MoHURD Eco-City Implementation Guideline for

Clean Energy

Preamble. This Eco-City Implementation Guideline has been developed with the assistance of the Europe-Chine Eco-Cities Link Project (EC Link), and been submitted by the Chinese Society for Urban Studies (CSUS). It draws on the work done by the EC Link project in the development of sectoral toolboxes[1] which present European and Chinese best practices, urban development standards, indicators and methodologies for verification. Further, the development of this Guideline is informed by project work of MoHURD-affiliated pilot cities which are implementing eco-cities activities, and piloting innovative practices. EC Link has provided as inputs toolboxes for the following 9 sectors: compact urban development (CUD), clean energy (CE), green building (GB), green transport (GT), water management (water supply, waste water treatment and flood control) (WM), solid waste management (SWM), urban renewal and revitalization (URR), municipal finance (MF), and green industries (GI).

Objectives. The objectives of this Eco-City Implementation Guideline is to provide guidance, and to ensure compliance. The document is meant for all Chinese cities which are participating in the national MoHURD-supported eco-cities programme. Besides guidance, the document will help to ensure compliance of cities with the normative part proposed under this guideline.

Legal Basis. This Eco-City Implementation Guideline is complementary to the existing urban planning legislation of the People´s Republic of China (PRC), and other guidelines of the Ministry of Housing, and Urban-Rural Development (MoHURD), particularly those pertaining to eco-city development.

- Urban Planning Law. 1984. In 2008 updated as “The Urban and Rural Planning Law of People’s Republic of China”; latest revised in April 2015.
- Land Management Law. 1998.
  And based on the law, the detailed Enforcement Regulation has been developed, and undergone revisions for several times. The latest is the 2014 version.
- Environment Protection Law. 1990. Latest revised in 2014 and applied since 2015.
- MoHURD. March. 2013. The 12th 5-Year Plan on the Green Building and Green Ecological Districts.
- CCPCC and State Council. March, 2014. National New-type Urbanization Plan 2014-2020.
- State Council. April, 2015, Suggestions on Enhancing Eco-civilization.
- CCPCC and State Council. 2016. Central Government Guideline on Urban Planning.
- CCPCC and State Council. 2016. The thirteenth Five-Year Plan (2016-2020)

The relevant legal reference documents related to the energy sector are:

- Energy Conservation Law. 1998. Latest revised in 2008.

[1] EC Link Toolbox. 2016. *Clean Energy*. Beijing. Draft English version. www.eclink.org.

- National Energy Administration. 2012. Notice of 12th Five Year Plan on Development of Biomass Energy.
- State Council. 2014. Notice of Action Plan for Energy Development Strategy
- National Energy Administration. 2014. Notice of Policies for Promoting Distributed PV Power Generation.

This Eco-City Implementation Guideline is *mandatory* for all Chinese cities which are participating in the national MoHURD-supported eco-cities programme. Compliance with its missions and technical targets will be monitored and reviewed by MoHURD. Compliance will be rewarded through special allocation of funding and technical implementation support.

Scope of this guideline. The geographical scope of this Eco-City Implementation Guideline are urban areas as defined by the existing legislation. The application of this Eco-City Implementation Guideline may be extended to Districts which are under the jurisdiction of a city (urban area), as applicable.

Substance of this guideline. This Eco-City Implementation Guideline is dedicated to Clean Energy (CE). The implementation of eco-city development approaches concept makes it necessary to deal with clean energy at building level, in neighborhoods, in urban transport, urban infrastructure, at city level, and in industries. To implement a clean energy agenda it will be necessary to have committed city and district governments so rules can be enforced.

Justification

Cities and carbon emissions. Energy use and related carbon emissions are concentrated in cities. In China, cities concentrate energy uses and carbon emissions even more than population. That makes urban energy a principle concern in low-carbon strategies, in particular for China's cities, and gives energy an outstanding position in the sustainable low-carbon agenda of MoHURD.

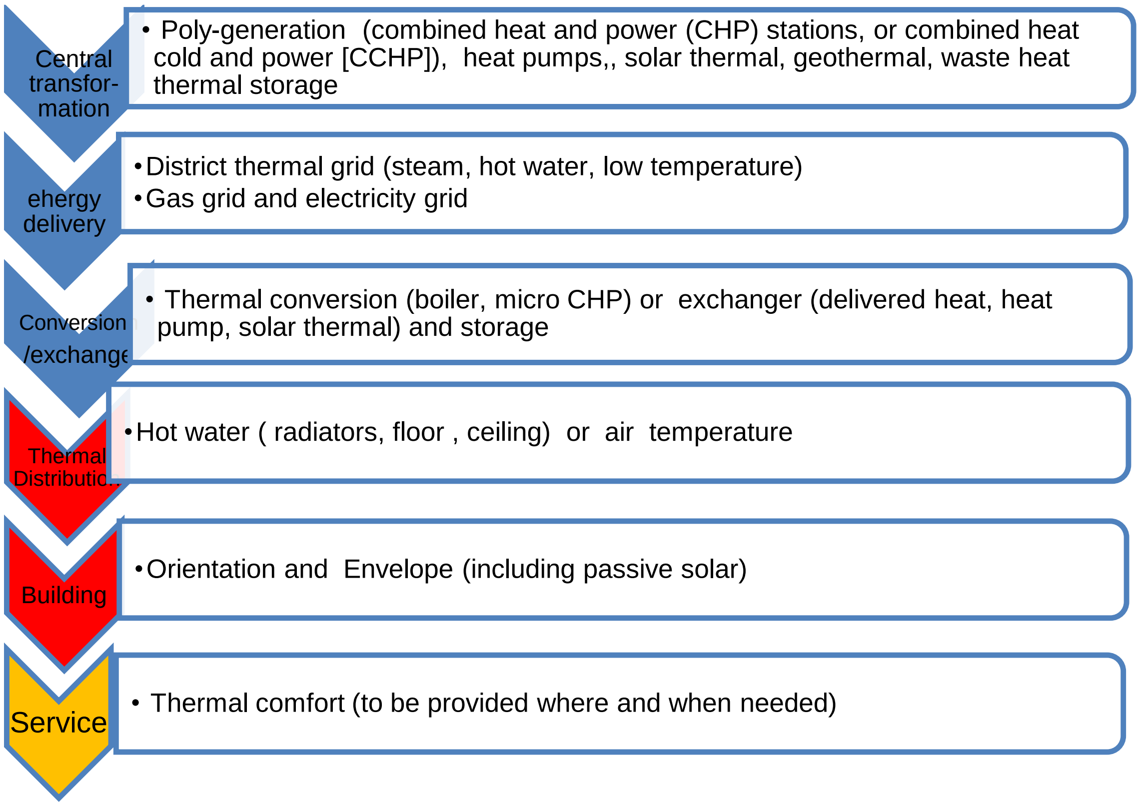
Chinese cities are carbon-intensive. One driving factor for higher energy use and carbon emissions in cities is the activity level, i.e. the higher degree of agglomeration of productive and consumptive activities in cities compared to rural areas. Another factor is the location of power generation and energy intensive industrial production within cities, which is particularly frequent in China. This raises the relative carbon emission (measured per capita) intensity of Chinese cities compared to similar sized cities in other countries, where large power stations and basic industries are only exceptionally situated within major cities. But also building and transport energy use, and related carbon emissions in large Chinese cities are already on a similar level per capita compared to cities to Europe in similar climatic zones.

