement may not be tailored to the needs of the participants. Moreover, the scaling up may have adverse effects to Small Medium Enterprises (Giffin, 2011).

4.1.4 Building standards/policies

Helsingborg

There are a lot of green building certifications worldwide. Sweden Green Building Council which is a nonprofit organization that works to influence and develop the environmental and sustainability programs in the building industry aims to certify as many buildings as possible. Four certification schemes have been selected to suit various types of buildings and properties.

Table 4.1: Comparison on green building standards, taken from SGBC (2013).

	EU GreenBuilding	Miljöbyggnad*	BREEAM*	LEED*
Energy	O	O	O	O
Materials		O	O	O
Indoor environment		O	O	O
Water			O	O
Management			O	O
Building waste			O	O
Location and infrastructure			O	O
Innovation in design			O	O
Regional priority			O	O

* Miljöbyggnad: Environmental Building (Swedish), BREEAM: BRE Environmental Assessment Method, LEED: Leadership in Energy and Environmental Design

Miljöbyggnad is a Swedish system for certifying buildings in relation to energy, materials and indoor environment. This system offers certification in different grades such as Gold, Silver and Bronze, and is used for both residential and commercial buildings, new and existing buildings, regardless of building size. This certification is most frequently used in Sweden. The specifications of Miljöbyggnad are summarized in the following table.

Table 4.2: Specifications of Miljöbyggnad, taken from MILJÖBYGGNAD (2013).

Issue	Indicator	BRONZE	SILVER	GOLD	Explanation
Energy	Bought energy	< SBC	≤ 0.75 SBC	≤ 0.65 SBC	SBC = Swedish Building Code
	Heating power requirement	≤ 60 W/m^2 HA	≤ 40 W/m^2 HA	≤ 25 W/m^2 HA	HA = Heated Area
	Solar heat load	≤ 48 W/m^2 FA	≤ 43 W/m^2 FA	≤ 32 W/m^2 FA	FA = Floor Area
	Fraction of energy carriers	< 50% Cat4	> 10% Cat1 or > 50% Cat2 and < 25% Cat4	> 20% Cat1 or > 50% Cat2 and < 20% Cat4	Cat 1 = Renewable recurrent Cat 2 = Biofuels Cat 4 = Else (fossil, nuclear, …)
Indoor environment	Noise protection	≥ Sound Class C	≥ 50% of the parameters Class B	≥ Sound Class B ≥ 80% of users satisfied	Classes accoding Sw. Standard 25268
	Radon content	101-200 Bq/m^3	51-100 Bq/m^3	≤ 50 Bq/m^3	
	Ventilation rates	≥ 7l/s,pers + 0,35 l/m^2 FA	+ VAV in rooms with varying load	+ VAV in all populated rooms. ≥ 80% of user satisfied	VAV = Variable Air Volume
	N2O to indoor air (from traffic)	> 40 $\mu g/m^3$ or unknown	≤ 40 $\mu g/m^3$	≤ 20 $\mu g/m^3$ or > 250m to road with > 10 000 veh./day	veh. = vehicles
	Moisture prevention	Moisture proof design according to BBR 6:5	+ Moisture proof design according to Bygga F	+ A certified moisture expert	BBR = Swedish Building Code Bygga F = specific method for moisture proof design
	Thermal climate winter	PPD ≤ 20%	PPD ≤ 15%	PPD ≤ 10% + ≥ 80% of users satisfied	PPD = Predicted Percentage Dissatisfied
	Thermal climate summer	same	same	same	
	Daylight	DF > 1.0%	DF ≥ 1.2%	DF ≥ 1,2 % + ≥ 80% of users	DF = Daylight Factor

				satisfied	
	Legionella	≥ 60oC in HWS. Demands on hotwater pipes	+ SWI is applied	+ thermometer s on all WWD-loops	HWS = Hot Water Store SWI = Secure Water Installation (spec. insustry rules) WWC = Warm Water Circulation
Material & chemicals	Documentation of materials	LB on building products	+ LB is digital	+ LB with amount and place for each prod	LB = Log Book with product type, name, producer, year and content of subtances
	Absence of hazardous substances (in design-ated building parts)	No information	Some POS above content limits occur and are listed	POS above content limits do not occur in LB	POS = Phase Out Substances according to Swedish Chemicals Agency

Tianjin Eco-City

Evaluation Standard for Green Building (GBES): In the GBES, separate standards are developed for residential buildings and commercial buildings, and both include six categories that cover the life cycle of buildings. The six categories are: (1) Land saving and outdoor environment, (2) Energy saving and energy utilization, (3) Water saving and water resources utilization, (4) Materials saving and materials resources utilization, (5) Indoor environment quality, and (6) Operation and management. The GBES of Tianjin Eco-City follows the similar hierarchy as the Chinese national GBES. The following table shows the comparison among Tianjin Eco-City GBES, China National GBES and Tianjin local requirement.

Table 4.3: Tianjin Eco-City GBES and National GBES for Residential Buildings (World Bank, 2009).

Category	Tianjin Eco-City GBES	National GBES	Tianjin Requirements
Land conservation and outdoor environment			
Per capita land occupation	Low rise: <43m^2, mid to high rise:<24m^2, high rise: <15m^2	NSR*	NSR
Green coverage	>35%, >2m^2 per capita	>=30%, 1-2 m^2 per capita	NSR
Roof green coverage	>=10%	NSR	NSR

Public transportation	Less than 500 m walking distance	General elective item	NSR
Other items: flood and radiation protection, day lighting and natural ventilation, and noise limit.	Refer to national standards	Refer to national standards. Standard on noise is a general elective item.	National standards
Energy conservation and utilization of energy resources			
Building energy efficiency	Refer to Tianjin standard	Refer to national standard and local standards.	Tianjin standard: 65% heating energy savings
Sunlight hours	Two hours during the “Severe Cold Day.”	same	same
Renewable energy	10% of the total building energy consumption	General elective item: 5% of the total building energy consumption; Preferred elective item: 10%.	NSR
Lighting	Refers national standard	General elective item	National standard
Water conservation and utilization of water resources			
Utilization rate of non-conventional water resources	No lower than 20% by 2012.	General elective item: no lower than 10%.	NSR
Other items: water system design, water conservation equipment, non-conventional water.	Refer to national and Tianjin standards and regulations	Qualitative descriptions and many are general elective items	National and Tianjin standards and regulations
Materials conservation and utilization of materials resources			
Wall materials	Use of clay cannot exceed 20%.	NSR	NSR
Limitation on toxic contents in building materials	Refers to national standards	Refers to national standards	National standards
Indoor environment quality			
Heat engineering	Refers to national standards	General elective item	National standards

Temperature control	Indoor temperature can be controlled when heating or air conditioning is used.	General elective item	Same as in SSTEC GBES
Other items such as day lighting, indoor air quality, and building accessibility.	Refer to national standards	Refer to national standards	National standards
Operation and management			
Building intellectual system	Includes security, telephone, cable TV, internet, and operation and management system.	General elective item	National standards

*NSR: No specific requirement

Rating system: The rating system for SSTEC is similar to the United States Leadership in Energy and Environmental Design (LEED) rating process. In the GBES, the performance standards under each category are classified into prerequisite and credit items. In order to be qualified as a green building, all prerequisite items have to be met. Based on the credit items and their weights, a green building can be rated as one-star, two-star, or three-star.

Table 4.4: Item Requirement for Rating of Green Residential Building National GBES (China, 2006).

Grade	General Items (Total: 40 Items)						Preference Items (Total: 9 Items)
	Land Saving & Outdoor Environment (Total: 8 items)	Energy Saving & Energy Utilization (Total: 6 Items)	Water Saving & Water Resource Utilization (Total: 6 Items)	Material Saving & Material Resource Utilization (Total: 7 Items)	Indoor Environment Quality (Total: 6 Items)	Operating Management (Total: 7 Items)	
★	4	2	3	3	2	4	-
★★	5	3	4	4	3	5	3
★★★	6	4	5	5	4	6	5

Comparison on Building standards

The table below shows the comparison among green building standards and contents covered by each standard.

Table 4.5: Comparison on green building standards, taken from SGBC (2013).

	GBES*	EU GreenBuilding	Miljöbyggnad*	BREEAM*	LEED*
Energy	O	O	O	O	O
Materials	O		O	O	O
Indoor environment	O		O	O	O
Water	O			O	O
Management	O			O	O
Building waste				O	O
Location and infrastructure	O			O	O
Innovation in design				O	O
Regional priority				O	O

* GBES: Evaluation Standard for Green Building Miljöbyggnad: Environmental Building (Swedish) BREEAM: BRE Environmental Assessment Method LEED: Leadership in Energy and Environmental Design

GBES is Evaluation Standard for Green Building, which is based on green building practices in both China and Singapore. According to the KPIs, 100 percent of the buildings in the Tianjin Eco-City will be green buildings in line with the GBES, so GBES should be the regulation to be followed.

Regarding EU GreenBuilding, Miljöbyggnad, BREEAM and LEED are green building certifications which are used in Sweden, with Miljöbyggnad being the most frequently used. Therefore, a comparison between GBES and Miljöbyggnad is carried out. Table 4.5 shows that Swedish standard covers only energy, materials and indoor environment while GBES covers more contents than Miljöbyggnad like water, management, and location and infrastructure. These difference in building standards and its possible reasons will be examined further.

Moreover, buildings that are built in Tianjin Eco-City must cover GBES, while there are only guidelines and certifications in Helsingborg. Therefore, it can be mentioned that Tianjin Eco-City has stricter green building standard than Sweden.

The table 4.6 shows the specifications of standards. In Miljöbyggnad, there are 3 grades, Bronze, Silver, and Gold and each grade has different requirements.

Table 4.6: specifications of standards, taken from GBES (2013) and MILJÖBYGGNAD (2013).

	Tianjin Eco-City	Miljöbyggnad			Explanation
	SSTEC GBES	Bronze	Silver	Gold	
Fraction of energy carriers	> 10% Cat1	< 50% Cat4	> 10% Cat1 or > 50% Cat2 and < 25% Cat4	> 20% Cat1 or > 50% Cat2 and < 20% Cat4	Cat1 = Renewable recurrent Cat2 = Biofuels Cat4 = Else (fossil, nuclear)
Heating power requirement	< 50 W/m^2	< 60 W/m^2	< 40 W/m^2	< 25 W/m^2	
Daylight	DF > 1.5% 75% of floor area	DF > 1.0%	DF ≥ 1.2%	DF ≥ 1.2% and 80% of users satisfied	DF = Daylight Factor

There are a few comparable contents between GBES and Miljöbyggnad. In the case of fraction of energy carriers, more than 10% of energy source of a building should be renewable energy in GBES. However, in Bronze grade of Miljöbyggnad, the portion of fossil and nuclear energy is less than 50%. In silver grade, more than 10% of the renewable energy or more than 50% of biofuel energy and less than 25% of fossil fuel is used. In gold grade more than 20% of the renewable energy or more than 50% of biofuel energy and less than 20% of fossil fuel energy should be used. Thus, it is obvious that in order to get the higher grade, portions of renewable and biofuel energy use should increase, while portion of fossil fuel energy utilisation should decrease. Furthermore, it can be identified that GBES standard is similar with silver grade of Swedish standard.

4.2 Implementation

4.2.1 Green buildings

Helsingborg

Green building refers to a structure that is eco-friendly and resource-efficient throughout a building's life-cycle: i.e. from the stages of design, construction, operation, renovation, to demolition. The green building practice complements the classical building design in terms of economy, utility, durability and comfort. The common objectives of green buildings are to reduce the impact of the natural environment and human health.

CONCERTO Guideline for green building

Traditionally, energy planning has been performed by the application of energy-efficient technologies and the use of renewable energy. The energy system has been optimized one-by-one by choosing the one with the lowest life cycle cost. In the recent years, however, a "whole building approach" is taken to achieve significant improvements in overall energy performance. This means that it is necessary to consider both demand and supply side combined. Therefore, one should begin with reducing the energy demand as much as possible, and then energy system should be chosen and designed to fit the low demand. This new energy planning design paradigm is based on the "trias energetica" principle, proposed by Novem in the Netherlands (Lysen, 1996). There are three steps in Trias Energetica as follows:

1) Reduce the energy demand, by applying energy-efficient technologies.
2) Use renewable energy sources as much as possible.
3) Apply fossil fuels in the cleanest possible way.

In order to adopt this principle in several low-energy dwelling projects in Norway, the Kyoto pyramid is proposed as shown in following figure. This approach is composed of 5 steps, 4 steps for energy demand and one step for energy supply.

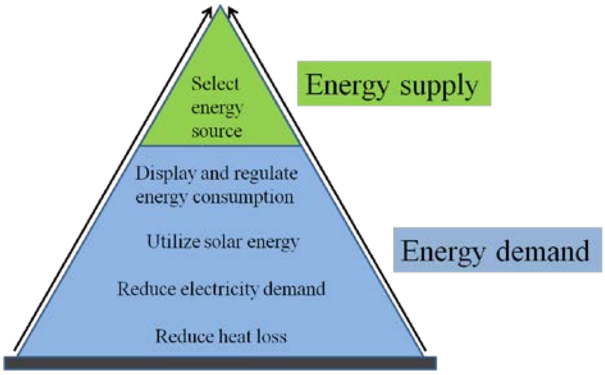


Figure 4.5: The Kyoto pyramid for design of low energy dwelling, taken from SINTEF (2007).

1. Reduce heat loss

- Extra insulated building fabric
- Super insulated windows
- Minimize thermal bridges and air leakage
- Exposed thermal mass in floor and ceiling
- Balanced ventilation with heat recovery

2. Reduce electricity demand

- Reduced energy demand for DHW (Domestic Hot Water)
- Minimize water consumption, better insulated reservoir and pipes
- Low energy lighting
- Low energy appliance

3. Utilize solar energy

- Passive solar orientation of the building and the windows arrangement

4. Display and regulate energy consumption

- A user-friendly information system

5. Select energy source (Energy supply)

- Choose the type of energy source depending on local conditions

Green building implementation

During the Eco-City project in Helsingør and Helsingborg, about 598 new eco-dwellings in total 74,820 m^2 are established with a saving of 25-30% in energy consumption. Also, approximately 584 dwellings in total 64,380 m^2 are eco-rehabilitated for high energy efficiency. In addition, 33,923 m^2 public buildings are included in eco-rehabilitation. The following buildings are examples of eco-dwellings built in Helsingborg (CONCERTO, 2013).

1) Maria Sofia 1-2 (Source: Eco-City, 2013b)

Table 4.7: Project information and list of ECO-technologies applied in Maria Sofia 1-2.

	Maria Sofia 1-2
Project type	New eco-light dwellings
End construction year	2008
Building type	Appartment row housed
Dwellings	69
Storeys	2
Persons in buildings	219
Gross area	7098 m^2
Net area	5675 m^2
Heated area	5879 m^2
Window/door area	1192 m^2

Special ECO-technologies applied:
• Optimisation of window type • Thermal bridges avoided • Increased insulation • Ventilation with heat recovery • Pipe/valve insulation on heating • DHW pipes + boiler room • Water saving fixtures • Demand controlled circulation • Central control system

Figure 4.6: Views of the green building, Maria Sofia 1-2.

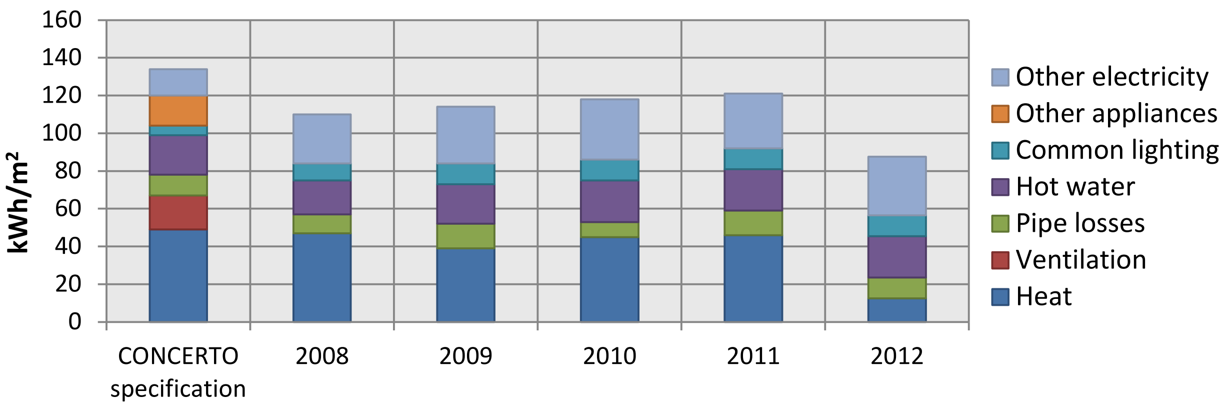


Figure 4.7: Energy specification and consumption.

2) Fronten (Source: Eco-City, 2013b)

Table 4.8: Project infomation and list of ECO-technologies applied in Fronten.

	Fronten
Project type	New eco-light dwellings
End construction year	2008
Building type	Multi family house
Dwellings	50
Storeys	14
Persons in buildings	119
Gross area	4591 m^2
Net area	3349 m^2
Heated area	4080 m^2
Window/door area	466 m^2

Special ECO-technologies applied:
• Optimisation of window type • Thermal bridges avoided • Increased insulation • Ventilation with heat recovery • Pipe/valve insulation on heating • DHW pipes + boiler room • Water saving fixtures • Demand controlled circulation • Individual metering • Heat pump

Figure 4.8: Views of the green building, Fronten.

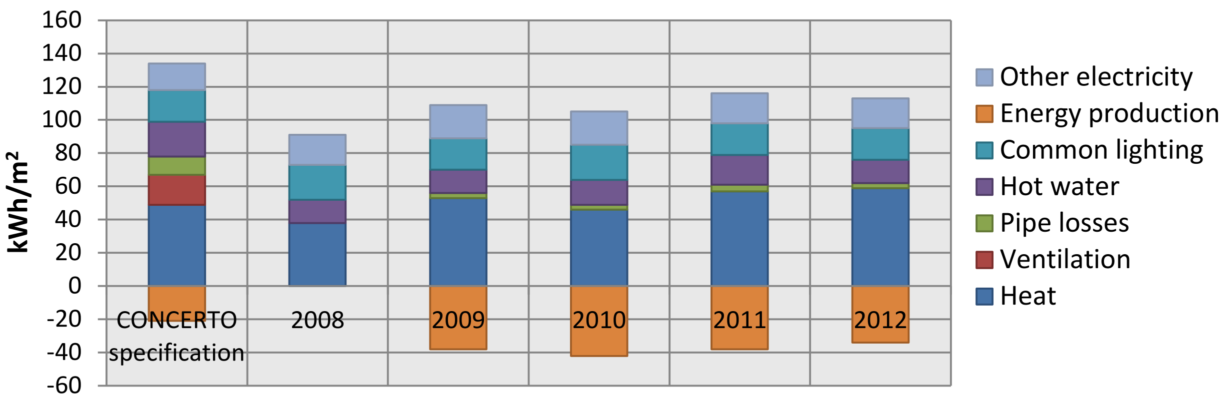


Figure 4.9: Energy specification and consumption.

Tianjin Eco-City

Buildings are major energy consumer in China. In 2006, buildings contributed more than 25 percent of China’s total energy use. Nearly half the world's new buildings are built in China each year. Buildings are projected to account for 40 percent of the country's total energy consumption by 2020 (CSY, 2009).

According to the KPIs, 100 percent of the buildings in the Eco-City will be green buildings in line with the Evaluation Standard for Green Building (GBES), which is based on green building practices in both China and Singapore, and aims to be more systematic, advanced, practical, and instructional.

Model of Green Building in Tianjin Eco-City: Tianjin Eco-City, all the buildings are green buildings based on GBES incorporating techniques like renewable energy, water saving, green material, ventilation and waste management to minimize the energy consumption and GHG emissions. The model of Green Building in Tianjin Eco-City is suggested to incorporate the following systems.

Figure 4.10: Model of Green Building in Tianjin Eco-City. (Source: Website of Tianjin Eco-City in Chinese, http://www.Eco-City.gov.cn/eco/html/zjstc/ztgh.html)

1) Roof green coverage
2) Underground garage natural ventilation
3) Radiant floor heating
4) Rain water harvesting
5) Vacuum powered recycling system
6) barrier free design
7) Central ventilation system
8) Heat insulation wall
9) Elevator natural ventilation

10) VVVF elevator motor
11) Solar water heating
12) Proper area ratio of window to wall
13) Solar light
14) The architectural layout meet the requirements for indoor and outdoor sunshine
15) Indigenous plants adapted to a local climate and soil condition
16) Water saving apparatuses and appliances
17) The broken bridge aluminum alloy doors and windows
18) Recyclable building material (Tianjin Eco-City, 2009)

Current Progress on Green Building: The buildings are in line with the SSTEC GBES. In the Start-Up area, there are 13 residential communities accounting for a total floor area of 1,600,000 m^2 (Tianjin Binhai Express, 2013). A national industrial district for animation with an area of 1 km^2 is also established. Other buildings like shopping center, schools and public services are also constructed and operating. As shown in the Figure 4.11, the buildings in the Tianjin Eco-City include:

Figure 4.11: Green buildings in Tianjing Eco-City start-up area (*Baidu Maps*).

Residential buildings:

A. Yuanxiong residential community; B. Shimao Eco-residential community; C. Chengpin residential community; D. Hechang residential community; E. Jijing residential community; F. Meilin residential community; G. Hongshuwan residential community; H. Jingshan residential community; I. Tianfang residential community; J. Wantong Eco-residential community; K. Wanke residential community; L. Ayalayajin residential community; M. Residential community for city constructor;

Public buildings:

N. The Hilton-shimao hotel; O. Tianjin Foreign Studies University Binhai School; P. Industrial district for animation; Q. Hi-tech district; R. Public service center.

As of August of 2013, more than 4,000 residents have already moved into the districts, which are almost completed. Furthermore, around 5,000 apartments have been sold (Tianjin Chengshi Express, 2013).

Comparison on green building

Buildings are major energy users in both Helsingborg and Tianjin Eco-City. Hence, in order to reach the objectives of coastal Eco-City, both Helsingborg and Tianjin Eco-City put great effort on the implementation of green buildings which can reduce energy demand, maximize the use of renewable energy sources and use fossil fuels in the cleanest possible way.

However due to different geological locations, environmental conditions, demands of residents, regional regulations and building standards, the special eco technologies applied in the buildings maybe different. Hence, one stereotype building from each city is chosen to be compared. The building from Helsingborg is Fronten, a new eco-light dwelling. The one from Tianjin Eco-City is Hongshuwan residential building, also a new dwelling. The general information on the two buildings is shown in the following tables:

Figure 4.12: Residential building in Helsingborg (left) and Tianjin Eco-City (Rght).

Table 4.9: General information of the building.

Green Building	Fronten (Helsingborg)	Hongshuwan residential building (Tianjin Eco-City)
Project type	New eco-light dwellings	New dwellings
End construction year	2008	2011
Building type	Multi family house	Multi family house
Dwellings	50	90
Storeys	14	21
Persons in buildings	119	280
Gross area	4591 m^2	9000 m^2
Net area	3349 m^2	-
Heated area	4080 m^2	-
Window/door area	466 m^2	-

The special green technologies applied in the two buildings are shown as follow:

Table 4.10: special green technologies applied in the two buildings.

	Fronten (Helsingborg)	Hongshuwan residential building (Tianjin Eco-City)
Heating, Cooling and Hot water	Solar heat	Solar water heating
	Heat pump	Geothermal Heat Pump
	Increased insulation	Heat insulation wall
	Thermal bridges avoided	
	Ventilation with heat recovery	
	Pipe/valve insulation on heating	
	DHW pipes + boiler room	

Water	Water saving fixtures	Water saving apparatuses and appliances
		Rain water harvesting
Material	Optimisation of window type	Proper area ratio of window to wall, the broken bridge aluminum alloy doors and windows
		Recyclable building material
Monitoring System	Demand controlled circulation	
	Individual metering	

In the comparison, the special green techniques used in the building are divided into four categories: Heating, Cooling and Hot water, Water, Material and Monitoring System. From the comparison above, following conclusions can be drawn:

- In Heating, Cooling and Hot water section, heat pump and solar water heating is adopted in both cities, which is energy efficient and environmental friendly. Moreover, heat insulation techniques are widely used in both cities. In addition, in Helsingborg, intelligent techniques like ventilation heat recovery and DHW pipes are applied in heat insulation.
- For the water sector, water saving fixtures is adopted to save household water consumption in both cities. In Tianjin Eco-City, a rain water harvesting system is established in combination.
- For the material and building decoration, window optimization is conducted in both cities to provide sufficient natural sunlight and insulate heat loss. In Tianjin Eco-City, recyclable building materials are utilized.
- In Helsingborg, energy consumption monitoring system gives the inhabitants feedback on energy use and user habits.

4.2.2 Energy supply

Helsingborg

In Helsingborg, an energy system is used in effective and sustainable way. The energy used in Helsingborg comes from sustainable, renewable energy sources, e.g. biomass fuelled plant, heat pump system and so on. Energy utilization is also effective and efficient. There seems to be good collaboration on energy-related issues within the municipal authority.

Energy supply system

In Helsingborg, most of heating energy comes from the district heating system. About 78% of the household heating and warm water is produced using the district heating system as shown in the following table. The concept of district heating was implemented in 1964 as the city's main energy system. An aim of this district heating project was to replace the small fossil fuelled decentralized heating systems with a large state of the art centralized power plant (Öresundskraft, 2011).

Table 4.11: Household heating in Helsingborg at 2004, taken from Öresundskraft (2011).

	Amount (GWh)	Portion (%)
District Heating	730	78.49%
Electrical Heating	80	8.60%
Gas heaters	40	4.30%
Biofuelled heaters	20	2.15%
Oil heaters	60	6.45%
Total	930	100%

To comprise the district heating system, all available local energy sources are combined into the local energy system, together with a biomass fuelled main production plant. This highly complex production system is efficiently managed and balanced with minimum environmental impact (Öresundskraft, 2011).

The district heating system is composed by:

- Waste heat from local industry
- Local landfill gas fuelled boiler
- Heat pumps in sewage purification tank
- Cogeneration power plant that uses 100% bio fuel (wooden pellets)
- Peak load unit (CHP gas turbine)

Table 4.12: Composition of district heating production unit, taken from Öresundskraft (2011).

	Amount (MW)	Portion
Waste heat from local industry	40	14.81%
Landfill gas fuelled boiler	9	3.33%
Heat pumps in sewage purification tank	30	11.11%
Cogeneration power plant	138	51.11%
Combined heat and power gas turbine (peak load unit)	53	19.63%
Total	270	100%

(a) Waste heat from local industry

(b) Cogeneration power plant

(c) Heat pumps in sewage purification tank

(d) Landfill gas fuelled boiler

Figure 4.13: Views of district heating production unit, taken from Öresundskraft (2011).

In order to operate this district heating system, 98% bio fuel and only 2% fossil fuel are used. It is the largest district heating system in Sweden with low dependency of fossil fuel.

Biogas plant in Helsingborg

Main purpose of biogas plant is to treat various organic wastes that are unsuitable for landfill. The biogas plant in Helsingborg is designed to accept up to 80,000 tonnes organic waste per year of different source, including waste that can be pumped, source-sorted compressed food waste and packaged foods. To ensure a constant supply to the biogas plant, contracts have been drawn up with local farmers and food manufacturers. The following figure and table shows views and information of biogas plant in Helsingborg (Baltic Biogas Bus, 2012a).

Figure 4.14: Views of biogas plant in Helsingborg, taken from Eco-City (2013).

Table 4.13: Basic information on the biogas plant in Helsingborg, taken from Baltic Biogas Bus (2012a).

	Biogas plant
Start year (biogas production)	1996
Digester volume	2 x 3,000 m^3, 1 x 1,000 m3
Process temperature	37°C
Start year (upgrading)	1997, 2002 and 2007
Upgrading method	PSA and Water wash
Total investment costs	120 million SEK
Substrate	
Source-sorted organic food wastes	5,600 tonnes
Pig manure	3,400 tonnes
Process wastes from food industry	35,200 tonnes
Biogas	
From the biogas plant	23,000 MWh
Upgraded biogas	12,000 MWh
Bio-manure	
Total bio-manure	44,000 tonnes
Bio-manure in pipeline	20,000 tonnes

Energy strategy and energy plan

The energy strategy is an important element to meet the city's objectives and visions. The vision of Helsingborg is that Helsingborg shall be Sweden's most attractive city for people and companies. An energy plan has a key role to play to satisfy the city's visions. The main purpose of the energy strategy and the energy plan is to set up the direction for an energy shift in more sustainable way. Furthermore, increased collaboration within the municipal authority is sought. Table 4.14, depicts a specific energy plan (Helsingborg, 2013).

Table 4.14: Specifications of energy strategy and energy plan, taken from Helsingborg (2013).

