The water sector in China

Market opportunities and challenges for European companies

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Executive summary

This report provides an overview of the existing market situation of China's water sector, highlights the main areas of opportunity for EU SMEs, and provides practical information on how to access these opportunities. The overall issues driving the water market and issues facing European companies wanting to enter are considered and then the specific opportunities and challenges in different sectors of agricultural, municipal, industrial, river basin management / flood control and water for energy are considered.

China is a decentralised administrative system. Responsibility for water services is devolved to municipal and county level government authorities. They are responsible for water resources, water treatment and supply, sewerage and collection, wastewater treatment, sludge treatment and environmental quality. They deliver these services based on policy and advice from the central government.

An overall policy framework of "Ecological Civilisation" has been declared at the highest levels. This is driving a transformation of the Chinese economy to be more environmentally aware and sustainable. There are many new laws and regulations that have taken effect in the last few years that drive compliance with quality standards and set out massive investment programmes to achieve these. This is driving investment in new technology and innovative solutions to deliver better environmental and living conditions for the population. Guidance and regulation in meeting these conditions is provided by central government. Senior officials in local governments have personal performance targets for meeting environmental quality standards in their jurisdictions. The process of oversight in the meeting of these targets compensates for what might otherwise be seen as a weak regulatory system. This coordinates the country, the government and state industries to achieve the objectives. The financing of this investment has shifted to a hybrid mix of public investment and support to private investment. In working to reach these objectives there are opportunities for European companies to engage with Chinese partners to supply equipment, infrastructure and services.

Many cities in China face severe challenges of water scarcity, pollution, flooding and inadequate infrastructure. All new development must meet water resource allocation limits, pollution load allocations, water reuse / recycling targets and comply with "Sponge Cities" standards. New rules are driving integrated approaches to water management as a part of overall sustainable urban planning. Drainage management, water reuse and decentralised treatment must be designed into new urban developments and be integrated with the urban waterbodies. For industry water saving is driven by objectives for water efficiency per unit of production and compliance with stricter quality standards. Agriculture, as the largest overall user of water, has to greatly improve efficiency of water use and reduce diffuse pollution while maintaining food production objectives and producing higher quality products demanded by consumers. Large quantities of water are used for energy production, both in hydropower and as cooling water for thermal generation and for unconventional gas production. The needs of energy users must be considered in the water resources allocations and drive investment in more sustainable practices. These challenges are all driving opportunities for European companies with appropriate technology and services to find markets in China.

However, China is a large, complex and confusing market to enter and there are many barriers in the way of starting and successfully sustaining a business there. Products need to adapt to the local requirements and companies will need to develop their relationships with partners and clients as well as complying with the local business processes. Winning contracts and orders will also require an understanding of the procurement processes.

The letting of contracts for infrastructure delivery through Public Private Partnerships (PPP) is an important mechanism for achieving the objectives. Over the last two decades water supply and wastewater treatment has become a mixture of public provision by local government departments and contracting out through BOT, TOT and concession agreements to first international and now national utility companies. New rules require that ALL new environmental infrastructure is to be provided by a PPP mechanism.

The procurement processes for major infrastructure projects are complex with feasibilities and approvals required at local and central levels before entering the stage where bidders can position themselves in the competitive bidding process. Knowing when to engage in this process is challenging; if you chase projects too early you may waste effort on projects that will never happen, if you engage too late the best partnerships will already be locked down. Understanding the processes and the position of projects in this pipeline is vital to success in choosing the right partners to bid with.

Over the years, these procurement processes have developed many barriers for foreign companies seeking to compete fairly with increasingly strong local companies. There have recently (April 2017) been State Council notices on reform of procurement processes to make them more open, transparent and to encourage fair competition between local and foreign bidders. Though there is some way to go in seeing these reforms implemented there is hope that some areas of the market may become more accessible in future.

Water services used to be provided by local government departments at very low cost to the users. This did not encourage efficiency or good quality. This public provision approach has been reformed to various hybrid public and private partnerships with the cost of water to users, and the price returned for resource use, having increased significantly. Water operations are now generally run on a near commercially viable basis, though there is still a degree of subsidy at various levels. Chinese Water Utility companies have evolved from BOT / TOT operation of water supply and wastewater treatment plants to delivering integrated water and energy utility services to the municipalities. In many cases half their business now is construction of urban environmental infrastructure such as parks, river restoration schemes and ecological housing developments to meet Sponge Cities standards. This is a very different role for “water” companies in China, reaching into whole urban catchments, than is generally seen in Europe. For industry there is also very active development of PPP and EPC arrangements for the provision of industrial water treatment processes. In the agricultural sector village communes have been able to set up agricultural equipment enterprises which can operate regionally to buy and lease equipment and supporting services and labour to farmers for the provision of irrigation, fertigation, flood and drought management and related services. These reforms are opening some routes to market for European companies while also enabling the development of a very large and powerful Chinese water sector industry.

