LESSONS LEARNT FROM A SINO - GERMAN LOW CARBON CITY PROJECT:

A MANUAL

LOW CARBON FUTURE CITIES

A Sino-German Cooperation on an Integrated Climate and Resource Proof Urban Development

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Funded by

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1 INTRODUCTION

Cities are home to between 50% and 60% of the global population and are the engines of economic development. Globally, urbanisation has already reached a very high rate and is projected to continue to rise rapidly over the coming decades. Increasing urbanisation has already imposed pressures on the environment and will continue to do so; e.g. cities are responsible for up to 80% of global greenhouse gas (GHG) emissions and consume approximately 75% of global energy and material flows (UNEP, 2013). At the same time, cities are particularly vulnerable to the impacts of climate change and, therefore, must learn to adapt.

"The LCFC project aims to develop an integrated low carbon strategy for pilot areas in China (the city of Wuxi) and in Germany (the Düsseldorf+ region,...)"

Although cities are faced with these challenges, they also provide fertile ground for the development of innovative solutions. Over the last decade, a myriad of initiatives from governments and non-governmental organisations have emerged in cities worldwide. The Low Carbon Future Cities (LCFC) project, funded by Stiftung Mercator, is one of these initiatives. It interlinks municipal representatives from Germany and China – two countries that offer excellent examples of the highly dynamic evolution of low carbon city approaches. **The LCFC project aims to develop an integrated low carbon strategy for pilot areas in China (the city of Wuxi) and in Germany (the Düsseldorf+ region**, which encompasses the cities of Düsseldorf, Ratingen and Neuss as well as the districts Rhein-Kreis Neuss and Kreis Mettmann). The project brought together the concepts of low carbon, sustainable resource use and adaptation to climate change and combined robust scientific analyses with the active involvement of stakeholders. This integrated approach makes the LCFC project a forerunner in its field and this, naturally, implies several challenges. The project is conducted by a truly Sino-German consortium, which is coordinated by the Wuppertal Institute and encompasses five esteemed partners including Tsinghua University, the National Climate Centre of the China Meteorological Administration, Chinese Society for Sustainable Development, the Wuxi Low Carbon Development Research Centre,

and Collaborating Centre on Sustainable Consumption and Production.

In this manual, the consortium wants to **share the key lessons we have learnt throughout this three-year project and, by doing so, to contribute to the scaling-up of low carbon city development in emerging economies, especially in China.** This manual targets organisations from the scientific and civil society sectors that are involved in international low carbon city projects, especially those with a focus on Chinese cities, as well as local governments that are eager to develop a comprehensive low carbon strategy. What makes this manual different from others is the participatory way it has been developed. The manual is the result of various interviews with the experts in our consortium who have been engaged in the different project tasks. Fig. 1 illustrates the structure of the manual.

"...share the key lessons we have learnt throughout this three-year project and, by doing so, to contribute to the scaling-up of low carbon city development in emerging economies, especially in China."

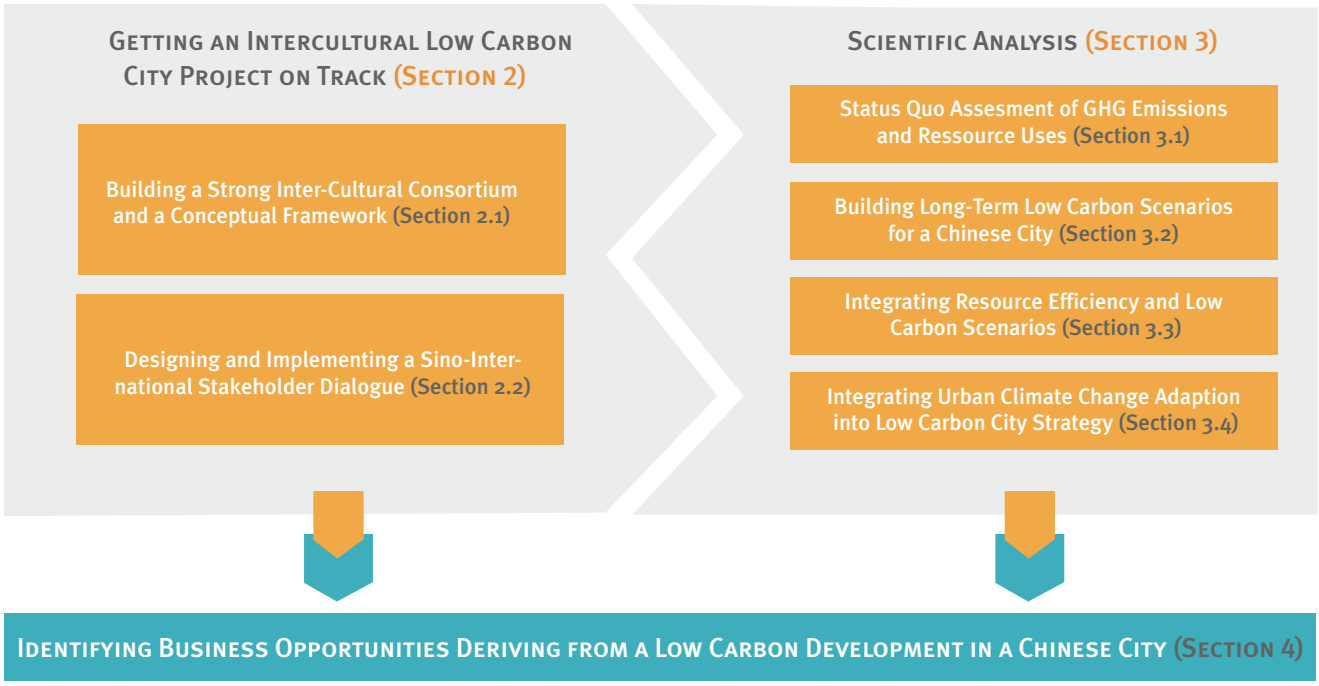

Fig. 1: Structure of the Manual

2 GETTING AN INTERCULTURAL LOW CARBON CITY PROJECT ON TRACK

Robust scientific analysis is a key prerequisite for developing integrated low carbon strategies for both pilot studies in the LCFC project. To meet this precondition, a strong inter-cultural consortium, a consistent conceptual framework shared by the consortium members as well as a vivid dialogue process with relevant decision-makers and experts are needed. The following sub-sections elaborate on these aspects.

2.1 BUILDING A STRONG INTERCULTURAL CONSORTIUM AND A CONCEPTUAL FRAMEWORK

Fig. 2: The LCFC project consortium with city representatives from Wuxi and the Düsseldorf+ region at the 2nd Sino-German Stakeholder Forum in Wuxi in October 2012

Key Characteristics of a Successful Intercultural Consortium

A successful consortium in the field of low carbon city development in China needs to be **well balanced with strong Chinese and international consortium members.** In many cases, research consortia are formed under time pressure due to tight project deadlines. However, we recommend that the project coordinator should have a clear picture of the strengths and weaknesses of potential project partners in order to assess whether or not they are qualified to join the consortium. This may be usual practice for proposal processes in general; however, for intercultural projects, the skills required in consortium partners reach beyond scientific know-how. It is imperative that the **language barrier** does not inhibit project work. Therefore, it is key that each project partner has staff with good English and, ideally, good Chinese language skills (written and oral), as this will enable good communication within the consortium. In addition, the consortium members should have **experience of working in intercultural projects.** The consortium members must be tolerant and open towards different styles of work culture/communication and be willing to adapt their own styles (to some degree) to those of the Chinese or international project partners. If consortium members can do this, intercultural projects can be a rewarding experience.

To successfully analyse a pilot project in a Chinese city, especially if the project aims to develop policy recommendations or to facilitate international stakeholder dialogues, it is key that the consortium encompasses at least one partner who is located in the Chinese pilot city. This partner should possess close network links to the relevant departments or bureaus of the city government, which will ensure that the consortium has **access to important decision-makers.** This is key for understanding the needs and policy priorities of the city government, as well as for identifying leverage points for action. Without close ties to the city government, it is difficult to develop policy recommendations that are relevant to the decision-makers. Furthermore, a good network on the ground may be useful when coping with data issues, scenario assumptions or institutional issues. As a rule of thumb, we conclude that a **"red telephone" in the pilot cities,** allowing you to make contact with local experts, decision-makers or practitioners at short notice, is very important for a successful intercultural low carbon city project.