1) District heating and district cooling
Objectives for 2035
1. No fossil fuels are used to supply electricity, district heating or district cooling.
2. In the first instance, sun protection and corresponding methods shall be used to reduce the heat in premises. If there is any additional need for comfort cooling, the choice of technical solution shall be based on environmental and climate performance.
3. Waste heat is used to supply district heating and district cooling as far as is technically and financially possible and also justified in terms of the environment and health.
Interim objectives before 2020
4. District cooling supplies only use non-fossil fuels and electricity from renewable energy sources in 2010.
5. Waste heat is used to supply district heating as far as financially possible.
2) Wind power and wave power
Objectives for 2035
1. Energy from wind power and wave power totals at least 240GWh per annum.
Interim objectives by 2020
2. Energy from wind power and wave power totals at least 60GWh by 2020.
Interim objectives before 2020
3. By 2012 at the latest, we know the potential for renewable energy that exists within the municipal region.
3) Solar energy
Objectives for 2035
1. Energy from solar panels for heating and hot water totals at least 15GWh per annum.
2. Energy from solar cells to supply electricity increases and the installed production output is at least 2.5MW.
Interim objectives by 2020
3. In 2020 energy from solar panels totals at least 3GWh per annum.
4. In 2020 energy from solar cells totals at least 0.5GWh per annum.
Interim objectives before 2020

5. By 2012 at the latest, we know the potential for renewable energy that exists within the municipal region.
4) Biogas and biomethane
Objectives for 2035
1. The production of biogas and biomethane totals at least 314GWh per annum.
Interim objectives by 2020
2. Production capacity is increased to at least 84GWh biogas by 2020.
5) Security of supply – electricity and heating
Objectives for 2035
1. At least 600GWh electrical energy is produced per annum.
2. At least 1000GWh heating energy is supplied to the district heating network in Helsingborg per annum.
Interim objectives
3. In 2020, at least 935GWh heating energy is supplied to the district heating network in Helsingborg per annum.
3. See sections on wind power and wave power, solar energy and biogas.
6) Energy utilisation
Objectives for 2035
1. No firing of fossil fuels for heating takes place within the Municipality's boundary.
2. The industrial, service and transport sectors jointly reduce their use of energy by at least 30% from the level in 2005.
3. The use of purchased energy per inhabitant is a maximum of 25MWh per annum. (This objective represents a reduction of approximately 30% from the level in 2005 and applies to total energy utilization)
Interim objectives by 2020
4. The use of fuel oil of fossil origin is phased out completely among business operators within the Environment Board's supervisory area by the end of 2020 at the latest.
5. The use of other fossil oil within industry shall have fallen by at least 50% by 2020 from the level in 2005.
6. The industrial, service and transport sectors jointly have reduced their use of energy by at least 15% from the level in 2005.
7. The use of energy per inhabitant shall be a maximum of 30 MWh per annum in 2020, representing a fall of approximately 15% from the level in 2005.
Interim objectives before 2020
8. Issues relating to energy are a specially prioritized element of the Environment Board's supervision of environmentally hazardous businesses. All businesses that are subject to registration or permit obligations under the Swedish Environmental Code and that fall within the Board's supervisory area will have been visited by the end of 2011 at the latest in this context.

Tianjin Eco-City

Tianjin Eco-City relies on green energy. Its energy supply strategy is based on a combination of conventional more energy-efficient technologies (e.g. CHP) and non-conventional technologies (e.g. geothermal, heat pumps, solar water heaters). According to the KPIs of Tianjin Eco-City, 20% of the energy supply should come from renewable energy sources by 2020. Additional quantitative objectives on energy saving from heating, renewable energy use and solar energy application are also developed, as shown in the following table. In order to achieve this goal, the Eco-City has actively promoted the establishment of wind, solar and biomass energy projects.

Table 4.15: Additional quantitative objectives on energy supply taken from World Bank, (2009).

Indicator	Indicative Value
Heating energy saving of residential buildings	≥ 70% (compared the current Tianjin standard of 65%)
Heating/cooling energy saving of public buildings	≥ 55% (compared with the current Tianjin standard of 50%)
Renewable energy usage in heating/cooling systems	≥40% of building floor area
Solar energy usage in hot water system	≥ 80% of building floor area
Solar energy usage in road/landscape lighting system	≥ 90%
Natural gas usage in residential and public buildings	100% of buildings

Space Heating

Space heating accounts for the largest parts of energy use in buildings. The strategy of the Tianjin Eco-City heat plan is to utilize waste heat from the CHP plants, to adopt renewable energy, and to improve system efficiency.

All buildings in Tianjin Eco-City will be covered by central heating. The projected heat load of Tianjin Eco-City in 2020 is about 800 MW. This is based on the residential building load of 38W/m^2 and the public/industrial building load of 50W/m^2 as shown in table 4.16.Of the total heat load, 75.49 percent will be covered through a district heating network supported by two external coal and gas-fired CHP plants. The remaining 24.51 percent of the total heat load will be provided by distributed systems with internal sources in Tianjin Eco-City, including renewable energy, such as geothermal and heat pumps, and tri-gen (electricity, heating, and cooling) systems (world bank, 2009). Sources, types and capacity of heating system of Tianjin Eco-City are shown in table 4.17.

Table 4.16: Objectives of Heat Supply in Tianjin Eco-City taken from World Bank, 2009

Contents	Normal Practice	Tianjin Eco-City	Note
Coverage rate of heat supply (%)	/	100	All areas
Proportion of heat supply by renewable energy (%)	/	15	Geothermal energy, heat pump, solar energy, etc.
Building Design Heat Load (W/m^2)			All buildings should meet the energy-saving requirements.
Residential	55	38	
Public	70	50	
Industrial	70	50	
Network loss (%)	5	2	Hot water network
Utilization rate of condensed water (%)	/	100	-

Table 4.17: Sources, Types and Capacity of Heating System of Tianjin Eco-City, taken from World Bank (2009).

Heat source			Heating Area ($1000m^2$)			Proportion (%)
			2010	2015	2020	
External	Steam of power plant	Beitang Heat-Power Plant	0	2190	7320	62.93
		Beijiang Power Plant	2640	2950	2950	
		Subtotal	2640	5140	10270	
	Waste heat of power plants	Beitant Heat-Power Plant	0	440	1460	12.56
		Beijiang Power Plant	530	590	590	
		Subtotal	530	1030	2050	
	Subtotal		3170	6170	12320	75.49
Internal	Renewable energy	Geothermal	220	220	600	22.67
		Water-source heat pumps	300	300	600	
		Sewage-source heat pumps	490	590	920	
		Ground-source heat pumps	800	1160	1500	
		Road energy system	80	80	80	
		Subtotal	1890	2350	3700	
	Electricity, heating/cooling tri-generation system/gas		200	300	300	1.84
	Subtotal		2090	2650	4000	24.51
Total			5260	8820	16320	100

Geothermal: Currently in Tianjin, geothermal is selected as the principal type of renewable central heating and cooling system to be used. The noiseless system, which also avoids the creation of a heat island around its equipment, uses the earth as a heat source in the winter and as a heat sink in the summer. According to Nanjing-Shanglong Communications, the 2011–2015 Tianjin Geothermal Resource Plan projects 45 million m^3 of geothermal fluids to be exploited across the city by 2015. As of the end of 2011, Tianjin was home to 349 geothermal wells with a total annual yield of 29.8 million m^3 of geothermal fluid. And they are the energy source for 5% of the city's central heating systems (Green Prospects Asia, 2012).

Figure 4.15: Geo-thermal heating system in Tianjin Eco-City (Source: Website of Tianjin Eco-City in Chinese, http://www.Eco-City.gov.cn/eco/html/zjstc/ztgh.html).

The planed geothermal energy plant in Tianjin Eco-City will provide 20MW of cooling in the summer and 14MW of heat in the winter, plus an electrical energy output of 1.5MW (Grogan, 2013).

Solar hot water system: Solar powered hot water will play a major role in achieving the renewable target. 60 percent of residential hot water supply will use solar water heaters, with a solar collector area of 320,000 m^2 providing about 1.85 million MJ of heat, equivalent to annual savings of 49,000 tonnes of standard coal (World Bank, 2009).

Electricity Supply

Apart from the electricity from the National Grid, the Tianjin Eco-City is planning on using the electricity generated by solar panel and wind turbine.

Until the end of 2013, after the finish of two solar power plants, there will be totally 6 solar power plants and 1 wind farm operating in the Tianjin Eco-City. The renewable energy will account for a capacity of 17.8 MW, about an annual electricity output of 19 GWh which can supply for about 8000 houses a year.

Figure 4.16: location of renewable power plants in Tianjin Eco-City (*Google Maps*).

The location of the existing renewable power plants is shown in the Figure 4.17.

A. Northern solar power plant I;

B. Northern solar power plant II;

C. Animation building solar power plant;

D. Car park solar power plant;

E. Zhongyang Ave. solar power plant;

F. Wastewater treatment plant solar power plant;

G. Wind turbine farm (4.3MW);

Figure 4.17: Renewable power plants and solar lighting, taken from
http://www.tianjinecocity.gov.sg/gal.htm.

Also in Tianjin Eco-City, over 700 street lights has been installed, running on a combination of solar and wind to provide a constant power during cloudy or clear days. Furthermore, the system will provide 60 percent of street and landscape lighting.

Comparison on energy supply

The energy supply strategy of Tianjin Eco-City is based on a mix of fossil fuels and renewable energy, to prioritize renewable energy. Helsingborg also has its own energy supply strategy. All available local energy initiatives (waste heat, sewage, land fill) are integrated into the local energy system together with a large scale cogeneration plant.

Objectives on energy supply of Helsingborg and Tianjin Eco-City differ as shown in the following tables.

From the objectives on energy supply of both cities, several conclusions can be drawn:

- Both cities focus on the implementation of renewable energy, and at the same time get rid of energy from the fossil fuel;
- Tianjin Eco-City put a lot effort on the development of wind farm and solar plant, while Helsingborg focuses much on energy from Biogas and Bio-methane.

Table 4.18: Objectives on energy supply of Helsingborg.

	Immediate	By 2020	By 2035
District heating and district cooling	-	No fossil fuels for cooling Waste heat	No fossil fuels for electricity, heating and cooling Waste heat
Wind and wave power	-	>60GWh/year	>240GWh/year
Solar energy	-	Energy from Solar panels and cells > 3.5GWh/year	solar panels for heating and hot water > 15GWh/year solar cells to supply electricity > 2.5MW
Biogas and biomethane	-	>84GWh	>314GWh
Security of supply	-	>935GWh for heating	>600GWh for electricity >1000GWh for heating
Energy utilization	-	industrial, service and transport sectors energy usage decrease 15% energy per inhabitant decreases 15% from the level of 2005 and < 30MWh/year	industrial, service and transport sectors energy usage decrease 15% energy per inhabitant decreases 30% from the level of 2005 and < 25MWh/year

For space heating, the sources of heating system in Tianjin and Helsingborg differ from each other as shown in the following table.

Table 4.19: Objectives on energy supply of Tianjin Eco-City.

	Immediate	By 2020
District heating and district cooling	-	Renewable energy usage >40% of floor area
Wind and wave power	Wind farm 4.3MW	-
Solar energy	6 solar power plants 13.5MW Solar hot water 60% of hot water supply	Solar energy in hot water system >80% of floor area Solar energy in road lighting system >90%
Biogas and biomethane	-	-
Security of supply	-	-
Energy utilization	-	Heating energy saving of residential buildings >70% Heating energy saving of public buildings >55%

From these table and graphs certain things are identified;

- In Tianjin Eco-City, more than 70% of heating energy comes from the centralized power plant while in Helsingborg, 50% of heating energy comes from power plant and 35% comes from decentralized energy sources like combined heat and power gas turbine, electrical, gas and oil heating.
- Other things should be noticed is the fuel used in heat and power plant. In Tianjin Eco-City, the main fuel of power plant is fossil fuel like coal and natural gas while wooden pallets are used in Helsingborg power plant.
- The portion of renewable energy in Tianjin Eco-City is larger than Helsingborg.

Table 4.20: Comparison on the source of heating system in Tianjin and Helsingborg

<table>
<tr><th colspan="2"></th><th>Tianjin Eco-City</th><th>Helsingborg</th></tr>
<tr><td colspan="2">Heat and power plant</td><td>62.93%</td><td>40.12%</td></tr>
<tr><td colspan="2">Waste heat from power plants and local industries</td><td>12.56%</td><td>11.63%</td></tr>
<tr><td colspan="2">Combined heat and power gas turbine</td><td>0%</td><td>15.41%</td></tr>
<tr><td rowspan="7">Renewable energy</td><td>Geothermal (Tianjin)</td><td rowspan="7">22.67%</td><td rowspan="7">13.49%</td></tr>
<tr><td>Water-source heat pumps (Tianjin)</td></tr>
<tr><td>Sewage-source heat pumps (Tianjin, Helsingborg)</td></tr>
<tr><td>Ground-source heat pumps (Tianjin)</td></tr>
<tr><td>Road energy system (Tianjin)</td></tr>
<tr><td>Biofuelled power plant (Helsingborg)</td></tr>
<tr><td>Landfill gas fueled plant (Helsingborg)</td></tr>
<tr><td colspan="2">Electrical, gas and oil heating</td><td>1.84%</td><td>19.35%</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td></tr>
</table>

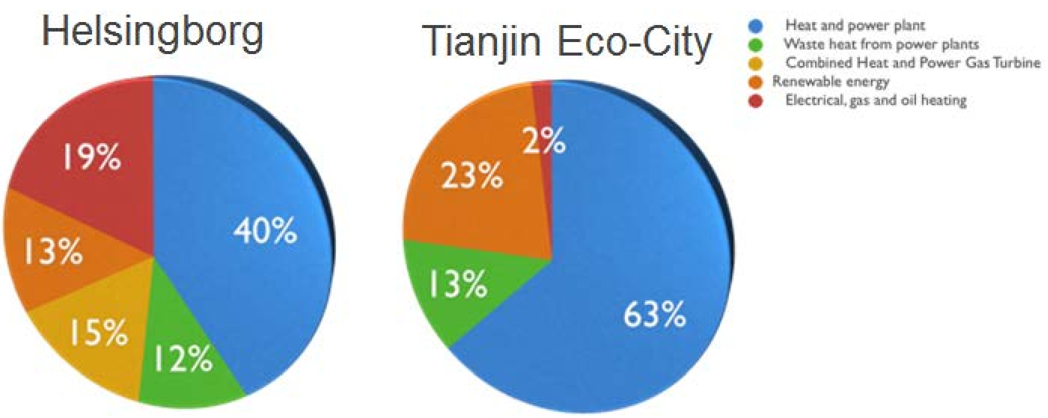


Figure 4.18: Comparison on the source of heating system in Tianjin and Helsingborg.

4.2.3 Waste management

Helsingborg

Waste management is prioritized according to following waste hierarchy:

1) Prevention
2) Preparation for reuse
3) Reuse
4) Recycling
5) Other recycling, e.g. waste-to-energy
6) Disposal

The Swedish government implemented a set of new objectives related with waste management in May 2012.

- The objective of greater economisation of resources in the food chain requires by 2018. Implementation of measures to ensure that resource economisation in the food chain manifests itself by at least 50 % of food waste from households, large-scale kitchens, stores and restaurants being separated and treated biologically to recover plant nutrients, and by at least 40 % being treated to recover energy.
- The objective regarding construction and demolition waste requires the implementation by 2020 of measures aimed at ensuring that the preparation for reuse and material recycling and other material utilisation of non-hazardous construction and demolition waste is at least 70% in weight (AVFALL SVERIGE, 2012).

In Sweden, there are four waste treatment methods; material recycling, biological treatment, waste-to-energy, and landfill. The material recycling includes paper, scrap metal, waste from electrical and electronic equipment (WEEE) and batteries, etc. and it reduces their environmental impact, saves energy and natural resources. In biological treatment, bio-waste is treated as anaerobic digestion or composting. Anaerobic digestion produces biogas which is used as energy generation fuel and vehicle fuel. Composting produces fertilizer which can be used as soil improver. Waste-to-energy recovery is an efficient and environmentally-friendly method for recovering energy from waste by incinerating waste. Waste-to-energy is suitable for waste, which cannot be recycled in any other way. Landfill treats waste that cannot be recycled. In that case, waste is stored in landfill land in a safe and proper manner, and this treatment method is controlled by a strict regulation. The following table and figure shows the amount of waste treated by each method in Sweden. As shown in the figure, the amount of waste treated by landfill decreases while the amount of waste treated by the others steadily increases (AVFALL SVERIGE, 2012).

Table 4.21: Treated volumes of household waste in Sweden, 2007-2012 (tonnes), taken from AVFALL SVERIGE (2012).

	2007	2008	2009	2010	2011	2012
Material recycling	1,591,180	1,520,470	1,604,400	1,414,410	1,425,690	1,422,250
Biological treatment	561,300	597,280	617,680	623,200	650,300	673,180
Waste-to-energy	2,190,980	2,292,970	2,173,000	2,123,680	2,235,720	2,270,650
Landfill	186,490	140,250	63,000	42,000	38,200	32,600
Total treated volumes	4,529,950	4,550,970	4,458,080	4,203,290	4,349,910	4,398,680

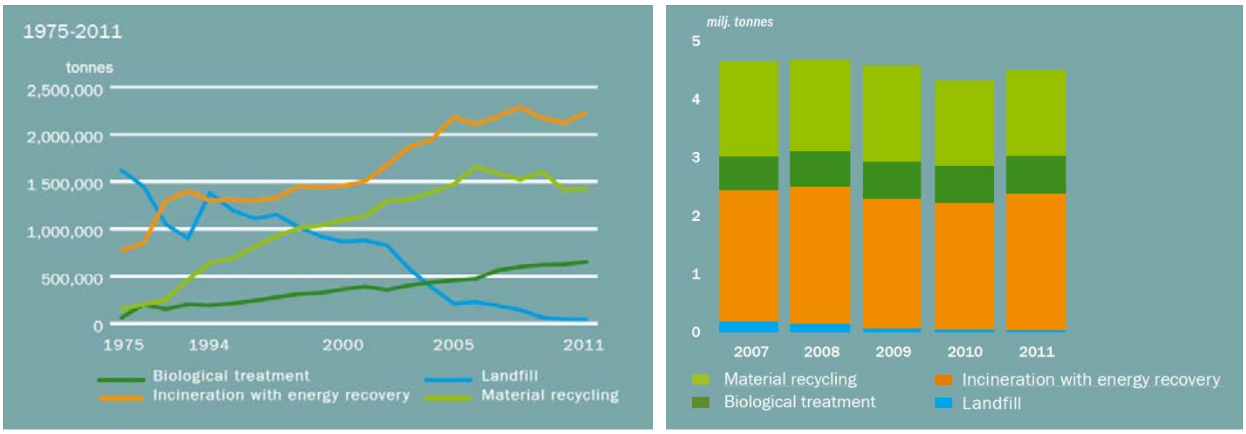


Figure 4.19: Treated volumes of household waste in Sweden, taken from AVFALL SVERIGE (2012).

Collection and Transport

The household waste in bins is collected as a mixed fraction - one for food waste and one for combustible waste. In order to collect source-separated waste, multi-compartment bin is used, one for bio-waste and one for combustible waste. These waste bins are regularly emptied by using the multi-compartmented vehicles. These days, automated systems such as refuse vacuum systems and underground container systems are used to collect waste. These systems do not require heavy manual handling.

(a) Waste collection vehicles (b) Multi-compartment bin

Figure 4.20: Waste collection method, taken from Gille (2012).

Tianjing Eco-City

The waste management system in Tianjin Eco-City is an integrated comprehensive one including conventional technology (e.g., waste segregation, landfill) and non-conventional technologies (e.g., Pneumatic Collection System, Aerobic Composting).

The Key Performance Indicators (KPIs) for the waste management of Tianjin Eco-City include:

- Per capita domestic waste generation: 0.8kg
- Overall solid waste recycling rate: larger than 60%
- Treatment to render hazardous waste non-toxic: 100%

The overview of waste management plan in Tianjin Eco-City is shown in the following diagram:

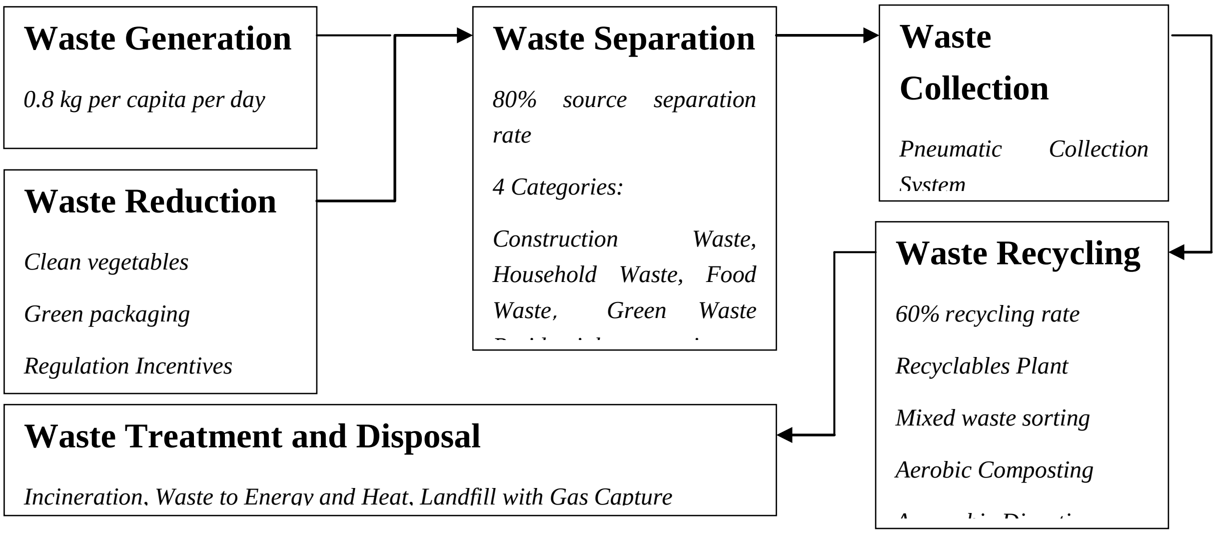


Figure 4.21: Overview of waste management plan in Tianjin Eco-City.

Waste Generation: According to KPIs on solid waste, the net waste generation rate should be less than 0.8 per capita per day by the year 2020. And the forecast net waste generation rate is shown in the table 4.22.

Waste Reduction: In Tianjin Eco-City, waste reduction measures are undertaken to reduce the waste discarded. These measures include:

- Clean Vegetables: vegetables sold will be processed into prepared foods
- Green Packaging: merchants aren't permitted to offer a 'free' plastic bag for client purchases

The waste reduction measures could be implemented through regulations and financial incentives. If the waste reduction measures are implemented, the forecasted net generation rate should fall by about 25 percent in 2015, and again in 2020.

Table 4.22: Forecasted Net Generation Rates in Tianjin Eco-City 2010-2020 taken from World bank (2009).

Year	Permanent Population	Net Generation Rate (kg/capita/day)	Net Waste Quantities (tonnes / day)	Net Generation Rate With Waste Reduction (kg/capita/day)	Net Waste Quantities With Waste Reduction (tonnes/day)
2015	50,000	1.17	58.5	0.88	44
2020	350,000	0.81	431	0.62	330

Waste Composition: China's waste composition profile has traditionally varied among areas using coal for cooking and home heating, and areas using gas. In 2003, food and organic waste represented about 57 percent of Tianjin's municipal solid waste. In comparison, it is expected that in the Eco-City the share of food and organic waste will be 52 percent in 2015.

Table 4.23: Waste Composition, China and Tianjin (World Bank, 2009).

Material	Urban MSW China Using Coal	Urban MSW China Using Gas	Urban MSW China	Tianjin	Eco-City With Implementation of Waste Reduction, 2015
Food/Organics	41%	65%	51%	56.9%	51.8%
Paper	5%	9%	15%	8.7%	14.4%
Wood	-	-	-	1.9%	2.80%
Metals	1%	1%	2%	0.4%	0.9%
Glass	2%	2%	3%	1.3%	4.4%
Plastics	4%	13%	14%	12.1%	11.2%
Textiles	-	-	-	2.5%	4.3%
Miscellaneous, ash and other	47%	10%	15%	16.2%	10.2%

Waste Segregation: In Tianjin Eco-City, a source segregation rate of 80 percent is required. To achieve the goal, the waste in the Eco-City is separated into 4 categories: Construction Waste, Household Waste, Food Waste and Green Waste (Tianjin Daily, 2013).

The construction waste includes ash, metal, wood and others. Ash is used for landfill, while metal and wood are recycled. Others are incinerated for energy and heat. The green waste is used as feedstock for aerobic composting. The end product of composting is a soil conditioner that provides benefits to agricultural soils. The food waste recovered from the Eco-City is sent to a food waste aerobic microbial digester located at Zhongjin Avenue. In the treatment plant, 90% of the food waste is digested while the remaining 10% can be used as soil conditioner. The treatment plant has a capacity of handling 700kg of food waste per day (Tianjin Morning Post, 2013).

Figure 4.22: Recycling Bins (left) and food waste digestion plant in Tianjin Eco-City (right), taken from www.tjbhnews.com , http://www.Eco-City.gov.cn/eco/html/xwzx/tuxw/20130723/9043.html)

Furthermore, the household waste is separated into 3 categories with 3 symbol colors: recyclable waste (Blue), kitchen waste (Green), other waste (Grey). To ensure an effective source waste segregation, each community has an inspector in charge of re-sorting the waste in the wrong categories, educating residents and business on the value of separating waste for recycling and monitoring the implementation of source waste segregation. Also regulations and financial incentives are implemented to encourage source waste segregation of local residents and business.

Waste Collection: A Pneumatic Collection System is introduced to waste collection of Tianjin Eco-City. It is an underground piping network with pneumatic pressure to transport waste from residential and commercial facilities to consolidation point.

The way it works is described below (STSE, 2012): Waste is sorted into two categories, dry (e.g., plastic, paper, ash), and moisture (e.g., food). Dry and moisture waste are disposed in separate hoppers installed in the residences, common hoppers or outdoor drop off points. The waste will be temporarily stored in the storage area above the discharge valve. Exhausters create a suction pressure and air flow in the pipeline. The discharge valve is opened and the waste drops to the main line. The air stream transports the waste to the collection station center. The waste drops into refuse containers via cyclone, the air separator. Refuse containers will be transported by trucks to dumping grounds, incineration plants, etc. The exhaust air will pass through the Dust and Odor Filtration before being discharged into the atmosphere.

Figure 4.23: Peumatic Waste Collection System, taken from http://www.stse.com.sg/en/pdf/PWCS%20Catalogue.pdf.

In the Start-up area of Tianjin Eco-City the public pipeline and infrastructure of the Pneumatic Collection System has been laid and established. The system contains 4 similar sub-systems, and each sub-system consists of public pipeline, household pipeline and collection station. When completed, it will have a waste collection capacity of 87 tonnes per day, cover an area of 7.8 km^2, and provide waste collection service for 100,000 residents. The public pipeline and collection station are fully invested by governmental funds with a total investment of about 150 million RMB (China Daily, 2011).

Figure 4.24: Pneumatic Waste Collection System In Tianjin Eco-City, taken from http://www.tianjinwe.com/tianjin/tjyw; http://img.soufun.com/news/2011_07/29/news/1311929289172_000.png

By the end of 2012, all the public pipeline and collection stations were finished, and almost 1/3 of the household pipeline was under construction. Concurrently almost all the public buildings are using the Pneumatic Collection System. And some residential buildings including Meilin residential community, Jingshan residential community, and shimao Eco-residential community are equipped with household pipeline for the Pneumatic Collection System (China Daily, 2011). In the Jingshan residential community, the household pipeline is expanded to every floor of the building. However, the residents living in a building with pneumatic collection system may be charged extra for the use of this system.

The benefits of the Pneumatic Collection System include: (STSE, 2012)

- "Enclosed System" - improves hygiene standards
- Automated Processing System - increases efficiency, reduces manpower input
- High safety and security standard
- Gross Floor Area savings
- Less garbage truck and bins and improve city image, create pleasant surrounding
- Less noise
- Adaptable for food waste, recycling collection, and hospitals

The main disadvantages relative are high capital investment costs, inconveniences during construction, and possible blockages in the piping network and at collection points.

Waste Recycling: According to KPIs, the recycling and source segregation rates are expected to be 60% and 80% respectively. Given that the world highest recycling rate (on country basis) of 52% in Switzerland, the objectives are highly ambitious.

Table 4.24 Recycling rate taken from World Bank (2009).

Country	Switzerland	Austria	Germany	Netherlands	Norway
Recycling Rate	52%	50%	48%	46%	40%

Therefore, to achieve the goal on waste recycling in Tianjin Eco-City, several measures are undertaken along the whole process of waste management.

- ***Source waste segregation***: the solid waste in the Eco-City is separated into 4 categories: Construction Waste, Household Waste, Food Waste and Green Waste. The Household Waste is separated into 3 categories: Recyclable Waste, Kitchen Waste, and Other Waste.
- ***Waste recyclables re-sorting center***: To ensure the high source waste segregation rate, each community has a waste resorting center with an inspector in charge of re-sorting the waste in the wrong categories.
- ***Aerobic composting/aerobic microbial digester***: The green waste is used as feedstock for aerobic composting. The end product of composting is a soil

conditioner that provides benefits to agricultural soils. The food waste is sent to a food waste aerobic microbial digester located at Zhongjin Avenue. In the treatment plant, 90% of the food waste is digested while the remaining 10% can be used as soil conditioner. The new treatment plant has a capacity of handling 700kg food waste per day (Yu, *et. al*., 2013).

Waste Treatment and Disposal: During waste recycle process, almost 60% of the waste including metal, wood in construction waste, green waste, food waste and recyclable kitchen waste in household are recycled. The waste that remains after recycling will be sent to an incineration facility or a landfill site. One incineration facility Hangu waste power plant (combined with a power and heat plant) is currently operating in Tianjin. The plant has a waste treating capacity of 1500t per day. It is equipped with 2 gas turbines with a power of 12MW each, and generates130MWh electricity per year. The air emission is purified base on EU 2000 air quality regulation (Tianjin Daily, 2009).

In addition, the Shuangkou landfill has a registered Clean Development Mechanism (CDM) project that captures methane gas generated from waste decomposition and uses it to generate electricity, which is then sold to the power grid (World Bank, 2009).

Comparison on waste management

As mentioned before, waste management is a highly integrated system incorporating processes like waste generation, segregation, recycle, treatment and disposal. To reach the goal of becoming a costal Eco-City, these two cities have their own objectives on waste management. The objectives of Helsingborg focus on food waste and construction waste, while the goals stated in KPI of Tianjin Eco-City focus on waste generation and waste recycle, as shown in the following table:

Table 4.25: Objectives of Helsingborg and Tianjin Eco-City

Helsingborg	Tianjin Eco-City: KPIs
- 50% of food waste in biological treatment, 40% in waste to energy by 2018 - Reuse and recycle of 70% construction and demolition waste by 2020	- Per capita domestic waste generation: 0.8kg - Overall solid waste recycling rate: larger than 60% - Treatment to render hazardous waste non-toxic: 100%

For both cities, the whole process of waste management is similar. However the specific techniques adopted in every process differ.