Companies such as Beijing Enterprises Water Group have revenues of many billions EUR and are bigger than most EU water companies, approaching Veolia and Suez in their scale of operations. They are now looking at overseas investments and operations. The major construction contractors such as China State Construction Engineering Corporation are setting up both water and environmental services divisions and overseas investment companies to target international markets. Under China’s One Belt One Road Programme Chinese companies are becoming major Infrastructure providers around the world including in the water sector, with strategic support from their government, so the “Chinese Market” has also now become a route to accessing a global market.

European water sector innovators currently have a window of opportunity to build partnerships with Chinese companies where they are starting from the stronger position of being technically more advanced and experienced and so can negotiate good terms. However, with a very strong educational system and organised system of government supported research, innovation and systems for bringing to market, it is only a matter of years before China is able to pull ahead and will not need to find such favourable terms when forming partnerships. The leading Chinese water sector companies are now in the top 3 globally by size and revenue, with massive ongoing investment to the sector, a regulatory environment dominated by public private partnerships and an expansion by Chinese companies to overseas markets there is considerable opportunity for European companies with the right innovative technologies to form partnerships that will achieve access to global markets and growth if they can be supported in how to effectively adapt to the Chinese market. Most small and medium sized companies do not have the resources to do this on their own. These factors are common with other sectors and if the European Union is to be effective at building its place as an innovation led open and exporting economy companies need to be supported in engaging in sometimes difficult to understand foreign markets.

To successfully obtain a foothold in China, EU water sector companies will have to adapt their products and business processes to fit the local culture and market. In all cases the provider of the technology must be able to demonstrate the business case for customers to adopt their solution rather than the status quo or cheaper local alternatives by quantifying the added value provided through innovation, quality, reliability, and efficiency. They must build a viable and robust business in China, working together with local partners and customers. We have identified the following proven strategies to achieve this:

1. Understand the market and the procurement processes – who are the real clients and key partners and which actions need to be taken at which stage of the procurement process; from profile raising and intelligence gathering to positioning, partnering, tendering and the delivery of projects;
2. Match the product that the company is selling (be it services, expertise or technology) to the needs and expectations of the clients – these are likely to be quite different to typical European client

expectations. This will mean doing research and listening very carefully to what potential clients are demanding;
3. Map the revenue streams of the clients and the supply chain – make sure that the company is entering the deal at a point at which clients have revenue available with which to pay the company;
4. Companies will have best chances of successful entry in niche, emerging or high-risk areas of the market;
5. Keep the product simple so that clients can easily understand its purpose and function;
6. Adapt, tailor and package the product to comply with local standards and market prices. This may mean adapting any patented IP to fit local conditions;
7. It will be very difficult to find success in commodity markets where your costs will inevitably be higher than the local competition's. Define a premium product that still offers good value in the longer term. If done successfully, it is possible to achieve very high margins in China – potentially higher margins than in the EU;
8. Though the greatest skill that Europeans have is the ability to efficiently manage complex integrated systems, this can be very difficult to explain to Chinese clients who are likely to be used to the more compartmentalised Chinese approach to operations. Therefore, express yourself in simple terms;
9. Have strategies to protect your IPR, either by filing for patents or maintaining secrecy;
10. Assume that any IP-related secrets you bring to China will be compromised, as both data security and trust can be low in China. Therefore, keep essential trade secrets offshore wherever possible;
11. Acquire knowledge of the financing options available to support the growth of your business. If finance is required, ensure you have staff who fully understand Chinese banking and accounting procedures;
12. Understand the reforms to the procurement regulations and the actions now available to push for fair access to bidding processes;
13. Invest in building relationships with technical, business and financial partners and exercise due diligence.

Entering the China market requires commitment of time, resource and energy. Prepare, plan and budget. If not serious about it then don't waste efforts dabbling.