"A successful consortium in the field of low carbon city development in China needs to be well balanced with strong Chinese and international consortium members."

Building a Sound Conceptual Framework

Environmental and climate policy-related challenges at local level are multi-dimensional in character. Although GHG mitigation has become a more important policy topic in the last years, city governments often perceive issues such as air pollution or resource scarcity as more pressing. This means that the vision of decarbonising urban operations must be connected to more urgent policy issues. Consequently, **low carbon city projects should be highly integrative in character.** They should integrate different problem dimensions, such as resource efficiency, adaptation to climate change and GHG mitigation, and promote cross-sectoral solutions, like linking sources of heat such as industrial plants with potential heat-consuming infrastructures such as public buildings (e.g. schools, swimming pools). As a consequence, low carbon city projects require a sound conceptual framework, which brings together several methods (both quantitative and qualitative) in a consistent framework concept.

Within the Low Carbon Future Cities project, we decided to **dedicate the first work package to designing a coherent conceptual framework for the overall project.** The framework was summarised in a scoping paper. The paper defines the objectives and the conceptual frameworks for both the Chinese and the German pilot studies. For example, it specifies the approach for modelling long-term scenarios for Wuxi up to 2050 and in doing so defines three main scenarios, which are fed with the outcomes of several sub-scenarios.

As well as the objectives and methodologies of the pilot studies and the relevant work packages, the scoping paper includes **definitions of key terms and concepts as well as the geographical boundaries of both pilot areas.** Early discussions among the German and Chinese consortium partners illustrated that there was different understanding of key terms and concepts such as "cities" and "low carbon". By developing commonly shared definitions of such terms and concepts, work package 1 and the scoping paper served as a means of clarifying crucial questions within the consortium, which were key for the further project work. Therefore, we recommend that sufficient time at the beginning of the project should be invested in generating a common understanding of basic concepts and terms in order to build a consistent conceptual framework. Otherwise, it becomes difficult to integrate several problem dimensions and to address potential at the interfaces of single sectors.

FOR INTERESTED READERS:

Further detailed information on the methodologies of the key work steps is available in the full report "Scoping Paper: Specification of the Pilot Studies and Methodological Framework" (www.lowcarbonfuture.net).

Key Recommendations:

- A consortium for a Sino-International low carbon city project needs to be well balanced and wisely composed. Therefore, it is recommended that the profiles and qualifications of all potential project partners should be carefully researched.
- The members of the consortium should have relevant language skills to ensure that the language barrier is minimised.
- A strong partner with close links to the decision-makers in the pilot cities is a must.
- Sufficient time should be dedicated to building a consistent conceptual framework for the overall project and to establishing a common understanding of key terms and concepts. This will be time well spent.

2.2 DESIGNING AND IMPLEMENTING A SINO-INTERNATIONAL STAKEHOLDER DIALOGUE

A Sino-German stakeholder dialogue, in which the project team discussed preliminary project outcomes with practitioners and decision-makers from Wuxi and the Düsseldorf+ region, was a key element of the LCFC project. The dialogue process provided a "reality check" of the project outcomes and significantly enhanced local authorities' sense of ownership of the low carbon strategies recommended by the project team. Equally, the dialogue stimulated an exchange of know-how and experiences between decision-makers in both pilot areas.

An increasing number of research projects do encompass modules that aim to involve stakeholders and decision-makers. However, project developers and coordinators should be aware of the fact that conceptualising, organising and implementing a dialogue among Chinese and international stakeholders requires significant manpower. Furthermore, the dialogue process needs to be well designed in order to achieve the desired objectives and reach the target group. In the LCFC project, the stakeholder dialogue turned out to be a constant challenge and continuous learning process. That said, a well thought-out dialogue process can boost the policy impacts of a project. In our experience, some basic logistic and conceptual rules should be followed when realising a stakeholder dialogue with Chinese and international decision-makers.

Conceptualising the Stakeholder Dialogue

As a first step of the conceptualisation of the dialogue, the project team needs to **specify the target group it wants to reach and the purpose the stakeholder dialogue should fulfil within the overall project design.** The LCFC stakeholder dialogue chose policy-makers from the city governments of our pilot cities Wuxi and Düsseldorf+ as the prioritised target group. The first Sino-German Stakeholder Forum in October 2011 was hosted in Düsseldorf with about 100 participants. It was designed as a classic "flagship event" with presentations and panel discussions. The event aimed to promote the basic concept and objectives of the project to high-ranked representatives from Wuxi and the Düsseldorf+ region. Both the format and the audience were a good choice for this purpose. However, later in the project, smaller workshop formats proved to be more suited to the increasingly specific needs of both the project consortium and the decision-makers from the pilot cities. The project consortium was in need of specific information (e.g. data, background information about policies and institutional barriers) from the city representatives of Wuxi; the Chinese city government's main interest was to learn about concrete examples of good practice from German low carbon city projects. For these purposes, **workshop**

events with interactive sessions and about 15-20 participants were the best format. We learnt that such events combine content-related and logistical advantages: first of all, preparation is significantly cheaper and less time-consuming than organising a large conference; secondly, the format allows for very intensive and fruitful discussions with city representatives, generating valuable learning experiences for both sides. If possible, we **combined workshop formats with excursions** to showcase examples of good practice in the Chinese or German pilot city to the visiting city representatives. These examples should be carefully selected to meet the needs and interests of the visiting city authority. For example, at the third Sino-German Stakeholder Forum in September 2013, the delegation of Wuxi city government visited examples within the Düsseldorf+ region, which addressed key needs identified in the low carbon scenarios of the LCFC project and in earlier discussions with the city government of Wuxi. This shows that it is important to **embed the stakeholder dialogue into the overall project framework.**

> "...most government representatives welcome a detailed briefing on the objectives of the workshops and the information expected from them."

Organising the Stakeholder Dialogue

In order to ensure that the stakeholder dialogue has a reasonable impact, it is important to follow some logistical and organisational rules. These may seem trivial but are key to the success of the project. Firstly, it is **never too early to embark on the visa process.** During the LCFC project period, Chinese regulations for approving international trips by Chinese government officials became increasingly strict. For example, government officials need to outline prospective international trips in a travel plan, which they are requested to deliver at the beginning of each year. If trips are not part of the travel plan, the plan must be revised before the internal process to obtain a visa can start. Expect this to take months rather than weeks. Secondly, the **network links of the project's local partner are decisive in reaching the target audience** within the city government. In the LCFC project, it was particularly challenging to ensure the participation of a stable group of city representatives instead of a fluctuating set of participants. The only way to avoid this fluctuation seems to be where there is already a long-established relationship of trust between the local partner and the city government. Thirdly, most government representatives welcome a **detailed briefing on the objectives of the workshops and the information expected** from them. We learnt that a briefing paper (in Chinese), which briefly summarises the objectives of the event and lists concrete questions that the city representatives will

FOR INTERESTED READERS:

Further detailed information on the methodologies of the key work steps, especially the stakeholder dialogue process, is available in the full report "Scoping Paper: Specification of the Pilot Studies and Methodological Framework" (www.lowcarbonfuture.net).

Fig. 3: Key Aspects to Be Considered for a Successful Sino-International Stakeholder Dialogue

be expected to answer, can greatly improve the discussion during the workshop and its outcomes. Fourthly, **the organisation and design of the workshop needs to take into account intercultural differences and language barriers.** It is recommended that a facilitator with significant intercultural competence is engaged. Furthermore, it is important to ensure high-quality translation. In our experience, the quality of Chinese interpreters varies greatly. We recommend choosing interpreters who are recommended by trusted partner organisations. Even the best interpreters need to be briefed before the event. This means that slides should be sent to them some days in advance. If possible, slides should be bilingual. At LCFC stakeholder events, we did our best to translate all slides into German and Chinese. However, this requires additional financial resources and time and this should be taken into account when planning the project budget.

Key Recommendations:

- Define the objectives and the target group of stakeholder events carefully so that they are well embedded into the overall project framework.
- Small and interactive workshop formats allow for more intensive and fruitful discussions among and between the Chinese and German city representatives.
- Workshops should be combined with study tours to showcase examples of good practice.
- Take into account the restrictive visa approval procedures for Chinese government officials when planning stakeholder events outside China.
- Detailed briefing of government representatives on workshop objectives and the input expected from them can significantly improve the quality of the discussion.
- Workshop organisation and design needs to take into account intercultural differences and language barriers, e.g. through ensuring high-quality interpretation.