Both cities have their own waste prevention and reduction methods. Waste management in Sweden is focusing more and more on waste minimization and waste prevention. Waste minimization is a top priority and this philosophy is exemplified by the long term vision – "Zero Waste". This vision includes two long-term goals for 2020:

- To break the relationship between waste and growth
- To achieve clear, strong upward movement in the waste hierarchy.

In Tianjin Eco-City, more detailed waste reduction measures are taken including:

- Clean Vegetables: vegetables sold will be processed into prepared foods
- Green Packaging: merchants aren't permitted to offer a 'free' plastic bag for client purchases

During waste segregation, the household waste is normally sorted into several categories. And these cities have their own waste segregation system. In Tianjin Eco-City, the Household Waste is separated into 3 categories: Recyclable Waste, Kitchen Waste, Other Waste. While in Sweden, there are two categories: Bio-waste and Combustible waste. However, food waste is also put in an important role in both cities, because according to the waste components of each city, food waste accounts for almost half of the household waste, and they cannot be recycled directly.

Table 4.26: Waste composition of Helsingborg and Tianjin Eco-City.

<table>
<tr><th>Material</th><th>Tianjin</th><th>Tianjin Eco-City 2015</th><th>Helsingborg 2012 (estimated)</th></tr>
<tr><td>Food/Organics</td><td>56.9%</td><td>51.8%</td><td>41.11%</td></tr>
<tr><td>Paper</td><td>8.7%</td><td>14.4%</td><td>8.80%</td></tr>
<tr><td>Wood</td><td>1.9%</td><td>2.80%</td><td>3.41%</td></tr>
<tr><td>Metals</td><td>0.4%</td><td>0.9%</td><td rowspan="3">19.09%</td></tr>
<tr><td>Glass</td><td>1.3%</td><td>4.4%</td></tr>
<tr><td>Plastics</td><td>12.1%</td><td>11.2%</td></tr>
<tr><td>Textiles</td><td>2.5%</td><td>4.3%</td><td>1.04%</td></tr>
<tr><td>Miscellaneous, other</td><td>16.2%</td><td>10.2%</td><td>26.55%</td></tr>
</table>

Thus, to treat the food waste particularly, both cities utilize the biological treatment for food waste recycle. In Tianjin Eco-City, the food waste is sent to aerobic microbial digestion plant located at Zhongjin Avenue. In the plant, 90% of the food waste is digested while the remaining 10% can be used as soil conditioner. The new treatment plant has a capacity of handling 700kg food waste per day. In Helsingborg, anaerobic digestion and composting are used to produce biogas, which consists of methane and carbon dioxide. Almost 55% of the food waste is used for anaerobic digestion while 45% is used for anaerobic composting.

Figure 4.25: Food waste treatment plant in Tianjin and Biogas plant in Helsionborg, taken from www.chinadaily.com.cn/hqpl/zggc/2013-03-12/content_8475898.html; www.ecocity-project.eu/ProjectResults_HelsingorHelsingborg.html).

The two cities have different waste collection system. Helsingborg which is an old city, uses the traditional truck based collection system. Tianjin Eco-City is a newly built city so it established an innovative pneumatic collection system, which is an underground pipeline harnessing pneumatic pressure to transport waste from residential facilities to the consolidation point.

Table 4.27: Proportion of waste recycling and treatment.

		Helsingborg,2012	Tianjin Eco-City, Planed
Waste Recycled	Material recycling	32.33%	>60%
	Biological treatment	15.30%	
Waste Treated and disposed	Waste-to-energy	51.62%	<40%
	Landfill	0.74%	

For the waste recycle and treatment, both cities use methods like material recycling, biological treatment, waste-to-energy techniques and landfill. In Helsingborg the waste recycle rate is about 48% in 2012, while in Tianjin Eco-City the planned rate is 60%, which is quite ambitious. To achieve this goal, residents will need to be encouraged to separate waste. Municipal officials and non-government organizations (NGOs) should also be involved and regulation incentive policies should be enforced.

In Helsingborg, waste-to-energy accounts for large share in the waste treatment. So during waste segregation, combustible waste is separated from other waste as one category. However, there are concerns that waste-to-energy may generate more GHG emission and are not quite environmental friendly compare to recycling.

It is worthy to mention that the landfill part is very small because the enforcement of a much stricter EU landfill regulation set in 2008.

4.2.4 Transportation

Helsingborg

The city of Helsingborg has tried to improve the negative environmental impacts of traffic, e.g. emissions to air, noise pollution and congestion that affect the natural environment, public health and climate. The city has a major responsibility for planning correctly, encouraging and making it possible for citizens to use transportation in a sustainable way.

The result in 2009 for the target 'Less air pollution in Helsingborg' shows that the emission level of nitrogen dioxide met the Environmental Quality Standards by a mere margin. The city also managed to satisfy the relevant standards for sulphur dioxide, ozone and particles concentration in 2009. The County Administrative Board had developed a mandatory action plan for the period 2009-2012 in order to satisfy the environmental quality standards for sulphur dioxide in Helsingborg City. The plan incorporated tangible actions that reduced high volumes of traffic along the major streets. The traffic infrastructure was also improved by adopting better cycle paths and traffic lanes for public transport and green cars. Other major traffic routes implemented similar improvements such as new cycle paths, bus lanes, traffic signals and reduced speed limits. (Helsingborg, 2010)

The following table shows specifications of transportation plan for the period 2035.

Table 4.28: Specifications of transportation plan, taken from Helsingborg (2013)

1) Goods transport operations
Objectives for 2035
1. The number of goods transport operations using the road is lower than in 2005.
2. Greenhouse gas emissions from road traffic have fallen by at least 55% from the level in 2005. (This objective relates to both goods and personal travel operations.)
3. Freight logistics within the whole of Helsingborg is coordinated and efficient
Interim objectives by 2020
4. Greenhouse gas emissions from road traffic have fallen by at least 35% compared to 2005.
Interim objectives before 2020
5. The connecting track between the main railway network and the port is electrified by 2015 at the latest.
2) Personal travel
Objectives for 2035
1. The proportion of personal travel represented by car journeys is a maximum of 38% of the total number of journeys within the municipal region
2. The proportion of personal travel represented by public transport is at least 25% of the total number of journeys within the municipal region.
3. The proportion of personal travel represented by cycle traffic is at least 18% of the total number of journeys within the municipal region.
4. The proportion of personal travel represented by pedestrians is at least 19% of the total number of journeys within the municipal region.
Interim objectives by 2020
5. The proportion of personal travel represented by car journeys is a maximum of 48% of the total number of journeys within the municipal region
2. The proportion of personal travel represented by public transport is at least 21% of the total number of journeys within the municipal region.
3. The proportion of personal travel represented by cycle traffic is at least 15% of the total number of journeys within the municipal region.
4. The proportion of personal travel represented by pedestrians is at least 16% of the total number of journeys within the municipal region.

Biogas bus in Helsingborg

The biogas is non-fossil gas, which is produced from sewage, manure, landfills or food industry waste. The potential of the European biogas production is so large that it could replace 12 to 20 % of the natural gas consumption. Sweden is the most advanced country in Europe in biogas production, with about 1500 vehicles and 22 biogas refuelling stations (Biogas as Vehicle Fuel, 2003).

Table 4.29: Comparison of gaseous emissions for heavy vehicles, taken from Trendsetter (2003).

g/km	CO	HC*	NOx	CO_2	Particles
Diesel	0.2	0.4	7.73	1053	0.1
Natural gas	0.4	0.6	1.1	524	0.022
Biogas	0.08	0.35	5.44	223	0.015

Biogas is one of the best vehicle fuels because of small gaseous emissions. As shown in the table, the biogas shows better characteristics than the natural gas. For environmental-friendly reasons, biogas as vehicle fuel seems more interesting than the natural gas, especially in those times of pollution revaluation.

Figure 4.26: Biogas fuelled bus in Helsingborg, taken from Gille (2012).

The city of Helsingborg also operates many vehicles by using biogas as a fuel: 70 urban buses, 30 regional buses, 25 refuse collection Lorries and a large number of private cars. In Helsingborg, local gas transmission networks have been also installed for widespread use of biogas as a vehicle fuel.

Tianjin Eco-City

Tianjin Eco-City is located in the outskirt of Tianjin. It is 10 km from the center area of Tianjin Binhai New District, 45 km from the Tianjin main city and 150 km from Beijing. Figure 4.27 shows the locations of Tianjin Municipality and the Tianjin Eco-City. The main regional transportation corridors connecting Tianjin Eco-City and Binhai New district, Tianjin main city and Beijing are shown along with details that highlight the Eco-City's location. For Tianjin Eco-City, it is vital to establish a sound and efficient transport connection with these local centers, which will be a great benefit for the development of the Eco-City.

The Key Performance Indicators (KPI) for the transportation sector of Tianjin Eco-City is the proportion of green transport, which should be larger than 30% by 2013, and 90% by 2020. “Green transport” is defined as walking, cycling, and taking public transport.

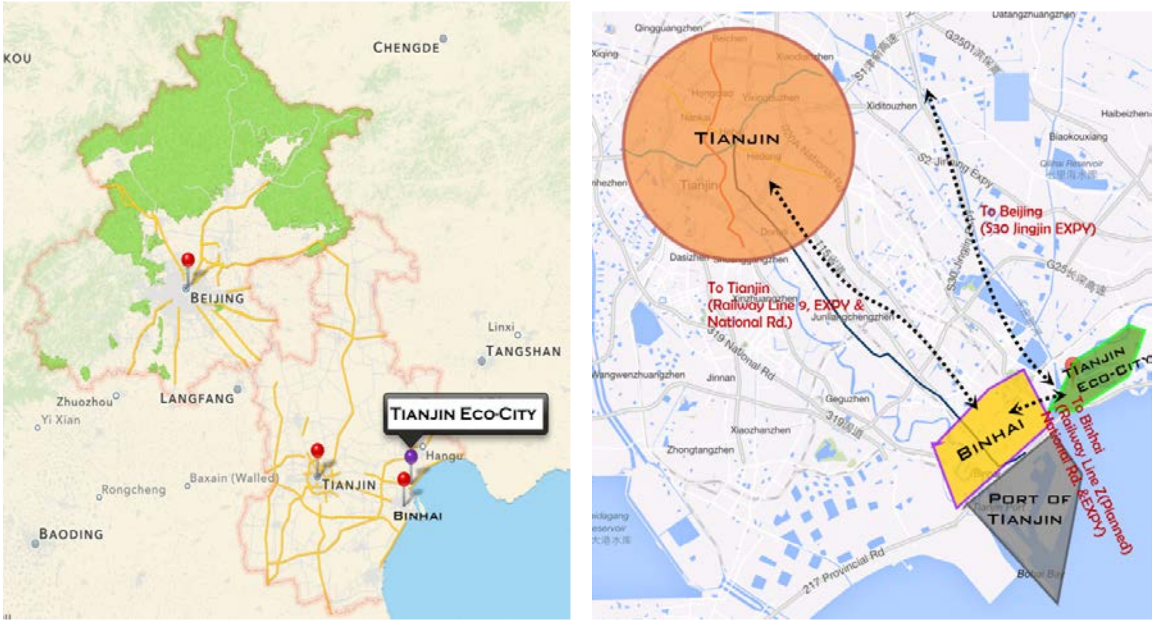


Figure 4.27: Location and external transportation of Tianjin Eco-City (Apple Maps).

The proportion of green trip in domestic and international cities is depicted in the following table.

Table 4.30: Proportion of green trip, taken from World Bank (2009).

KPI Area and Details	Indicative Value	Timeframe	Domestic Standards	Domestic Benchmarks	International Benchmarks
Proportion of green trips	≥ 30 %	By 2013	Garden City Standard: Proportion of public transportation ≥20% for big cities; ≥15% for medium cities	Tianjin (2000): 91.5% Shanghai (2006): 56% Beijing (2006): 64% Hong Kong SAR (2001): 83.8%	Rio de Janeiro 85% Bogota 85% Lima 84% Moscow 73.7% New York ≥ 60% Tokyo ≥60%
	≥ 90 %	By 2020			

The proposed 90 percent share of green transport consists of 60 percent from public transport and 30 percent coming from walking and cycling trips. The proportion of car, public transport, walking and cycling in SSTEC is compared with the one in Shanghai (2006), Binhai (2020) and Tianjin Economic-Technological Development Area (2008) is shown in the following table.

Table 4.31: Proportion of car, public transport, walking and cycling (World Bank, 2009).

	Car	Public transport	Walking & cycling
Shanghai 2006	18.4%	23.5% (incl. taxi)	58.1%
Binhai 2020	20-25%	55-60% (incl. taxi)	15-20%
TEDA 2008	36.8% (incl. taxi)	15.4% (bus, metro)	47.8%
SSTEC	10-15% (incl. taxi)	55-60%	30%

The transportation plan of Tianjin Eco-City is conducted within the whole regional context and from a multi-layer perspective. The master plan covers:

- participation in external transportation plan
- integration of urban and transport planning
- planning of the internal road network
- planning of public transport network
- promotion of green vehicle
- encouragement on walking and cycling

External transportation plan: Tianjin Eco-City is located 10 km from Tianjin Binhai New Area, 45 km from Tianjin main city and 150 km from Beijing. The main regional transportation plan providing the connection between Tianjin Eco-City and these main cities is shown in Figure 4.25.

Currently, Tianjin Eco-City and Binhai New Area are connected by three main bridges: Caihong Bridge, Yongding Xinhe Bridge and Yongding Xinhe Grand Bridge. Two Tianjin Metro line Z2 and Z4 are planned to connect the Eco-City and Binhai New Area. The Jingjin Expressway starts from Tianjin Eco-City and connects with Beijing. From Binhai New area to Tianjin main city, there are several ways including roads (expressway and provincial road) and metro (Metro line 9).

Regional transportation connections are not the responsibility of Tianjin Eco-City. However, an efficient transport connection with these local centers will be a great benefit for the development of the Eco-City.

Urban and Transport Planning: The transport planning of the Eco-City is integrated with the whole urban planning. To achieve its strategic goal as an Eco-City, the urban plan includes transit-oriented developments (TOD).

Internal Road Network: The design of the internal road network consists of six-lane main roads, four-lane secondary roads and non-motorized roads. Bus lanes and bus priority regulations are adopted on the roads.

The major roads are six-lane main roads as shown in Figure 4.28. The main roads are as wide as 51 m with 4 car lanes and 2 spare lanes for bus transport system. Moreover, walking and cycling lanes are provided on the side. The layout of four-lane secondary roads is similar to the six-lane roads with four car lanes and width of 44 m as shown in Figure 4.28.

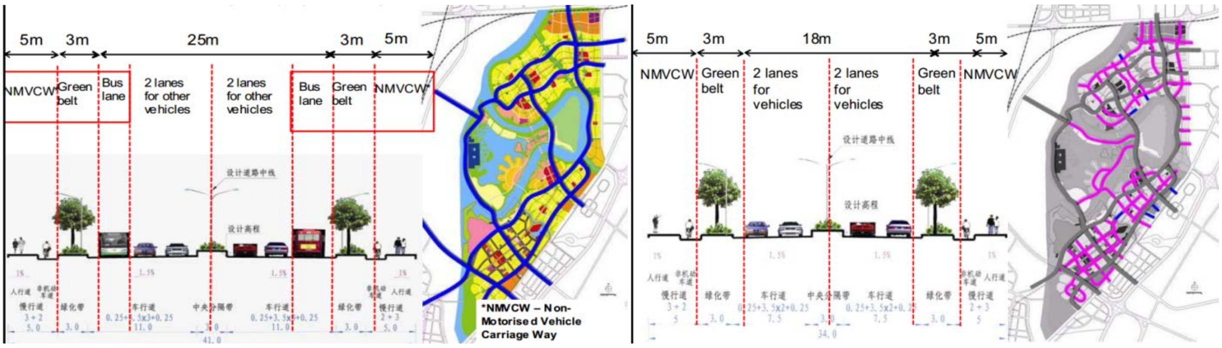


Figure 4.28: layout of six-lane (left) and four-lane roads (right), taken from http://wenku.baidu.com/view/c0d8bdadd1f34693daef3e38.html.

However, there are concerns on the design of six-lane main roads, which will encourage undesirable car travel. If road capacity is excessive and the design of the road network fails to minimize car use, it will be difficult to achieve its 90 percent green transport KPI, as residents maximize the advantages created by a car-centric road layout (World Bank, 2009).

Public Transport Network: The public transport system of Tianjin Eco-City consists of three major components:

- a mass transit rail corridor transiting north to south through the Eco-City
- a light rail network (BRT or LRT) connecting to the metro station

➢ a network of eco-friendly buses connected to the metro line and the BRT routes

As mentioned in the external transport plan, two metro lines Z2 and Z4 are planned to connect Tianjin Eco-City and Binhai New Area, as shown in Figure 4.29 (left). Between Binhai New Area and Tianjin main city, there is a metro line 9 connecting them together. The metro extensions are an important element of the overall public transport plan for Tianjin Eco-City. The metro will provide a mass transit corridor for journeys across the region.

The light rail network (BRT or LRT) is planned for the connection within the Eco-City and to support the metro corridor. According to the master plan, a LRT route of 12 km with 8 stations will be constructed as show in Figure 4.29. The LRT network will run through the 50-100 m wide Eco-valley connecting the whole Eco-City (Boon, 2010).

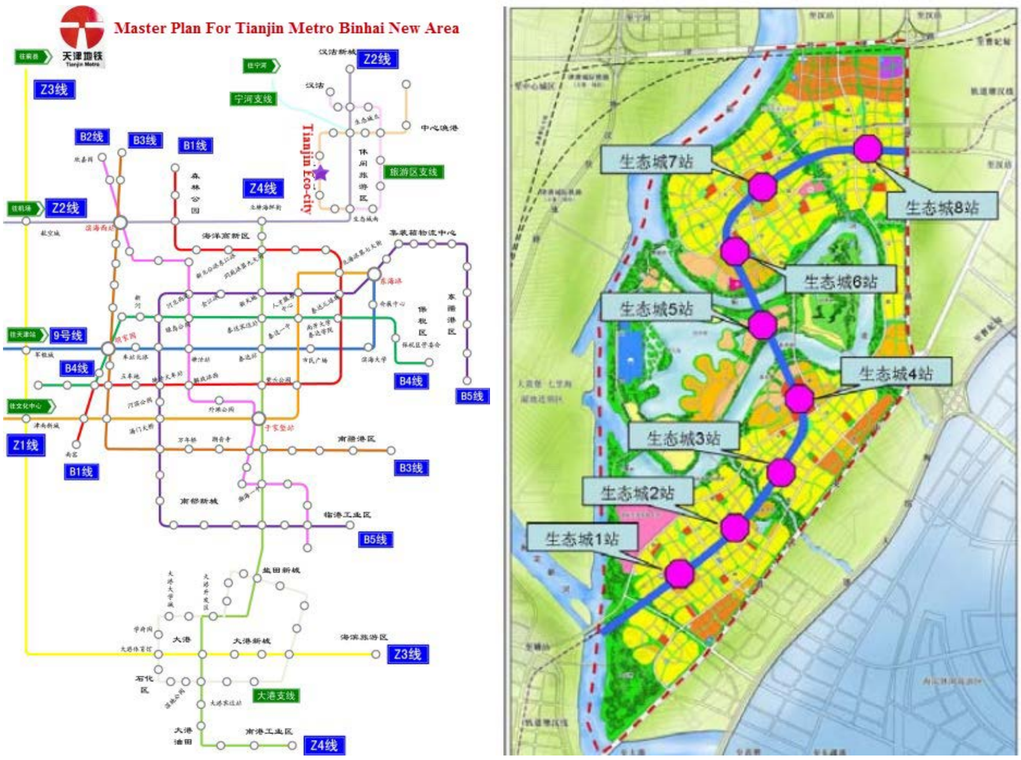


Figure 4.29: Plan of Tianjin Metro (left) and Tianjin Eco-City BRT (right), taken from Boon (2010).

There are several inter-regional bus routes passing through Tianjin Eco-City. An eco-friendly bus network is also planned to provide connectivity between homes, districts and transit centers inside the Eco-City. Concurrently in the start-up area, one bus line with 16 bus stops has already commenced operation, as illustrated in figure 4.30

Figure 4.30: Existing bus line in Tianjin Eco-City, taken from http://www.tjEco-City.com/cn/news_1.asp.

Green Vehicles: A green vehicle is a road motor vehicle using green power like electric power that produces less harmful GHG emissions compared to conventional internal combustion engine. The Tianjin Eco-City establishes several measures to promote the popularization of green vehicles.

In the national level, the "green-car subsidy program" came into effect in 2010 to cut vehicle emissions. In the Tianjin Eco-City, 105 charge stations for electric vehicles have been installed to provide electricity and promote travel using green vehicles. Moreover, in the public transport network, electric bus with zero emissions will be introduced to all the bus lines within the Eco-City (Tianjin Binhai Times, 2013b).

Non-motorized Pedestrian and Cycling Network: To achieve the goal of 30% travel by walking and cycling, a network of non-motorized transport roadways dedicated to cycling and walking will be established. Non-motorized, five meter-wide lanes will be provided on each side of motorized roads to provide equal thorough fares for walking and cycling.

In the Eco-City, several Eco-valley and special streets for commuters will be established to encourage travel by walking and cycling and reduce demand on motorized vehicles (Boon, 2010).

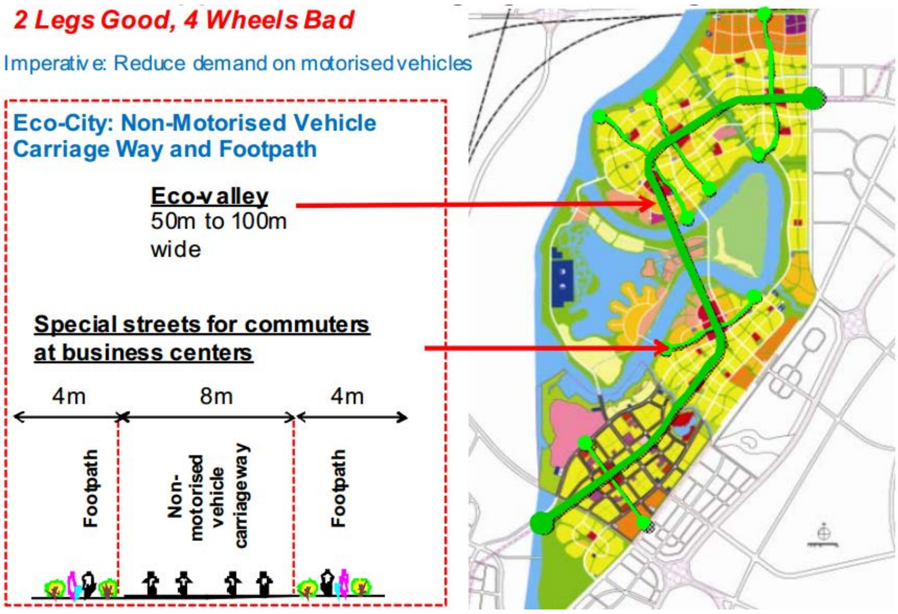


Figure 4.31: Plan of Tianjin Eco-City non-motorized networks taken from Boon (2010).

However, there are doubts on whether the motor-oriental road network and 400 x 400m community block can provide enough incentives for traveling by walking and cycling.

Comparison on Transportation

According to the Key Performance Indicators (KPI) for the transportation sector of Tianjin Eco-City and transportation plan in Helsingborg, the proportions of transportation means are summarized in the following table. In Tianjin Eco-City, proportion of green transport that is defined as walking, cycling, and taking public transport is almost 90% while Helsingborg has about 60% of green transport.

Table 4.32: Proportions of each transportation means

	Tianjin Eco-City (2020)	Helsingborg (2035)
Car	10-15%	38%
Public transport	55-60%	25%
Walking & cycling	30%	37% (walking 19%, cycling 18%)

Another difference between two cities is green vehicle. Helsingborg has employed green vehicles by using biogas as a fuel, while Tianjin Eco-City has road motor vehicle using electric power. Biogas and electricity produce less harmful greenhouse gas emissions compared to conventional fossil fuel vehicles. Both cities have put effort to reduce vehicle emissions.

Figure 4.32: Comparison between green vehicles in both cities.

4.2.5 Coastal infrastructures

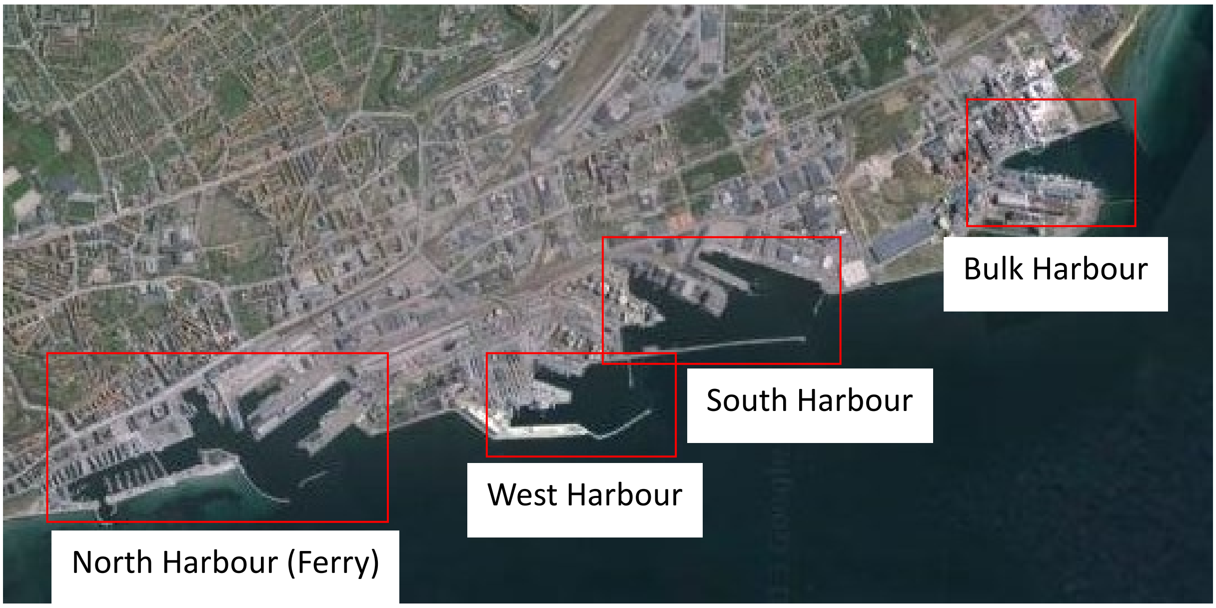
Helsingborg

Helsingborg is located in right at the strait of Oresund, which is one of the busiest stretches of water in the world. Because of its ideal position, as well as the outstanding road and rail connections, Helsingborg could have the largest port in Sweden in respect of the number of vessel calls, which is about 45,000 per year. Helsingborg port is an important transport hub for sea freight to and from the Baltic and northern Europe.

Three separate business areas are concentrated in Helsingborg port: container traffic, ferry traffic/cruise ships, and bulk. In order to handle all different types of goods, the six kilometre-long port areas are made up of specially built terminals. Approximately 20,000 tonnes of cargo are handled and about 33,000 passengers take the ferry across the strait per day.

Table 4.33: Information of Helsingborg port, taken from Helsingborg Hamn AB (2013).

	Port of Helsingborg
Location	at the narrowest part of Öresund, by the entrance to the Baltic Sea
Infrastructure	sea, rail and road links for freight
Typical cargo	pellets, vegetables and other foods, chemicals, fruit, paper, iron powder etc.
Ferry connections	11 million passengers and 2.5 million vehicles per year
Combiterminal	40,000m^2 within port area
Cargo handling	approx. 8 million tonnes per year
Depth of water in port	up to 13.5m



(a) Total view of Helsingborg port

(b) North harbour

(c) West harbour

(d) South harbour

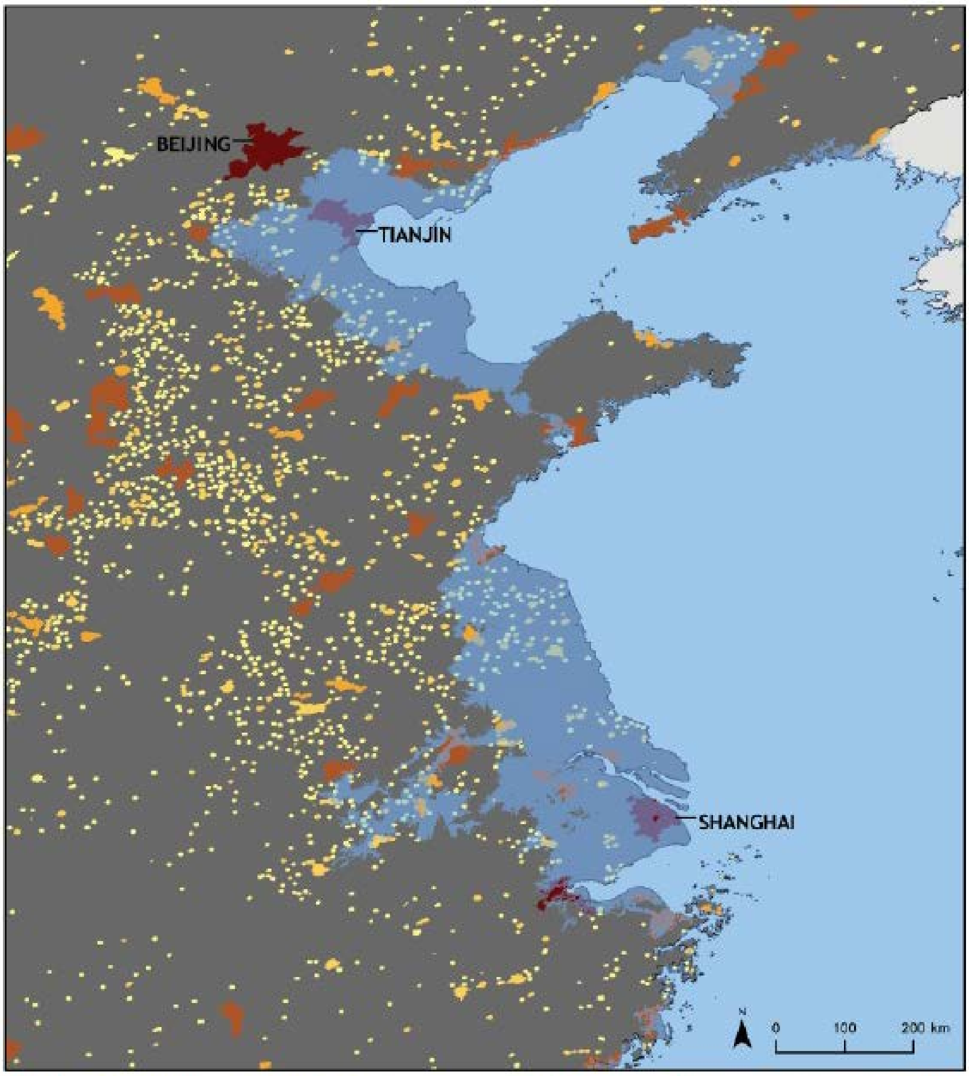
(e) Bulk harbour

Figure 4.33: Views of the port of Helsingborg, taken from Google map, Helsingborg Hamn AB (2013).