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Figures and tables

Abbreviations

ADB	Asian Development Bank
BOT	Build-Operate-Transfer
CEWP	China Europe Water Platform
CNY	Chinese Yuan
CPC	Communist Party of China
DBO	Design Build Operate
DDD	Demand Driven Distribution
EPC	Engineer, Procure and Construct
EU	European Union
EUCCC	European Chamber of Commerce in China
MEP	Ministry of Environmental Protection
MIIT	Ministry of Industry and Information Technology
MOHURD	Ministry of Housing and Urban-Rural Development
MOST	Ministry of Science and Technology
MWR	Ministry of Water Resources
NDRC	National Development and Reform Commission
OFWAT	Water Service Regulation Authority (UK Economic Regulator)
PPP	Public Private Partnership
WB	World Bank
WG	Working Group (of EUCCC)
WTW	Water Treatment Works
WWTP	Wastewater Treatment Plant

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1. Introduction

Rapid economic expansion and urbanisation, limited water resources and tightening environmental regulation in China has created an expanding market for water sector technologies, but European businesses with technology products wanting to access this market in China face many challenges and barriers.

The general opportunity that any business faces on entering the Chinese water sector is that of a partially developed but growing market with sufficient infrastructure that an effective technology that has been developed in Europe can rapidly achieve high sales if the producers are able to adapt to the specific conditions of the market and localise the product to make it acceptable to clients and consumers.

However, China is a daunting market for any new entrant with a complex procurement system that is operating in different political and cultural settings to what most Europeans are used to. There are some opportunities and barriers that apply to all water sector areas and there are others that are specific to the market niche that a particular technology is targeting.

In this report we set out a framework for analysing the opportunities and barriers at the whole market level and then more specifically for market sub-areas.

1.1.1. Framework for analysis

Understanding the drivers, opportunities, barriers and strategies for the China water market requires an analysis of the structure of the market in terms of

- Major policies driving change – these generally target environmental, social and economic outcomes. New infrastructure and organisation will be required to deliver these;
- Technological responses – How the outcomes of scientific research and development can be used to develop the technologies that will deliver the policy outcomes;
- Incentives that support innovation - Mechanisms to help move research based ideas to be pilots of innovative technologies that may find application in the market;
- Business models for delivering the change – building the commercial structures around the technologies and how they are implemented plus the economic regulation of the systems;
- Procurement models – within the political and regulatory model what are the processes for procurement of contracts to deliver the infrastructure and organisation that will deliver the policy outcomes. This will need to take account of the investment and financing models employed – Public, Private or Public Private Partnership (PPP);
- Agents for delivery – Clients, buyers, contractors, distributors – the partners that ultimately buy, own and operate the technology to deliver service to the end users.

In this report some key elements of the current policy framework of China are summarised. Policy issues relevant to the market areas are also considered in turn. A more detailed analysis of the China Water Policy situation is provided in CEWP China Water sector analysis reports.

The technological responses and how the EU and its institutions can facilitate the process of applying scientific research and development to drive innovation is addressed in the Strategic Research and Innovation Agenda (SRIA) of the PIANO project[1] which looks at some of the incentives that support innovation.

This report will consider the business models and regulation both in general for the water sector and in sub sector areas of the market. Likewise, for the procurement models and processes, which follow some common features and then have some specific issues related to each sector area.

Finding the right partners and or distributors and customers for a product is of course one of the most important elements of a successful business. In this report we can make some general comments with regard to this, but ultimately this will be a specific challenge to every market entrant.

The technology responses to a policy driver, once implemented also have strong feedback effects to the policy development process – the innovation and application of new technologies make it possible to

[1] See: http://project-piano.net/piano-documents/sria/

propose new and more advanced policies that will in turn force the development of more advanced technologies.

1.1.2. Market sector areas

The opportunities have been identified in 5 main market areas:

1) agricultural water management;
2) municipal water management;
3) industrial water management;
4) river basin management and flood control;
5) water for energy.

In each of these areas there are sub categories considered which are listed at the start of each chapter.

1.2. Major policy drivers in Chinese water sector

The policy framework of China works down from the broad ecological civilisation goals through laws and action plans that direct the government administration and State Enterprise sectors to deliver outcomes utilising innovative financing methods. The party overseas and manages this process.

- **Ecological Civilisation** – The overarching framework
- **State decrees and state level environmental laws** – e.g. 2011 No1 policy document on water reform with subsequent 3 redlines policy documents, 2015 revised Environmental Protection Law, 2008 Water Pollution Control and Protection Law. – Provide legal framework
- **Five Year Plans** (13th) – at national, provincial and municipal levels provide priorities for investments and cross sector planning
- **Action Plans** - Water Pollution Prevention & Control Action Plan, 2015 – provide sector specific programmes with investment levels
- **Ministerial Reorganisation** – 2018 reorganisation of Ministry for Ecology & Environment (MEE) and Ministry for Natural Resources (MNR)
- **PPP Finance and Regulation** – The financing mechanisms being developed to facilitate the construction of infrastructure.
- **Party Cadre Performance assessments** – The criteria against which the performance of officials is assessed by the party. Very important to the real priorities that will be followed and will drive decisions and behaviours.