Urban carbon emissions. In the carbon statistics, the energy emissions are accounted where the CO_2 and other green-house gas (GHG) emissions actually take place when energy is transformed. Thus, apart from the energy supplying industries, also the energy transformation GHG emissions of the energy use sectors are classified under the energy category, specifying (i) manufacturing and construction, (ii) transportation, and (iii) other fuel combustion including residential, commercial, public and other small sectors, mainly in buildings.

Scope of clean energy. Clean energy covers a wide scope including the energy use as well as the energy supply sectors according to the pervasiveness of energy and the energy-related GHG emissions. This is necessary to capture the comprehensive nature of urban low-carbon concepts, which follow the energy flows and include the energy use sectors. In addition, cleaner energy technologies are increasingly applied on site. Considering the energy interrelationships, cities have developed comprehensive low-carbon development concepts, covering all sectors which entail GHG emissions. In such a comprehensive approach, cities pull together all efforts related to reduce GHG emissions in a concerted and rational way.

Complexity of low-carbon development. Low-carbon options may be some of the low-carbon urban energy solutions, e.g. district systems for thermal comfort and other thermal services, are complex and consists of several successive and interrelated elements (see Figure below). A district thermal system also involves numerous users within reach of the grid. To conceive such systems in which economies of coalition operate, an integrated community energy concept is required. Such integrated community concepts for thermal energy encompass many buildings and other users as well as various sources, and provides the information for making rational use of the multitude of clean energy options. Clean options include efficient buildings, decentralized generation and storage, district grid and heat sources, for each of which there are technical alternatives with different economic, financial and environmental implications. To be able to identify preferable options for the low-carbon agenda, many cities have taken an integrated perspective and developed a very detailed view and model of the thermal energy system, when districts or urban areas are rehabilitated or new urban developments are planned.

Delivery chain for thermal comfort service for the case of district heating



Source: Chevron

Note: blue indicates the steps where clean energy technologies are applied; red illustrates the steps of building technologies. Energy efficiency principles apply along the whole chain.

Definition. There is an official globally accepted definition of clean energy. In the framework of the urban sustainable low-carbon agenda**,** "clean" is understood as "low-carbon". Carbon emissions are also a good indicator for other air emissions, and therefore low-carbon also corresponds to low air emissions in general.

Clean energy. Against this background, clean energy is the low-carbon subset of the energy technologies and sources. Of the many individual technologies and combinations which are employed to deliver energy services we consider those as clean energy, which are characterised by low-carbon emissions over the whole delivery chain. This delivery chain can be very long and involve all the steps from primary production and transport, central transformation, transmission and distribution to the end user, or short and involve only a decentralised provision of the respective energy service using ambient sources, or interim solutions.

Terminology of low-carbon. Low-carbon is a relative term. Therefore, we consider as clean energy in addition to zero carbon technologies also those which reduce significantly the overall GHG emissions compared to the alternative of ¨Business as Usual¨ (BAU). If for instance the alternative of a combined heat and power (CHP) station, fired by biomass, is electricity from a coal fired power station and decentralised fossil-based heat generation, this CHP is considered low-carbon, i.e. clean energy.

Clean energy technologies. In practical terms, we consider as clean energy all those technologies which reduce fossil fuel, combustion and GHG emissions[2], making use of

- renewable energy sources, including hydro, solar, wind, geothermal and bioenergy with exception of bioenergy which induces as much carbon emissions in the delivery chain as the main alternative fuel; but also
- passive solar energy;
- ambient energy, in particular with heat pumps;
- land-fill and sewage gases;
- solid waste (provided the combustion complies to low emission standards); and waste heat.

We also include poly-generation technologies (combined heat and power [CHP] and combined heat cold and power [CCHP]), even when fired by a fossil fuel with specific carbon emissions coefficients on the lower side such as natural gas, provided that it replaces power and thermal energy from high emitting plants, and provided the overall carbon reduction is clearly positive. Poly-generation plants will become complementary cornerstones for energy systems with high renewable energy shares. Thus, district thermal (heating and/or cooling) systems are part of the clean energy technologies; provided they are they are fed from clean energy technologies.

Energy efficiency. Energy efficiency is another category which fulfils the criteria – reducing carbon emissions – for considering it clean energy technology. Energy efficiency reduces energy input in relation to the respective output. Energy efficiency is rather a principle than a set of specific technologies and can be applied in all stages, technologies and processes of the energy use and supply chain, which can be demonstrated also along the links.

Reducing carbon emissions actually begins with fitting provision of an energy service exactly to requirement, provide thermal comfort where and when needed, and avoid squandering of heat. In transportation avoid travel when possible, possibly substitute it by communication.

In some energy use sectors, it is possible to apply different modes for the service which involves very different energy intensities. In transportation, shifting of modes from individual to mass transport or even to biking are very well established ways of reducing fossil energy consumption and related emissions. In thermal services of buildings, the choice of building types and density (urban morphology) can also be considered as a modal shift.

The next area with many options for reducing final energy consumption is the sector specific technology which is incorporated in buildings (orientation, compactness and envelope), appliances, vehicles, industrial equipment and processes. In other words, energy efficiency is an important feature of building technology, transportation technology,

[2] Sometimes Carbon Capture and Storage (CCS) is included under clean energy, although the carbon captured is stored and leakage is a risk. In any case, the CCS development however is stalled and it is basically a technology related to large power stations or energy production. This is not the focus of this toolbox. For similar reasons, nuclear energy is not included in clean energy.

industrial process technology and other technologies which are not genuine energy technologies.[3]

Transformations in energy needs. In-situ energy transformation technology needs to be conceptionally distinguished also. For example for thermal comfort, the options include a heat exchanger, a boiler, a heat pump, a solar water heater, micro-CHP or other technology. In case of transportation the options include different engines which for electric vehicles involve charging stations and batteries. In case of industrial process heat larger boilers and cogeneration plants are the main choices. In the sense of low-carbon, all this energy transformation technology should become more efficient, or use non fossil energy.