Tianjin Eco-City

Given its coastal location, and Tianjin's projected exposure to rising sea levels, the storm water and drainage system will need to be designed to reflect the future impact of climate change.

Tianjin Eco-City is considered as the most coastal flood risk affected city in China. According to estimates from the Asian Development Bank, 100% of the population and urban area of Tianjin would be affected by coastal flooding (CHS, 2012).



Note: Low-elevation coastal zone depicted in medium blue shading. Urban areas shown as points of light or patches of yellow or brown.
Source: McGranahan et al., 2007.

Figure 4.34: Impact of Sea level rise on Tianjin Eco-City (Low elevation coastal zone depicted in medium blue shading) taken from CHS (2012).

4.3 Performance

4.3.1 Financial benefits

GDP per capita as a Measure for Economic Growth and Sustainable Development

The levels of Gross Domestic Product (GDP) per capita are extracted by dividing GDP at current market prices by the population and is measured in $USD. It is an economic indicator and measures the level of total economic output relative the population of a country. All changes in citizens' well-being are reflected in this indicator.

Furthermore, it is related to sustainable/unsustainable development as the growth in the production of goods and services is a basic determinant of how the economy fares. By apportioning the total production to each head of population, shows the extent to which the total production of a county can be shared by its population. The growth in real GDP per capita states the pace of income growth per head of the population. It is a powerful summary indicator of economic development when it is utilized as a single composite indicator. Even though it does not directly measure sustainable development, however, it is a critical standard for the economic and developmental aspects of sustainable development (United Nations, 2013)

Helsingborg

The project of Helsingborg/Helsingor Eco-City development commenced in October 2005 and the works were completed in December 2012. Compared to Tianjin Eco-City the city was populated before the development commences (Eco-City, 2013a).

The city of Helsingborg belongs to Skåne County along with Malmö, Lund, Kristianstad and Hässleholm (DB-City, 2013). The comparison of Helsingborg's GDP will be conducted in three steps:

- Yearly basis from 2004 (before the works start) until 2010 (latest available data).
- Comparison to Sweden's GDP per capita so that we can better perceive the trend in each year, and:
- Comparison of the municipality of Helsingborg (Skåne County) to the rest of Sweden's Counties in order to interpret the financial status of the area.

Yearly basis

The data examined will include years 2004 to 2010. Even though the project was not finalized by then it was near completion as several facilities were completed and the benefits of the implementation of the “Eco-facilities” started to show on the citizens’ income. Due to the data being in SEK and the GDP is globally measured in USD, the exchange rates per year were calculated based on the website X-rates.com (X-Rtaes.com, 2013). The following Table and Graph depict the fluctuation of the GDP per capita in Helsingborg in USD $:

Table 4.34: Yearly range of GDP per capita in Helsingborg, taken from http://www.regionfakta.com/Skane-lan/IN-ENGLISH/Regional-economy/Regional-GDP-per-inhabitant-by-municipality/

Year	Helsingborg (SEK)	Exchange rates (SEK to US$) per year	Helsingborg (US $)
2004	334.000	0,136346321	45.540
2005	356.000	0,134194132	47.773
2006	364.000	0,13584397	49.447
2007	370.000	0,148194764	54.832
2008	362.000	0,15330824	55.498
2009	348.000	0,131474811	45.753
2010	357.000	0,139108742	49.662

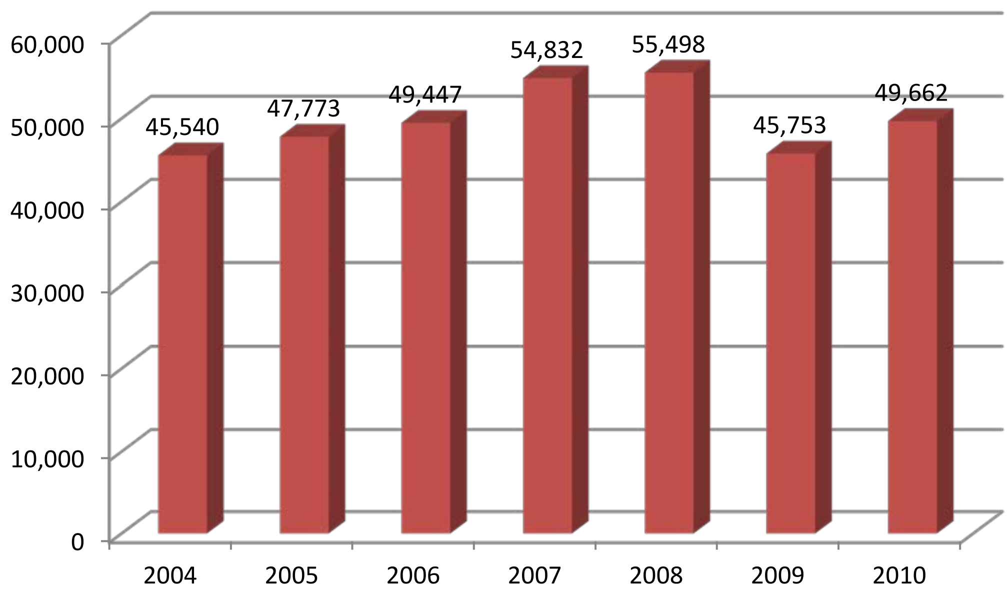


Figure 4.35: GDP per capita per year (US$).

Comparison to Sweden’s GDP per capita

This comparison is conducted in order to identify trends in the GDP; growth or reduction; so that a better analysis of Helsingborg's financial status can be made. Data for Sweden's GDP were acquired from IndexMundi (2013). The following graph illustrates both (Helsingborg and Sweden) GDP per capita in among the years 2004-2010, in USD $:

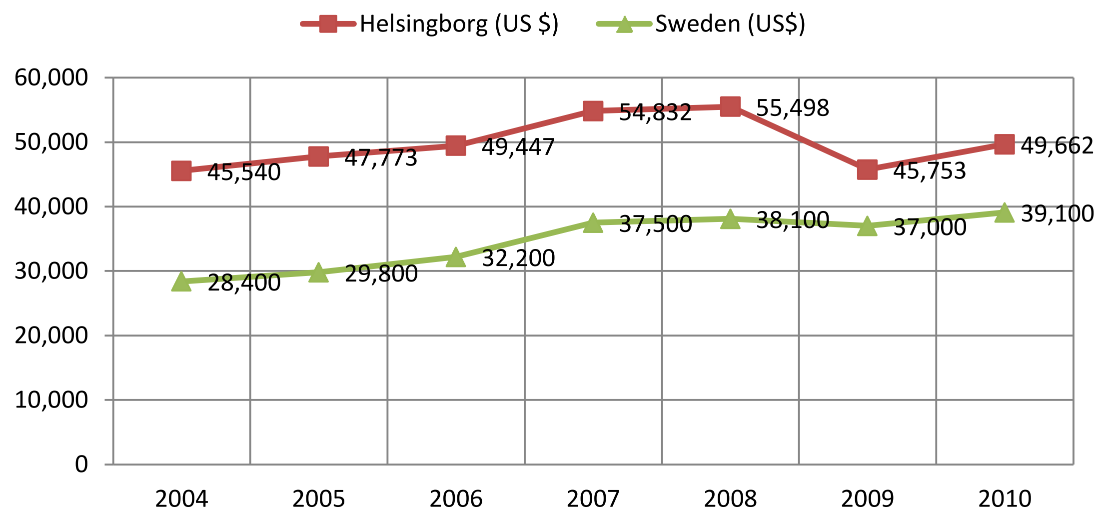


Figure 4.36: GDP per capita (US$): Helsingborg-Sweden, taken from Index Mundi (2013).

From the Graph it can be identified that Helsingborg's GDP per capita reduction in 2009 is in line with Sweden's GDP per capita and can be attributed to a general trend within Sweden.

Comparison of the County within Sweden

Table 4.34 depicts the distribution of National GDP per capita in Sweden, as well as the Regional GDP in all Swedish Regions in 2010. From this table the contribution of Skåne County in the national GDP per capita can be identified. Furthermore, the level of GDP per capita of the other Counties is also shown (Statistics Sweden, 2010). In this case the figures were not exchanged in US$ as the aim of the comparison is to calculate the percentage of contribution of each region to the national GDP per capita.

Table 4.35: Regional GDP of Sweden in 2010, taken from
http://www.scb.se/Pages/PressRelease____345461.aspx

County	GDP Regional change in volume (%)	Rank Order	Contribution to change in GDP (%)	GDP Regional per capita (SEK) thousand current prices (2010)
Norrbottens län	18,3	1	0,4	406
Södermanlands län	15,3	2	0,3	284

Jämtlands län	14,6	3	0,2	348
Värmlands län	10,1	4	0,2	287
Kronobergs län	9,4	5	0,2	328
Gävleborgs län	9,4	6	0,2	308
Västmanlands län	9,2	7	0,2	308
Kalmar län	9,2	8	0,2	303
Hallands län	8,8	9	0,2	310
Örebro län	8,4	10	0,2	310
Blekinge län	7,8	11	0,1	290
Västra Götalands län	7,1	12	1,1	340
Skåne län	**6,6**	**13**	**0,8**	**308**
Dalarnas län	6,4	14	0,2	311
Västerbottens län	6,4	15	0,2	315
Uppsala län	6,1	16	0,2	304
Jönköpings län	5,8	17	0,2	307
Västernorrlands län	5,2	18	0,1	341
Östergötlands län	4,1	19	0,2	297
Stockholms län	3,1	20	1,1	486
Gotlands län	3,0	21	0,0	271

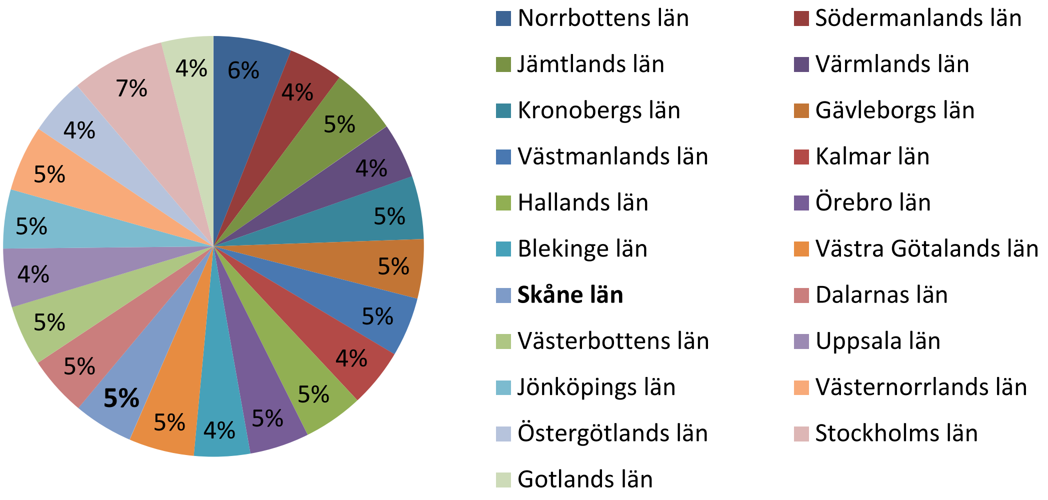


Figure 4.37: GDP Regional per capita (2010), taken from http://www.scb.se/Pages/PressRelease____345461.aspx

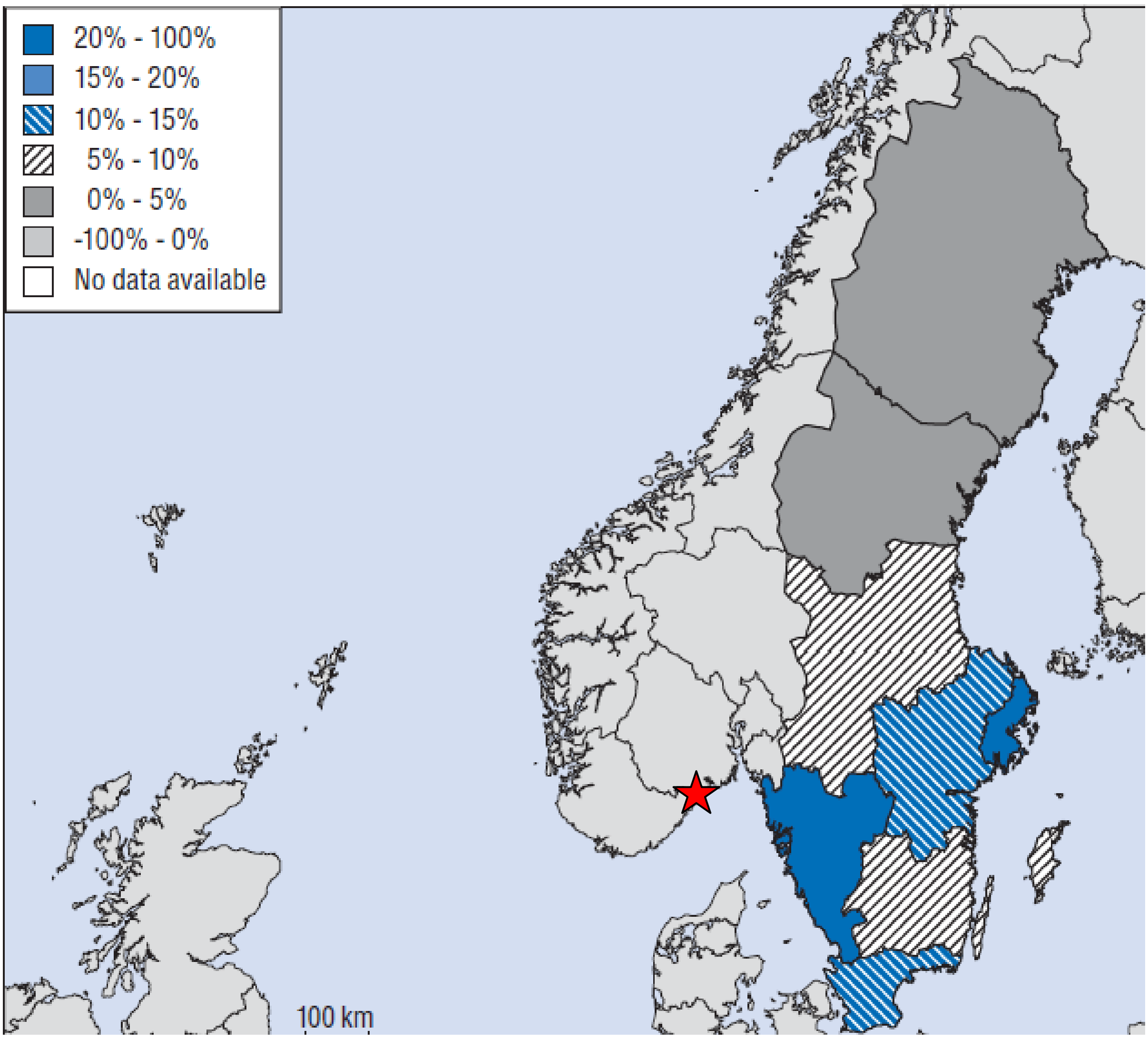


Figure 4.38: Regional contribution to national GDP growth, 1995-2007, taken from http://www.oecd.org/gov/regional-policy/49077327.pdf

From Table 4.34 and Figure 4.39 it can be seen that Skåne County does not contribute much to the National GDP per capita (almost 5%). However over the years has largely conduced to the National's GDP growth as shown in Figure 4.40.

Influence of Sustainable Facilities in Helsingborg's Financial Standing

The "Helsingborg/Helsingor Eco-City" project has undoubtedly benefited the residents of Helsingborg. The benefits do not just include the environmental and the living conditions, which have been significantly upgraded, but also the living costs.

The introduction of sustainable facilities in the city has aided in reducing the citizens' yearly expenses; a fact that is depicted in the city's GDP per capita growth over the years of the project implementation.

The redevelopment of the city included the introduction of renewable energy sources by installing wind turbines (2MW), biomass boilers (5.5 MW), solar collector for domestic hot water (228 m^2) and photovoltaic plants. Furthermore, regarding the energy efficiency in buildings 543 new Eco-dwellings were constructed, 259 dwellings were eco-refurbished and 37.884 m^2 tertiary buildings were also were also fitted with enery efficient systems. Polygeneration systems were utilized by extending an existing biogas plant producing gas for public transport. Renewable Energy Sources (RES) and Rational Use of Energy (RUE) were integrated by extra RES accounting for covering needs of the eco-buildings after improving their energy efficiency. Moreover, Rational Use of Energy was introduced at tertiary buildings that cover administration offices, schools and institutions. Last but not least, specific innovations were facilitated in the redevelopment of the city by establishing comfort metering and control systems and expanding the potential for geo-thermal exchange and energy storage (Eco-City, 2013a).

A sustained growth over the years 2004-2008 period is clearly identified and can be partially attributed to the project's financial benefits. In 2009, a reduction of the GDP per capita is seen. However, a comparison with Sweden's GDP per capita shows a general reduction within the country, therefore it can be attributed to other reasons and not relating to the eco-project. Nonetheless, the percentage of reduction in Helsingborg's GDP per capita is substantially smaller (0.0288%) than of entire Sweden (0.17559%). Furthermore, it is noticed that the County's GDP per capita does not contribute much to those of Sweden's, leading to rather weak financial standing among the rest of the Counties.

Tianjin Eco-City

The Tianjin Eco-City is still under construction and is not fully populated yet. The estimated time of completion of the works is 2020, however part of the city is finalised and approximately 4000 residents are located there. The residents are originated from Tianjin city and due to lack of data from Tianjin Eco-City specifically, in this case the data of GDP per capita analysed will be from Tianjin city; an area which includes Tianjin Eco-City.

Due to the fact that the city was not populated before, there will be no comparison of the GDP per capita throughout the years. Instead, it is meaningful to compare the latest GDP per capita figure (from 2011) with the ones of the rest of the cities/ provinces in China. This comparison will provide us an insight on the different living conditions of the residents in Tianjin, which is a sustainable city, to the other cities in China where no project like that has been carried out. This comparison will ultimately reveal the financial benefits of the people living in Tianjin with people living in Beijing or Shanghai.

Beijing and Shanghai were chosen for this comparison as it was found in contemporary sources (Pang, 2012) that these provinces are compared to Tianjin due to them have shown significant economic growth over the years and due to the fact that they possess the highest GDP per capita figures in China.

Tianjin's GDP reached 1.12 trillion yuan in 2011 and was increased by 16.4% compared to 2010. The city's GDP per capita exceeded 80,000 yuan in 2011, when calculated according to population figures taken from the sixth national census data, which was conducted in November 2010. Beijing's GDP per capita also reached figures above 80,000 yuan, with estimates putting the figure at 81,584 yuan, equivalent to $12,631. These calculations were based on dividing the released provisional provincial-level GDP figures by the population figures that were collected as part of the sixth national census that was conducted at the end of 2010 (Pang, 2012).

The following figure depicts China's GDP per capita in 2011 distribution along the provinces. It is noticed that the highest figures are concentrated along the coast (McVey, *et. al.,* 2013).

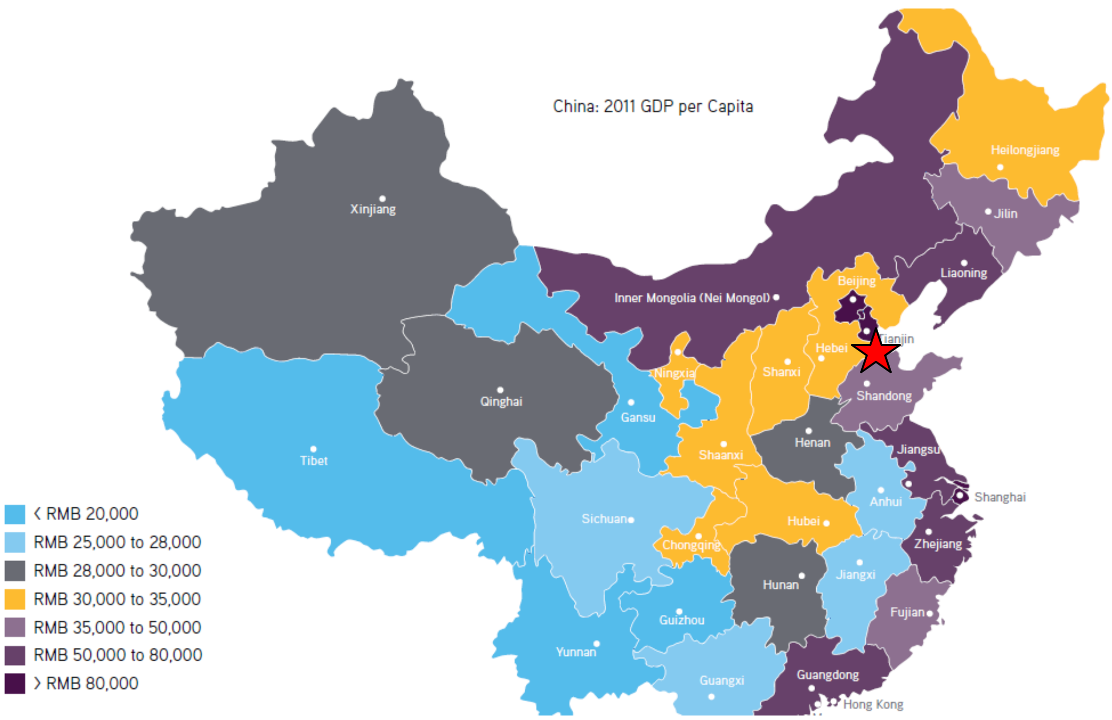


Figure 4.39: China's GDP per capita in 2011, taken from McVey*, et. al.,* 2013.

More accurate figures of GDP per capita in the provinces are provided by “The Economic Observer”, a Chinese newspaper, in which the GDP per capita in Tianjin, Beijing and Shanghai; the three cities with the highest GDP per capita figures in China, reach the figures depicted in the following graph.

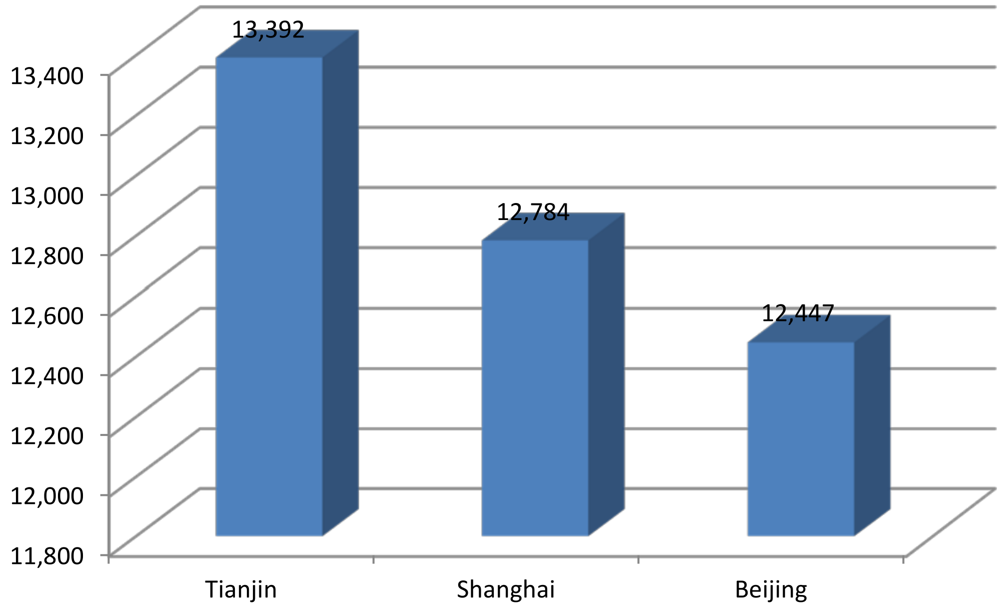


Figure 4.40: GDP per capita in 2011 in US $, adapted from Pang (2012).

Influence of Sustainable Facilities in Tianjin’s Financial Standing: The city of Tianjin used to be an industrial base for chemical manufacturing in northern China, which had provoked extensive chemical pollution. One third of the area was occupied by deserted saltpans, saline-alkaline non-arable land and polluted water. However, implementing the project of “Sino-Singapore Tianjin Eco-City” has managed to transform the area into a green place and a comfortable environment to live and work. Notwithstanding, the project of the Eco-City is not benefiting only the environment but also the residents of the city as it helps reduce living costs. For example, the solar heating systems aid in reducing electricity consumption and the energy-efficient traffic system cuts back transportation costs. Moreover, living in a digital city is easier and more efficient (China Daily, 2011).

To be more specific, the sustainable facilities established in the Eco-City scheme that aid in reducing the living costs of the residents are in terms of renewable energy solar PV, solar water heaters, wind turbines, street lamps powered by wind and solar energy, and ground-source heat pumps. Five large scale wind turbines provide five million kilowatt-hours every year, enough for 4,000 households, while solar panels installed along the city's boundary have a total installed capacity of 6.6 million kilowatt-hours, enough to power 5,000 households.

The sector of energy efficiency is equally important though and its design has been taken very seriously. Almost 700 street lamps line the green boulevards of the city, running on a combination of solar and wind to provide a constant level of power during cloudy or calm days. Nonetheless, at the centre of Tianjin Eco-City's effort is its geothermal energy plant, dubbed Energy Station II, providing 20,000kW of cooling in the summer and 14,000kW of heat in the winter, plus an electrical energy output of 1,500kW (Grogan, 2013).

The implementation of the Eco-City project has offered undoubtedly reductions in the residents’ income as they can utilize the “Eco-features” of the city, such as the renewable energy sources and the digital systems, to better control their expenses. Thereafter, their total annual income will be increased leading to a subsequent increase in the city’s GDP (Gross Domestic Product). As it is shown at the Figure 4.36, the GDP per capita in 2011 in Tianjin had the highest figures compared to Shanghai and Beijing. The difference does not merely lie on the sustainable facilities established in the city but also on the fact that Tianjin is not fully occupied yet. The project of the Eco-City is expected to be completed by 2020, although several facilities are completed and around 4000 residents live in the city (China-Singapore Tianjin Eco-City, 2013a).

4.3.2 Improved environmental aspects

Helsingborg

On the pathway towards the development of Helsingborg as an Eco-City, there have been a number of successful environmental initiatives in place regarding certain aspect effecting the quality of the local area as well as contribution to national and international environmental problems.

A pilot of phosphorus recovery from sewage has been trialled in Helsingborg since 1997. The city of Helsingborg uses the KREPRO (Kemwater REcycling PROcess) for wastewater sewage treatment, as the disposal of organic waste became illegal in 2005 due to strict on-going effluent standards in Sweden (Karlsson, 2001).

This has a number of environmental benefits across a range of factors. Firstly, the sewage output is removed of contaminants, such as heavy metals and organic micro-pollutants (Karlsson, 2001). Phosphorus, organic matter and precipitants are valuable products that are extracted from the waste. The dry organic content is approximately 50% of the original mass, and this can be used for burning, co-fired with wood chip (Karlsson, 2001).

The hydrolysed sludge is not deemed as viable for commercial sale due high concentrations of heavy metals; however the recovered ferric phosphate has potential for resale/reuse as fertiliser depending on the concentration of heavy metals, which during trials remained low (Stowa, 2006).

Air pollution in Helsingborg comes from a number of sources, notably energy production, Ocean going vessels, logistics transport (commercial vehicles) and private vehicles. Conventional air quality measurement is in place with cabin containers and chemical analysers. These are stationary equipment suitable for roadside monitoring and peak pollution levels.

Open path monitoring uses light to simultaneously measure a number of pollutants, particularly with regard to the shipping around Helsingborg on the coast including Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), and Benzene (C_6H_6).

There are 7 ferries that make 125 departures every 24 hours at the port in Helsingborg, which is over 96% of the total traffic arising from the port. Without the end-of-pipe control measure Selective Catalytic Reduction (SCR) NO_x emissions are over 290 tonnes each year (Jupen, 2006). This would contribute greatly to a number of hazards to human health, including various respiratory ailments, as well as being a precursor to ground-level ozone.

The measure of a policy order on SCR technology in all ships permanently frequenting the Helsingborg port saves 100 tonnes of NO_X locally and 230 tonnes overall, which is an 80% reduction. This has also allowed Helsingborg to have a feasible opportunity to meet the national minimum air quality standard for NO_x (Jupen, 2006).