1.2.1. Building an ecological civilisation

China faces severe water challenges of water scarcity in many parts of the country, severe pollution of water bodies (rivers, lakes and groundwater), significant flood hazards and a major programme of hydropower development. Rapidly growing cities are competing with agriculture and industry for resources and there are rising expectations of water quality and reliability of supply and the need to meet much higher environmental standards. There is a vast legacy of infrastructure and common practice that treats water as a freely available consumable commodity for use and for waste disposal. China understands the need to transition to water efficient, clean technologies and a circular economy – these ambitions are set out under the broad policy ambitions of developing an "Ecological Civilisation", as expressed by Hu Jintao in 2007 at the 17th Party Congress.

> "…the essence of the construction of ecological civilization is building a resource-saving and environment-friendly society based on the environmental carrying capacity of resources, the laws of nature and sustainable development... "[2]

This has been repeated and strengthened by Xi Jinping in the 18th and 19th party congresses since then and is a central part of the Chinese constitution.

Much of the policy framework for achieving this in the water sector was set out in the 2011 No 1 policy document on Water Reform, the revised Water Pollution Prevention and Control Law, (last revised 2017), and the Environmental Protection Law, 2015. These, together with supporting regulations and guidelines, establish a system of setting quotas and targets for water resources use, pollution load controls, water efficiency, permitting and enforcement with penalties. The approach to delivery is then set out in the 13th

[2] Hu Jintao's speech at the seminar on studying and Carrying Out the achievements of CPC's 17th National Congress

Five-Year Plan and in sector plans such as the Pollution Control Action Plan (also known as Water Ten Plan). These action plans also have specified investment programmes to match them which can run to €100's billions per year. The implementation of these plans is through a coordinated process between central government guidance and approvals and the provincial and municipal governments who will plan, contract and supervise the operation of the required assets and institutions. The motivation and oversight of this process also comes from the Communist Party of China who set and assess key performance indicators for senior officials at local and central levels which relate to their progress in implementing the plans and objectives. The number and priority of environmental objectives in these most important of all political and administrative mechanisms has risen greatly in recent years.

In the 2018 National Party Congress a major reform of Ministries was announced that re-organised the central government – and subsidiary local departments – to streamline the management of water quality and pollution control in an expanded Ministry of Ecological Environment (MEE), and the management of water resources and abstraction permitting into the Ministry of Natural Resources (MNR). Many other duties were also transferred to these enhanced ministries as a step in the path to creating an administrative system suited to the delivery of an Ecological Civilisation.

The action plans and investment plans are also matched with research and development plans to develop the techniques and technologies for implementation.

The use of Public Private Partnerships (PPP) to deliver infrastructure projects was pioneered in China in the water sector starting in the late 1990s, and is now mandatory for all water and environment projects. For most projects where they have finance in place, the appropriate level of government will run a competitive tendering process to which consortia of PPP investors, contractors and design institutes will bid to deliver infrastructure to meet performance and service delivery criteria that, if achieved, will trigger regular payments to the supplier. In other cases the local government may engage directly in negotiations with investors and contractors to provide a financing structure, as well as deliver the project. For highly politically sensitive and time critical projects, such as the construction of the new Xiong'an administrative city near Beijing, the PPP requirements may be suspended and direct government appointment to state contractors implemented with a limited degree of competition.

Thus, the policy framework is driving a need for massive investment in water and environmental improvements that will be supplied primarily through the PPP projects, to mostly be delivered by consortia of public and private companies together with a vast number of sub-contracted suppliers of technology and equipment. Since many traditional water technologies may have reached and/or exceeded the limit of sustainable water provision, an opportunity exists for innovative (and integrated) solutions capable of addressing environmental concerns[3] which return better value to the projects and are in line with recent policy development thereby resulting in higher returns and greater success. The 2011 Number 1 Policy document on water reform takes as its fifth principle the promotion of innovation in water infrastructure provision. Consequently, there is now significant demand for innovative water management technologies across China and mechanisms to drive innovation in the local market. The challenge to European innovators is how to access and succeed in this market.