Energy supply. Next element upstream is the energy supply network, in case of thermal, gas and electricity actually in form of grids consisting of pipes and lines. In terms of low-carbon, the imperative is to reduce energy losses. The thermal or electrical energy lost in the grids would need to be produced, additionally causing respective additional CO2 and air emissions. In case of natural gas losses mean a release into the atmosphere of methane with high global warming potential (GWP).

Energy generation. The next upstream step, the generation of thermal energy and electricity, is the effective step in the chain in terms of a low-carbon strategy. Poly-generation is an efficient technology, and low-carbon if compared to separate fossil fuelled generation of heat and power. Here the choice of fuel is another key measure to reduce carbon emission, with natural gas emitting approximately less than half CO2 per unit energy generated than coal. In case of biomass the life cycle of the respective fuel must be considered for classifying it low-carbon.

Recently, local grids have become less unidirectional. In case of thermal grids, low-carbon sources have been added at different points and caused multidirectional flows. This is true for both, thermal and electricity grids and has allowed to incorporate clean energy technologies at the grid level. In case of thermal grids, solar water heaters, heat pumps, shallow geothermal sources may contribute, and in particular waste heat from industry or surplus from commercial users and buildings. In case of electricity, distributed generation situated at the consumer plant feeds into the grid. In some cases local micro-grids are established below the level of the customary low voltage distribution level.

Poly-generation plants are situated within or near city boundaries to reduce capital intensive pipeline investment and energy losses, whereas power plants without extraction of thermal energy are only occasionally located within cities.

Renewable energy. However, in addition to the traditional hydro power, other renewable energy technologies on utility scale including wind and solar have become available also for energy generation to be fed into the medium voltage and even high voltage levels, and replacing fossil-generated electricity, at increasingly competitive conditions.

[3] End-use energy efficiency which is achieved by building, transport, or industrial technology is rather addressed in the toolboxes of those sectors, although the delineation is not always strict and overlap is acceptable.

Going a step further, also energy storage technologies may be considered as part of clean energy technologies, above all since storage permits to bring more renewable energy into the system instead of dispatchable fossil fuel generated power or thermal energy.

Availability and costs. In all these sectors, energy use and supply, the availability and cost of clean energy technologies has dramatically evolved and fallen respectively in recent years and continues. The most dramatic change has taken place in power generation, where solar power from photovoltaic technology is becoming competitive and offers the option of consumer site generation, i.e. inside urbanised areas.

Sometimes carbon capture and storage (CCS) is also included under clean energy, although the carbon captured is not definitely removed, and leakage is a risk. In any case, it is basically a technology related to large power stations or energy production, not for cities.[4]

Community-level energy. Integrated community energy concepts are information, planning and decision support tools for local energy systems. These are prepared for areas of a city (district, urban quarter) or towns at the occasion of rehabilitation of an existing quarter or for a new urbanization.

Usually these concepts were established for the provision of thermal energy services within a defined boundary in order to capture the advantages of a joint concept, including the economies of coalition and the reduction of the number of stationary emissions sources, i.e. combustion of fossil fuels in the buildings.

Seasonal energy needs. Customarily in cities in winter cold regions, households or businesses used individual solid or liquid fuel fired boilers or even stoves for heating. An environmentally preferable but capital-intensive line-bound system such as district heating could only become economically and financially feasible with a high load factor, thus high demand density, which in turn requires to include in the system as many users as possible. This has led in market economies to some kind of prioritization, in cases where the joint supply by district thermal scheme looked economically favorable. Frequently cities have ordered a limitation of choice of competing systems, also citing clean air motives. Such urban development decisions needed a systemic comparison as a decision support tool, for which integrated urban thermal energy concepts were developed.

Using GIS. These integrated concepts are modeled in great detail and the information is geographically referenced in geographical information systems (GIS). They use individual buildings (or even typified users) as basic unit, integrating demand along streets, blocks, or quarters according to information needs. Demand scenarios are elaborated, in particular for varying levels of energy efficiency in the building system and taking into account the user behavior, and appropriate alternative delivery chains are designed accordingly. The various options then are evaluated using ecological, economic, financial and also social criteria, for information and decision making, depending on the competence and participation of the stakeholders.

[4] However, this is not the focus of this guideline, and equally, nuclear energy is not addressed here.

Integrated community concepts. Integrated community concepts are designed for long-term implementation. Their time horizon of planning, therefore, corresponds to a development cycle of 10 to 15 years.

With growing climate change concerns on the one hand and increasing technology choices on the other hand the integrated community concepts have become even more relevant, every time when a new urbanization is developed or an existing urban quarter is rehabilitated.

More recently, with the rise of distributed power generation and enabled by information and communication technology (smart grids), such integrated concepts become relevant also for the design of local electricity systems. The decentralized generation offers clean energy contributions to the power supply, alternatives to central generation and possibly also grid configuration and cost. Again, the advantages may be captured best when an integrated concept is developed and alternatives are analyzed systematically.

Distributed renewable energy power generation, high building energy efficiency and ambient heat sources can be combined to new options of clean energy, at the building level but also at the local level, in particular new urbanizations. To realize such options, hybrid thermal and power energy concepts are being employed.

Integrated energy concepts for communities may also include local transportation schemes and connections, as well as water and waste management and other local concerns. Objectives often include more than energy and environmental aspects and extend to socio-economic aspects and quality of life in these communities. Such concepts resemble more and more comprehensive urban low-carbon concepts.

Comprehensive concepts. Comprehensive urban low-carbon concepts encompass all urban activities which involve energy flows and entail (or reduce) carbon emissions.