3 SCIENTIFIC ANALYSIS: A SOLID FOUNDATION FOR LOW CARBON URBAN DEVELOPMENT

The core of the LCFC project is a series of robust scientific analyses, providing a solid foundation for developing integrated low carbon strategies for both pilots in the project. The scientific analyses actively linked GHG mitigation to adaptation and resource efficiency and encompassed both quantitative and qualitative methods as well as status quo assessments and exploration of future pathways.

In this chapter, we share with you our experiences relating to:

- How we conducted the status quo assessment of GHG emissions and resource use.
- How we built up long-term low carbon scenarios to explore pathways for a low carbon future for the Chinese city of Wuxi.
- How we integrated resource use with GHG mitigation.
- What the key is to integrating climate change adaptation into a low carbon city strategy.

3.1 STATUS QUO ASSESSMENT OF GHG EMISSIONS AND RESOURCE USE

The first step towards developing a low carbon pathway is to understand the status quo of the city's GHG emissions and to identify hotspots for mitigation. This means that it is most important to analyse and understand which processes, technologies and behaviours lead to GHG emissions and where resources are used. Therefore, GHG emissions must be quantified, key sources and sectors must be identified and the impacts of measures, which have been or are being implemented, must be monitored.

However, this is often easier said than done. The assessment of emissions and material use is not – as one might assume – "pure and simple counting".

The decision on the **method and system boundary to be chosen** is an important first step. Then follows the search for the **right emission factors and the actual data collection,** which can be very time consuming, as well as communication (and even negotiation) intensive. However, it is crucial for the overall quality of the inventory/assessment. In order to be able to monitor the impacts of mitigation measures, **establishing a monitoring system that allows for the regular updating of assessments of GHG emissions and resource use** (annual and institutionalised) should ideally be integrated into the work plan of low carbon city projects.

All these efforts are worth investment as a weak GHG emission assessment can lead to ineffective measures or even bad decisions or inadequate targets. Furthermore,

regular updating of the GHG inventories is needed in order to monitor compliance with emission reduction targets.

For the Wuxi pilot study within the LCFC project the status quo of GHG emissions was assessed based on the internationally standardised IPCC-Guidelines (in a simplified approach) for national GHG inventories (IPCC 1996 and 2006). Data collection did benefit from the well-structured and – rather detailed at city level – official Statistical Yearbook of Wuxi (for 2009). Furthermore, questions about data or assumptions were forwarded to the local city authorities through close cooperation with the Wuxi Low Carbon Development and Research Centre (WLCC). However, the inventory provided for Wuxi can only be regarded as a first attempt as it still has several gaps and uncertainties, with the result that it has good potential for further refinement.

Finding the Appropriate Scope, Method and Defining Objectives

There are several approaches for assessing GHG emissions and environmental impacts at city level. Numerous cities, both in Europe and China, have started (or are about to start) to formulate an inventory of their emissions. However, until now there has been no global standardised method, common reporting format and/or quality assurance at city level; decisions on inventory methods are in the hands of each city authority. The following issues need to be considered when planning emission inventories:

↘ **Geographic Counting Scope:** the "traditional" emission inventory approach is to assess the "territory" or "in-boundary" emissions, which stem from/are produced solely from or within the city's administrative boundaries, the so-called "**Scope 1**" (Chavez and Ramaswani, 2011). This approach is followed in the IPCC-guidelines for national inventories, but is also frequently used in the city context (as in our LCFC project). "**Scope 2**" includes indirect GHG emissions from the imported electricity used within the city. "**Scope 3**" counts emissions from transboundary infrastructure such as transportation fuels, airborne or shipping activities, commuter travel or transboundary waste disposal. Scope 2 and 3 can be regarded as providing a "more realistic" impact assessment of the city as these methods attempt to consider resources used and emissions related to real city activities. This is a particularly important aspect for cities with high levels of imports and exports of products and electricity. On the other hand, both scope 2 and 3 increase the need for data, require greater effort and reduce the chances of comparing the results with regional or national emission reporting. Depending on the scope, the methods as well as the need for data also differ. Hence, **the scope should be defined according to the main rationale and objective of the inventory.**

↘ **Method, Gases and Sectors:** Accounting methods that differ from the IPCC-Guidelines have been published and are in use on a global scale by initiatives and cities, such as ECO2-Region or GRIP. Their approaches are slightly different and they account for different gases and sectors.

The **choice of the method and scope also depends on the objectives of the assessment for the city.** Important criteria in the decision-making process should be the given data and manpower capacities, comparability to neighbouring cities or regions as well as the feasibility of subsequent follow-up and monitoring. ↘ **Box Page 14**

The LCFC team decided to use the "classic" methodology of the IPCC-Guidelines due to their high international standards and quality as well as the comparability to national and regional statistics.

For the **assessment of material use,** we concentrated on the energy (heat and power) sector and the construction sector. For both sectors, the entire life-cycle was considered. With regard to material or resource flows all natural resource inputs (direct or indirect, economically used or unused, domestic or foreign) that result from human activities in Wuxi – including trade – were calculated. Two main methods, selected from a wider material flow analysis (MFA) toolbox, were applied: **Material Input per Unit of Service (MIPS) and Economy-Wide Material Flow Analysis (EW-MFA).** They are explained in more detail in section 3.3. These analyses can be very useful as resource-efficient planning is an important trigger for mitigating GHG emissions. However, detailed assessments of resource or material flows can be very time-consuming and complex and may overstretch the capacities of city authorities. Therefore, cooperation with scientific partners is strongly recommended.

"The choice of the method and scope also depends on the objectives of the assessment for the city."

Tools for Increasing the Comparability of GHG Inventories in China

For a single city it is quite complex and labour-intensive to establish the best tool for the purpose. It is, therefore, helpful that in 2011 the central government of China issued a publication for the provinces, entitled "Guidelines on Provincial Greenhouse Gas Emission Inventories (Trial)", which also serves as a basis for developing city inventories and is based on the IPCC-Guidelines and Chinese experiences (Bai et al., 2013). Furthermore, the World Resources Institute (WRI), together with the Chinese Academy of Social Sciences (CASS), WWF China and the Institute for Sustainable Communities (ISC) recently launched a first version of a GHG Accounting Tool for Chinese Cities entitled **"Greenhouse Gas Protocol".** The tool enables cities to create a sound and comparable GHG inventory for key emission sources (http://www.ghgprotocol.org/chinese-city-tool) (WRI et al. 2013). If successfully applied, the tools from WRI et al., as well as the guidelines from central government, may help to reduce the diversity of GHG inventory approaches and enhance comparability.

Data and Data Gaps

Moving from the "theory" of optimal method choice to the "reality" of Wuxi's city inventory, we had to accept the limitations of data availability and suitability of the IPCC method. Furthermore, we needed to make a realistic estimate of our time and manpower capacities when designing and carrying out the LCFC inventory. Despite the well-structured Statistical Yearbook of Wuxi, we realised that the available statistical data was still not sufficient to fulfil the requirements of a comprehensive inventory. Wuxi has several direct emission sources closely linked to the energy industry. In other industry sectors that are almost impossible to calculate. Due to the high number of complex industry processes and limited data on these processes in the statistical yearbook, it was mostly direct CO_2 emissions that could be quantified in the inventory, while for most other process-related emissions and so-called "Kyoto-gases" it was only possible to provide some qualitative assessments. To monitor future GHG emissions, the data quality and calculation methodologies would have to be improved in accordance with local conditions. There is **high improvement potential for data and methods, especially for non-CO_2 sources** such as waste disposal and agriculture (which we could not include due to data uncertainty) and **also for process-related emissions.** This is certainly not only the case for Wuxi but also for other industry-dominated cities in China and across the globe. National inventories often face similar problems, but normally have greater capacity to deal with these challenges. Realistically, pragmatic solutions have to be found for cities and the process of data collection from different departments should be coordinated by a powerful authority, such as the municipal Development and Reform Commission.