Consideration of the more specific objectives in the five-year plans and the action plans can help in understanding where the focus of reform, improvement and investment lies.

1.2.2. 13th Five Year Plan 2016-2020 context

The Chinese government adopted the *13th Five-Year Plan for economic and social development 2016-2020* in 2016 to set national goals until 2020.

In context of the 13th plan, China implemented a revised Environmental Protection Law, which among other things introduced tougher punishment of environmental violations and new discharge standards for municipal wastewater treatment plants.

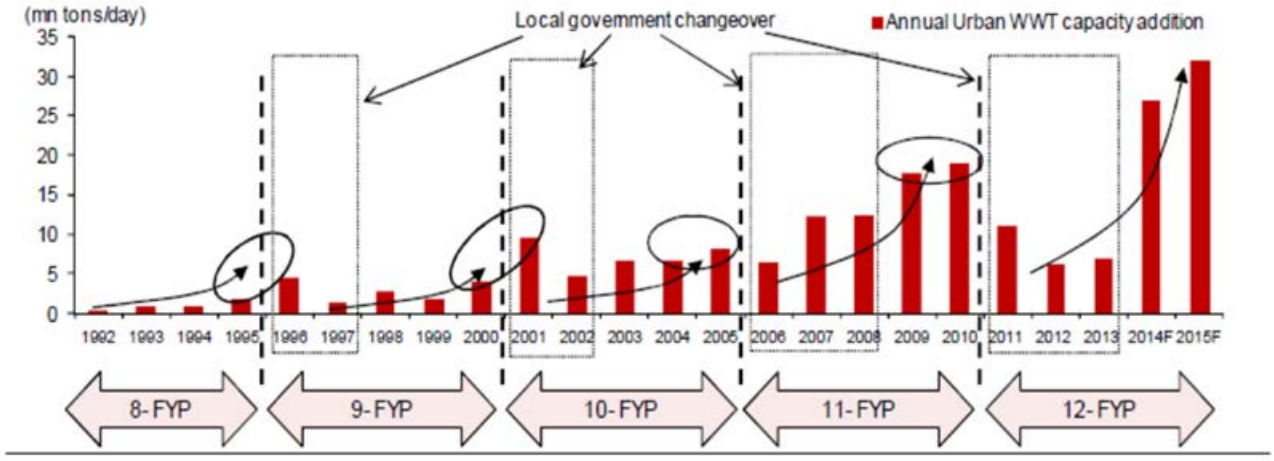
Examples of targets to be meet by 2020:

- Upgrade of municipal wastewater treatment;
- New wastewater capacity- estimated new capacity 55 million m^3/d;

[3] Moro, M.A., McKnight, U.S., Smets, B.F., Min, M., Andersen, M.M. (2018). The industrial dynamics of water innovation. A comparison between China and Europe. International Journal of Innovation Studies. Accepted, In Press.

- Sludge management- 90% of sludge must be treated (today 70-80%, though likely much less);
- Wastewater reuse- direct reuse more than 20%, from less than 10%;
- Installation of centralized wastewater treatment plants in all industrial parks- today less than 50%;
- All industries must meet the discharge standards in the 13th Plan;
- 20% of cities to meet "Sponge Cities" Standards, 80% by 2030.

The effect of the five year planning cycle on investment in environmental projects can be clearly seen as illustrated in Figure 1-1 for the annual investment rates in wastewater treatment capacity.



Source: NOMURA, from Clean Technologies – China Market Study, 2016, EU-Gateway project

Figure 1-1 Rates of annual investment in municipal wastewater treatment capacity for 8 to 12th FYPs

The Water Reform and Development 13th Five Year Plan acknowledged the significance of accelerating the improvement of water conservancy infrastructure, promoting scientific development, rational deployment, efficient use and effective conservation of water resources, and comprehensively enhance the water security capabilities. The plan emphasised on the optimising the allocation pattern of water resources and improving the integrated flood and hazard control system. To give an impression of the nature of these plans, some more specific objectives in the plan are:

Add more than 6,500 km^2 of farmland water-efficient irrigation systems;
- Construct 60 GigaWatts capacity conventional water to energy;
- Construct transmission channels for major hydropower and coal power stations;
- Construct more than six major water diversion projects;
- Construct more than 6 large reservoirs;
- Improve rural piped drinking water coverage to 80% of population;
- Ensure water pollution control and comprehensive environmental remediation in major bays such as Jiaozhou Bay, Liaodong Bay, Bohai Bay, Hangzhou Bay, Xiamen Bay, and North Bay;
- Implement monitoring projects for major water consumption units;
- Ensure strict water environmental protection of river sources. Drinking water sources, and improve 378 rivers to water quality better than Class III;
- Add an additional water and soil conservation area of 270,000 square kilometres and ensure national wetland coverage exceeds 530,000 square kilometres.