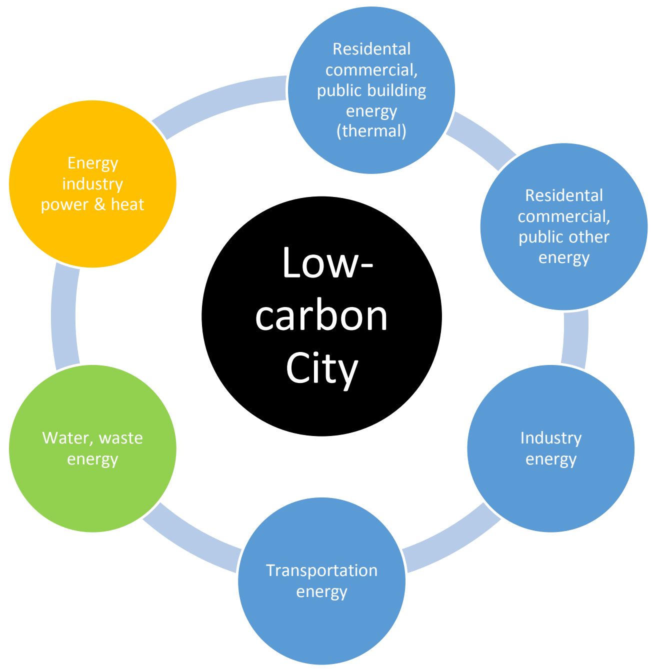
In addition to the thermal energy and the local electricity system of the residential, commercial and public energy use sectors, which are subjects of the integrated community concepts, the comprehensive concepts also address other energy uses namely transportation and industry and the whole energy industry sector, including supply from outside city boundaries. It also includes the water, waste water and solid waste sectors. For a city the water and sanitation sector is an important activity in several respect including carbon since it discharges GHG emissions and in particular methane gas, and municipal solid waste can become sources of energy.

Strategy for comprehensive low-carbon urban energy. Below graph visualizes the most important sectors of a comprehensive low-carbon urban energy strategy. It is useful to distinguish:

- Residential, public and commercial sectors with two subsectors (building and other energy services), including distributed generation;
- Industrial energy sector, including auto-generation;
- Transportation energy subsector;
- Water, waste water and waste management sectors; and
- Energy supply sector, including electricity, heat and CHP plants (public plants as well as auto-producers), and refineries.

It is important to consider the energy interrelations between the sectors. Such strategies also include more generic urbanization aspects such as the density or compactness of urban development and urban renewal and revitalization, which have a strong impact on carbon emissions via the transport and building sectors.

Conceptual Overview: Sectors of urban energy



Source: Paul Suding, EC Link consultant

Characteristics. These sectors may also be regarded as strata, or vertical layers of the urban energy system. In terms of planning this view connects to spatial conceptualisation in the planning and decision tools.

Sectoral interrelations. Many interrelations between these sectors or strata exist, in particular between the energy utilities as suppliers of power and heat in particular and their relationship to the building energy strata (i.e. residential, commercial, and public users, and industry). Energy intensive industry traditionally includes auto-producers and has strong interchanges with grid operators and power sector, increasingly also with heat utilities. Gas or power generated from municipal waste may add energy supply for the use sectors.

Interchanges between these strata currently grow also because of the rise of decentralised generation with renewable energy, and potential interconnections multiply. The current disruptive change in the electricity sector with high renewable energy shares seeks opportunities for storage or other flexibility solutions in use sectors, such as heat storage, storage in batteries of plug-in electric cars, and transformation to gas (power to gas) which can be stored or used in premium applications. Comprehensive concepts comprise the area of the whole administrative city and may include the wider metropolitan area.

Comprehensive concepts usually have a longer time perspective (up to 30 years) than the integrated community concepts, but use intermediate milestones. They are less detailed than the community concepts for parts of the city, but may incorporate these concrete concepts as implementation steps or measures.

Role of municipality and other stakeholders, policy options and financing. The concrete configuration of the urban energy systems are the result of a myriad of past decisions by many actors in each case. In order to redirect and implement the development towards a future sustainable low-carbon system several groups of stakeholders must interact.

The stakeholders groups are characterised by different levels of ability of decision making and different responsibilities. The distinction between private and public organizations is of highest importance, particularly with regard to social and economic responsibility:[5]

- The political leadership, legislators and administration of the respective authority: depending on the location include regional, metropolitan, municipal or lower district authorities; or departments of public administration, i.e. environmental, energy, urban planning, housing, infrastructure, public spaces, etc.
- Funding and information agencies: public funding organizations and energy agencies, maintained entirely or partly by national, state/provincial or local governments. These organisations usually work with the local authorities.
- Energy supply, including energy service organisations (ESCO) and energy management companies: these may be municipal, private and mixed ownership companies; usually, the municipal owned utilities are more directly controlled by the public authorities.
- Water and waste management, transport organisations: public or private companies.
- End users and auto-producers, and associations: industry, commerce, residential; owners, tenants, employees, and facility managers.
- Developers and building owners: housing companies, social housing associations, other private or public developers.
- Design and consultancy: urban planning (and architectural) firms, transport engineering companies, technical consultancy firms, or universities, usually contracted to contribute their subject matter expertise.

Institutions, process organisation and participation mechanisms. A deliberate effort to develop and implement a clean energy concept requires a specific project organisation, led by the authority and involving the stakeholders concerned.

[5] cf. IEA_ ECBCS Annex 51 - Subtask A: Descriptions of state- of-the-art energy efficiency projects on the level of neighborhoods ; Koch, A., Kersting J., EIFER Karlsruhe 2011, pp 66 http://www.annex51.org/media/content/files/casestudies/subtaskA/SubA_report_120405.pdf IEA ECBCS Annex 51 – Subtask ; also Immendoerfer , A. Winkelmann M. , Stelzer V. , The Institute for Technology Assessment and Systems Analysis (ITAS), Solutions for Smart Cities and Communities - Recommendations for Policy Makers from the 58 Pilots of the CONCERTO Initiative; Concerto Premium; Karlsruhe Institute of Technology ; European Union. 2014. http://concerto.eu/concerto/images/library/concerto_publications/2014-01_concerto_premium_recommendations_for_policy_makers_final.pdf

For the institution concept there are numerous options. Energy operators can be created with their own legal status and rules, own budget governance, and a formalised participation of stakeholders and hired management. Alternatively there can be temporary project organisations (non-institutionalised), with a professional project management and voluntary participation of stakeholders (non-formalised).

Organisational structures may include governing board, steering council, consultation groups, project management, technical support structures, and contracted consultants.