Follow-up, Monitoring and Institutionalisation of Inventories

Preparing an inventory and status quo assessment is important; but, even more important for the success of a low carbon pathway, is the subsequent monitoring of the positive and negative changes in material use, emission trends and – possibly – the verification of the impact of implemented measures. Consequently, it is highly recommended **that the first inventory is documented and regular (annual or bi-annual) inventory reporting is established.** Ideally, the monitoring and assessment team is based in one central institution, has direct and good contact with the data providers (who are cooperative) and that clear responsibilities are assigned. Due to changes in staff over the years, the probability of knowledge-loss, work duplication or inconsistencies/incompatibilities with former inventories is quite high. To counteract this, the monitoring and reporting processes need to be well structured and documented so that staff changes can be overcome. As mentioned above, cities can benefit in different ways from GHG reporting. The reporting can enable city authorities to set appropriate mitigation targets, implement improved and adapted policies and, as a consequence, increase their credibility (Sippel, 2011).

FOR INTERESTED READERS:

Further detailed information on the status quo of material flows and GHG emissions in Wuxi is available in the full report "Integrated Status Quo and Trends Assessment in Wuxi" (www.lowcarbonfuture.net).

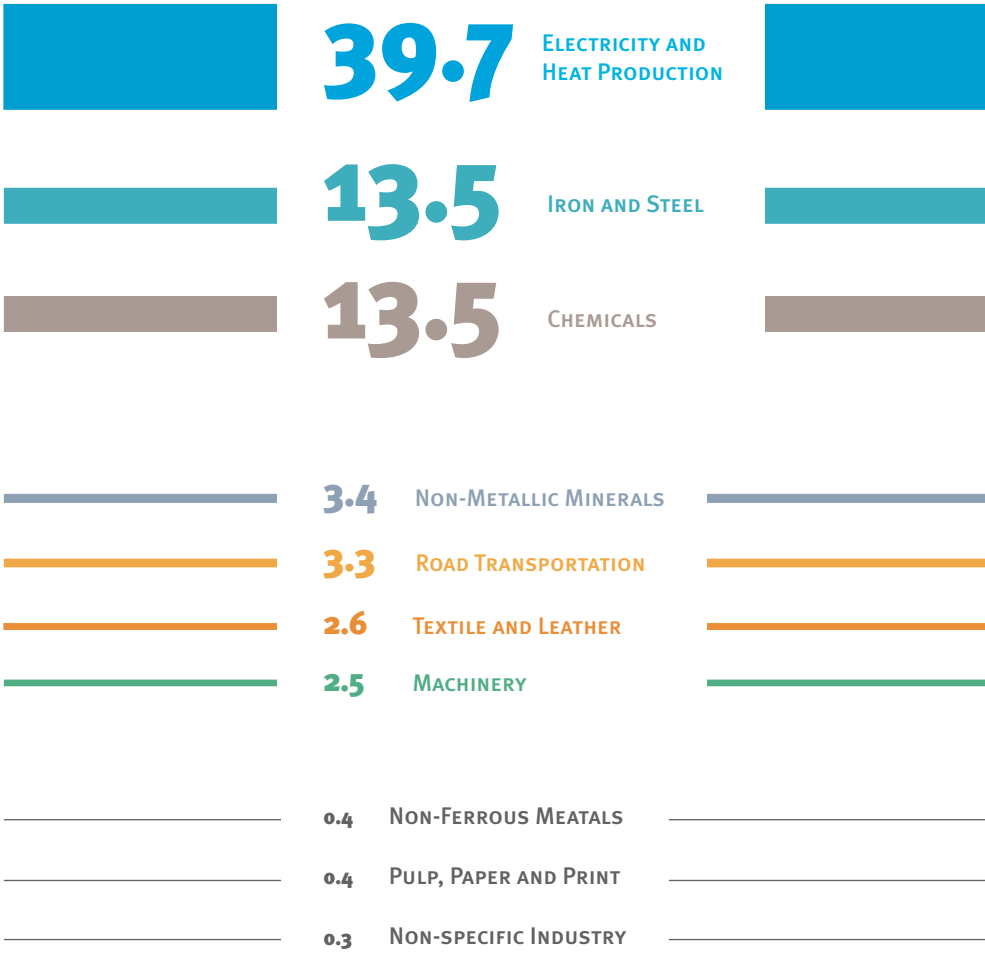

FIG. 4: WUXI'S TOTAL DIRECT CO_2 EMISSIONS (IN MILLION TONNES) IN THE IPCC-ENERGY SECTOR IN 2009

Key Recommendations:

- Developing a robust and accurate GHG emission inventory is essential for quantifying the low carbon development and identifying hotspots for emission reduction. Therefore, cities are recommended to pool resources and capacities for emission inventories and assessment as these are key to defining city-specific mitigation targets and appropriate policy measures.
- The scope and calculation methods should be chosen according to local conditions, given capacities, data availability and the city government's policy objectives. Ideally, a standardised method - already in use in similar or neighbouring cities – should be used to facilitate implementation.
- The mandate to develop an inventory should be given to a strong and central authority (e.g. the municipal Development and Reform Commission in Chinese cities) at local level in order to facilitate data collection and cooperation with related institutions.
- Detailed and transparent reporting of the assessment/inventory (data sources, used emission factors, calculation tables), as well as data gaps and challenges, is needed to enable traceability and later modification.
- Implement annual or bi-annual reporting, ideally carried out by a stable team (from one institution) with clear responsibilities, in order to reduce the possibilities of failure/ inconsistency or knowledge loss.

3.2 BUILDING LONG-TERM LOW CARBON SCENARIOS FOR A CHINESE CITY

The status quo assessment of GHG emissions and resource use provided a good starting point for exploring a low carbon future strategy for Wuxi. Developing such a strategy calls for integrated tools that can address high complexities and uncertainties inherited with urban systems and their development. Meanwhile, the temporal scope of such a strategy goes beyond the short and mid-term horizon of common urban planning practices that have, until now, been applied by the Wuxi city government and the rest of China. Most Chinese planning documents cover the period to 2020 or 2030 (maximum). However, a low carbon strategy needs to incorporate an **understanding of long-term challenges and low carbon solutions up to 2050.** As such, it requires tools that can explore the challenges, technologies and measures which might shape Wuxi's low carbon future over a longer time span.

"...the political situation and culture of a country or city needs to be taken into account when choosing a modelling approach."

Scenario analysis, which has been widely applied in sustainability research during the last decade, is such a tool and it was used by the LCFC team to explore different pathways for future developments in Wuxi and the associated energy demand and CO_2 emissions. We elaborated **three scenarios.** The Current Policy Scenario (CPS) indicates how GHG emissions would develop if no additional policies or targets (beyond those already in place) were adopted. The Low Carbon Technology Scenario (LCTS) shows the degree to which emissions in the selected key sectors (power/heat, industry, buildings/households and transport) could be reduced if incumbent technologies were replaced with best available technologies as soon as they are ready. Finally, the Extra Low Carbon Scenario (ELCS) combines a market introduction of best available technologies with substantial behavioural change, such as moderate growth of individual motorised transport despite rapid improvements in living standards and an emerging urban middle class. All scenarios are composed of sub-scenarios for the selected key sectors.

The scenarios follow a **bottom-up approach to indicate to Wuxi's city government which technical and behavioural strategies could be most effective** in reducing emissions in the selected key sectors in the short, mid and long-term. The scenarios explicitly avoid the definition of long-term carbon mitigation targets for Wuxi as this would have required a top-down modelling approach. Such targets would have been highly politically sensitive and could have impeded a constructive dialogue with Wuxi's city government. By choosing a bottom-up approach, we showed decision-makers a pathway of potential future developments and strategies and demonstrated to them the need to integrate a long-term perspective into their low carbon planning. Experiences from the LCFC scenario process suggest that scenario development can be politically sensitive. Therefore, **the political situation and culture of a country or city needs to be taken into account when choosing a modelling approach.**

As well as the aforementioned issues, major challenges the LCFC team faced during the scenario process included how to adapt scenario assumptions to local conditions and how to ensure that scenario results effectively contributed to the development of the integrated low carbon strategy in Wuxi. In order to address these two challenges, we integrated quantitative scenario modelling with a qualitative approach. The reason for this is that quantitative modelling has its limits in simulating complex systems, such as an urban system, over a long timeframe. Qualitative analyses can better capture the various "soft" factors of complex systems, for instance political or institutional barriers. Indeed, they can be used effectively to complement quantitative methods, resulting in a broader perspective for exploring the future (Swart et al., 2004). In the following two sub-sections, we will briefly elaborate how the LCFC team adapted its scenario assumptions to Wuxi's specific conditions and how the modelling approach was complemented by qualitative institutional analysis.