Local governments also have respective local FYPs to correspond with the central government plan. Local government plans often have more specific targets and goals that impact the local business environment and incentive programs. For instance, Shanghai developed the Shanghai Water 13th Five Year Plan with major focuses on standards and quality improvement, ecological environment enhancement, and implementation of smart management. To enter the Chinese market, it is important to have an in-depth understanding of both national and local development plans.

The 13th FYP will drive technological water innovations in areas such as membrane water treatment, sponge city, rural water environment management, urban black smelly water management, groundwater restoration, industrial zero emissions.

2015 'Water Pollution Prevention & Control Action Plan'

16 April 2015, State Council issued the 'Water Pollution Prevention and Control Action Plan' (or known as the "Water Ten Plan")..

It sets out 10 general measures which can be broken down to 38 sub-measures with deadlines with responsible government departments identified for each action. In general, the plan covers the following four broad actions:

- Control pollution discharge, promote economic & industrial transformation and save & recycle resources;
- Promote science & technology progress, use market mechanisms and enforce law & regulations;
- Strengthen management & ensure water environment safety; and
- Clarify responsibilities & encourage public participation.

In total, there are 238 specific actions involved. Some key targets and actions are listed below:

Overall objectives & targets

- By 2020, China's water environment quality will gradually improve; To greatly reduce the percentage of badly polluted water bodies – over 70% of water in 7 key rivers shall reach Grade III or above;
- To improve the quality of drinking water – over 93% of urban drinking water sources shall reach Grade III or above;
- To reduce groundwater over extraction and control groundwater pollution – groundwater falling under "very bad" category shall decrease to around 15%;
- To improve the environmental quality of coastal areas – up to 70% of coastal water shall reach Grade I or II;
- Improve urban water environment in key regions – the amount of Grade V+ water in Beijing-Tianjin-Hebei shall fall by 15%, and Grade V+ water shall be eliminated in Yangtze River Delta and Pearl River Delta;
- By 2030, the overall quality of the ecological environment will be improved; and
- By the middle of 21st century, the quality of the ecological environment should be fully improved and the ecosystem should realise a virtuous cycle.

Key focus water bodies & areas

- 7 key rivers: Yangtze, Yellow, Pearl, Songhua, Huai, Hai & Liao River;
- 9 key coastal bays;
- 3 key regions: Beijing-Tianjin-Hebei, Yangtze River Delta & Pearl River Delta; and
- 36 key cities: Beijing, Tianjin, Shanghai, Chongqing, 27 provincial capitals & 5 cities specifically designated in the state plan (including Dalian, Ningbo, Qingdao, Shenzhen & Xiamen).

For some actions, the 3 key regions are required to meet the targets one year before the national deadline.

The new plan puts tough controls on polluting industries with emission limits and provides stricter supervision from authorities and the public. It has also listed targeted industries:

Small factories in 10 industries shall comply with relevant national policy, standards & industrial regulation by the end of 2016; otherwise they will be shut down:

- Paper & pulp;
- Leather;
- Textile dyeing;
- Dyes production;
- Coking;
- Sulphur smelting;
- Arsenic smelting;
- Oil refineries;
- Electro-plating;
- Pesticide production;

The following 10 major polluting industries are targeted for technological upgrades, emission reductions and to achieve clean production:

- Paper & pulp;
- Coking;
- Nitrogen fertiliser;
- Textile dyeing & finishing;
- Agriculture food production & processing;
- Pharmacy production;
- Leather;
- Pesticide;
- Electro-plating;
- Non-ferrous metals.

Thus, companies with technologies appropriate to the water treatment in these sectors will be particularly welcome.

Moreover, the plan also covers pollution control, water efficiency improvement in agriculture, municipal water use, coastal water management and overall ecological environment protection. Controlling total water use to stay within the Three Red Lines is key. To stay within the 2020 cap of 670 billion m^3 of water use the Water Ten Plan uses a mix of water efficiency targets and market mechanisms such as water tariff reform, revised water fees, credit financing and environment performance and eco compensation.

The government expects the new plan to boost GDP by around RMB5.7 trillion and to result in RMB1.9 trillion of new investment in the environmental protection related industries (in which RMB1.4 trillion will go to purchasing products & services) and create 3.9 million new non-agriculture jobs[4].