In the process, classic steps and specific mechanisms include:

- Preparation and decision making phase: objective setting, strategy formulation, establishment of targets, definition of delivery trajectory and tasks and operational mechanisms, business plan formulation, guidelines for safeguards, mechanisms for stakeholder and customer consultations;
- Implementation phase: concrete projects need their own organisations, possibly a public-private partnership body; tendering and award of concession to an existing or new organisation;
- monitoring and supervision: review of performance, and continuous improvements and adjustments where necessary; and
- Information sharing: Internal training, external training and dissemination.

Financing of project preparation and implementation by projects. Comprehensive energy concepts are usually financed by city budgets, with possible contributions from regional and national programs. However, there is scope for participation from utilities and the energy industry in general. Within the sector there exist many public-private participation modalities.

In the case of integrated land development projects, new districts or neighbourhoods, creation of energy utilities can be achieved through mixed financing, for instance through private investors with vested interest in a specific area development. The provision of public infrastructure can be supplied by the utility companies. Private developers may prefinance municipal facilities, as well as commercial and housing investments.

Development Objectives

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the Five Year Plan objectives has stated several key objectives for the energy sector:

- Increased efficiency of energy resources development and utilization; effective control total aggregate of energy and water consumption, construction land, and carbon emissions. The total emissions of major pollutants shall be reduced significantly.
- Pilot projects will be introduced to promote comprehensive use of combined heat and power, the wide-spread adoption of energy saving regulations in government agencies, and of municipal green lighting and other urban energy saving projects.
- Technical specifications for the safety of heat supply will be introduced, as well as strengthened regulatory frameworks supporting urban energy savings, environmental protection and improved sanitation.
- Related service quality standards and evaluation methodologies will be optimized.

- Consumption-based billing for residential households will be promoted nationally, and all newly built residential buildings will need to be equipped with meters for heating, while existing buildings will be gradually retrofitted to reach 100% metered heat provision.
- Support reduced emission standards, and implement demonstration projects of ¨near-zero¨ carbon emission.

New Urbanization Policy 2016. Following the Central Urban Work Conference (20-21 December 2015) - the second such meeting on the issue 37 years after the first meeting in 1978 - on 6 February 2016, the Communist Party of China Central Committee and the State Council issued a roadmap for city development, including energy conservation: [6]

- **Promote the development of energy conservation in the city**. Promote the district combined heat and power (CHP), green lighting, energy conservation in government departments; improve heat production efficiency; newly built residential buildings must be equipped with individual measurement of household heating consumption, while that shall be gradually provided for existing residential buildings.

China Development Bank Capital (CDBC) Policy for Green Urban Development. The CDBC´s policy document for Green Urban Development states several principles for the energy sector:

- **Renewable and District Energy:** Every project should analyze the potential for district energy, such as combined heat and power (CHP), waste to energy, and waste heat re-use. There should be 5-15% local renewable energy generation for residential areas and 2-5% for commercial areas.[7]
- **Smart Technologies:** Smart lighting Systems, and smart grid technologies which support higher energy performance targets:

[6] Extracted and translated from: http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm)

[7] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

Relationship between Smart and Green Guidelines

Smart Guideline	Relevant Green Guidelines	Relationship	Relevant Smart Technologies
Smart Energy Management	Renewable and Distributed Energy	Smart energy management technologies help to improve decision-making and even automates many decisions, which improves energy efficiency. Smart grid technologies help integrate a diverse mix of renewable and distributed energy sources to the grid and gives grid operators the flexibility to use the most efficient sources as conditions change throughout the day.	Smart Lighting Systems; Smart Grid Technologies
	Green Buildings	Even if a building is equipped with all the right energy efficient fixtures, building management systems can ensure that buildings actually capture these efficiencies. Otherwise, many green buildings end up operating at a much lower efficiency due to lack of robust management.	Building Management Systems

Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

Competence and policy options. Energy policy is widely considered a national responsibility and competence, but cities do have many options to influence energy development in their sphere of authority, within the national framework and the competences of provinces or regions. Depending on the status and role of cities in different countries, cities wield varying influence over their energy systems.

Policy mechanism. The policy mechanisms available to cities may be categorized as follows:

- Policy direction and target setting
- Regulatory schemes, including spatial and urban planning, contractual agreements, building regulation, standards and labeling, organization of local markets; including penalties;
- Incentive schemes, in particular financial incentives such as tax reductions, tax credit, soft loans, capital investment support, or operating grants and subsidies, feed-in tariffs; but also other incentives; cities may be intermediates for investment financing, including guarantees;
- Rules that affect use and operation of clean energy equipment , including municipal assets, such as low-carbon buildings, decentralized facilities for clean energy generation, or a low-carbon vehicle fleet;
- Voluntary actions by agencies and government serving as a role model, promoter and / or facilitator of innovations; and
- Capacity development including awareness building, knowledge and information sharing, capacity building, training, awards, and demonstration projects.

Quality of life objective. In view of the pervasiveness of energy services, use and transformation in all productive and consumptive activities, even leisure, energy development objectives relate closely to general urban development goals, in particular in the longer term. On the vision level, objectives like quality of life, attractiveness, and economic competitiveness, quality of the environment, healthiness, and even social cohesion are set to frame the city's future energy system into the overall vision for the respective city. More generally formulated, sustainable energy development is seen as a part of economic, environmental, social and even political sustainability of the city.

Low-carbon development as objective. Although carbon emissions are not felt on the local level, cities all over the world have embraced low-carbon as a long term objective, with strong implications for the energy system. Cities do so being committed and wanting to lead in taking on responsibilities in climate change mitigation, in view of the concentration of energy transactions and emissions caused by urban activities. In addition, low-carbon associates well with other urban development objectives. Carbon emissions correlate to locally felt air emissions such as SO_2, NO_x and particles. Although there are specific means to reduce each of these, the general principle is, that reduction of GHG emissions (i) can only be achieved through systemic change; and (ii) brings reduction of other emissions as well, even noise emissions. Additionally, carbon capture and the reduction of carbon in the atmosphere can be done through CO_2 photosynthesis of the flora. Thus, the global objective of maintaining carbon concentration below certain limits associates well with maintaining green areas for quality of life and also for biodiversity in cities. Also 'greenness' bodes well with modernity, new technologies, high tech, and lifestyle. Finally, low-carbon constitutes a quite operational objective, since it can be measured by a scientific indicator (GHG emissions), it can be scaled over time, even attributed to sectors of sources or causes (i.e. energy services) which can be provided with value chains, i.e. energy technologies and sources of extremely different carbon intensity.