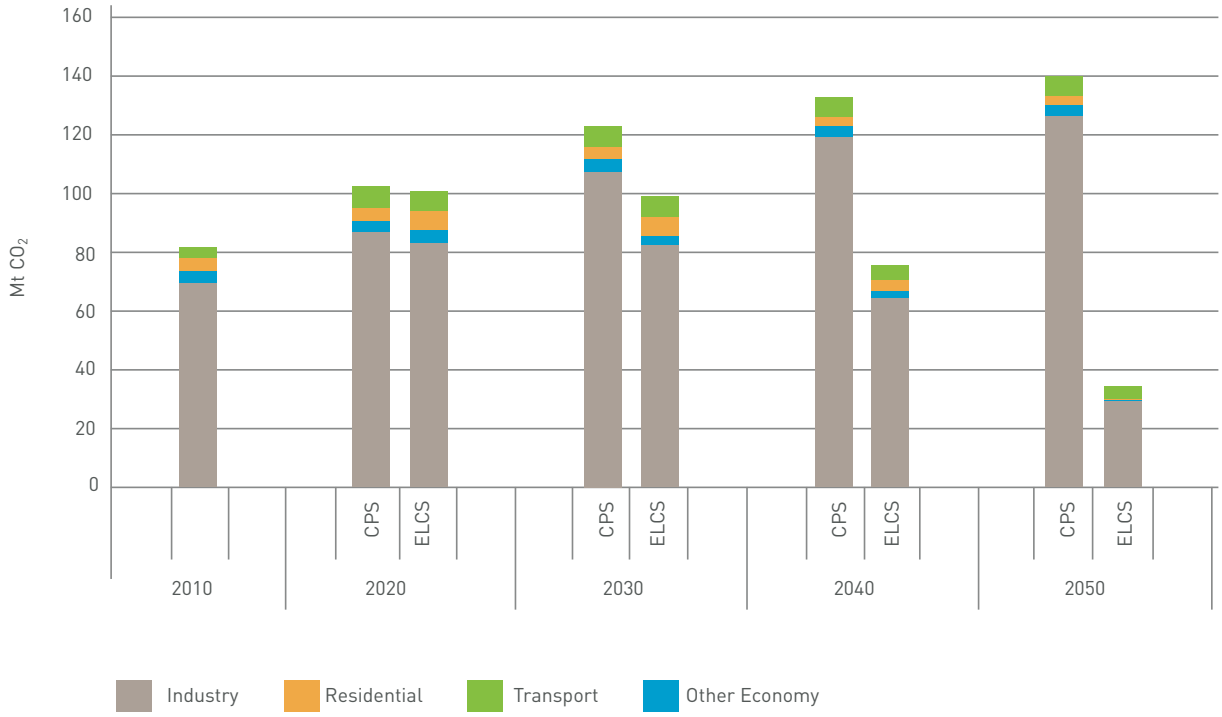

Fig. 5: Wuxi's Direct and Indirect CO_2 Emissions in the Current Policy Scenario (CPS) and the Extra Low Carbon Scenario (ELCS), 2010-2050.

Adapting Scenario Assumptions to Local Conditions

It is essential that scenario assumptions reflect local conditions, as this makes scenarios acceptable and relevant for local policy-makers. Local data is key for developing robust assumptions. However, data availability turned out to be very challenging in the pilot study. For the status quo assessment of local GHG emissions the main source of local data was the Statistical Yearbook of Wuxi. The Yearbook offered quite a comprehensive database; however, the availability and quality of data differed significantly across the selected key sectors. While there was a good set of statistical data for the power sector, data on energy-intensive industry operations and plants was very limited. Also in the building sector, the data requested by the modelling structure went beyond the data available at local level. For example, the model required very detailed behaviour-related and action-level data for different building types in Wuxi, which was not available.

One way to fill these data gaps was to **employ the key assumptions from scenarios developed at national level by Chinese research institutes.** Here, the scenario "China 2050" by the Energy Research Institute (ERI) proved to be useful ("2050 China Energy and CO_2 Emissions Report" Project Team, 2009). Using national assumptions for local scenarios, however, compromised the scenarios' local characteristics and increased the uncertainty of the outcomes. In order to adapt the scenarios to Wuxi's

situation, the modelling team consulted local stakeholders and experts about whether certain low carbon technologies were tailored to local conditions and would be, therefore, applicable to Wuxi. However, due to time and resources constraints, levels of stakeholder participation, ranging from consultancy to active participation of representatives from government and business, was limited. We recommend allocating more time for the active participation of key stakeholders, experts and practitioners, in the form of interviews and workshops, as this would probably result in more effective scenario development.

"A participatory process of scenario development could generate more robust and widely shared scenario assumptions..."

A participatory process of scenario development could generate more robust and widely shared scenario assumptions due to the integration of broad knowledge and experiences. As a consequence, it could improve the quality of the scenario results and enhance their acceptance by decision-makers. However, a participatory scenario process should not be expected to be smooth or easy due to the different and sometimes conflicting interests and perspectives of the various stakeholders. Therefore, careful consideration should be given to establishing which aspects can be effectively discussed with stakeholders and which stakeholders could make constructive contributions.

Combining Quantitative Scenarios with Qualitative Institutional Analysis

To further develop an integrated low carbon strategy, the scenario analysis was complemented by an analysis of existing policies and responsibilities of the administrative units involved in fostering low carbon development in the identified key sectors. The institutional analysis contributed to identifying the opportunities and barriers for coping with climate mitigation and resource efficiency. Therefore, it helped to understand the political leeway for pursuing a low carbon future in Wuxi. The analysis was conducted by screening existing literature and policy documents as well as by face-to-face interviews with officials from relevant departments/bureaus in the Wuxi city government. The institutional knowledge was used to translate the scenario outcomes into policy recommendations, which include suggestions for concrete next steps, policy instruments, administrative responsibilities and which stakeholders to involve. This would not have been possible without a good understanding of the institutional setting for low carbon development in Wuxi.

However, the **institutional analysis could be even more effective if it were conducted and inter-linked with the scenarios at an earlier stage of the project.** For example, the selection of technological strategies, which were fed into the scenarios, would benefit from a deeper understanding of the city government's political leeway in the field of low carbon development within the Chinese multi-level system. Accordingly, an institutional analysis for future low carbon city projects could consist of two phases:

↘ **Phase 1:** an overall institutional analysis to understand the general opportunities and barriers for coping with climate mitigation, adaptation and resource efficiency at local level. This phase could be conducted before the development of low carbon scenarios, enabling robust scenario assumptions and a selection of technical strategies tailored to the needs of the relevant city and the political leeway of the city government.

↘ **Phase 2:** a series of more strategy-specific institutional analyses illustrating how certain low carbon strategies/measures could potentially be implemented. This phase would help to translate the scenario results into policy recommendations and, therefore, provide a reality check of the modelling outcomes. Local stakeholders should be actively involved in this phase.

Key Recommendations:

- Sustainable development requires city governments and other relevant organisations to take a long-term perspective. Scenario analysis is a useful tool for exploring different long-term pathways and, therefore, supports sustainable transition.
- For scenarios to effectively influence the decision-making process, the integration of quantitative modelling with qualitative approaches is essential. The latter includes a range of qualitative methods, such as participatory tools, expert interviews and institutional analysis. As a consequence, the design of low carbon city projects should allocate sufficient finances and manpower to conduct interviews and organise workshops with experts who possess profound knowledge about the local policy framework for implementing important low carbon strategies.
- Participatory development of scenario assumptions that actively involves stakeholders can integrate a range of knowledge, experiences and expertise into the scenarios and, by doing so, help to make their results more robust. Furthermore, it ensures that local conditions and needs are always at the forefront and facilitates the implementation of recommendations derived from the scenario outcomes.
- Modelling processes often suffer from data gaps. Local policy documents and scenarios developed by Chinese research institutes can serve as valuable sources for filling these gaps. Nonetheless, the availability, quality and access to data for scenario modelling should be assessed in the design phase of the project so that the modelling structure and complexity can be developed accordingly.
- A comprehensive institutional analysis serves as an important input for scenario development and as a basis for translating scenario outcomes into future urban development strategies. It should provide a general overview of the existing policy framework and resources available in the city. Subsequently, when specific technical strategies or policy measures are recommended, institutional analyses can be very useful in helping to understand the institutional framework, thereby enabling the implementation of these strategies. As a consequence, the timing of carrying out the institutional analyses and their synchronisation with other work packages needs to be well planned to ensure effective integration with quantitative methods.