1.2.3. Ministerial reorganisation

In the March 2018 Party congress, a significant reorganisation of responsibilities between ministries was announced. This was intended to better streamline the government apparatus to deliver the goals of Ecological Civilisation and of the China outbound policies of One Belt One Road. The main changes were to streamline the management of river basins, water quality and pollution control in the ministry for Ecology and Environment, which also has responsibility for agriculture, soil, oceans and air management. The allocation of water resources and other natural resources was moved to the new Ministry for Natural Resources with a programme of redlines for resource allocations that must be implemented at all administrative levels. This should form a more streamlined and logical structure as illustrated below.

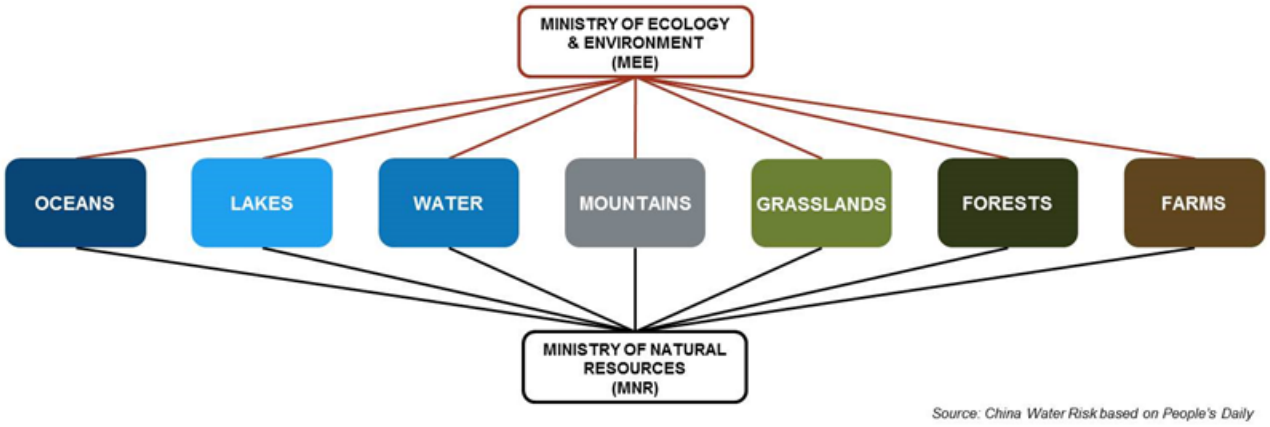


Figure 1-2 Reorganisation of key ministries

Certain planning functions also moved to these ministries from the powerful National Development and Reform Commission (NDRC) though NDRC will still maintain control over the approval of major capital works and also extends its role in planning infrastructure on a global scale. A fuller description of these reforms can be found at China Water Risk site[5]. The role of the Ministry of Water Resources (MWR) has been greatly reduced following this reform, though it still has overall responsibility for water resources policy, protection and investment planning, flood control, drought relief and soil protection. How this reorganisation translates down to the subsidiary departments at provincial, municipal and county levels still remains to be seen.

[4] Pers Comm: From slide contributions of Yan Qian (MEP FECO) and Li Peipi (MWR DRC) at 2016 Stockholm water week PIANO project workshop.
[5] After http://chinawaterrisk.org/resources/analysis-reviews/ministry-reform-9-dragons-to-2/

1.2.4. PPP finance and regulation

In the last few years there have been changes in way that major infrastructure projects are financed, moving away from direct local government procurement to letting of contracts through Public Private Partnership mechanisms. This has important implications for the procurement processes and for who will be the client / purchaser of innovative EU water sector technologies, products and services. Though drawing much from western experiences of PPP the Chinese models have distinctive differences, the main one being that the "Private" actor in these arrangements is often a state-owned enterprise and so in some ways this may become Public Public Partnership. This is discussed further in section 1.6 below.

1.2.5. Party cadre assessments

The Communist Party of China (CPC) operates a system of administrative assessment by which individual officials as well as departments and state companies are subject to an annual assessment process. This is a principal – agent system by which the agent (the department, company or individual) submits to assessments against a matrix of criteria set by the Principal (the CPC). There is a round of self-assessment against the matrix of indicators followed by a review by the CPC official. Scores that are achieved strongly influence the individual's future career prospects or the department / company's standing. Individual assessments are generally confidential while departmental or company ones may be published.