Energy efficiency as cross-cutting dimension. Instead or in addition to the low-carbon objective, cities choose energy efficiency, low energy intensity, low or zero fossil energy use, and certain renewable energy objectives. These objectives are generally in line with the low-carbon idea and correspond similarly to other objectives, in particular local atmospheric emissions. These objectives, however, do not need a justification from the angle of global climate change mitigation, but may be justified by the developmental interests of cities.

Classic objectives in the energy sector remain permanently important and include the two groups:

- availability, sufficiency and security of energy supply; and
- Cost efficiency, price of energy, competitiveness, energy budgets and affordability which are economic and financial concerns depending on the standpoint (overall energy system; city administration concerns; interests of industrial, commercial or residential users).

Need to balance objectives. Cities must not lose sight of these objectives and solve potential conflicts with other ambitious objectives within their strategy and in cooperation with concerned stakeholders. Thus, these aspects may be considered more like boundary conditions to be observed rather than objectives.

Cost of energy. With respect to the economic and financial implications, it is important to note, that the price of the energy commodity (electricity, gas or oil products) is not any more as important, when energy services are provided at very low energy input. The cost of the respective energy service is increasingly determined by capital cost, when highly efficient, renewable or other distributed generation technologies are applied.

Decentralized systems. These new more decentralized clean energy systems require a more qualified local workforce and intelligence in construction, engineering and operations Therefore, qualified local job creation and business development become objectives in energy concepts. In addition, smarter management systems require higher education levels, innovation and research, and therefore, could influence curricular changes in local capacity building and research institutions. Developing and implementing a clean energy concept strengthens local energy institutions, and improves the quality of municipal services, both short and medium term objectives.

Changing urban energy concepts. Obviously, changing the energy system and exploiting the clean energy potentials in a city needs time, in particular in an existing built environment, due to the technologies locked-in the capital stock of infrastructure, buildings, and industrial and power plants. Even when implemented in a smaller new greenfield development, the full implementation takes as long as new quarter is completed and the clean energy system operates. The transformation of the energy system of a whole city to clean energy is a matter of decades.

Planning for clean energy. Correspondingly, planning horizons for a clean energy concept are set: Very long term, i.e. three to four decades for the completion of transformation of a complex city, medium term, i.e. approximately one decade for a greenfield or rehabilitation area within a district. Since a clean energy concept for a whole city also consists of many clean energy concepts within, a comprehensive city concept requires also medium and shorter term intermediate planning terms. The intermediate terms and milestones are also important to define, they need to be monitored to measure the overall progress.

Establishing city-level energy objectives. Cities formulate vision-type objectives for the very long term, with measurable indicators. The vision is the end point of the strategy and provides an orientation for the urban development as a whole and includes clean energy prominently, if low-carbon is determined as a key element of a city's vision.

Tangible targets. The objectives for the shorter term are much more concrete and tangible. In part, they are milestones on the path to the longer term vision, but they also are subdivisions described quantitatively with indicators and add up logically to the milestone at a determined point in time. To a large extent, they include concrete objectives for focal areas of the city and specific projects.

From vision to action. As discussed above, on the long term urban vision level, long term objectives like quality of life, attractiveness, economic competitiveness, quality of the environment, healthiness, even social cohesion are relevant to set a city's energy framework.

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Acting locally – for global impact. Although carbon emissions are not felt on the local level, cities all over the world have embraced low-carbon as a long term objective, for its own importance but also for its correspondence to many other objectives and for its practical operationally. Instead or in addition to the low-carbon objective, cities choose energy efficiency, low energy intensity, low or zero fossil energy use, and high renewable energy objectives.

For the medium term, i.e. a decade or more, the low-carbon and energy intensity, renewable energy share objectives can be scaled as milestones.

Medium-term goals are more ambitious. More concrete, mid-term objectives may relate to the completion of specific clean energy area projects, renewable energy demonstration objects, implementation of clean energy in key or high profile urban projects, distributed generation and mini-grids, integration of clean energy in smart city concepts, network of electric car charging stations and similar smart technologies. Whether these are new greenfield or rehabilitation projects depends on the priorities of the respective city. In the medium-term, energy goals also effect of job creation and business development.

Short-term plans are the "lower-hanging fruits". In the shorter term, say in 3 to 5 years the targets within a comprehensive long term projects may be related to laying the groundwork and have the strategy ready, and start the first implementation steps.

In addition the clean energy concept may have reached a number of concrete agreements with developers, industry and energy sector stakeholders on projects, including whole areas, new plants, plant closure, fuel switching, interconnections and use of waste heat, etc. As energy efficiency targets or compacts are established in the short term, and supply contracts are adjusted, short-term green energy supply targets are included. Low hanging fruits, i.e. actions and projects which are identified in the analysis as quick wins, are already harvested.

Clean Energy Approaches and Packages

1. **Thermal energy services in residential, commercial or public buildings:** heating and cooling; hot water

Characteristics:

- Provision of thermal energy services adds up to significant energy demand, and causes significant carbon emissions. Energy requirements depend on indoor thermal comfort purposes in cold climate zones (heating), as well as in hot summer climate zones (cooling);
- Major fossil energy combustion and carbon emissions, locally felt at the end user level; or indirectly in the form of power, heating or co-generation plants;
- Service demand is scattered over the city, with varying density according to building and activity concentration;
- Energy demand depends on behaviour of users;
- Need for active energy input (delivered energy commodities) can be reduced significantly by passive building technologies, including orientation, compactness, insulation and natural ventilation, which reduce energy requirements.

Clean energy technologies:

Clean energy technologies and sources, alternatively or in combination. Once energy demand is reduced by smart building technologies, the demand may be met by following low-carbon technologies:

- decentralised internal systems:
  - heat pumps, geothermal, solar thermal water heaters;
  - high efficiency boilers for solid biomass, biogas, bio liquids, co-firing with fossil fuels,
  - decentralised cogeneration (micro CHP);
  - use of accessory electricity, generated again by clean technologies including photovoltaics;
  - highly efficient devices and small air conditioning units specifically for small cooling seasonal demand, generated by clean technologies;
- grid connected external systems, involving or supplied by

- heat exchangers, possibly heat storage on the building level;
  - chillers, gas-fired absorption or electric compressed-vapour, both supplied from local neighbourhood combined heat and power (CHP) or combined heat, cold and power (CCHP) (bioenergy or fossil co-firing);
  - waste heat;
  - central district energy network supplied from district CHP plants; or
- small efficient gas or electricity systems required for cooking and hot water in laundry and other cleaning purposes.