FOR INTERESTED READERS:

Further detailed information on the scenario pathways is available in the full reports "Integrated Status Quo and Trends Assessment in Wuxi" and "Integrated City Strategy for CO_2 Emission Reduction, Resource Efficiency and Climate Resilience" (www.lowcarbonfuture.net).

3.3 INTEGRATING RESOURCE EFFICIENCY AND LOW CARBON SCENARIOS

One of the innovative features of the LCFC project is that it did not focus in a one-dimensional way on GHG reduction, but also aimed to investigate how GHG mitigation interacts with adaptation to climate change and resource use. The integration of an urban adaptation strategy into a low carbon city strategy is discussed in section 3.4. In this section we will illustrate how the project consortium managed to link low carbon scenarios for the Chinese city of Wuxi with resource use scenarios.

Key Tools for Analysing Resource Use in Wuxi

The assessment of resource use was based on two main methods from the wider material flow analysis (MFA) toolbox:

↘ **Material Input per Unit of Service (MIPS):** This method, also referred to as material footprint, belongs to the larger family of life cycle studies and operates at micro-level. It focuses on the input side of the life cycle inventory of the studied product, service or process and demarks itself by accounting for economically non-valued resource extraction (Saurat and Ritthoff, 2013; Ritthoff et al., 2002, Schmitt-Bleek, 1993).

↘ **Economy-Wide Material Flow Analysis (EW-MFA):** This covers in principle all material flows of the studied region (all materials entering the economy as extraction or imports and all materials existing in the economy in the form of emissions, waste or exports). For feasibility reasons, the scope of the analysis in the LCFC project was circumscribed to well-defined economic sectors and relevant input and output material flows.

These two methods helped us to derive a variety of material flows and stocks associated with Wuxi's production and consumption activities. All flows and resource use were summarised in a **headline indicator referred to as Total Material Requirement (TMR).** It aggregates in one variable the domestic and foreign resource extraction (vis-à-vis Wuxi's boundaries) that can be directly or indirectly linked to Wuxi's production and consumption activities. The absolute value of the TMR measures the environmental pressure associated with resource use and consumption in Wuxi.

Selecting Key Sectors

Due to limitations in time and manpower, the LCFC team decided to limit the analysis of resource use in Wuxi to two of the LCFC **key sectors: construction and power/heat production.** These two sectors were selected, because they are resource-intensive, offer significant potential for GHG mitigation in Wuxi and are, therefore, in the focus of the LCFC project. The focus in the construction sector was mainly on residential buildings due to a lack of data on public and commercial buildings. As in most other cities or countries, the construction sector proved to be of great significance with regard to Wuxi's present resource use and also its future levels of waste materials due to demolition. Wuxi's power and heat sector, in turn, was selected mainly because of its high upstream resource use as it is nearly 100% reliant on coal.

Furthermore, both sectors seemed to be **well suited to be integrated with the LCFC low carbon scenarios.** For the power sector, the project team wanted to find out to what degree a shift from Wuxi's coal-dominated power supply to a larger share of renewable energy sources, as foreseen in the Extra Low Carbon Scenario, could have implications on the sector's resource use. For the building sector an important aspect for analysis was the degree to which improved insulation in new buildings would increase material use in the building sector and whether the consequent reduced power/heat demand due to better insulation could over-compensate for this increased material use.

Integrating Resource Use Models with Low Carbon Scenarios

The modelling of future resource and material use in the power/heat and construction sector up to 2050 was **based on the same basic assumptions and parameters as the Extra Low Carbon Scenario** for projecting Wuxi's long-term energy demand and CO_2 emissions. Furthermore, the LCFC team used a detailed energy balance for Wuxi, which was produced as part of the status quo assessment and scenario development, for deriving material and water intensity and to deliver a resource flow analysis model for the power/heat sector. For the construction sector, a stock dynamics model for material and resource flows was developed and this was also built on the same key parameters as the Extra Low Carbon Scenario, such as population development, per capita floor space and the lifetime of buildings.

Integrating mitigation and resource efficiency scenarios as previously described presents a number of challenges related to process management and data availability. In the LCFC project, low carbon scenarios and resource scenarios were undertaken by different modelling teams. Therefore, it turned out to be **essential to synchronise the process of researching and defining basic scenario parameters** for both teams. Due to the tight schedules of the team members involved, this turned out to be difficult. For future projects, it is therefore recommended that a more detailed and synchronised work plan for the modelling

FOR INTERESTED READERS:

Further detailed information on the integration of resource efficiency and low carbon scenarios is available in the full reports "Integrated Status Quo and Trends Assessment in Wuxi" and "Integrated City Strategy for CO_2 Emission Reduction, Resource Efficiency and Climate Resilience." (www.lowcarbonfuture.net).

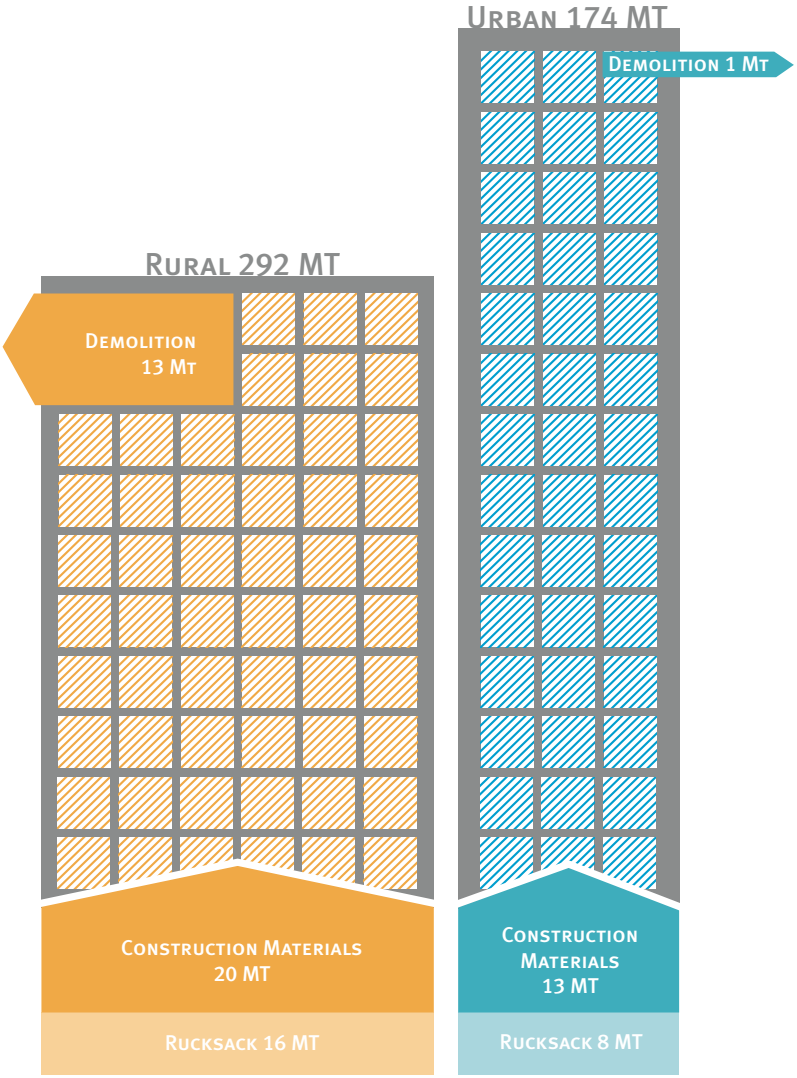

Fig. 6: Material Stocks and Flows in Residential Buildings (2005)
* rucksack refers to hidden (indirect) material flows

process should be developed, which establishes regular meetings at fixed times for exchanges between the modelling teams with the involvement of the project coordinators. Furthermore, the process should include one or two workshops for the modelling teams to collaborate with carefully selected experts to set and streamline the common assumptions for the resource and low carbon scenarios.