Another notable successful aspect of changes within Helsingborg over the last decade is the implementation of the district energy scheme which serves over 10,000 residents (78% of the population). Business to customer is around 180 GWh per year (20% of total), and business to business at 720 GWh per year (80% of the total) (Hermansson, 2011).

Heat sources for the district energy scheme include waste heat from local industry, landfill gas fuelled boiler, and heat pumps from the sewage purification plant. The total comprises of only 2% fossil fuel use, and this has led to a reduction in CO_2 emissions of 340,000 tonnes from 2007-2011 (Hermansson, 2011).

Tianjin Eco-City

Tianjin and the surrounding natural environment is victim to the consequences of swift and unsustainable population growth. Because of this the environmental priorities for Tianjin Eco-City were focused on the main anthropogenic factors that threaten quality of life, and the resources available to the residents.

The Key Performance Indicators for Tianjin Eco-City set out the minimum performance requirements to meeting low carbon objectives for the development. There are four categories of KPI for measuring the city, 22 quantitative (Figure 4.41) and 4 qualitative, all split into four categories.

Figure 4.41: Quantitative KPIs for Tianjin Eco City taken from Government of Singapore (2013).

The KPI for Carbon dioxide emissions per unit GDP is that emissions should not exceed 150 tonnes CO2 per $1 million (USD). The five year plan aims to cut china's emissions 17% during 2010-2015 period. From Figure 4.42 it is evident that green building compliance takes an undeniable key role in meeting the Eco-City concept.

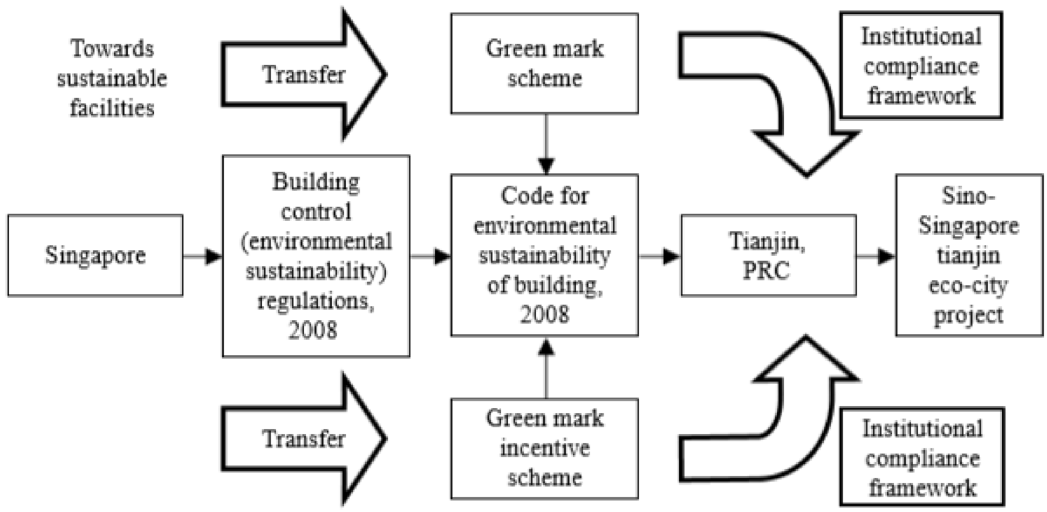


Figure 4.42: The Tianjin Eco-City development schematic taken from Low, *et. al.,* (2009).

Table 4.36: Annual CO_2 emission calculation for Tianjin Eco-City public buildings (at design stage) for electricity 7.18 x 10-4 metric tonnes CO_2/kWh, annual CO_2 output emissions factor using Egrid2007 version 1.1 U.S. For natural gas 5 x 10 metric tonnes CO_2/therm value taken from Wu, *e.t al.,* (2012).

Item	Baseline (kWh*000)	Enhancement case 3a (kWh*000)	Demand Reduction (kWh*000)	CO_2 Footprint (CO_2et)
Electricity demand (1)	3070	1703	1367	-
Avoided CO_2 emissions on (1)	-	-	-	981.8
Natural Gas demand (2)	3110	1909	1201	-
Avoided CO_2 emissions on (2)	-	-	-	204.9
Avoided CO_2 emission in total	-	-	-	1186.7

Furthermore, having accounted for the degradation of the local wetland environment, coupled with the demand in improvements of treated wastewater, alternative wastewater treatments have been developed. Traditionally, chemical coagulation and filtration is used, however North Cixi Waste Water Treatment Plant is using a constructed wetland system.

Whilst meeting the discharge standards this was intended to not only increase the ecological and touristic value of the area but to use the wetland as a carbon sink. The cost of this programme is 0.022 RMB higher than traditional tertiary sewage treatment, but saves 6000t/ CO_2 annually or 180RMB per tonne (Wu*, et. al.*, 2012).

Water use in Tianjin and the surrounding area puts great pressure on limited freshwater resources and the ecological environment. The Eco-City development aims to keep water use in Tianjin Eco-City to below 120 litres per person per day, and a third of water will be from a recycled source. The quality of water bodies in the surrounding area is set at a minimum of grade IV national standards for China (PUB, 2011).

5 BARRIERS and INDICATORS

5.1 Financial

5.1.1 The case of Helsingborg

The project of Helsingborg was conducted under the Sixth Framework Programme, partially funded by the European Commission. However, several financial issues were raised regarding the remaining funding of the projects. In this specific case, the project's contract type was "Integrated Project", of which the implementation plan coherently describes tasks, work package, activities, etc. At the point of submitting the proposal or even at the negotiation level, there is no contractor proposed to give the option to the consortium to select the appropriate entity(ies) during the implementation of the project by employing competitive calls for proposals.

The calculation of a grant to the budget (the way the EU funds the project) is based upon, among others, the cost reporting model employed by the contractors, the estimated eligible costs of the resources needed to implement the aforementioned tasks, work packages and activities, etc. These factors have to be evaluated according to a cost reporting model combined with the legal entity considered for the implementation.

For example, if a Small Medium Enterprise (SME) is considered, the cost has to be estimated with the two ways described:

- Using the FCF (Full cost with indirect flat rate costs) model it is perceived that all eligible direct costs and a flat rate for indirect costs are charged. The flat rate is 20% of all direct eligible costs minus the cost of sub-contracts.
- Employing the FC (Full cost) model in which all eligible direct and indirect costs are charged by the contractors.

In the case of the FC model being used, it is recommended to estimate indirect eligible costs based on the economic environment of the expected legal entity (labour intensive or capital intensive environment). A general rule is to value the costs to 20% of the eligible direct costs for labour intensive environment and up to 80% of the eligible direct costs for capital intensive environment (European Research Area, 2005).

5.1.2 The case of Tianjin Eco-City

Taking into consideration the magnitude of the project, it is imperative to ascertain financial sustainability, which can be a major challenge. Nonetheless, good investment planning has to be conducted beforehand, including a strict lifecycle cost benefit analysis for all the project facilities at the outset of the decision-making process. It should be noted however, that the application of lifecycle cost analysis is rarely conducted in China although it is standard practice elsewhere. In the case of this project it is considered as a critical procedure to be applied given the size of the case study projects and the fact that the expenses and the benefits of the environmental investments will be realised over time. Initial review of the draft sector plan indicates that the cost benefit analysis is not systematically implemented. There are certain instances where potentially higher cost alternatives considered, which could in fact affect the project's financial viability. An example of that is the proposed district heating system and the preference of Light Rail (LR) over a Bus- Rapid Transport (BRT) system. Apart from evaluating the investments in terms of costs effectiveness and cost-benefits, it is important that SSTEC (the joint venture company developing the project) develops a comprehensive strategy to ascertain that all its investments are financed on a sustainable, long term basis (The World Bank, 2009).

5.2 Social

It is widely accepted that may European nations have a well-developed, well founded environmental agenda. Therefore, it would be reasonable to assume that public attitudes in these nations would be both based on a broad environmental knowledge, and acceptance of environmental initiatives.

The ambitious CO_2 reduction targets in Sweden are limited by the task of decoupling the rise in CO_2 with the rise in economic growth (Martinsson, *et. al.*, 2011). As a member of the European Union (EU) since 1995, Sweden has been subject to integrating all aspect of EU law into national legislation. Because of this, Swedish nationals are accustomed to the standards required for environmental stewardship. Initiatives based from a top-down perspective tend to be the social norm among the people, however individual attitudes are accepting of new policies.

The CONCERTO project, of which the Helsingborg project is a part thereof, has specific view on the significance of stakeholder engagement. It is of absolute importance that stakeholders are consistently engaged throughout the planning and implementation process to keep them in full understanding of the developments (European Commission 'CONCERTO', 2010). Special emphasis is given in order to develop both cognitive and emotional involvement. By identifying issues at early stages through questionnaires, these issues can be derived and addressed. However, environmental attitudes in Southern Sweden take precedence over factual knowledge, in the sense that 'green drivers' i.e. avoidance of the threat of environmental impact has the most impact on travel choices, in particular the use of personal vehicles (Nilsson and Kuller, 2000). As opposed to more specific information, the Swedish public will tend to view some environmental issues as more important than others, for example, protection of the ozone layer, a shared environmental problem, as more important than the protection of wetlands, which, technically, has a higher degree of personal relevance to the individual (Boman and Mattsson, 2008).

It is a shared sentiment in Sweden that the actions of the individual are deemed as less important than society working as a whole, in order to share the burden and benefits, of sustainable living (Boman and Mattsson, 2008).

Age, housing type and income are indicative of environmental attitudes in Sweden, but attitudes towards environment are equally driven by general environmental attitude. However, domestic energy use is heavily driven by social demographic. For example, homeowners in Sweden are more likely to respond positively to an economic incentive. Furthermore, residents in co-operative and rented housing are less likely to respond to an incentive based solely on attitudes; however this is partly because they are restricted in terms of options for improvement on an individual basis (Martinsson, *et. al.,* 2011).

Research has indicated that there is less support for actions at the individual level to improve the environment, in comparison for the higher level of support given to societal changes through technology of policy intervention (Boman and Mattsson, 2008). This is indicative that smaller scale projects such as the Helsingborg project has potential for the successful integration of low carbon schemes from a top-down perspective, and community involvement as whole would ensure behaviours change as a whole.

5.3 Legal

5.3.1 Comparison of the concept behind the contract arrangement

The two case studies utilized different forms of contracts and agreements to materialize the projects. The concept behind the two contractual arrangements is of the essence as it indicates the progress of the project as well as its results. As analyzed earlier, in the case of Sino-Singapore Tianjin Eco-City a Framework Agreement along with a supplementary agreement was used. In the case of Helsingborg, the project was part of a Consortium

Agreement and the contract type was that of an Integrated Project. The following Table compares the two concepts:

Table 5.1: Comparison of the concept of the contractual agreements of the two case studies.

Sino-Singapore Tianjin Eco-City: FRAMEWORK AGREEMENT	Helsingborg : INTEGRATED PROJECT
Utilized for purchase of goods among suppliers and purchasers	Utilized to promote research and development objectives in projects
Reduced bureaucracy by the award of “call-off” contracts for individual works within the Framework Agreement	Increased bureaucracy as it is imperative for the project’s proper progress to have well-documented contracts for each purpose and work.

As the table indicates, the Framework Agreement is tailored in the needs of the demands of suppliers and purchasers, hence the “reduced bureaucracy” element in the agreement in order to ease multi-supply needs. On the other hand, the Integrated Project promoted primarily research and development purposes. It is formed in the basis of integrating knowledge in different levels, however the need for clear identification of the roles of the participants and generally the establishment of well documented contracts in all levels generate increased bureaucracy and do not favour the project.

5.3.2 Comments

Therefore, there is an advantage in creating a research-driven project by establishing the contractual arrangement of an integrated project and equally there is the reduced bureaucracy, which a Framework Agreement provides.

Apart from the clearly technical barriers, such as the formulation of a template and the legislative establishment of the contractual type in the Framework Agreement or in the Integrated Project, other reasons can be used as barriers for transferability.

Regarding the “bureaucracy” element, it is imperative to pre-exist trust among the contracting members. The element of “trust” is of the essence especially in the case of Framework Agreements as the awards of “call-off” individual contracts do not occur within the process of procurement. Therefore, there should be mutual trust that the award of contract was made according to the perceptions and beliefs of all implicated parties. Hence, in case of choosing the path of a Framework Agreement there should pre-exist mutual trust among all participants.

In the case of the project being conceived as a research/development opportunity or simply as a "purchase of goods", it lies completely in the perception of the contracting authorities. As it was identified, in one case (Tianjin Eco-City) the authorities conceived the project as "a purchase of goods" that all of them combined will create an Eco-City and this project could be scaled for other city-cases. However, in the case of Helsingborg the project was regarded as an opportunity for research of new technologies and transferring the research and development results among different levels (industry, academia and the value-chain involved). It is a contradiction of beliefs and the best results from the citizens' perspective are yet to be identified.

5.4 Eco-City Indicator Systems

As noted in chapter 1, there is no single publically accepted definition of Eco-City. The so-called Eco-City constructions are very different from one another. Because there is no particular physical example as standard, it becomes increasingly difficult for inter-comparison studies. Thus researches have discussed evaluating Eco-Cities based on alternative indexes such as the human development index, social process index, ecological footprint, index for sustainable economic welfare, and material input per service (Zhang, *et. al.,* 2008). This leads to the emergence of indexing/indicating system in Eco-City constructions. In China, for example, Performance index of constructions are used for evaluation and certification of Eco-Cities. Generally, Indicator systems are widely used by researches and policy makers to define the scope, set targets, and assess the progress of Eco-City programs (Zhou*et. al.,* 2012). However, with no coordination and information sharing each agency and government in partnership with research institutes, made their own indicators for Eco-Cities. The tables below list a concise view of the greater spread of indicators used by different organisations. The table shown here are a combination of two studies. Majority of the information are adopted from Zhou et al., (2012) and the World Bank study on Chinese Eco-City constructions. Though there are international benchmarks that are noted in the tables, it is noteworthy that the information is mainly biased towards Chinese practices.

The sustainable development systems indicators developed by the Chinese Academy of Science has the largest number of indexes; 146. The Caofeidian Eco-City contain 141 indicators, these are developed in collaboration with Sweden's Swecco cooperation. On the other hand, the indicator system developed for Tianjin Sino-Singapore Eco-City has a total of 26 indicators (Zhou, *et al.,* 2012). There are 9 key categories – energy, water, air, waste, transport, economy, land use, social aspects and infrastructure. Each key category contains subcategories, which also vary greatly. There is also difference can be found in timeframe and units used by different schemes. Each indicator system has their own priorities and expert experience in few particular fields, hence that field tends to dominate and have more subcategories. From the tables, it is evident that the systems described here more focussed on physical environment, with air, energy and land-use are major components (Zhou, *et. al.,* 2012).

Preliminary studies shows that the primary indicators on both Chinese and international systems are similar (Zhou, *et. al*., 2012). However, compared to international systems Chinese systems have significant differences on the structure of categories of indicators, the concentration of specific type of indicators, the methodology and weighing systems, and the purpose of applying the indicator systems (Zhou, *et. al*., 2012). International cities tends to include indices such as happiness index, while energy and carbon category is considered more favoured by the Chinese policy makers (Zhou, *et. al.,* 2012; Williams, *et al.,* 2012). There is lack of commonality has seen in both Chinese and international systems. However, it is put forward that the international systems has better representation of energy and carbon indicators (Zhou *et. al.,* 2012; Williams, *et. al.,* 2012). Furthermore, public participation and stakeholder involvement in the process need to be addressed in china, along with greater transparency in policy and decision-making (*Zhou, et. al.,*2012). It is useful tool for comparison if we have an internally accepted indicator system. The likelihood of coming up with an international standard for Eco-City indicators is very marginal. As such a system have to meet the challenges of data availability and sources of data, and to face trade-offs in choosing indicators between comprehensive versus qualitative, standardize versus adaptive, stable versus dynamics. On top of that, the political, legal, social and cultural barriers restrain such efforts even further.

Table 5.2: Waste Indicators (source: Zhou, *et, al*., 2012; World Bank, 2009; Avfall Sverige, 2012).

Subcategory	Indicator	Units	Criteria	Source
Waste disposal	Daily waste per capita	kg/capita/day	≤0.8	Tianjin
			International standards	

			Southeast Asia (0.74) Singapore(0.89) East Asia(1.01) Japan (1.1) South-central Asia (0.57) USA (2.18)	
	Comparable area total waste per capita	kg/capita/day	328(2020) 438(2007)	Caofeidian
	Comparable area recyclable solid waste per capita	m^3/capita/day	3	Caofeidian
	Animal waste resource rate	%	70%(2010) 90%(2020)	Wu, *et. al.*, 2005
Waste treatment	Urban garbage harmless treatment rate	%	80%(2010) 100%(2020)	Wu, *et. al.*, 2005
	Hazardous waste and garbage (harmless) treatment rate	%	100	Tianjin
			≥90	MEP MoHURD Eco-Garden City
			>95	Guiyang City, 2008.
			60	Garden City
	Industrial solid waste utilisation and treatment rate	%	≥90	MEP
	Rate of landfill waste	%	<10	Caofeidian
	Rate of waste	%	>50	Caofeidian

	incineration			
	Rate of biological processing	%	>80	Caofeidian
			>50 of food waste	Helsingborg
	Rage of waste to energy processing	%	>40%	Helsingborg
Waste recycling	Rate of waste recycling	%	≥60	Tianjin
			>60	Caofeidian
			International Bench marks Singapore (60) Seattle, Washington(60) Curitiba (70) Reykjavik (53)	
	Rate of construction and demolition waste recycling	%	>70	Helsingborg
	Rate of hazardous waste recycling	%	100	Caofeidian
	Per-capita energy demand for waste collecting, transporting, and processing	kWh/capita/yr	<500	Caofeidian
	Per-capita energy from waste processing (incineration, biogas, or landfill gas)	kWh/capita/yr	>500	Caofeidian

	Comprehensive rate of waste utilisation	%	>62	Guiyang City
			≥95	Li and Yu, 2011
	Residential waster utilisation rate	%	≥70	Li and Yu, 2011

Table 5.3: Transportation Indicators (source: Zhou, *et, al*., 2012; World Bank., 2009; Helsingborg, 2012).

Subcategory	Indicator	Units	Criteria	Source
Ease of transport	Average road area per capita	m^2/person	9	Guiyang City, 2008
	Buses per 10,000 person	buses/10,000	15	Guiyang City, 2008
	Average speed of primary and secondary roads	km/hr	≥40	MoHURD Eco-Garden City
	Average commute time	mins	≤30	Li and Yu, 2011
Green Transport	Percentage of green transportation / Percentage of public transportation	%	≥30 (2013) ≥90 (2020)	Tianjin
			≥50	Li and Yu, 2011
			≥20	Garden City
			≥52 (2020) ≥62 (2035)	Helsingborg
			International bench marks Rio de Janeiro (85) Bogota (85) Lima(84)	

			Moscow (73.7) Curitiba (71) Amsterdam (66.1) Prague(64.4)	
Accessibility	Access to transportation system from major office area (walking distance 600-800 m)	%	100	Caofeidian
	Accessibility of residential areas to public transportation (walking distance < 800 m)	%	90	Caofeidian
	Accessibility of office place to public transportation (walking distance < 800 m)	%	90	Caofeidian
	Difference in time/distance to home/office time by public transportation vs. auto	%	<1.5	Caofeidian
	Difference in time/distance to home/office by biking vs.auto	%	<1.5	Caofeidian

Table 5.4: Economic Indicators (source: Zhou, *et, al*., 2012; World Bank., 2009).

Subcategory	Indicator	Units	Criteria	Source
GDP	Average GDP per capita	10,000 RMB	1.8 (2010) 5.8 (2020)	Wu, *et. al*., 2005
			3.46 (2012)	Guiyang City, 2008
Growth	Annual growth rate of GDP	%	8 (2010) 7 (2020)	Wu, *et. al*., 2005
Productivity	Land productivity	10,000 RMB/km^2	1850 (2010) 4000 (2020)	Wu, *et. al*., 2005
Sectorial	Ratio of investment in fixed assets to GDP	%	33 (2010) 38 (2020)	Wu, *et. al*., 2005
	Value of service section in GDP	%	50 (2012)	Guiyang City, 2008
	Growth rate of high-tech industry	%	25 (2012)	Guiyang City, 2008
	Growth rate of average general budget revenues	%	12 (2012)	Guiyang City, 2008
	Ratio of R&D spending to GDP	%	>2 (2012)	Guiyang City, 2008
	Disposable income of urban residents	RMB	18,000 (2012)	Guiyang City, 2008
	Net rural per-capita income	RMB	6,000 (2012)	Guiyang City, 2008
	Employment-housing equilibrium index	%	≥50	Tianjin

Table 5.5: Land Use Indicators (source: Zhou, *et, al*., 2012; World Bank., 2009).

Subcategory	Indicator	Units	Criteria	Source
Forestry	Forest coverage	%	25 (2010)	Wu, *et. al*., 2005
			45 (2020)	Guiyang City, 2008
Protected lands	Recovery rate of degraded land	%	96 (2010) 100 (2020)	Wu, *et. al*., 2005
	Rate of protected arable land	%	15 (2010) 20 (2010)	Wu, *et. al*., 2005
	Percentage of protected area	%	≥17	MEP
Public green land	Average per-capita public green land	m^2/capita	≥12 (2013)	Tianjin
			≥11	MEP
			20	Caofeidian
			≥10 (2012)	Guiyang City, 2012
			52	Curitiba
	Green coverage in built-up area	%	≥45	MoHURD Eco-Garden City
			35	Caofeidian
	Rate of green land in built-up area	%	≥38	MoHURD Eco-Garden City
			≥40	Li and Yu, 2011
	Per-capita public green space in built-up area	m^2/capita	≥12	MoHURD Eco-Garden City
	Local plant index	N/A	≥0.7	Tianjin Eco-Garden City
	Percentage of wetland and natural land in green land	%	20	Caofeidian

	Residence accessible to parks and public spaces within less than 3,000 m	%	100	Caofeidian
	Accessible to city green land (>10 ha) in less than 1,000 m	%	100	Caofeidian
	Residence accessible to shoreline or river banks in less than 1,000 m	%	100	Caofeidian
	Accessible to city green land in less than 500 m	%	≥80	Li and Yu, 2011

Table 5.6: Infrastructure indicators (source: World Bank., 2009).

Subcategory	Indicator	Units	Criteria	Source
Service Network	Provision of free recreational and sport facilities within walking distance of 500 m	%	100	Tianjin
	Provision of free recreational and sport facilities within walking distance of 1000 m	%	100	National Liveable City Guideline
	Barrier-free accessibility	%	100	Tianjin National Barrier-free City standard All most all

				developed countries
	Central sewage treatment	%	100	Tianjin
			≥85	Eco-City standard
			≥70	Eco-Garden city standard
			International Benchmark Singapore (100) Tokyo (100)	
	Tap Water	%	100	Tianjin
			100	Eco-Garden City standard
			90	Garden City standard
			International Benchmark Tokyo (100)	
	Central Heating	%	100	Tianjin
			65	Eco-City standard
	Gas	%	80	Garden city standard
	Proportion of public housing	%	20	Tianjin
			International Benchmark Hong Kong (50) Singapore (80)	

Table 5.7: Social Indicators (source: Zhou, *et*, *al*., 2012; World Bank., 2009).

Subcategory	Indicator	Units	Criteria	Source
Satisfaction	Public satisfaction with the environment	%	90 (2010) 95 (2020)	Wu, *et. al*., 2005
R&D	Percentage of personnel in R&D	%	14 (2010) 18 (2020)	Wu, *et. al*., 2005
	Percentage of spending on R&D	%	≥2	Li and Yu, 2011
	Number of R&D Scientists and engineers per 10,000 labour force	man-year	≥50	Tianjin
			International benchmark Japan (101) USA (92) France (71) Germany (68)	
Education	Average years of education for adults	yr	12 (2010) 14 (2020)	Wu, *et. al*., 2005
			>10	Guiyang City, 2008
	Public eco-civilisation literacy and participation rates	%	100	Guiyang City, 2008
	Public environmental literacy and participation rates	%	75 (2010) 90 (2020)	Wu, *et. al*., 2005

	Fiscal spending on education in GDP	%	≥4	Li and Yu, 2011
Equity	Sex ratio at birth	Girls = 100	100-108 (2012)	Guiyang City, 2008
	Gini coefficient inverse	N/A	2.6 (2010) 2.9 (2020)	Wu, *et. al.*, 2005
	Coverage of social insurance	%	>80	Guiyang City, 2008
	Registered urban unemployment rate	%	<4.5	Guiyang City, 2008
Culture	Cultural industry in GDP	%	4	Guiyang City, 2008

Table 5.8: Energy Indicators (source: Zhou, *et, al*., 2012; World Bank., 2009; Helsingborg, 2012).

Subcategory	Indicator	Units	Criteria	Source
Energy	Energy Production	10,000 GDP/tce	1.6 (2010) 2.8 (2020)	Wu, et al., 2005
	Energy consumption per GDP	tce/10,000		
	Reduction of total energy use compared to 2005	%	15% (2020) 30% (2035)	Helsingborg
Carbon	Carbon productivity	10000 GDP/tCO_2	20% above average;	Zhung., Pan. and Zhu., 2011
	Average carbon emission per capita	tCO_2/Person	low carbon = <5; medium = 5-10; high => 10	Zhung., Pan. and Zhu., 2011
	Average carbon emission per capita by residence	tCO_2/Person	low carbon = <5/3; medium = 5/3-10/3; high	Zhung., Pan. and Zhu., 2011

			= >10/3	
	Carbon emission per GDP	tC/millions USD	150	Tianjin
			Country wide targets by 2012: USA : 122 Japan : 59 EU : 103 Singapore (2006) : 350	
	Total carbon emission by transportation	$kgCO_2$/capita/km	20	Caofeidian
	Reduction of carbon emission by transportation, compared to 2005	%	35% (2020) 55% (2035)	Helsingborg
Sectorial energy use	Commercial building electricity consumption	kWh/m^2/yr	50	Caofeidian
	Commercial building heating	kWh/m^2/yr	15	Caofeidian
	Commercial building air conditioning	kWh/m^2/yr	20	Caofeidian
	Residential building electricity consumption	kWh/m^2/yr	25	Caofeidian
	Residential building heating	kWh/m^2/yr	45	Caofeidian
	Residential building air-conditioning	kWh/m^2/yr	0	Caofeidian
	Total energy (including transportation)	kWh/capita/yr	10,000	Caofeidian

	Electricity	kWh/capita/yr	3,500	Caofeidian
	Government/public building energy consumption per unit	$kWh/m^2/yr$	<90	Li. and Yu., 2011
Energy security	Rate of self sufficiency	%	80	Caofeidian
			100	Rejkjavik
Renewable energy and clean energy	Renewable power production / total power consumption	%	85	Caofeidian
			100	Rejkjavik
	Non fossil fuel in primary energy	%	low = >20; medium=10-20; high = <10	Zhung., Pan. and Zhu., 2011
	Reduction of fossil fuels for heating compared to 2005	%	50% (2020) 100% (2035)	Helsingborg
	Renewable energy utilitarian rate	%	≥20	Tianjin
			≥15	Li. and Yu., 2011
			20% from biogas 15% from wind & wave 1% from solar	Helsingborg
			International bench marks Finland (25) Sweden (33) Holland (20 by 2020) EU (20 by 2020)	
	Proportion of	%	95	Caofeidian

	renewable energy (excluding transportation)			
	Renewable/total energy (transportation)	%	75	Caofeidian
	Utilization rate of clean energy	%	>50	Guiyang City, 2008

Table 5.9: Water Indicators (source: Zhou, *et*, *al*., 2012; World Bank., 2009).

Subcategory	Indicator	Units	Criteria	Source
Water resources	Penetration of running water	%	100 (24 hr)	MoHURD Eco-Garden City
	Utilization of reclaimed water	%	≥30	MoHURD Eco-Garden City Li. and Yu., 2011
	Rate of rain storage	%	90	Caofeidian
	Extent of wetland	%	1	Caofeidian
	Water supply source (surface/run off)	%	>70	Caofeidian
	Recyclable waste water	%	<10	Caofeidian
	Industrial water recyclable rate	%	≥80	MEP
			>90	Li. and Yu., 2011
			>75	Guiyang City, 2008
	Net loss of natural wetlands	N/A	0	Tianjin
	Water supply from non-traditional	%	≥50	Tianjin
			≥40	Caofeidian

	sources		≥50	Singapore City (currently)
Water consumption and utilisation	Freshwater consumption per unit of industrial added value	m^3/10,000 GDP	≤20	MEP
	Effective utilisation coefficient of irrigation water	m^3/10,000 GDP	≥0.55	MEP
	Daily consumption per capita	L/capita/day	≤120 (2013)	Tianjin
			100-120	Caofeidian
			International standards Beijing(110-130) Singapore(154) Cologne(137) Amsterdam(154) Sydney(254) Tokyo(268) Los Angeles(440)	
	Utilisation rate of non-conventional water resources	%	≥50 (2020)	Tianjin
	Hot water temperature	°C	70	Caofeidian
Water Quality	Compliance rate for quality of centralised source of drinking water/ Tap water compliance rate/	%	100	MEP Tianjin Guiyang City, 2008. MoHURD

	primary drinking source/ Comprehensive compliance rate for quality of city pipeline water/			Eco-Garden City
	Portion of regional water quality great than level 3	%	80(2010) 95(2020)	Wu, et al., 2005
	Water quality and near-shore water quality	N/A	Meets functional area standard, and no water quality worse than standard V	MEP
	Water quality meets functional area compliance rate	%	100	MoHURD Eco-Garden City Li and Yu, 2011
	Water quality	N/A	Meets GB3838 water quality standard IV	Tianjin Caofeidian
Water treatment	Urban sewage treatment rate	%	≥70	MoHURD Eco-Garden City
			≥85	MEP
			≥90	Guiyang city,2008

Table 5.10: Air/Noise Quality Indicators (source: Zhou, *et, al*., 2012; World Bank., 2009).