2. Other energy services in the residential, commercial and public sector buildings: light, communication and information, operation of pumps for water and air circulation and also include food preservation, dishwashing and laundry**,** food conservation and preparation, hygiene, laundry and other cleaning, dishwashing.

Characteristics:

- various cleaning purposes;
  - electricity demand reduced by building technologies (daylight), by energy efficiency of appliances, natural lighting, or by user behavior;
  - conventionally remaining electricity supply;
- the low voltage grid, clean energy rather through the way electricity is produced;

Clean energy:

- Clean energy produced within or outside city;
- Distributed energy generation at neighbourhood level (local or mini grid; virtual power plants);
- Renewables or poly-generation on-site; storage by electricity consumers (*prosumer)*, in particular energy from solar photovoltaic rooftops, and wind energy.

3. Industrial energy: stationary and concentrated high energy use and transformation in designated urban areas.

Characteristics:

- Heavy industries: very energy and carbon emission intensive, using steam and other forms of process heat;
- Transformation in situ;
- Use of fuels or electricity in the process of energy generation;
- Punctiform concentration and point source of emissions
- Location dependent on urban land use planning and zoning;
- Opportunities for heat and process heat to interact with district heating and cooling supply, but also interactive lines in medium and high voltage.

Clean energy:

- industry cogeneration;
- may generate more energy than used or at other times so integration into heat, steam, gas or power grid;
- technologies: energy and resources efficiency in the process, heat recovery, poly-generation.

4. The transportation energy: small non-stationary energy services, provided on big scale for mobility, and the fuel for power loading stations.

Characteristics:

- Quantity of these services add up to significant energy demand;
- Energy use and emissions are all over the city (and beyond), but tank fuelling or battery loading is stationary.

- Air emission policy may require a spatial concentration of transport modes, but carbon emission issues do not require this;
- Mobility provided with different energy intensity, from zero in case non-motorized transit (walking and bicycling), low intensity in mass transit to high intensity (individual car-based transport). This emphasized the need for green transport and compact urban development highly relevant reduction of energy related carbon emissions in cities;
- Energy use and emissions can be reduced by energy-efficiency of specific equipment or motors; and also by behaviour, which in turn can be influenced by transport policy.

Clean energy:
- Technologies include electro-mobility, in particular if power is provided from renewables;
- Intra–urban rail transit which is mostly electric; bus transit (electric, or bio-gas powered); electric cars;
- For plug-in electro-mobility loading stations are necessary, which need provisions from the city and power grid.
- Required opportunities to store electricity in batteries and help balance demand and variable renewable energy supply.

Other clean energy technologies:
- Blended fuel (ethanol/gasoline);
- Biogas, bio-gasoline, and biodiesel, provided that the delivery chain and life cycle is low-carbon (and not competing against food and fodder production); intermediate technology is natural gas;
- Low-carbon fuels from coal (coal to liquid or gas); and
- Fuel cell or hydrogen technology.

5. **Urban infrastructure services:** water management, waste water and municipal waste, street lighting

Characteristics:
- services as energy users: water pumping, distribution networks;
- services as energy producers: waste water treatment gas, used for internal purposes or for external users (residential users, transport).

Clean energy:
- bioenergy from waste water in treatment plants; biogas used as such or transformed to electricity in situ;
- municipal solid waste: heat and power from incinerators;
- landfill gas capture; and
- small solar applications in lighting of streets, parking areas, parking meters.

6: Energy utilities and central energy transformation

Characteristics:
- Highly concentrated punctiform energy transformation;
- Point sources of emissions, important for local emissions, but not important for carbon emissions;
- Cogeneration of heat products or cooling.

Clean energy technologies:
- Centralised and connected to distribution grids through middle or high voltage lines;
- Cogeneration (poly-generation): combined heat and power (CHP) or combined heat, cold and power (CCHP);
- In case of bioenergy fired utilities, or biomass co-firing to fossil fuel, natural gas is preferable. Note: bioenergy is storable, transportable;

- Concentrated solar power technologies, in particular parabolic through thermal technology providing heat and power;
- Hydropower or geothermal as non-variable renewable energy options for power depending on resources availability in or near the urban area;
- Onshore wind energy;
- Offshore wind energy;
- Tidal, wave and ocean energy for coastal cities: variable renewable energy options depending on resources availability in the respective city);
- Solar photovoltaic in central solar parks;
- Natural gas, blended with biogas;
- Future applications of power-to-heat, power-to-gas, to make use of surplus renewable energy power during low load; use of central power storage facilities. Synchronisation of demand and renewable energy supply may lead to power-to-heat or power-to-gas options.

Source: EC Link

Indicators. MoHURD has set (national-level) indicators for eco-city development (and so has the MEP) but these indicators focus largely on buildings and green space, they are construction-oriented and they fall short of addressing broader parameters related to land use, clean energy supply, or GHG emissions monitoring. The specific set on clean energy - 20% Renewable Energy supply - is still vague. And it is unlikely that it will be reached: supply of heat and power is via CHP plants outside the eco-city, and all the Tianjin EC can generate in RE is street lighting via PV and some geothermal. For the urban energy sector, the key performance indicators of the Sino-Singapore Tianjin Eco-City (SSTEC) are interesting and need to be referred to:

- Carbon emissions per unit GDP: 150 tons per one million US$. [8]
- Proportion of green buildings: 100%. The percent of green buildings in new construction was practically zero in Tianjin in 2008.
- Usage of renewable energy: share of renewable energy in energy supply shall be at least 20%, compared to the national target of 15% by 2020.
- Central heating coverage: 100% as compared to Tianjin´s target of 90% by 2015.