Analysing resource and material flows was affected to an even greater degree by incomplete and inconsistent data than was the modelling of greenhouse gas emissions. Therefore, we suggest **that data availability should be checked as a first step and that the project and the related work packages should then be designed accordingly.** Of course, we are aware that this type of preparatory study is often constrained by tight deadlines for the submission of project proposals, but it could significantly enhance the modelling process during the project. Furthermore, good contacts with local experts are a must in order to gain access to or verify the required data. For example, all new buildings in China need to deliver a bill of quantity, which details the quantities of materials, parts, labour etc. used for constructing a new building. These bills of quantity would have provided an excellent source of data but were not made available to the LCFC team.

Key Recommendations:

- Data availability should be checked before designing the project and work packages for resource use assessment. This could significantly enhance the modelling process during the project.
- The scope and complexity of the model, as well as the boundaries of the considered sectors, should be decided based on the data available as well as on their direct and indirect linkages to GHG mitigation and energy demand.
- The process of modelling GHG emissions, energy demand and resource use needs to be synchronised by a commonly agreed work plan and regular exchanges between the modelling teams. The project coordinators should be involved in these exchanges in order to be aware of communication problems or inconsistencies during the modelling process.
- It is recommended that workshops should be organised to set the basic assumptions and parameters of both low carbon and resource use scenarios before the actual modelling process begins. These workshops should also include external experts with knowledge about the local conditions for the sectors concerned.

3.4 INTEGRATING URBAN CLIMATE CHANGE ADAPTATION INTO LOW CARBON CITY STRATEGIES

Regardless of how effective mitigation efforts are, climate change is already a reality. Cities are potential hot spots of vulnerability to climate change impact due to the high concentration of infrastructure and population. As a result, it is important that cities develop and implement urban adaptation strategies in order to prepare for the impact of future climate change, which may affect both city operations and the well-being of residents. These strategies must be based on robust analyses of climate impacts and on integrated assessments of the different applicable adaptation options (EEA, 2012; Carmin et al, 2012). Meanwhile, urban strategies for adapting to climate change should be integrated with on-going mitigation efforts, i.e. generating synergies between adaptation and mitigation.

In general, the development and implementation of an urban adaptation strategy should follow a systematic and iterative process, as illustrated in figure 7 (EEA, 2012).

The LCFC project focused on the first three steps of the illustrated cycle. The following sections present guidelines relating to these three integrated steps based on the lessons learnt from the Low Carbon Future Cities project.

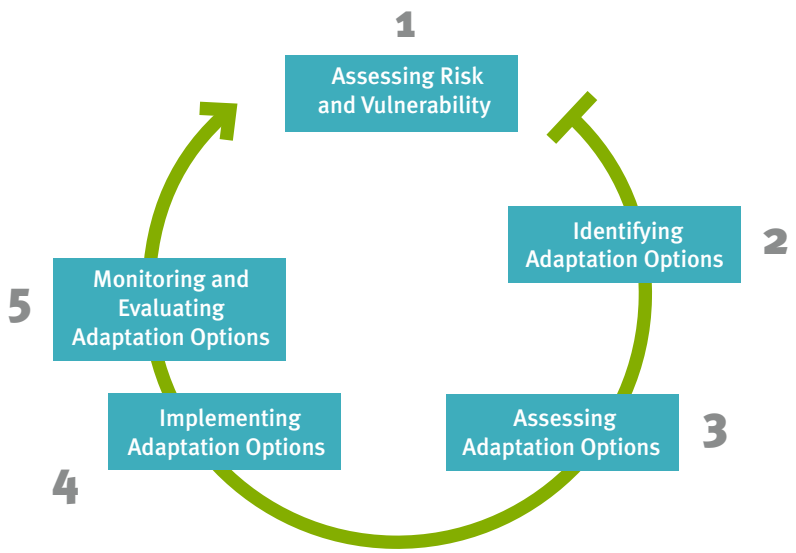

Fig. 7: Approach for Developing and Implementing Urban Adaptation Strategies

Source: adapted from EEA, 2012

Step 1: Assessing Risk and Vulnerability

Vulnerability refers to the susceptibility of the economic, social or ecological system to potential damage. It is a product of the coping capacity and damage potential and interacts with a hazard[1] to generate risk (Cardona et al., 2012).

In order to understand the potential trends in climate hazards in Wuxi, we analysed the historical changes of different climate parameters (such as mean/maximum temperatures, frost/summer days, warm/cold spell durations and precipitation) and projected their future trends. The analyses were based on observed daily data of these climate parameters collected from seven meteorological stations in Wuxi and its surrounding areas, while the projections were based on modelling aggregated results from several international General Circulation Models (GCMs) as well as one Regional Climate Model (RCM), i.e. Cosmos-CLM.

"Further research on methodologies of downscaling existing regional climate models to higher resolutions at local scale was required..."

We encountered two major challenges at this stage of the project. Firstly, all climate models are generally comprised of a relatively coarse resolution in time and space. This coarse resolution is not well suited to small spatial scale assessments, e.g. of an individual city. The projection results have a particularly high uncertainty of the climate change impact at city level. In our project, given the limited time and resources, we averaged the results from global and regional models in order to reduce uncertainties. However, this was not sufficient to achieve a satisfactory level of accuracy. **Further research on methodologies of downscaling existing regional climate models to higher resolutions at local scale was required** to obtain a sound foundation for assessing the vulnerability to climate hazards and climate-related risks at city level.

The second challenge was to enhance data availability of relevant climate parameters. In our project, despite the data availability from seven meteorological stations, more point-based data observations were needed for better accuracy in the assessment of climate hazard impacts and the vulnerability of the exposure. In fact, this is a general problem when analysing trends of climate parameters in China. There are, in total, more than 2,500 meteorological stations in China that record daily climate parameters. However, most of these stations are located in the eastern coastal region, in which each county has one station on average. In comparison with some European countries the number of stations within Chinese cities is very limited (Germany, for example, has more than 4,000 stations). Combined with the uneven distribution of the stations, it is very difficult to generate an accurate projection of climate hazards. **A much closer network of (simple) weather stations for Chinese cities, such as Wuxi, is needed** to obtain observations of climate parameters of a high spatial resolution. This would enhance local and regional projections of future climate change impacts.

[1]Hazards refer to "the possible, future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements" (Cardona et al., 2012).

Steps 2 and 3: Identifying and Assessing Adaptation Options

A major finding in Step 1 of our project was the projected trend of decreasing cold spells and cold days and of increasing warm spells and summer days up to 2100. This is highly relevant for both mitigation and adaptation efforts in Wuxi. For example, higher summer temperatures would lead to more air conditioning systems being installed and used, creating greater electricity demand and probably leading to higher GHG emissions. The question is how best to adapt to the increasing temperatures in line with the developed mitigation strategies.

The answer to this question needs to be considered from different angles. At consumer level, more efficient air-conditioners or cooling devices should be purchased and newly constructed buildings should conform to low or ultra-low energy standards to reduce their energy consumption and associated expenditure. At city level, given the long-term impacts of climate change, a new management paradigm that takes a long-term perspective into consideration when taking local decisions is required. **The local government needs to integrate adaptation into urban planning,** for example with the design of new infrastructures and buildings that are able to reduce heat waves and the heat island effect in the city (e.g. green infrastructures, building exposition, pavements and roofs with high solar reflectivity). The national and provincial governments should set up an institutional framework that stimulates the market breakthrough of energy-efficient cooling devices and low and ultra-low energy buildings, as well as regulating adaptation into urban planning.

As well as the adaptation measures we addressed in the Low Carbon Future Cities project, we are also aware of the **need to improve the current early warning system for extreme weather events.** The current system is very much centralised, i.e. the local bureau has to report local extreme weather events to the central unit at national level and ask for approval to transmit the early warning locally. This can cause significant delays in reacting to extreme weather events and, therefore, can result in greater damage.

Key Recommendations:

- In order to reduce the uncertainties associated with the projection of climate trend parameters and hazards, the Chinese government should consider increasing the number of meteorological observation stations that collect daily climate parameters relevant to climate hazards and should distribute these stations evenly.
- The city government needs to integrate adaptation into urban planning. The national and/or provincial governments are recommended to set up an institutional framework that regulates adaptation into urban planning. Exchange and collaboration between European cities that already integrate adaptation into urban planning and Chinese cities could be beneficial.
- The national and/or provincial governments should create an institutional framework that stimulates the market breakthrough of measures that address the synergies between mitigation and adaptation.
- A more decentralised early warning system for extreme weather events could be helpful for reacting effectively to these extreme events.