Subcategory	Indicator	Units	Criteria	Source
Air Quality	Air quality index (annual percent of days that exceed level 3)	%	95%	Wu, et al., 2005
			≥82%	MoHURD Eco-Garden City
			≥82% (Exceed level 2)	Tianjin

	Compliance rate of downtown air quality	%	95%	Guiyang City, 2008
	Indoor air quality: radon	Bq/m^3	<50	Caofeidian
	Indoor air quality: nitride	Bq/m^3	<50	Caofeidian
	PM10 daily average density (annual days that exceed level 2)	days	≥347	Li and Yu, 2011
	SO_2 daily average density (annual days that exceed level 2)	days	≥347	Li and Yu, 2011
			≥155 (level 1)	Tianjin
	NO_2 daily average density (annual days that exceed level 2)	days	≥347	Li and Yu, 2011
			≥155 (level 1)	Tianjin
Pollutant control	Intensity of discharge of major pollutants (COD/SO_2)	kg/10,000 GDP	<4.0/<5.0	MEP
	Total emission of SO_2	10,000 ton	<18	Guiyang City, 2008
Noise Pollution control	Chinese national standard GB 3096-2008	%	95% (2015)	Tianjin Binhai New Area

6 DISCUSSION/FRAMEWORK

6.1 Explanation of the framework (schematic diagram)

The analysis of the two case studies will be conducted based on the following framework.

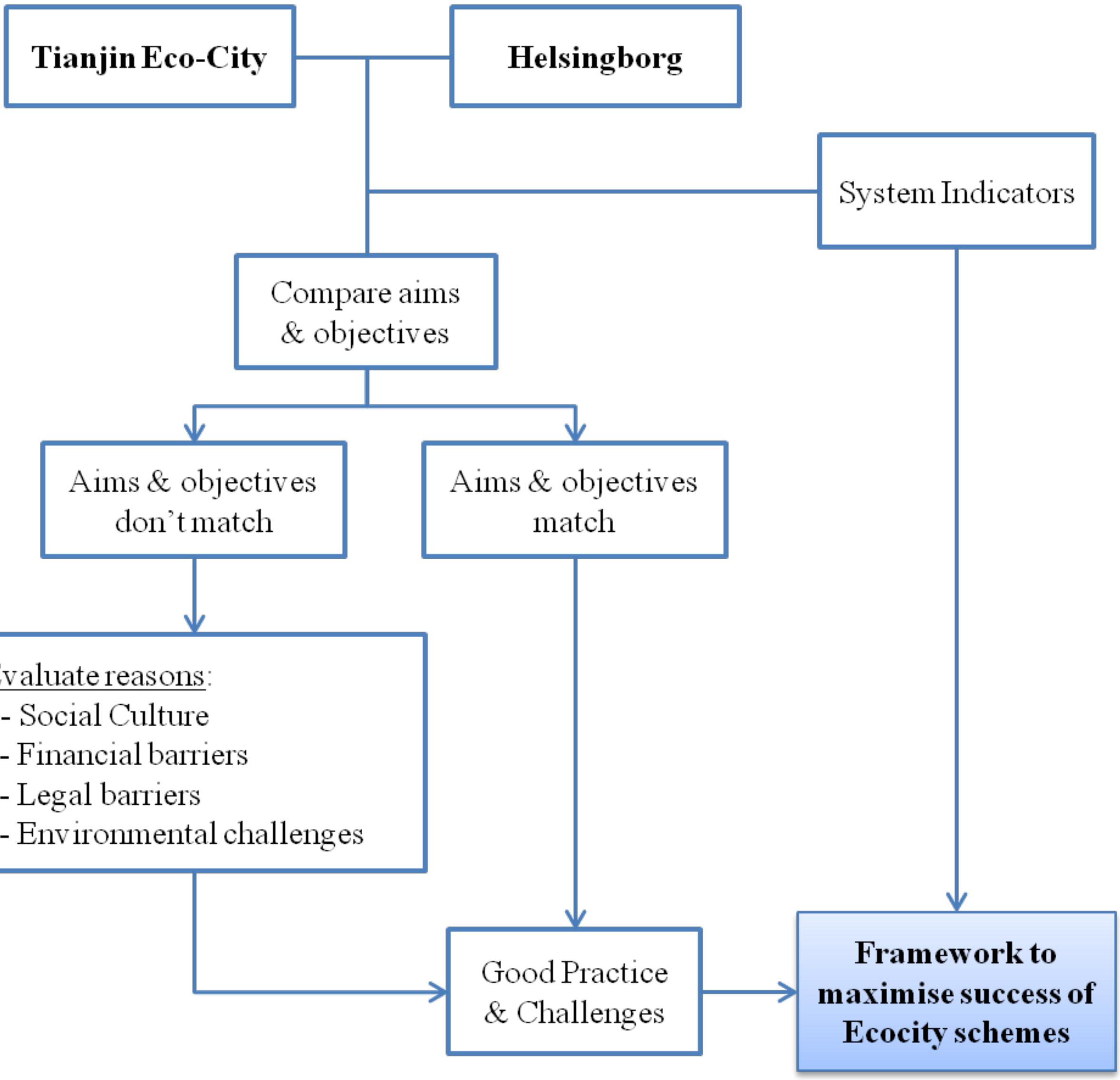


Figure 6.1: Schematic Diagram of the Framework.

The process commences by choosing one aspect of the development schemes and comparing its aims and objectives. Two possible outcomes are expected; either the aims and objectives will match or they will not. In the latter case, an analysis will follow by evaluating the reasons that lie behind it. Social and cultural barriers, financial barriers, legal barriers and environmental challenges will be examined as possible reasons for the mismatch. Based on these results and combining them with the project objectives that similarly exist in the two sustainable schemes developed, a certain context of "Good practice and challenges" can be produced. Next, the "Good practice and challenges" recommendations will be combined with international standards and performance indicators in order to develop a framework, which aims to maximise the success in developing ecocity schemes.

6.2 Application of the framework

6.2.1 Green buildings: framework, conclusions, summary

Buildings are major energy users in both Helsingborg and Tianjin Eco-City. Two cities have demonstrated great effort on the implementation of green buildings, which can reduce energy demand, maximize the use of renewable energy sources and use fossil fuels in the cleanest possible way. The following Table illustrates comparisons between the two cities with respect to green building aspect.

Table 6.1: Comparisons between Helsingborg and Tianjin Eco-city with respect to green building.

	Helsingborg	Tianjin Eco-City
Aims	- Reduce the energy demand - Use Renewable energy as much as possible - Apply fossil fuels in the cleanest way	According to the KPIs, 100% of the buildings will be green buildings in line with the GBES
Green building standard, certification	Miljöbyggnad covers the following categories - Energy - Materials - Indoor environment	GBES covers following categories - Energy - Materials - Indoor environment - Water - Management - Location and infrastructure
Green-technologies applied in buildings	- Renewable energy supply - Efficient heating system - Hot water supply - Water saving apparatus - Eco-friendly materials - Monitoring system	- Renewable energy supply - Efficient heating system - Hot water supply - Water saving apparatus - Eco-friendly materials - Monitoring system

* GBES: Evaluation Standard for Green Building, Miljöbyggnad: Environmental Building (Swedish)

From table 6.1, it is clear that the aims for the building constructions are different in the two cases examined. The difference lies in the disparity of green building standards and certification that they employed, as the green technologies facilitated were quite similar as analyzed below. Therefore, the mere utilisation of different certifications and standards led to the distinctly separated aims and subsequent structures.

In the case of establishing green buildings in Tianjin Eco city, GBES is employed. However, is also followed by a subsequent procedure to establish the buildings as 100% green building as part of the objective of the project. On the other hand, the certification and guidelines in Sweden, Miljöbyggnad, covers only energy, materials and indoor environment while more categories are covered by GBES like water, management, location and infrastructure. Therefore, Tianjin Eco-city was constructed based upon stricter green building standards than Helsingborg.

In the case of green technologies, most of green-technologies applied in both cities are similar to each other. Both cities have similar levels of technologies related to renewable energy supply, efficient heating system, hot water supply, water saving apparatus, eco-friendly materials, and monitoring system.

The reasons for the utilization of different standards will be further down explored.

Social Culture

There is no direct social context in the decision of choosing the building standards for constructing green buildings. Even though social issues are not directly involved on the result of the process; the construction of a green building is connected to social issues as it may affect property prices.

The indices employed to evaluate the property prices in both cities are the “Price to Income Ratio”, the “Mortgage as Percentage of Income” and the “Loan Affordability Index”. The indices are explained further down.

“Price to Income Ratio“ is the basic criteria to measure the affordability for apartment purchase. It is the ratio of median apartment prices to median familial disposable income, expressed in income per year. The formula used by the source (Numbeo.com, 2013) assumes the net disposable family income to be 1.5 times the average net salary. Furthermore, the average apartment to have 90 square meters and its price per square meter to be the average price of square meter in city center and surroundings.

The “Mortgage as Percentage of Income” criterion is the ratio of the actual monthly cost of the mortgage to take-home family income. The family income is valued as the average monthly salary. It is assumed that 100% of the mortgage will be taken on for 20 years for a house or an apartment of 90 square meters. The average price per square meter is the average of the price in the city center and its surrounding. The "Loan Affordability Index" is an inverse of the mortgage as percentage of income (Numbeo.com, 2013).

The data acquired regarding the aforementioned criteria for Helsingborg and for Tianjin are compared in the following graph (Figure 6.2). It should be noted that data concerning the Tianjin Eco city specifically are not available; however, due to the fact that the residents come from Tianjin and the property prices will be equal or even higher, the data from Tianjin city can be used to perform the comparison.

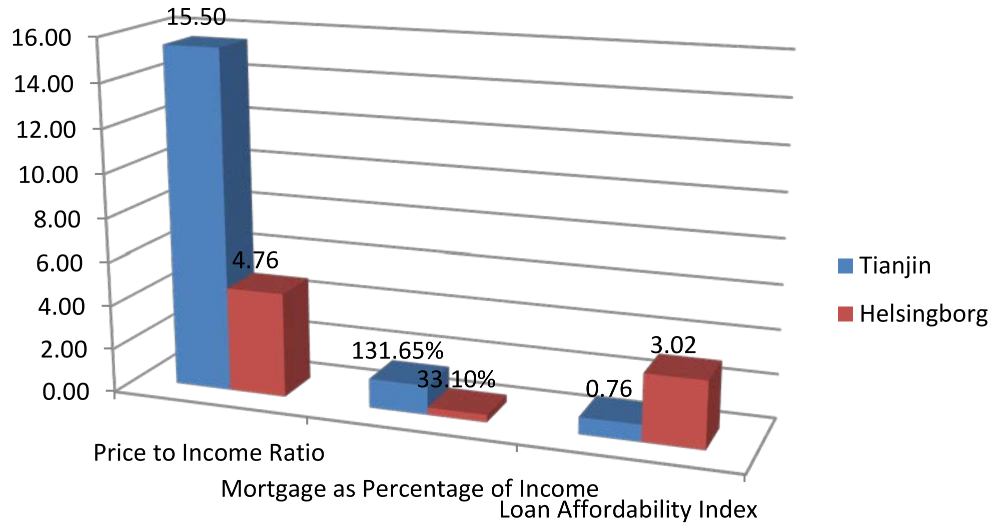


Figure 6.2: Comparison of property prices indices taken from Numbeo.com (2013).

All three indices show that in Helsingborg the property prices are rather affordable compared to Tianjin city. The main and distinct difference is the "Price to Income Ratio"; 15.50 in Tianjin and 4,76 in Helsingborg, which indicates rather unaffordable property prices for Tianjin. However, the developers acknowledged major issues that can be raised by high affordibility price, and facilitated an "Eco-city Public Housing Pilot Project" in the overal scheme (Nankai University, 2010).

Financial Barriers

In the case of Tianjin Eco city, the stricter regulations lead to increased financial resources for the implementation of a green building compared to Helsingborg. Taking into consideration the scale of both schemes and the funding that is demanded, financial reasons could be a barrier. In order Helsingborg to adopt the GBES standards, the allocation of funds would be much larger.

Legal Barriers

The standards and certifications used for green buildings are not legally established; therefore the developers in each case were not legally bonded to use them specifically. Thus, there are no legal barriers in the process of designing and constructing green buildings under specific standards.

Environmental Challenges

There are different environmental challenges that need to be tackled in each country. China has to cope with many issues regarding water, air and soil pollution. However, Sweden has lower level of pollution. Increased need to tackle environmental problems leads to stricter green building standards in China. It is clear from the standards set for the green buildings that China is striving to develop sustainable cities and as a means manage environmental problems. On the other hand, Sweden having less significant issues to tackle has set different certifications, which also promote sustainability but focus on fewer aspects on buildings. Another issue that should be considered is the targets set by Kyoto protocol regarding future greenhouse gas emissions. Different targets promote different strategies; hence it is not surprising that these countries do not have similar standards for green buildings.

Transferability

To cities within their region

Both schemes can be replicated in cities within the region of each project as the certifications and standards are valid and employed throughout each country. The type of green technologies facilitated can also be utilized in other project; however, this claim should be carefully made as logistics and availability could be an issue.

Across EU-Asia border

It was analyzed that the main difference in the green building aspect of the two case studies is the green building standards as the Chinese ones are stricter. Transferability from China to Sweden regarding the standards that govern green buildings can be conducted. Nonetheless, it should be taking into consideration that due to the additional elements that have to be examined, the cost of a development/redevelopment performed with Chinese certificates (GBES) may be increased.

Non-transferable aspects

In the case of green building there are non-transferable aspects as the green building standards of Sweden cannot be transferred to China. This can be attributed to the stricter environmental targets that Chinese eco-cities have to comply with. Hence, it is necessary to conduct all green building projects with specific certifications and standards.

6.2.2 Energy supply

As expained in Chapter 4.2.2, Helsingborg and Tianjin Eco-City have their own objectives and strategies on energy supply. The energy for heating and electricity in Helsingborg is supplied by a large scale cogeneration plant, along with the local energy system that integrates energy initiatives like waste heat, bio-gas and land fill. In Tianjin Eco-City, the energy supply includes two large heat and power plants and several renewable sources like wind turbine, solar power plant and geothermal.

Through application of the framework presented in Chapter 6.1, the objectives and practices on energy supply between the two cities share some similarities as well as differences.

Table 6.2: Match and dismatch items on energy supply.

<table>
<tr><th colspan="2" rowspan="2">Match Items</th><th colspan="2">Dismatch Items</th></tr>
<tr><th>Helsingborg</th><th>Tianjin Eco-City</th></tr>
<tr><td rowspan="2">Objectives</td><td rowspan="2">- Implementation of renewable energy and reduction on the usage of fossil fuel.
- Energy saving on residential and public buildings.
- Real time monitoring on energy usage of inhabitants.</td><td colspan="2">- Different major renewable energy source</td></tr>
<tr><td>Biogas, wind and wave power</td><td>Solar, wind power and Geothermal</td></tr>
<tr><td rowspan="2">Space Heating</td><td rowspan="2">- Combined Heat and power (cogeneration) plant
- Waste heat recovery from power plant and industries</td><td colspan="2">- Different share on centralized and distributed heat source</td></tr>
<tr><td>50% centralized source
35% distributed source</td><td>70% centralized source</td></tr>
<tr><td>Electricity</td><td></td><td colspan="2">- Higher proportion of renewable energy in Tianjin Eco-City comparing to Helsingborg</td></tr>
</table>

Match and dismatch items on energy supply are presented in three catagories: Objectives, Space Heating and Electricity in table 6-2. Match items are introduced in both Helsingborg and Tianjin Eco-City and can be considered as good practices with high transferablity within the same region and across EU-Asia borders. These good practices in energy sector for coastal eco-city include:

- to lower the dependency on fossil fuel and prioritize renewable energy like solar, wind and wave energy.
- to implement energy saving techniques like heat insulation, solar hot water and ventilation with heat recovery on residential and public building.
- to utilize real time monitoring on energy consumption of local inhabitants for avoiding unnecessary waste of energy and improving energy efficiency.
- to supply heating and electricity from combined heat and power (cogeneration) plant.
- to recover heat from power plants and local industries.

However, in the energy supply sector, significant differences between two cities are detected considering aspects like major renewable energy source and heat source centralization. To highlight the dismatch items, there are two major differeces between the two cities:

- Biogas in Helsingborg comparing to solar and wind energy in Tianjin Eco-City
- Distributed heat source in Helsingborg comparing to a more centralized heat source in Tianjin Eco-City

Biogas V.S. Solar and wind energy

The planed major renewable energy source is different for the two cities. According to table 4.18, the objectives on energy supply in Helsingborg by 2035 include a large share of biogas and wind,wave energy. However in Tianjin Eco-City, all the electricity is supplied by wind turbine and solar power plant. The share of major renewable energy source of the two cities is demonstrated in the following table.

Table 6.3: Proportion of major renewable energy source of the two cities.

	Helsingborg By 2035		Tianjin Eco-City By 2013	
	Absolute (GWh/year)	Percentage	Absolute (GWh/year)	Percentage
Biogas	314	19.6%	Not mentioned	Not mentioned

Wind and wave power	240	15.0%	3	100% of electricity in the start-up area
Solar power	15	1.1%	16	
Geothemal	Not mentioned	Not mentioned		3.7%(by 2020)

In table 6.3, the absolute value of wind and solar power is small. Because in the start-up area of Tianjin Eco-City, only 4000 residents are inhabitated currenlty (i.e. until 2013). Hence, the existing wind farm and solar power plant can provide all the eletricity needed for the residents. Meanwhile, the objectives of Tianjin Eco-City require that 20% of the energy supply is obtained from renewable energy sources by 2020 for a population of 350,000. A significant portion of that renewable energy will be coming from wind and solar energy.

From the difference on renewable energy source of these two cities, the following questions are raised:

- Why does Helsingborg show little interest on the development of solar power plants?
- Is biogas power plant an ideal renewable energy source for Tianjin Eco-City?

Regarding the first question:

According to the following figure, the peak sunshine hour in Helsingborg is less than 2 hours per day, while Tianjin Eco-city is more than 4 hours per day. So it is not practical to introduce solar power plant in Helsingborg due to the shortage in solar irradiance.

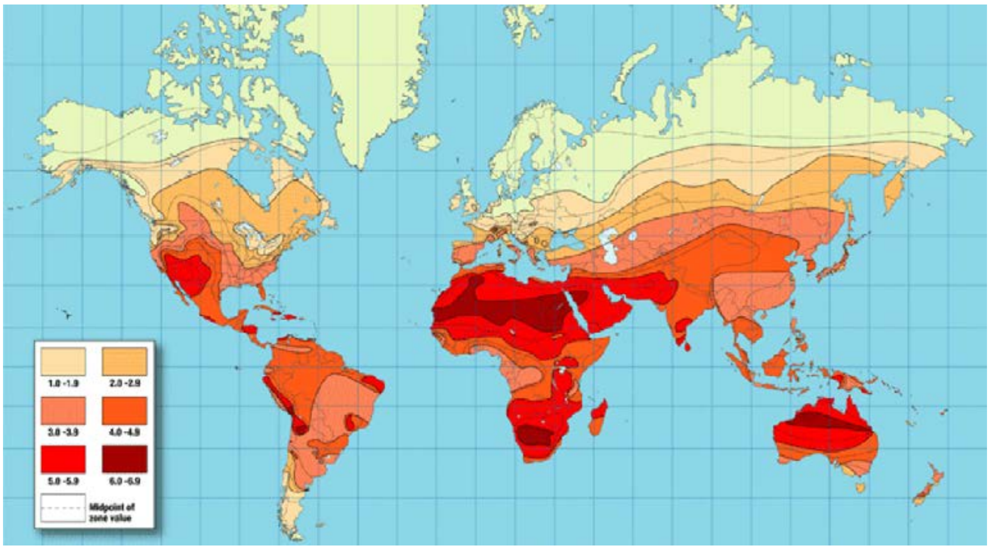


Figure 6.3: Worldwide peak sunshine hour taken from http://www.applied-solar.info/solar-energy/will-solar-panels-work-at-my-location/.

For the second question, the comparison on the total cost and GHG emission of solar, wind and biogas power plant in Tianjin Eco-City are compared in the following section.

When completed by 2020, Tianjin Eco-city expected to have 350,000 residents. In 2020, the electricity consumption per capita in Tianjin is predicted to be 1.852kW (CNMEDI, 2008). Electricity demand of Tianjin Eco-City in 2020 can be calculated as:

$$G_e=350000\times1.852kW\times24h\times365= 5678.2GWh \quad (1)$$

Given the proportion of solar and wind energy in electricity supply as 10% each, the power of solar and wind energy is 567.82GWh for each.

For solar power plant, the peak sunshine hour in Tianjin Eco-City ranks sixth among major cities in China, and is about 4.65 hours per day (Baike, 2012).

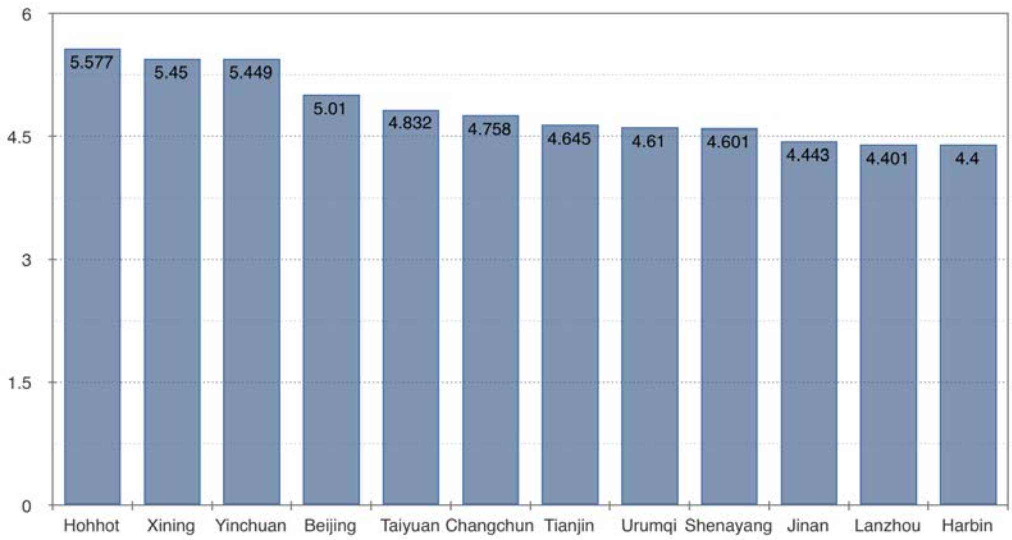


Figure 6.4: Peak sunshine hour of cities in China taken from Baike (2012).

The total power of the solar plant should be:

$$P_s=567.82GWh/365/4.65h=334.6MW \quad (2)$$

The unit power of solar cell is approximately $150w/m^2$. Hence the area of solar panel should be:

$$A_s= P_s/150w/m^2=2.23km^2 \quad (3)$$

For the wind farm, the annual available hour in Tianjin 2011 is 2014 hours (NEA, 2012). The total power of the wind farm is calculated as:

$$P_w=567.82GWh/2214h=257.6MW \quad (4)$$

If Gamesa G90 is chosen as the wind turbine in Tianjin Eco-City, the power is 2 MW (TWEA, 2009).

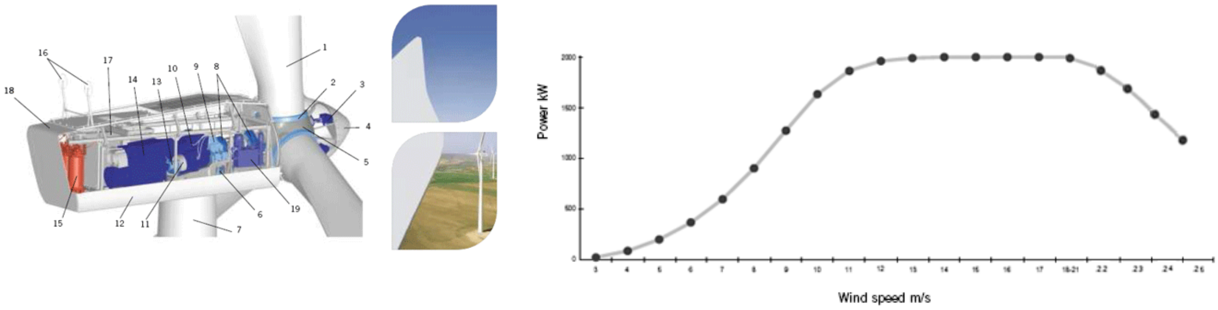


Figure 6.5: General information of Gamesa G90 2.0MW taken from TWEA (2009).

Using the above information the number of wind turbines needed is calculated using equation (5) :

$$N_w = P_w/2 = 129 \quad (5)$$

The estimated capital and operating cost of different power plants is shown in Table 6.4. The estimated lifecycle of GHG emissions from different power plants are presented in Table 6.5.

Table 6.4 Estimates of power plant capital and operating cost taken from EIA (2013).

	Nominal Capacity(MW)	Overnight Capital Cost ($/kW)	Fixed O&M Cost ($/kW/year)	Variable O&M Cost($/MWh)
Onshore Wind	100	2213	39.55	0.00
Offshore Wind	400	6230	74.00	0.00
Solar Photovoltaic	20	4183	27.75	0.00
Solar Photovoltaic	150	3873	24.69	0.00
Biogas*	22.5	900	105.63	-

* Biogas data is from table 4.13 assuming the annual operation time as 2000 hours, and the O&M cost is estimated from that of a biomass power plant in EIA (2013).

Table 6.5: lifecycle GHG emissions from different power plants (Sovacool, 2008).

	Descriptions	Estimated GHG emission ($g\ CO_2/kWh$)
Onshore Wind	1.5 MW	10
Offshore Wind	2.5 MW	9
Solar Photovoltaic	Polycrystalline silicon	32
Biogas	Anaerobic digestion	11

For the biogas power plant, the actual GHG emissions are high due to the high proportion of methane in the biogas. However, the net GHG emission of biogas is zero, as it is part of the biological carbon cycle, as opposed to releasing fossil carbon contained in geological fossil fuels.

Based on the data in table 6-4 and 6-5, the total cost and GHG emission of wind, solar and biogas power plant with same amount of electricity (567.82GWh/year) are compared as shown in the following table:

Table 6.6: Estimated total cost and GHG emission

	Power/ P (MW)	Overnight Capital Cost/OCC (million $/MW)	Fixed O&M Cost/OMC (million $/MW/year)	Years of operation/ Y	Total cost = P*(OCC+ OMC*Y) (billion $)	GHG emission (g CO_2/kWh)	Total emission(10^5t CO_2)
Solar	334.6	4.183	0.03955	25	1.731	32	4.54
Wind onshore	257.6	2.213	0.02775	25	0.749	10	1.42
Biogas	283.9	0.900	0.10563	25	1.005	11	1.56

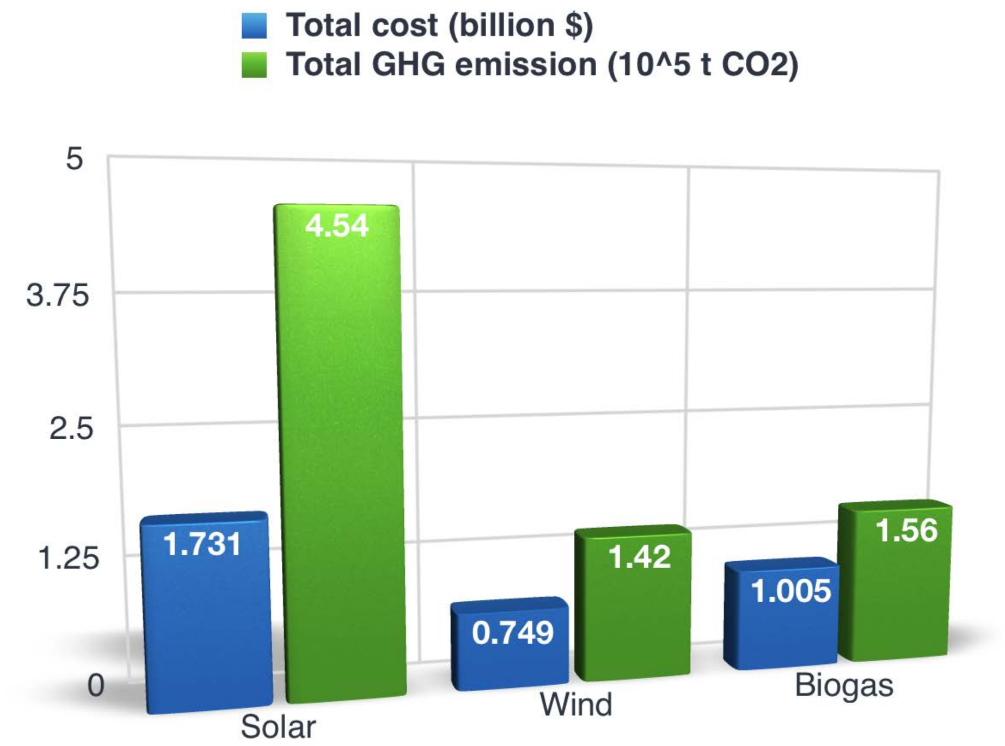


Figure 6.6: Estimated total cost and GHG emission.

According to the comparison results, solar power plant has the highest total cost, while wind power plant has the lowest cost. The total cost of biogas is higher than wind due to the high operation and maintenance cost. Moreover, GHG emissions show the same trend as the total cost. Solar power plant has largest lifecycle GHG emissions. The amount of GHG emissions generated by wind and biogas is almost the same and accounts for only one third compared to the solar power plant.

Tianjin Eco-City has profound wind and solar energy resources comparing to other cities in China. However, solar power plant is not suitable for Tianjin from the perspective of cost and GHG emissions. Wind power plant is the ideal renewable energy source for Tianjin Eco-City. Moreover, if there is enough organic food waste sorted from household and industries, biogas power plant is also an ideal renewable energy source that Tianjin Eco-City should consider exploiting.