[8] However, it is being queried whether the carbon emission per GDP indicator is adequate in a small city, since such an indicator may represent many economic and energy characteristics of larger economic regions. And its assumed clean industry-orientation is supposed to result in lower carbon emissions than in other cities with high shares of heavy industries. Hence, it has been suggested that an additional indicator like carbon emission per capita may be added to capture the effects of population density. See: World Bank. 2009. *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China.* Technical Assistance Report. Beijing. www-wds.worldbank.org/.../PDF/590120WP0P114811REPORT0FINAL1EN1WEB.pdf

Proposed Clean Energy KPIs [9]

	Clean Energy		
	Indicator Category	**Indicators: indicative values**	**Current achievements / Time frame for accomplishment**
1	Coal utilization rate of city [1]	__ % of total energy consumption	
2	Total residential energy input for heating and cooling within city boundaries. - Decentralised heat/cold generation (fossil energy sources, district heating and part electricity delivered to residential customers) - Delivery chain losses in district heating and electricity chain (distinguishing source of generation)	__ kWh/(m2a) __ kWh/(m2a) __ kWh/(m2a)	
3	Use of non-fossil energy [2] Renewable energy usage in buildings [3] Share of renewable-clean energy [4]	≥15% [2] ≥20% [3] ≥30% [5] ≥60% [6] ≥10% [4]	By 2020 [3] By 2030 [5]
4	Renewable energy generation: combined heat and power (CHP), waste to energy, and waste heat re-use [7]	5-15% local renewable energy generation for residential areas 2-5% for commercial areas [7]	By 2020 [7]
5	Emissions from district heating (based on renewable energy coefficient 0:8)	Reduced by 50% 105 kWh/(m2a) gross area	
6	Metered heating provision [8]	100% [8]	By 2020 [8]

Sources:
[1] UN-Habitat and Tongji Urban Planning & Design Institute, Shanghai. 2014. Guiyang Green and Sustainable City Programme – Sustainable City Reviews. See also: Guiyang Municipality. 2015. Guiyang Eco-Civilization City Indicators System. Guiyang (unpublished report).
[2] Qiu Baoxing. 2012. Combine idealism and pragmatism – a primary exploration of setting up and implementing low carbon eco city indicator system in China [in Chinese], China Construction Industry Publisher. Beijing
[3] World Bank. 2009. *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China.* Technical Assistance Report. Beijing. www-wds.worldbank.org/.../PDF/590120WP0P114811REPORT0FINAL1EN1WEB.pdf
[4] MoHURD. 2015 and 2016 versions. *Appraisal Standards for Green Eco-City/District Planning (draft)*. Beijing
[5] Innovative Green Development Program (iGDP). 2015. *Low Carbon Cities in China: National Policies and City Action Factsheets.* http://www.efchina.org/Attachments/Report/report-cemp-20151020/1_CityPolicyFactsheet_EN.pdf
[6] SWECO. No date. Caofeidian - Detailed ecological indicators system [unpublished document]. [Unofficial Translation].
[7] The Energy Foundation - China Sustainable Cities Program (ed.). 2011. *Design Manual for Low Carbon Development.* p .46. http://www.chinastc.org/en/research/34
[8] State Council, Government of People's Republic of China. 2016. 13th Five Year Plan. Beijing.

[9] These key performance indicators were prepared and compiled by the EC-Link Project. See: EC-Link. 2016. *Sino-EU Key Performance Indicators for Eco-Cities*. Beijing (unpublished draft)

Expected impact. The application of the clean energy approaches and technologies are expected to achieve a substantially higher, measurable impacts on energy-efficiency in cities. It will trigger increased investment, reduce energy consumption and CO2 emissions, and augment the number of jobs in the energy sector.

Responsibilities for Implementation. The responsibility for use and application of this Eco-City Implementation Guideline rests with the city administrations, provincial agencies, and the local MoHURD offices. MoHURD and CSUS will provide technical support and specific guidance where required. In its intention to pursue consistency of eco-city development, MoHURD is committed to verify the achievement of targets and to ensure improved performance on an annual basis.

Monitoring and review. MoHURD will monitor and review periodically (i.e. annually) the results of the application of this Eco-City Implementation Guideline. For monitoring and periodic review it will utilize indicators as provided above. The city administrations (and district administrations), supported by the local MoHURD offices, will make regular use of these indicators as a means to measure performance.

Outlook. The recent publication of China's Intended Nationally Determined Contributions (INDC) [10] not only announces the national targets for enhanced action on climate change for 2030 but also spells out policies and measures to implement them. Among these, the urban arena is explicitly mentioned several times as area for actions, most prominently in the section on regional policies and on controlling emissions from buildings and transportation. The energy supply sector is addressed in a separate section.

Obviously this announcement is the result of a wide ranging coordination of government departments which indicates the broad understanding of the pervasiveness and the wide permeation of the policies. Following this announcement, the drive for clean energy and urban sustainable low-carbon agenda will become even stronger, and the respective sector policies may become even more ambitious in the medium term.

The INDC is also a clear indication, that China is including systemic solutions in the policies in addition to the introduction of individual clean technologies Technological solutions are undoubtedly very important, but should not obscure the need for awareness raising about environmental behavior among citizens, companies and institutions and respective action.

As the Covenant of Mayors will be introduced to China from 2016 onwards, there is a good opportunity that Chinese cities will soon work on Sustainable Energy Action Plans (SEAPs). These SEAPs will be supplementary instruments to other eco-city planning documents.

[10] Department of Climate Change, National Development and Reform Commission of China, Letter to the Executive Secretary of the UNFCCC Secretariat, Beijing 30 June 2015, Enhanced Actions on Climate Change – Intended Nationally Determined Contributions, unofficial translation.

Date issued: _____ 201_

ANNEXES

Annex 1 – Technical Annex

(still to be added, once work in EC-Link cities completed)

Annex 2

MoHURD. 2015. *Appraisal Standards for Green Eco Districts.* Beijing. (draft).

Excerpt

Resource & Carbon Emission	Controlled Criteria	Develop energy conservation plan, integrated use of various energy.			
		Develop "integrated utilization plan of water resource" during the planning stage, while during the operation stage develop "the report on the status, assessment and development plan of water utilization".			
		Submit detailed and reasonable carbon emission calculation and analysis list, set carbon emission reduction goals stage for stage and the corresponding implementation plan.			
	Priority Criteria	Energy	1. Energy consumption sub-metering, consumption based charging for centralized heating/cooling.	Sub-metering for energy consumption is applied, and incorporated in the municipal energy monitoring platform	4
				Consumption based billing for centralized heating/cooling	4
			2. Share of renewable energy in primary energy consumption (R_p)	2.5%≤Rp＜5.0%	5
				5.0%≤Rp＜7.5%	8
				Rp≥7.5%	10
			3. Utilization of waste/residual heat	residual heat and waste heat is utilized in a ladder-type system	6
				distributed CCHP is applied, the comprehensive energy efficiency of the system is no less than 70%,	6
				heating or cooling oriented gas-driven CCHP system is applied, the system efficiency of primary energy is 100%,	6
			4. Area percentage of new buildings of which the designed energy consumption (An) is over 10% lower than the current national standard	50%≤An＜75%	5
				75%≤An＜90%	7
				An ≥90%	10
			5. Percentage of high-efficient system/equipment in the municipal facility reaches 80%.		6