FOR INTERESTED READERS:

Further detailed information on the climate change adaptation and scenario pathways is available in the full reports "Integrated Status Quo and Trends Assessment in Wuxi" and "Integrated City Strategy for CO_2 Emission Reduction, Resource Efficiency and Climate Resilience" (www.lowcarbonfuture.net).

4 IDENTIFYING BUSINESS OPPORTUNITIES DERIVING FROM LOW CARBON DEVELOPMENT IN A CHINESE CITY

Rigid scientific analyses play an important role in developing low carbon city strategies. However, it is important to keep in mind that entrepreneurs represent major potential with regard to innovation and local solutions for low carbon development in China. Consequently, a low carbon city strategy should systematically include entrepreneurs. The LCFC project made low carbon entrepreneurship an important pillar of the project and aimed to identify and showcase business opportunities that would arise from the development of a low carbon policy.

Integrating a Business Perspective into Low Carbon City Research

As a first step, the project team identified potential leverage points for low carbon entrepreneurship in Wuxi by investigating the general conditions and potential target markets for low carbon business models in Wuxi. In a second step, the project team identified and outlined about 20 successful examples of low carbon entrepreneurship in China, using them as a basis for identifying triggers that could help to improve the framework and environment for low carbon entrepreneurship in Wuxi.

Discussions with and feedback from the city government of Wuxi have repeatedly shown that it is of utmost importance to integrate a business perspective into low carbon city projects. Many urban decision-makers in China are currently searching for successful models that can combine economic and environmental benefits. They are not so much interested in strategy, but rather in concrete examples, blueprints for pilot projects and practical experiences. Such expertise and knowledge can be contributed by practitioners and entrepreneurs. Consequently, the LCFC project team tried to link up the city government with relevant German entrepreneurs and innovators. However, the project's stakeholder dialogue was mainly aimed at ensuring steady and continuous exchange among and between city representatives from both pilot regions. For future projects, however, it is recommended that **a stronger focus on business opportunities and implementation projects should be integrated into the dialogue process, linking up the city government with relevant companies.**

Furthermore, it seems to be worthwhile to build stronger links between the outcomes of the status quo and trends analysis and the business opportunities resulting from low carbon development. Therefore, long-term low carbon scenarios and their underlying basic assumptions, technical strategies and behavioural changes should be systematically assessed and translated into business opportunities. For example, entrepreneurs and practitioners could be invited to reflect on the outcomes of low carbon city scenarios and identify and discuss the innovation potential as well as business opportunities resulting from such scenarios.

Analysing Opportunities for Low Carbon Entrepreneurship

Due to growing political pressure from the central Chinese government, an increasing number of decision-makers from Chinese cities understand that acting as a first mover in low carbon business fields may secure long-lasting economic benefits for their city. Consequently, **combining the analysis of challenges and strategies for low carbon development with innovative concepts for entrepreneurship** may help to increase governmental ownership of the project objectives. However, analysing the environment and framework for low carbon entrepreneurship and developing blueprints for implementation projects in Chinese cities is a rather new approach. As a consequence, there is not much literature available on how to change entrepreneurship patterns in China. Furthermore, specific expertise on certain business fields or sectors, as well as on financial options in China or at regional or local level, would be required to develop concrete and applicable business models or blueprints for pilot projects. One option could be to reserve a specific lump sum of the project budget for acquiring the services of specialist experts once the business opportunities and targets markets have been identified following an analysis of the status quo and trends of low carbon development in the city concerned.

FOR INTERESTED READERS:

Further detailed information on low carbon entrepreneurship and China's low carbon landscape is available in the full reports "Leverage Points for Low Carbon Entrepreneurship in Wuxi" and "How Entrepreneurship Can Drive Low-Carbon Development" (www.lowcarbonfuture.net).

Key Recommendations:

- Scientific analyses on local low carbon development in China should be framed with a work package on the business opportunities and innovations that could arise from a low carbon city pathway.
- Stakeholder dialogues with Chinese cities should link up city government representatives with practitioners and entrepreneurs from key sectors for GHG mitigation with the explicit target to enable the implementation of low carbon strategies and measures recommended in the scientific papers. The participating stakeholders should be selected with regard to the key strategies/measures identified in the scientific analyses.
- It is recommended that a lump sum of the budget of a scientific project should be reserved for acquiring the services of specialist experts who could help to translate the project's recommendations into blueprints for pilot or implementation projects.

Fig. 8: Business Opportunities May Function as Trigger for a Low Carbon Development at the Local Level

5 CONCLUSION

The previous sections reflect on the key lessons learnt by our project team during the last three years of research on, and dialogue between, Wuxi and Düsseldorf. This manual delivers recommendations to organisations from the scientific and civil society sectors that are engaged in low carbon city projects, as well as to local governments that are eager to develop comprehensive low carbon strategies. The key recommendations from all sections can be summarised as follows:

↘ **An integrated low carbon strategy should not only address GHG mitigation but also consider its synergy with sustainable resource use and adaptation to climate change and vice versa**, taking a long-term perspective. Developing such a strategy necessitates integration between robust scientific analysis and active stakeholder involvement. In China, mitigation and resource efficiency has attracted increasing levels of attention over the last decade. However, at city level, adaptation has not yet become commonplace. Given that climate change is a reality, we recommend that city governments should systematically integrate adaptation with strategies for GHG mitigation and resource efficiency.

↘ **Decision-making about low carbon strategies should be evidence-based, in which scientific analysis plays an important role.** The following analytical steps need to be taken in order to develop a serious low carbon city strategy:

- **The development of an accurate GHG emission inventory for quantifying low carbon development and identifying mitigation hotspots:** we recommend that city governments pool sufficient resources and authorise an influential governmental entity to coordinate the development of a GHG emissions inventory. Transparent and regular reporting of inventories and associated processes is essential for the success of inventory development. Beyond the city level, we recommend that the government should further promote the standardisation of urban GHG accounting methodology.
- **The development of scenarios to explore different long-term pathways for future low carbon urban development:** for scenarios to effectively influence the decision-making process,

we recommend that quantitative modelling should be integrated with qualitative approaches that, for example, include a participatory scenario development process and a comprehensive institutional analysis. In order to overcome data gaps and to conduct a more efficient modelling process, we recommend that an assessment of the data quality and access is carried out during the design phase of the project.

- **The analysis of the resource impact of low carbon pathways in order to avoid trade-offs:** GHG mitigation measures may have negative or positive impacts or synergies on resource and material use. As resource efficiency is currently favoured politically in China, linking both issues may help to trigger low carbon development. Therefore, the process of modelling GHG emissions, energy demand and resource use needs to be synchronised by a common set of basic assumptions and close exchange between the modelling teams.
- **The carrying out of robust analyses of climate impacts and integrated assessments of different adaptation options:** we recommend that further research should be undertaken on methodologies for downscaling existing regional climate models as well as increasing the number of meteorological stations (evenly distributed) for data collection in order to reduce the uncertainties associated with climate impacts and hazard projections. The assessment of adaptation options should consider their synergies with on-going mitigation efforts.

↘ **Stakeholder dialogues are essential for developing a tailored strategy for local low carbon development and for enhancing local authorities' sense of ownership of the strategies developed in the project:** we recommend that these dialogues are facilitated in a small and interactive manner to allow for more intensive and fruitful discussions and are combined with study tours to showcase examples of good practice. In addition, such international dialogue processes require careful consideration of intercultural differences and language barriers.

↘ **An integrated low carbon strategy should systematically include entrepreneurs,** given their major potential for innovation and for implementing local solutions for low carbon urban development. The identification of low carbon business opportunities should be framed with scientific analysis and stakeholder dialogue processes. Sufficient resources should be set aside in the project budget for acquiring consultancy to facilitate the translation of the project's recommendations into implementation projects.

Last but not least, in order to get this type of large intercultural low carbon city project on track, we recommend **that the profiles and qualifications of potential project partners are carefully researched.** A strong partner with close links to decision-makers in the pilot cities is a must. In addition, we recommend that enough time is built into the project plan to establish a consistent conceptual framework for the overall project and a common understanding of key terms and concepts.

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