In addition, solar, wind and biogas could be suitable renewable energy sources for a coastal eco-city. However, the ideal renewable energy source combination is decided by the city's resources, i.e. the peak sunshine hour, the annual available hour for wind farm and supply of organic waste for biogas.

Distributed heating system V.S. Centralized heating system

According to the comparision in table 4.20, more than 70% of heating energy in Tianjin Eco-City comes from the centralized power plant. However, in Helsingborg only 50% comes from power plant and 35% comes from decentralized energy sources like combined heat and power gas turbine, electrical, gas and oil heating. Hence, it is reasonable to say; in Helsingborg distributed heat source is preferred while a more centralized heat source in Tianjin Eco-City is adopted.

Generally, the benefits of a centralized district heating system includes: lower capital costs, lower energy costs, lower operating and maintenance costs, stable competitive energy rates, more revenue-generating space, reliable heating service, lower costs through expansion and a cleaner environment (Concord Steam, 2011).

Considering the advantages of a centralized heating system, as Tianjin Eco-City is newly built, adopts a centralized heating system. The system can be easily implemented in a new city. However, only 78% of the household is supported by centralized district heating system in Helsingborg (Öresundskraft, 2011). This is mainly due to the fact that Helsingborg is an ancient city with some households, which are supplied by their own independent heating system powered by electricity, gas, biofuel or oil. Furthermore, distributed heating system is more energy consuming and less cost effective. This is one of the reasons more distributed heating systems exists in Helsingborg comparing to Tianjin Eco-City.

In general, a more centralized heating system should be implemented in a coastal eco-city, because it is more economical and environmentally friendly comparing to the distributed one.

Transferability

To cities within their region and across EU-Asia border

In the energy supply sector, some good practices with high transfariablity within the same region and across EU-Asia borders are found. These good practices for coastal eco-city includes:

- to low the dependency on fossil fuel and prioritize renewable energy like solar, wind and wave energy.
- to implement energy saving techniques like heat insulation, solar hot water and ventilation with heat recovery on residential and public building.

- ➢ to utilize real time monitoring on energy consumption of local inhabitants for avoiding unnecessary waste of energy and improving energy efficiency.
- ➢ to supply heating and electricity from combined heat and power (cogeneration) plant.
- ➢ to recover heat from power plants and local industries.
- ➢ to introduce a more centralized heating system.

Non transferable aspects

In the case of energy supply there are non transferable aspects:

- ➢ The solar power plant in Tianjin Eco-City cannot be transferred to Helsingborg. The biogas power plant can only be tranferred unless enough organic waste is generated. Generally, the ideal renewable energy source combination is determined by the city's local context, i.e. the peak sunshine hour, the annual available hour for wind farm and supply of organic waste for biogas.
- ➢ The centralized heating system, which Tanjin Eco-city heavely depends on cannot be transfered to Helsingborg.

6.2.3 Waste management

Based on the comparision of waste management in Chapter 4.2.3, Helsingborg and Tianjin Eco-City have their own aims and practices. Waste management is a highly integrated system incorporating processes like waste generation, segregation, recycle, treatment and disposal. To reach the goal of becoming a costal eco-city, these two cities both introduced active strategies (e.g. waste reduction, recycle) and cutting edge technologies (e.g. biological treatment, waste to energy).

Through application of the framework presented in Chapter 6.1, the objectives and practices on waste management between the two cities share some similarities as well as differences.

Table 6.7: Match and dismatch items on waste management.

<table>
<tr><th rowspan="2"></th><th rowspan="2">Match Items</th><th colspan="2">Dismatch Items</th></tr>
<tr><th>Helsingborg</th><th>Tianjin Eco-City</th></tr>
<tr><td rowspan="2">Objectives</td><td rowspan="2">- Active strategies on waste prevention and minimization
- Ambitious goal on waste</td><td colspan="2">- Different waste collection system</td></tr>
<tr><td>Conventional truck collection system</td><td>Pneumatic collection system</td></tr>
</table>

	recycling rate		
Waste management process	- Recycle and treatment oriented waste sorting system - Large share of food waste in household waste with biological treatment on food waste - Waste to energy techniques mainly waste incineration	- Different biological treatment techniques	
		Anaerobic digestion and composting	Aerobic microbial digestion
		- Different share on waste recycle and waste to energy	
		40% waste recycle 50% waste to energy	60% waste recycle 30% waste to energy

Match and dismatch items on waste management are presented in two catagories: Objectives and waste management process in table 6.7. The matching items are introduced in both Helsingborg and Tianjin Eco-City and may be considered as good practices with high transferablity within the same region and across EU-Asia borders. These good practices in energy sector for coastal eco-city include:

- prioritization of waste prevention and minimization through techniques like clean vegetables and green packaging
- increase of waste recycling rate actively by education on residents, policy incentives and waste resorting
- establishment of a waste segregation system guided by the practices in waste recycle and treatment process
- adoption of biological treatment on food waste
- use of waste incineration plant for waste disposal at the same time generating heat and electricity.

However in the waste management sector, some differences between two cities are found in respect of major waste collection system, biological treatment techniques and waste recycle rate. To highlight the dismatching items, there are three major differeces between the two cities:

- Conventional truck collection system in Helsingborg comparing to Pneumatic collection system in Tianjin Eco-City
- Anaerobic digestion and composting in Helsingborg comparing to Aerobic microbial digestion in Tianjin Eco-City
- High waste recycle rate in Tianjin Eco-City comparing to Helsingborg

Truck collection system V.S. Pneumatic collection system

As stated above, Helsingborg is an old city, uses the traditional truck based collection system. However, Tianjin Eco-City is a newly built city, hence, it established an innovative pneumatic collection system. The advantages and disadvantages of both collection system are summerized in the following table:

Table 6.8: Advantages and disadvantages of truck and pneumatic collection system

	Advantages	Disadvantages
Truck collection system	- Low capital costs - Flexible for expansion - Easy implementation	- Environmental impact of waste collection truck - Space needed for storing and removing waste - High operation cost
Pneumatic collection system	- Reduce the visual impact of containers - Reduces environmental impact of waste collection truck - Low operation cost - Allows for selective waste collection at source - Gross Floor Area savings	- High capital investment costs - Inconvenience during construction - Collection of limited types of waste - Possible blockages in pipeline - Huge effort on education for citizen participation

Despite the several advantages, the high capital investment and inconvenience on constuction seem to be the major obstacles for the implementation of pneumatic collection system. In the following table, the estimated costs of existing pneumatic collection systems are summarized:

Table 6.9: Estimated costs of existing pneumatic collection systems.

	Population in covered area	Year of completion	Capacity (t/day)	Capital investment (million US dollar)	Annual O&M costs (million US dollar)
Leon, Spain (WSA, 2002)	4,000 residents 150 bars	2002	10	6.884	0.1
Wembley City, UK (WIN, 2011)	10,000 residents	2010	24	17.05	0.324

Shanghai Expo, China (Wang and Li, 2010)	Shanghai Expo 2010 cental area: 0.5 km^2	2010	13	9.639	0.233
Tianjin, China (China Daily, 2011)	100,000 residents	2012	87	24.507	Not mentioned
Roosevelt island, USA (Envirogenics, 1975) (Fecht, 2012)	12,000 residents	1975	5.8	7.0 (1975)	2.3

The system is now used in more than 30 countries (BBC, 2008). Envac is one of the major designers of the pneumatic collection system. In Wembley city, UK, they conducted a comprison on the capital investment cost and operational cost between truck (EUROBIN) and pneumatic system (ENVAC):

Table 6.10: A comparison of Envac vs traditional collection methods using Eurobins for a development of 10, 000 flats (Comparison over 30 years) (WIN, 2011).

Capital Expenditure (CAPEX)	**ENVAC**	**EUROBIN**	**COMMENTS**
Eurobin cost	£0	£2,550,000	Total 1700 bins x £250/bin, replaced every 5 years
Envac capital cost	£11,000,000	£0	Design, supply and fix all pipe, inlet, collection station
Bin room housing cost	£500,000	£10,625,000	Eurobin, 1700 bins @ 2.5sq.m. per bin @£2500/sq.m.
			Envac is for building to house collection station
Trenching cost	£1,100,000	£0	

Total Capex	£12,600,000	£13,175,000	
Capex per flat	£1,260	£1,317.50	
Capex per flat/year	£42	£43.92	
Operational Expenditure (OPEX) per year			
Envac full service	£98,000	£0	Service/maintain Envac system
Envac energy cost	£11,000	£0	Power to run fans, compactors etc.
Eurobins maintenance	£0	£17,000	4% per year to replace lids/castors/vehicle damage
Eurobin annual clean	£0	£13,600	£8 per bin per year
Eurobin portering costs	£0	£160,000	1700 bins will require 8 full time staff @ £20k p.a. to move bins to kerbside and back to bin store
Waste collection cost*	£100,000	£480,000	£10/flat/year with Envac - £48/flat/year without Envac
Total Opex/year	£209,000	£670,600	
Opex per flat/year	£20.90	£67.06	

According to the table, the estimated capital investment cost and operational cost of pneumatic collection system can be lower than the truck collection system considering the total cost of EUROBIN. Moreover less GHG emissions are produced using the pneumatic system. Therefore, in the case of a new built city like Tianjin Eco-City, the pneumatic collection system may be an ideal choice for an ecological and economic waste collection system.

However, it is still not clear whether it is possible for an ancient city like Helsingborg to adopt the new system. It should be noted though, that the comparison above is conducted based on a new built city, and the extra construction cost in an old city and the inconvenience on local residents was not considered. However, in table 6.9 the case city of Leon, which is an ancient city refurbished with the new system, showed no significant extra cost, compared to new built cities. Hence regarding Helsingborg, it can be positive to adopt the pneumatic waste collection system to reach the goals set for Coastal Eco-Cities.

Biological treatment techniques

According to table 4.26, food waste accounts for almost half of the household waste, and they cannot be recycled directly. Both cities utilize the biological treatment for food waste recycle. However they have different techniques. Helsingborg uses anaerobic digestion and composting, while Tianjin Eco-City uses aerobic microbial digestion.

Anaerobic digestion is a complex biochemical reaction carried out in a number of steps by several types of microorganisms that require little or no oxygen to live. During this process, a gas that is mainly composed of methane and carbon dioxide, also referred to as biogas, is produced (Cathy, 2010).

Aerobic digestion is the natural biological degradation and purification process in which bacteria that thrive in oxygen-rich environments break down and digest the waste. During oxidation process, pollutants are broken down into carbon dioxide (CO_2), water (H_2O), nitrates, sulphates and biomass (microorganisms). Of all the biological treatment methods, aerobic digestion is the most widely used process that is used throughout the world (Cathy, 2010).

In Helsingborg, almost 55% of the food waste is used for anaerobic digestion while 45% is used for anaerobic composting. In the biogas plant, 44000 tons of organic food waste is used to produce biogas annually. In Tianjin Eco-City, the food waste is sent to aerobic microbial digestion plant located at Zhongjin Avenue. In the plant, 90% of the food waste is digested while the remaining 10% can be used as soil conditioner.

Compared to aerobic digestion, the advantages of anaerobic digestion are that it can produce biogas, and biogas can be used in heat and power plant as well as gas bus. Moreover biogas is an ideal renewable energy source with little GHG emissions as it was aforementioned in section 6.2.2. Hence, we can safely say, as long as there is enough organic supply, it is possible to introduce anaerobic digestion to Tianjin Eco-City.

Waste incineration and waste recycle

Based on table 6.6, waste incineration accounts for more than 50% of the total waste in Helsingborg, while in Tianjin Eco-City the planned percentage of waste incineration is

30%. Although waste incineration is a practical method of disposal that is cost effective on transport of waste to landfills, at the same time it can generate electricity. There are many disadvantages of incineration including:

- High cost of incineration plant.
- Need for huge waste to incinerate, which led to abandonment of other plans for recycling and reuse of waste.
- Dioxins are produced in the treatment and is a cancer forming chemical.
- Requirement of skilled personnel for operation and continuous maintenance.

Therefore, in a coastal eco-city, prevention, waste minimization, reuse and recycling of waste should all be preferred to incineration according to the waste hierarchy.

Transferability

To cities across EU-Asia border

In the waste management sector, some good practices with high transfariablity across EU-Asia borders are found. These good practices for coastal eco-city includes:

- prioritization of waste prevention and minimization through techniques like clean vegetables and green packaging
- increase of waste recycling rate actively by education on residents, policy incentives and waste resorting
- establishment of a waste segregation system guided by the practices in waste recycle and treatment process
- adoption of biological treatment on food waste
- Promotion on waste recycling in order to reduce the amount of waste used for waste incineration plant.

To cities within their region

In the case of waste management there are to cities within their region:

Pneumatic collection system in Tianjin Eco-City cannot be transferred to Helsingborg unless barriers like the extra construction cost in an old city and the inconvenience on local residents are overcome. But it can be used in new cities, new developed area in old cities and cities with limited roads.

Anaerobic digestion of food waste in Helsingborg cannot be transferred to Tianjin Eco-City unless enough organic waste is generated in the future.

6.2.4 Transportation

Transportation is a major atmospheric pollution source. Both cities have tried to improve the negative environmental impacts of traffic, e.g. emissions to air, noise pollution and congestion that affect the natural environment, health and climate. The following Table illustrates comparisons between the two cities with respect to transportation.

Table 6.11: Comparisons between Helsingborg and Tianjin with respect to transportation.

	Helsingborg		Tianjin Eco-City	
Aims (proportion of green transport)	62% at 2035		90% at 2020	
	Car	38%	Car	10-15%
	Public transport	25%	Public transport	55-60%
	Walking	19%	Walking & cycling	30%
	Cycling	18%		
Green vehicle	Biogas vehicle -70 urban buses - 30 regional buses - 25 refuse collection lorries - gas transmission networks		Electricity vehicle - 105 charge station - electric bus will be introduced	

From the Table 6.11, the aims of proportion of green transport are different between the two cities. In Tianjin Eco-City, the proportion of green transport which is defined as walking, cycling, and taking public transport is almost 90% while the proportion of green transport in Helsingborg is about 60%. This difference is originated at the proportion of private car possession. The following figure shows the relationship between vehicle ownership and per-capita income of various countries including Sweden and China. As shown in the Figure 6.7, there is a positive correlation between the vehicle ownership and per-capita income. China has lower per-capita income and vehicles ownership than Sweden; therefore, Tianjin Eco-city could set up the much higher proportion of green transport than Helsingborg.

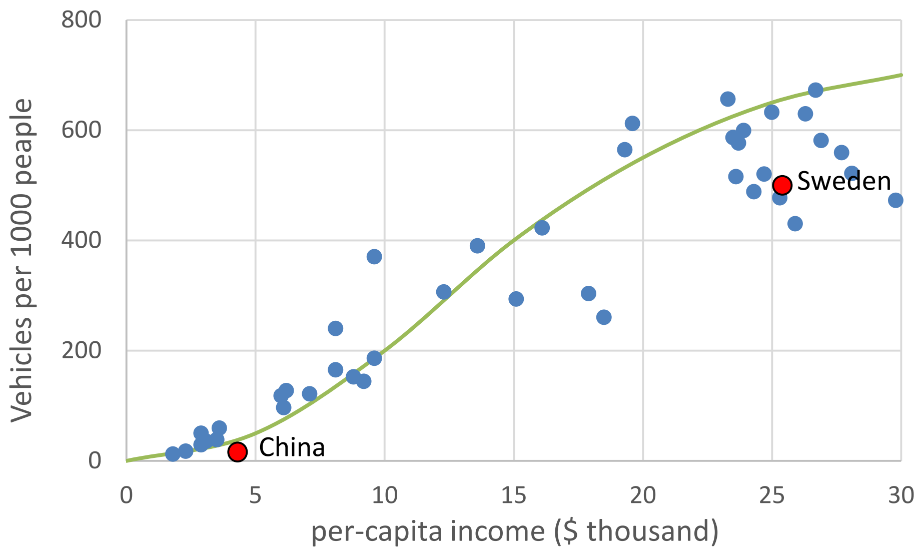


Figure 6.7: Relationship between vehicle ownership and per-capita income, taken from Dargay, *et. al.*(2007).

In the case of green vehicle applied in both cities, different kind of fuels are used; Helsingborg chooses biogas as vehicle fuel, while Tianjin Eco-City selects electricity. The reasons for this difference are further analyzed.

The European Commission proposed alternative fuels policy in December 2001. It has adopted an action plan and proposals for directives to foster the use of alternative fuels for transport, with an aim in 20% replacement of petroleum in transport sector targeted for 2020. The Commission considers that the use of fuel (such as ethanol and biogas) derived from agricultural sources has the greatest potential in the short-to-medium term. (Trendsetter, 2003)

Also, biogas infrastructures are well established in most of the European countries. In the case of Sweden, there were 229 biogas production plants (60% sewage treatment plants, 30% landfills, 10% co-digestion plants) and 47 biogas upgrading plants in operation in 2010. Furthermore, 35% of raw biogas is upgrading to vehicle fuel. In Helsingborg, there is a co-digestion biogas plant. Biogas plant was installed in 1996 and biogas upgrading plant was built in 2007 with the water wash technique. The methane content after upgrading is 98%, which means upgraded biogas matches vehicle fuel quality. An approximate amount of 12,000 MWh of upgraded biogas was generated in 2007 and the total production capacity is more than 40,000 MWh (Baltic Biogas Bus, 2012a).

In terms of environmental impacts, biogas is much more eco-friendly than diesel and gasoline, which are the most frequently used vehicle fuel. As shown in the following table, the amount of CO_2 emission per kWh from biogas is less than that from diesel and gasoline. Also, fossil fuels such as diesel and gasoline are fixed volume resources, while biogas is produced by the anaerobic digestion of the organic waste such as manure, sewage, plant material, and crops. Therefore, it can be mentioned that biogas is a renewable energy source, like solar and wind energy.

Table 6.12: Comparison of energy contents and CO_2 emissions from different fuels, taken from NGVAE (2003).

Fuel	% hydrogen (weight)	LHV MJ/kg	LHV kWh/kg	CO_2 emission g/kWh
Biogas (Methane)	25.00%	50	13.89	198
Diesel	13.50%	42.7	11.86	267.5
Gasoline	13.50%	42.4	11.77	279.5

Regarding the cost, biogas has economical advantage compared to diesel. The following figure shows the infrastructure, operational and environmental costs of biogas and diesel. The sum of infrastructure and operational costs of biogas is 5-8% higher than that of diesel; however, with future increasing costs for fossil fuels, biogas will be even more competitive. The environmental costs from global and local emissions include greenhouse gases, CO_2, particles and NOx. When environmental pollution and environmental damage costs resulting from the combustion are included, biogas without a doubt is the best fuel available (Baltic Biogas Bus, 2012b). Because of these political, social and environmental issues, Helsingborg select biogas as alternative fuels for transport.

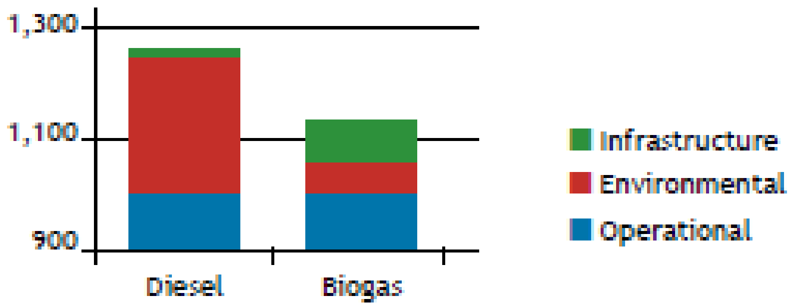


Figure 6.8: Cost comparison between biogas and diesel in SEK per 100 km, taken from Baltic Biogas Bus (2012b).

Electric vehicles have the unique advantage of using electricity generated from a variety of fuels and renewable resources; therefore, reductions in pollutants such as CO_2, CO, HC*, NOx, SOx and particles by using the electric vehicles vary according to region's power plant fuel mix. Moreover, power plants are often in rural areas where the emissions do not drive pollution levels above health standards and efficient emission controls can be more easily installed and maintained on power plants than on millions of individual vehicles.

In the case of Tianjin Eco-City, large portion of energy comes from the renewable energy source. According to KPIs, the proportion of renewable energy utilised in the Tianjin Eco-City, such as solar and geothermal energy, should be at least 20% by 2020. Therefore, electric vehicles offer great benefit in terms of environmental aspect. Also, infrastructures of electric vehicles are easy to install because Tianjin Eco-City is newly built.

Both cities have individual transportation aims and objectives to improve the negative environmental impacts of traffic. It is rather difficult to transfer one city's transportation aims and objectives to another city because each city has developed their transportation strategy according to their own regional context.

6.2.5 Coastal

The characteristics of the "coastal" feature of the cities and the structures constructed within the projects are both described in the following Table.

Table 6.13: Threats by the coastal feature of the cities and actions taken

Tianjin Eco City	Helsingborg Eco City
Threats	
- Immediate threat by sea level rise - Bears the highest risk from coastal flooding in China - 100% of the population and urban area of Tianjin would be affected by coastal flooding	No threat by sea level rise
Actions	
No actions were taken within the project	No actions were taken within the project

From Table 6.13 it can be identified that no actions regarding the coastal element of the cities were taken in both the cities. However, in the case of Tianjin Eco City there is immediate threat from sea level rise for the population and urban area, while in Helsingborg there is no immediate threat. Further down, the suggested actions will be proposed for Tianjin Eco city as the issue of climate change and coastal resilience should have been considered carefully by the developers.

Suggested Actions

In the case of planning towards coastal resilience, certain steps need to be followed as described by Coastal Resilience (2013a). The steps are clearly identified in the following Graph.

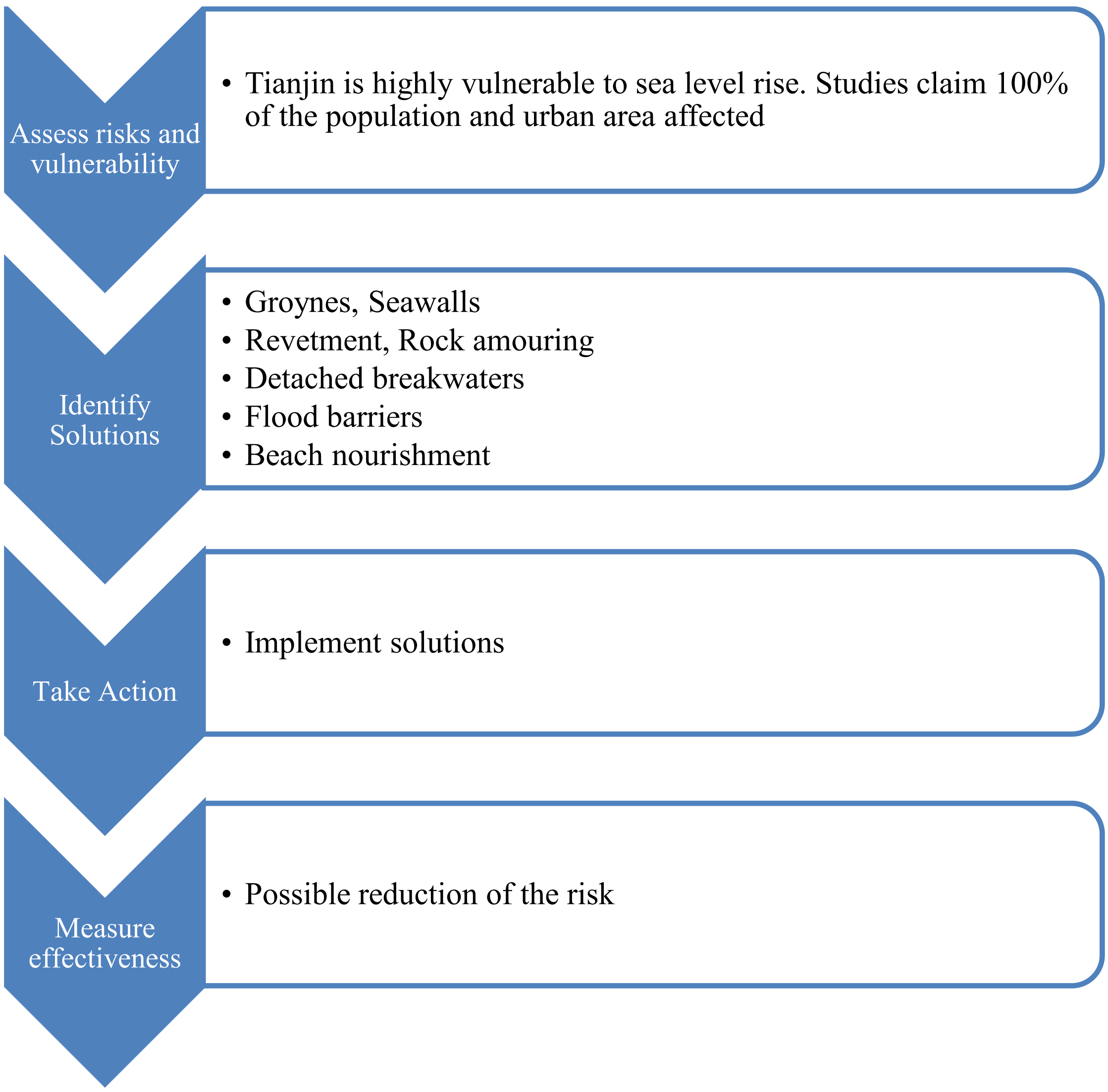


Figure 6.9: Actions for coastal resilience (Source: http://coastalresilience.org/).

For the case of Tianjin it has been identified that there are immediate threat by climate change effects. In cases of protecting the coast from sea level rise and coastal flooding certain traditional engineering approaches are employed, as suggested in Figure 6.9. Further down, these structures will be briefly analyzed (Coastal Resilience, 2013b).

- Groynes: they are barriers constructed by wood or rock and build to the shore perpendicular to the sea. In areas with long-shore currents in one predominant direction, sediments are accumulated on the downstream side. Usually they are placed in a short distance apart for long distances along the coast. Coastal erosion is increased in adjacent areas further along the coast.
- Seawalls: these are walls constructed from concrete or rock and placed at the top of a beach or the top of a cliff. Their aim is to absorb or deflect wave energy so that the waves will not cause excessive turbulence to the beach or erosion.
- Revetments: The structure falls into the same category as seawalls. However, revetments are slanted walls constructed at the top of the beach where the waves can break up and the energy will dissipate.
- Rock armouring: It is a simple structure of piles of large rocks or concrete placed along the shore in order to absorb wave energy. In certain cases smaller rocks can be used to form larger wire-mesh gabions.
- Detached breakwaters: Large structures constructed offshore from rocks or pre-formed concrete structures. Their aim is to cause the waves breaking further offshore and accumulate sediment among the coast and the landward side of the breakwater.
- Flood barriers: they are built across rivers or estuaries in order to prevent water flooding from the river. An example of this is the Thames Barrier in London.
- Beach nourishment: Beach nourishment is the process of releasing large volumes of sand onto intertidal coastal areas with erosion problems. This technique is an ongoing process and must be repeated at regular intervals, annually or every few years, however it is still widely employed in several high value coastal areas across the US and Europe.

Since the above step is completed and the technique to promote coastal resilience against the hazardous events and adaptive measures climate change are chosen, the next step is to implement the solution. The final step of the process is to measure the effectiveness of the solution by evaluating the reduction of risk.

More insight can be obtained from the coastal measures adopted in Caofeidian Ecocity, which is subjected to immediate threat from sea level rise. In this project, the developers took into consideration this problem and constructed dykes in order to provide coastal resilience to the city. As it is illustrated in Figure 6.10, dredged material has been extensively used in the structure. The main part of the dyke is constructed from geotubes of dredged material. At the outer seaward side, there is an extra layer of natural material for protection from coastal erosion. Furthermore, in both outer parts of the dyke, sandy soil (dredged material) has dumped, to give the dyke more strength and structural stability.

The following picture illustrates a cross section of a typical outer dyke the developers facilitated in the new built city.

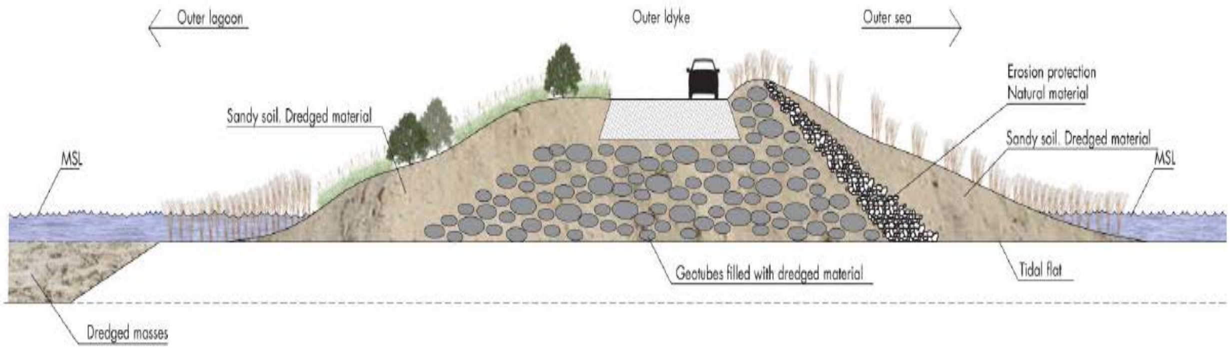


Figure 6.10: Typical cross section of a dyke employed in Caofeidian Ecocity taken from Ulf Ranhagen (2012)

Offshore wind farm

Given the fact that Tianjin is a coastal city with 150km of coastline, it has profound wind power in coastal offshore area. In the coastal area, offshore wind farms maybe an ideal renewable energy source. However, the capital cost and O&M expense of an offshore wind farm is higher comparing to the onshore wind farm according to Table 6.4 and 6.5. However the wind power in offshore area is fundamental. The average wind speed in the coastal offshore area is 7.0m/s, the average wind power density is 340W/m^2 comparing to 300W/m^2 in the onshore area (Yang, *et. al.*, 2011).

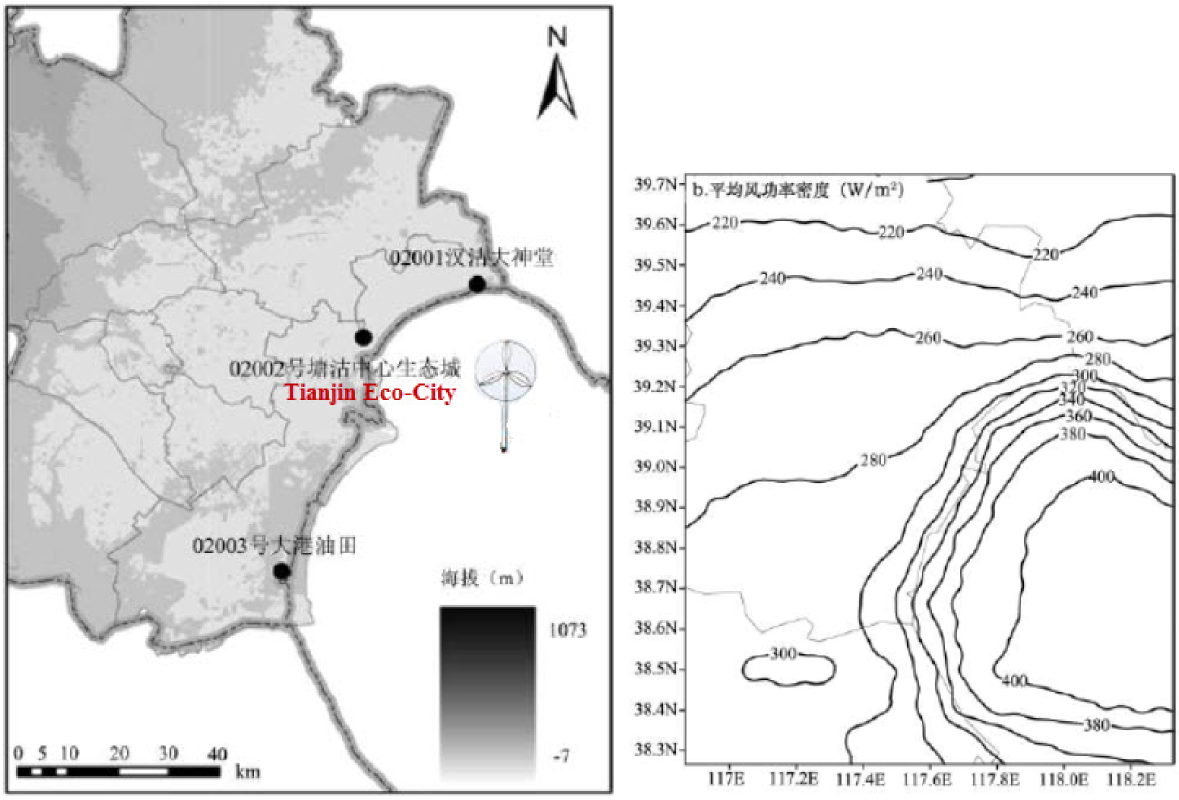


Figure 6.11: Wind power measure points in black dot (left) and the distribution of long-time wind energy resource at 70m height inTianjin coastal areas 2002(right) taken from Yang, *et. al.*, (2011).

Hence, an offshore wind farm is proposed to Tianjin Eco-City. In order to reach the goal of 10% of electricity supply from wind power, the total power of the offshore wind farm should be:

$$P_w=257.6MW\times300/340=227.3MW \qquad (6)$$

It is calculated based on the average wind power density difference of onshore and offshore wind farm. The total cost and GHG emissions of wind, solar and biogas power plant with same amount of electricity (567.82GWh/year) are compared as shown in the following table:

Table 6.14: Estimated total cost and GHG emissions

	Power/ P (MW)	Overnight Capital Cost/OCC (million $/MW)	Fixed O&M Cost/OMC (million $/MW/year)	Years of operation/ Y	Total cost = P*(OCC+ OMC*Y) (billion $)	GHG emission (g CO_2/kWh)	Total emission(10^5t CO_2)

Solar	334.6	4.183	0.03955	25	1.731	32	4.54
Wind onshore	257.6	2.213	0.02775	25	0.749	10	1.42
Wind offshore	234.4	6.230	0.074	25	1.836	9	1.28
Biogas	283.9	0.900	0.10563	25	1.005	11	1.56

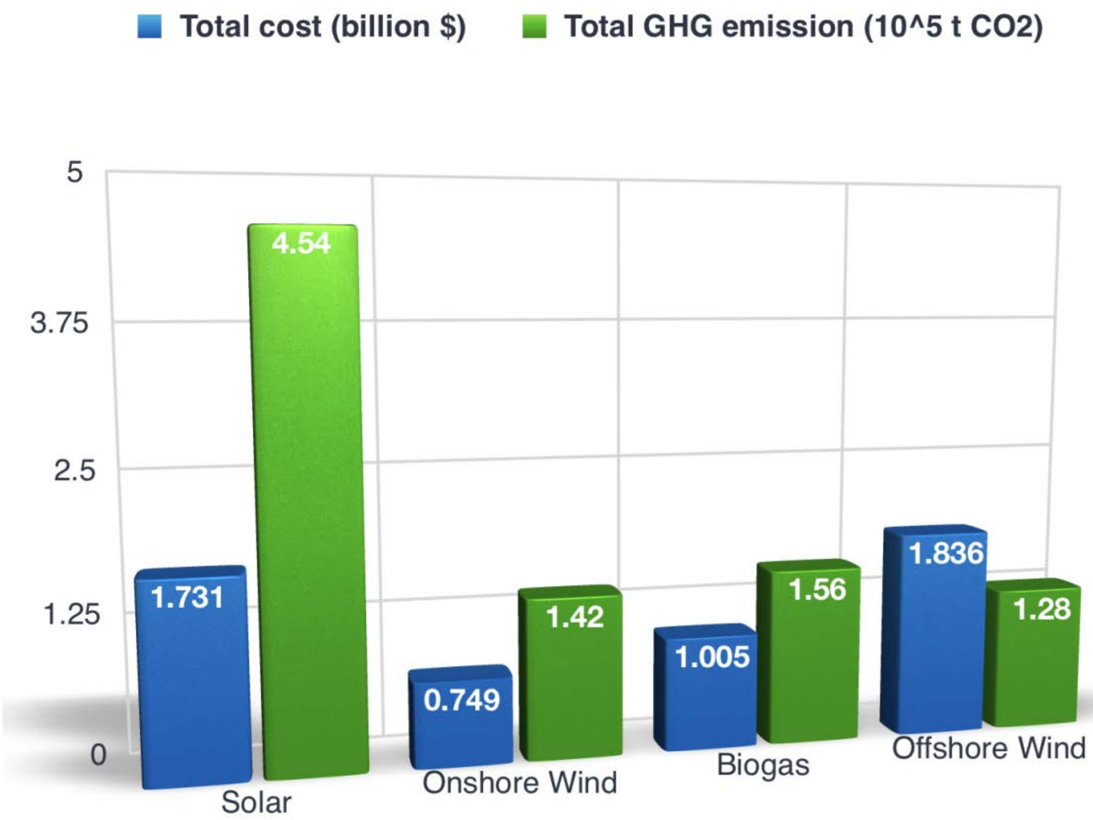


Figure 6.12: Estimated total cost and GHG emissions.

According to the comparison results, the offshore wind farm has the largest total cost and lowest GHG emissions in all four renewable energy sources. Generally speaking, it is possible to facilitate an offshore wind farm as renewable energy source in Coastal Eco-Cities with profound offshore wind resource.

6.2.6 Contract arrangement

The characteristics of the contract arrangement of the projects are depicted in the diagram:

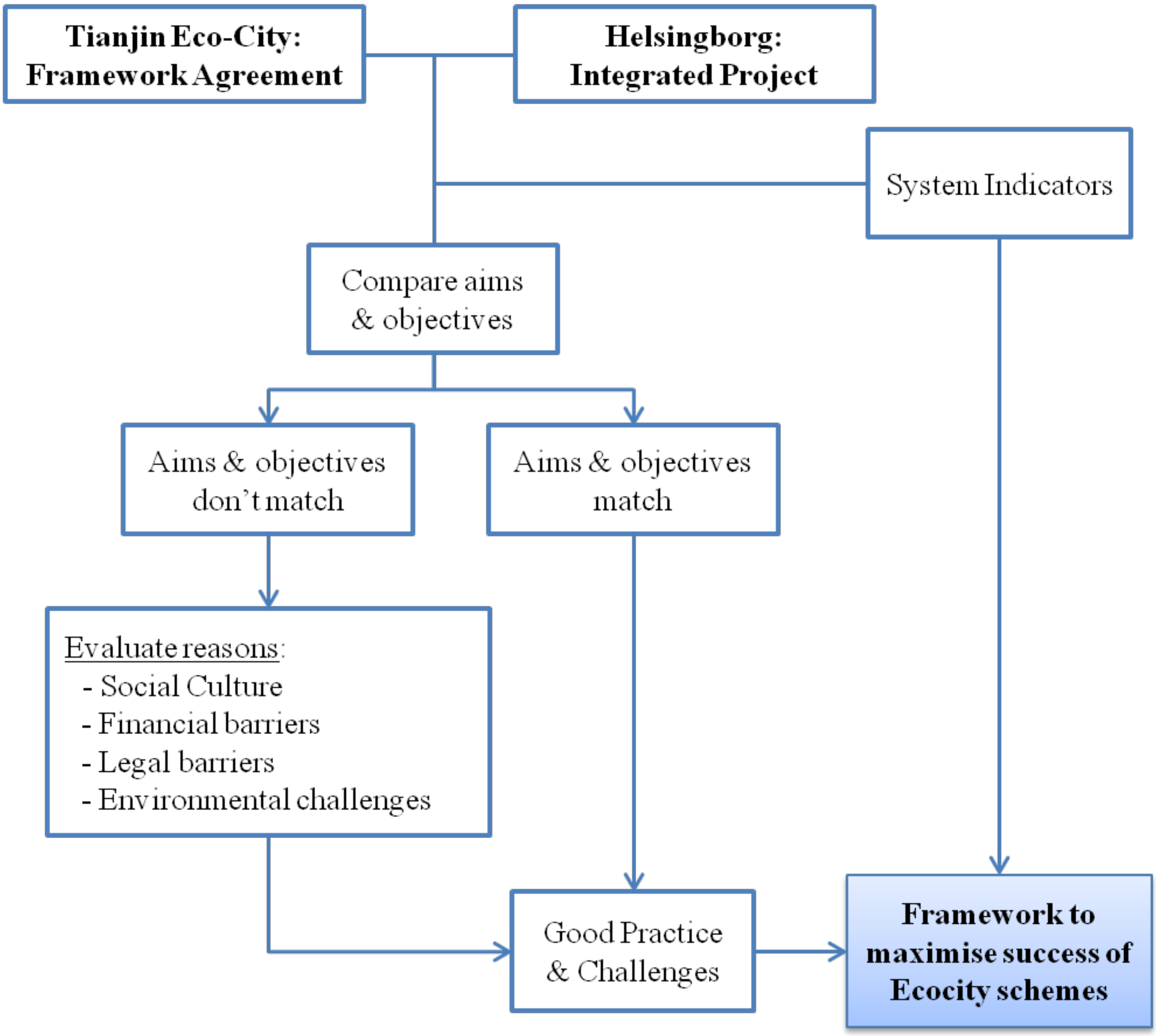


Figure 6.13: The framework for the contract arrangements.

As discussed in Chapter 4 and is depicted in the framework, the type of contract employed in the case of Sino-Singapore Tianjin Eco city is a Framework Agreement, while in the case of Helsingborg is an Integrated Project. The following Table illustrates the aims and objectives of each type of contract.

Table 6.15: Aims and objectives for each type of contract

Framework Agreement (FA)	Integrated Project (IP)
It is a "smarter way" to purchase works or supplies than placing "one-off" orders for repeated contracts.	Describe projects with multi-partners which are formed to support objective driven research, where the priority is to generate knowledge.

The volume purchasing discounts are optimized and repetition on purchasing tasks is minimized.	IPs bring forth a large amount of critical resources in order to achieve ambitious goals to upgrade Europe's competitiveness or cope with major social issues.
A mechanism is launched and applied for pricing particular requirements and tasks during the period of the framework.	It is imperative to contain a research element that may also involve technological development, demonstration components and perhaps a training elemen.t
The scope and types of services/works that will need to be called-off is established at the outset.	The fact that differentiates integrated projects is diversity and different levels of the "integration" within a project (knowledge integration).
In individual contracts under framework arrangements (call-offs) the contracting authorities in the public and utilities sector do not need to repeat the procurement process again, as long as the rules for establishing the framework agreement in the first place were correctly observed.	It is of the essence to have a series of well documented agreements upon the administrative arrangements that will efficiently tackle issues regarding the project's aims and objectives, the management of the project and the allocation of resources and risks.
Basically, a framework agreement is an agreement between two parties for the supply of an unspecified amount of product/works for a specified time period.	Efficient management of knowledge as well as its circulation and transfer is of the essence of every IP.

Based upon the aims and objectives of the Table 6.15, it is apparent that the aims and objectives do not match. In the case of Framework Agreement, the aim and objectives include to constantly procure an unspecified amount of works for a specific time period and develop a mechanism for reduced bureaucracy in order to facilitate the process. On the other hand, an Integrated Project's aims and objectives include the generation of knowledge and innovation. Circulation of them throughout the value-chain of stakeholders involved in the project. It is critical though, to have well documented agreements that will clearly establish the administrative arrangements, the management of the project and the allocation of resources and risks.

It is perceived that the case of an Integrated Project is favoured due it being research driven. However, the increased bureaucracy is a negative factor in the scheme. On the other hand, the case of a Framework Agreement is conceived as the accumulation of goods and works, where no research or innovation is cultivated. Nonetheless, the reduced bureaucracy offers great potential and is undoubtedly a positive aspect of the scheme.

The reason for the differences found in the aims and objectives will be evaluated looking at social culture reasons, financial barriers, legal barriers and environmental challenges.

Social Culture

The main difference of the two contracts is on the case of the Framework Agreement and Integrated Arrangement. In the Framework Agreement, the perception of an eco city as an accumulation of works/goods, which have to be procured. While in the other case it is conceived as a chance for research and knowledge circulation among the value chain but with need for clear documentation and identification of roles. This difference of perception of the developers is clearly identified in the type of contract they chose to implement.

Financial barriers

The funding of both projects was based on public-private funds. Therefore, there is no necessity for the choice of one certain type of contract for each case from financial perspective. However, certain barriers regarding the stage of the project where the contractors are chosen by the consortium in the case of Integrated Projects were identified. On the other case, in Framework Agreements there is a pre-selection of contractors and all call-off contracts will be awarded to one of them.

Legal Barriers

This factor would validly exist if the case of an "Integrated Project" was not legally established in China, as the Framework Agreements are globally established and employed. Notwithstanding, it was found that Integrated Projects are in force in China and used in many projects. Examples of these are the projects carried out by the Global Carbon Capture and Storage Institute in China (Global CCS Institute, 2013). Therefore, no legal barriers lie in implementing the contract type of an Integrated Project in the case of Tianjin Eco city, as it has already been implemented in other projects.

Environmental Challenges

Both projects aimed in tackling environmental issues at their implementation. However, the Integrated Project focuses in research and innovation, it is likely to manage the environmental challenges in a better manner. In the case of the Framework Agreement it is possible to establish works that will tackle environmental challenges, nonetheless, research and knowledge transfer is not cultivated excluding the circulation of potential innovative technologies that might be established.

Transferability

To cities within the same region

Both schemes can be transferred within their region as in the case of Helsingborg Eco city. It was knowledge driven where innovations were aimed to circulate among all levels of stakeholders in order to be replicated. In the other case (Tianjin Eco city) it can also be transferred as they developed a framework of procuring the works within, in order to establish the project being replicable and scalable.

Across EU-Asia borders

On one side is the benefit of creating a research-driven project by establishing the contractual arrangement of an integrated project and on the other side is the reduced bureaucracy, which a Framework Agreement provides.

Regarding the "bureaucracy" element, the pre-existence of mutual trust among the contracting members is imperative. The element of "trust" is of the essence especially in the case of Framework Agreements as the awards of "call-off" individual contracts are not made under the process of procurement. Therefore there should be trust that the whole procedure was conducted according to the perceptions and beliefs of all implicated parties. Hence, in case of choosing the path of a Framework Agreement it should pre-exist mutual trust among all participants.

In the case of the project being conceived as a research/development opportunity or simply as a "purchase of works", lies completely in the perception of the contracting authorities. As it was identified, in one case (Tianjin Ecocity) the authorities conceived the project as "a purchase of goods" that all of them combined will create an Ecocity and this project could be scaled for other city-cases. However, in the case of Helsingborg Ecocity the project was regarded as an opportunity for research of new technologies and transferring the research and development results among different levels (industry, academia and the value-chain involved). It is a contradiction of beliefs of the developers.

Non transferable aspects

This case could be valid if a type of contract, in this certain case, was not legally established in one of the two countries involved. However, Framework Agreements are conducted globally for purchase of goods/works (Blackburn, 2011) and on the other hand; Integrated Projects are conducted in China. Hence, in the case of contract arrangements there are no non transferable aspects.

6.2.7 Stakeholder engagement

The level of stakeholder engagement in the projects is depicted in the graph:

As discussed in Chapter 4, the level of stakeholder involvement was highly differentiated in the two cases. In Sino-Singapore Tianjin Eco city, the stakeholders were implicated shortly in the process, whilst in Helsingborg they were highly active in the project and their involvement comprised part of the project. The following table depicts the activities to enable engagement of the stakeholders in both cases.

Table 6.16: Activities to engage the stakeholders.

Tianjin Eco city	Helsingborg Eco city
Two demonstration projects were designed: a 20,000 m^2 school and a 600-apartment residential complex. They both showed a 65% saving in annual energy compared with the previous national standard benchmark	General information and awareness raising activities
The leading team for that (Mott Macdonald company) worked with local design teams on the demonstration projects to shape the sustainable design features and improvements that can be employed	Activities to involve stakeholders such as SMEs, developers, owners of non-residential buildings, energy suppliers and municipal employees
	Activities to change energy behaviour
	Trainings for professional and municipal employees

The approach of the stakeholders involved in both cases was very different. In Tianjin Ecocity they performed demonstration projects in order to convince the stakeholders about the energy saving that the new technologies provide. It can be related with the "awareness raising activities" that were employed in the case of Helsingborg Ecocity. In the case of Helsingborg Ecocity the activities to engage the stakeholders were part of the research regarding the social impact assessment of the developments of the project.

The reasons for the difference in approaching the stakeholders will be examined by searching the social context, financial and legal barriers and environmental challenges of the process that may have led the decision making process for this particular aspect.

Social Culture

Social context is not directly involved in the design of the activities to engage the stakeholders. However, the result of the process will highly and directly affect the success of the project at its operation stage. Thus, social issues such as the involvement of the stakeholders in maintaining the level of sustainability provided by the project after it has finished is highly important. It is recommented that this type of behaviour should be cultivated throughout the implementation of the project.

Financial Reasons

Financial reasons are not implicated in the process as the cost of the stakeholder engagement is not a barrier. In the case of Tianjin Ecocity, management tried to involve stake holders and create awareness. However, the management did not focus as much as they did in Helsingborg. Hence, eventhough certain funds were allocated in stakeholder management but the process was not well designed.

Legal Barriers

Legal issues are directly involved in the stakeholder management process. In the case of Helsingborg Ecocity, the project was research driven across all levels of the stakeholders involved. Hence, the stakeholder management was designed based upon research, knowledge transfer, involvement and training. These issues were documented upon the contracts as the type employed was that of "Integrated Project". On the other case, the legislative framework (Framework Agreement) did not provide specific arrangements for stakeholder management as the main interest was centred on the facilitation of the procurement process within the framework of purchasing. However, the developers recognised the affect of the stakeholders in the long term success of the project and performed two demonstration projects to create awareness.

Environmental Challenges

No environmental barriers exist in implementing one or the other approach of stakeholder involvement. However, as with the social issues implicated by the stakeholder management, the way that the developers will design and implement the stakeholder management highly affects the success of the project. However, the environmental challenges that were planned to be tackled by the project, should actually tackled in a long term perspective.

Transferability

To cities within their region

The activities to involve the stakeholders can be replicated within the region of both projects. There are no social, financial, legal or environmental barriers for performing the same activities to engage the stakeholders in the way it was performed in the aforementioned projects.

Across EU-Asia borders

The barriers existing in transferring the practices of stakeholder engagement from Helsingborg, as it was very carefully designed and implemented, to Tianjin Eco city, are purely attributed to the legislative framework surrounding the project. Helsingborg's legal framework was based upon research and knowledge transferred, which resulted in an in-depth design of activities to involve the stakeholders in the project with a view of its longterm sucess. In future sustainable schemes developed in Asia, the employment of Integrated Project should be seriously considered as it will assure high involvement management of stakeholders.

Non transferrable aspects

For the case of stakeholder engagement there are no non transferrable aspects, as the legal establishment of Integrated Projects in Asia exists and they has been employed in several projects.

6.3 Transferability

Table 6.17: Summery of transferability.

	To cities within their region	Across EU-Asia borders	Non transferrable aspects

Green buildings	The type of green technologies can be utilized throughout each country		Green building standards of Sweden cannot be transferred to China.
Energy supply	- Adoption of more centralized heating system in new cities	- Prioritization of renewable energy - Establishment of energy saving and monitoring system	- the ideal renewable energy source combination is determined by the city's local context
Waste management	- Pneumatic collection system in new cities - Anaerobic digestion of food waste for biogas in cities with profound organic waste	- Waste prevention and minimization - Higher waste recycling rate - Waste segregation system guided by the practices in waste recycle and treatment process - biological treatment on food waste	
Transportation		- Proportion of green transportation should enlarge in order to make city eco-friendly. - It is needed to adopt green vehicle to reduce GHG emissions.	- Specific proportion of green transportation and fuels used as green vehicle can be determined in terms of regional situation.
Coastal	Offshore wind farm in cities with profound offshore wind power	Coastal infrastructure for prevention of flooding	
Contract arrangement	The formation of the contract can be transferred to other cases within region	It can be transferred across EU-Asia borders under certain conditions: - Pre existence of mutual trust among the participants regarding the Framework Agreement - Conception of the project as an opportunity for research for the case of an Integrated Project	There are no non transferable aspects
Stakeholder engagement	Can be replicated within the region of both projects	The barriers existing in transferring the practices across EU-Asia borders, are purely attributed to the legislative framework surrounding the project	There are no non transferable aspects

6.4 Recommendations to stakeholders

6.4.1 For policymakers (national and local authority)

Regarding the group of policymakers, there are several lessons to learn from researching the projects of Sino-Singapore Tianjin Ecocity and Helsingborg Ecocity. The legislative framework of the two projects was highly differentiated, affecting the project progress in several levels. Therefore, it was identified that conceiving the project as an opportunity for research and knowledge transfer throughout the "value chain" of the stakeholders involved can provide outstanding benefits. Apart from the apparent advantage of incentivizing innovative technologies and research; there is also the benefit of engaging the stakeholders in the process providing better chances for success of the project in the long term. Hence, the choice of "Integrated Project" as the contract type should be preferred in such projects.

6.4.2 For developers

For the developers of coastal eco-cities, it is vital to understand the city's local context at the planing stage in order to develop an ecological and sustainable coastal city. These local context regarding aspects like building, energy supply, waste management, transportation and coastal infrastruces includs:

- the regional green building standards and practices.
- the assessment on renewable energy source, i.e. the peak sunshine hour, the annual available hour for wind farm and supply of organic waste for biogas.
- the current status on transportation, i.e. the vehicle ownership and the citizen's willingness on green transportation.
- the threats from both the land and sea such as shortage of land, coastal flooding and sea level rise.

During the developing stage, recommendations on green building, energy supply, waste management, transportation and coastal infrastruces for coastal eco-city are made.

For the green building sector, the certifications and standards followed are different in each region as the environmental challenges and financial resources differ. Although, the green technologies employed by both projects were quiet similar.

In regard to energy supply, the developers of coastal eco-city should prioritize renewable energy like solar, wind and wave energy and low the dependency on fossil fuel. Energy saving techniques like heat insulation, solar hot water and monitoring on energy consumption on residential and public building should be introduced. Combined heat and power (cogeneration) plant should be implemented in a more centralized heating system. Moreover, the developers are strongly recommended to determine the ideal renewable energy source combination based on the city's local context.

In the waste management sector, the developers are recommended to increase waste recycling rate actively by education on residents, policy incentives and waste resorting. Waste prevention and minimization techniques like clean vegetables and green packaging should be promoted. Waste segregation system should be guided by the practices in waste recycle and treatment process. Biological treatment on food waste ought to be introdued. Considering the disadvantages of waste incineration plant, the amount of waste used for incineration should be limited through waste prevention. Futhermore, Pneumatic collection can be consider in new cities, new developed area in old cities and cities with limited road. Anaerobic digestion of food waste for biogas can be consider in cities with profound organic waste

In the transportation, green transportation that is defined as walking, cycling, and taking public transport should be encouraged in order to make city eco-friendly. Also, it is needed to adopt green vehicle to reduce GHG emissions. Specific proportion of green transportation and fuels used as green vehicle can be determined in terms of regional situation.

With regards to the coastal sector, it was identified that coastal regions are more vulnerable to climate change, more specifically from sea level rise. This was not considered by the developers in China, failing to achieve coastal resilience to the new built area. Furthermore, it was found that the "coastal" was not exploited in facilitating an offshore wind farm as a significant renewable energy source for the city.

7 CONCLUSION

7.1 Main findings

This piece of research has led us towards some interesting findings, after having compared and analysed a significant range of factors for each development we can, with confidence come up with a summary of the following significant conclusions:

- During the planning stage the local context must be considered. For example, the most appropriate renewable energy source must be selected on the basis of the resources available as opposed to what may be preferred for any other factor. Other examples include transportation: one must consider the vehicle owner ship, i.e. the number of personal vehicles should be considered in order to develop the correct capacity for public transportation, as well as reducing the reliance on fossil fuels through the promotion of electric vehicles, or preventative methods such as emissions tax.
- There were key differences between the two projects that demonstrate how inconsistencies in green building standards can result in significant variability in performance. The engineering solutions used for energy supply will depend entirely on the local context and a number of factors will need to be considered (i.e. funding, public opinion, and availability of resources). Therefore, the energy mix, as well as the use of energy must be considered in parrallel. It would be impossible to generalise a heirachy of preferable energy types, for example biogas production (Waste-to-Energy) was successfully applied in Helsingborg, as they had established known waste volumes and biological fractions, however Tianjin as a city was not yet established and therefore the feasibility of such a project could not be analysed.
- Key Performance Indicators (KPIs) are one of the main drivers for dictating the direction of a project. KPIs vary depending from project to project, and draw upon different standards or examples to justify their use. It is therefore of significant importance to attempt to tackle the disparity between KPIs in differing geographical locations in order to achieve the same goals. KPIs between the examples analysed follow a similar set of ‘Main Categories’, however the content and sub-categories varies significantly, including both the values and the metrics used.
- To build a coastal eco-city, education of the local population is imperative. This is especially poignant in a coastal context as this frequently requires new or less understood technologies, in an area where two or three very different natural

environments overlap (for example coastal, estuarine and marine), as well as human settlement. Therefore the public need to understand the impacts their activities have, as well as the benefits of accepting new technological for the overall benefit of society and the environment. Furthermore, this is not fully covered by the KPIs studied, especially in the Asia example, and these KPIs are standards for the whole of China.

- There is significant benefit to be had, when a project is considered as an opportunity for research. This includes technological development, innovation and the transfer of knowledge. Stakeholder engagement is better designed, which therefore improves the chances of long-term sustained behavioural changes and public co-operation.
- Reduced beaurocracy is a preferred in such a development; however this requires mutual trust between the participants. Judging by the contracts used in the Tianjin development we can see that this level of pre-existing trust allowed for shortened the completion time for the project and reduced costs.
- Financial support is extremely important for large scale eco-city projects. A mixture of both public and private funds ensures that the technologies used will be promoted and will be much more likely to be financially viable do to the high level of risk to the investor. Both case study examples benefitted finanically from the project as the GDP per capita has been increased.
- Percieved risk is a significant driver for whether these cities acted to mitigate the effects of climate change, and most importantly, sea level rise. If we look at the example from Tianjin, they did not consider Sea Level Rise in the devleopment of any form of coastal defence integrated into the deisgn of the city. We have proposed a number of engineering approaches to improve coastal resillience and exploitation of wind energy. The main finding here is that from the case study and wider reading it is evident that a coastal location is often not exploited to its full potential.

7.2 Limitations

The in-depth study of singular eco-cities cannot be used to generalise an entire region. Therefore it is not possible from this alone to create rigid guidelines for eco-city development and sustainable schemes across European and Asian borders. It must be noted that analysing the studies in parallel have provided a number of interesting aspects that may contribute towards improving EU-Asia transferability, however we do not claim to have the necessary information to provide a complete EU-Asia Eco-city standard.

7.3 Future Research

The findings of this research would be supported by a widening of the scope to include a number of other coastal eco-city projects in Europe and Asia. This would contribute towards developing EU-Asia performance indicators and their transferability. This would also require exploring performance indicators from other international examples. Ultimately, the future of eco-city development will include perspectives from an international viewpoint; however this begins by merging these two key global players.

An international standard, must, without question draw upon existing coastal eco-city projects, as it is imperative that a framework allows for the consideration of the needs of the nation or city, and the resources available. This research has successfully demonstrated that there are a significant number of lessons to be learned from exploring existing, established eco city schemes, which will benefit future developments at a number of levels.

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