This is a primary means by which China has achieved the consistent delivery of economic growth, population control and public order goals over recent decades despite the apparent absence or weakness of formal governance and regulatory institutions. Many environmental and water related targets are now included in the assessment process. Exactly what these are each year and how the performance indicators are formulated has important implications for what will actually be done as these are probably the primary motivations for key decision makers. The role of the CPC is to translate the high-level policy objectives, such as Ecological Civilisation and the targets of the Five Year Plans, into quantifiable goals that can be set in the assessment system and so drive implementation of policy. The refocusing in recent years from just economic growth to achievement of improved environmental conditions has driven much of the remarkable progress in this endeavour.

1.3. Technology responses and innovation driven by the ecological civilisation policies

The Ecological Civilisation policy drives for improvements in the management of the water cycle in terms of resources, chemical quality, ecological quality and interaction with infrastructure. This means understanding the needs of a diverse and healthy ecosystem that will support human civilisation and designing infrastructure that can be sustainably operated so that people can live their lives in accordance with the goals of an ecological civilisation.

These are challenging targets and they drive technological responses to develop or acquire innovative or new technologies, systems and methods that will deliver the targets that have been set.

For the water and environmental sector some of these targets were set out by Ministry for Environmental Protection as in Figure 1-3 below.

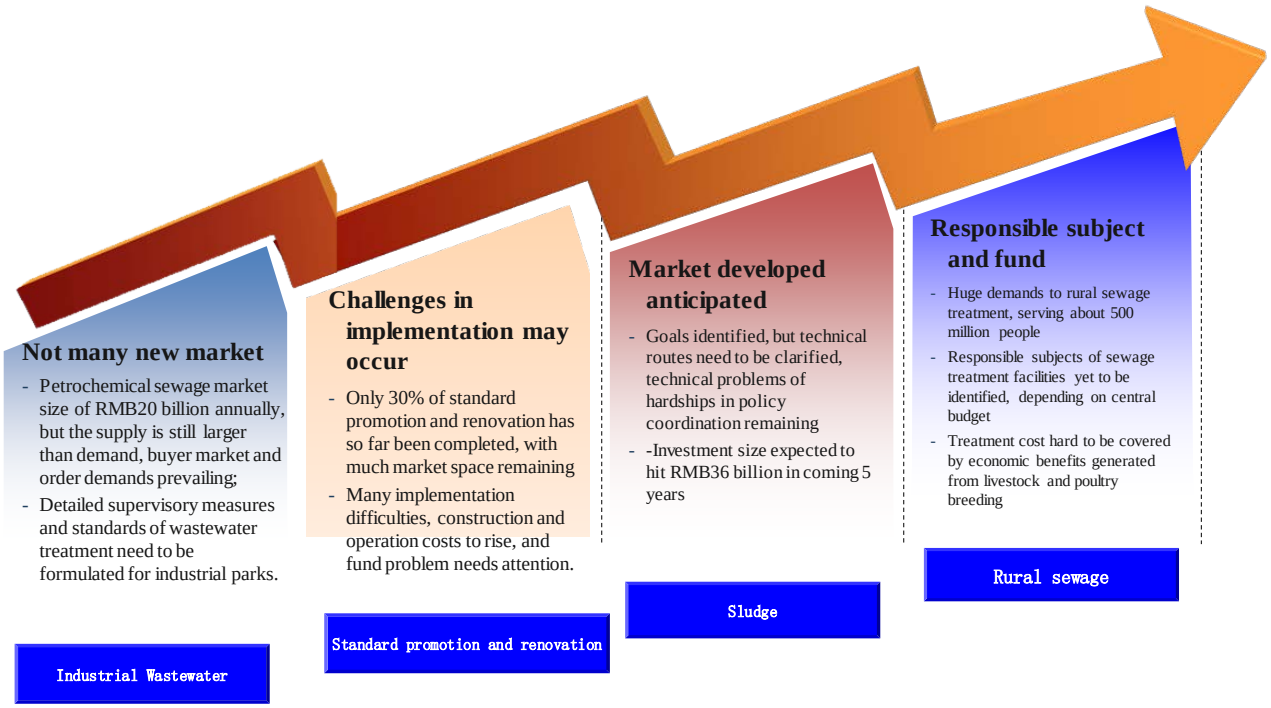


Figure 1-3 Key elements of ecological civilisation targets for water sector

These policy drivers will result in Technological responses which open opportunities to be implemented in a market system. There is a balance between the creation of opportunities and the barriers to market entry.

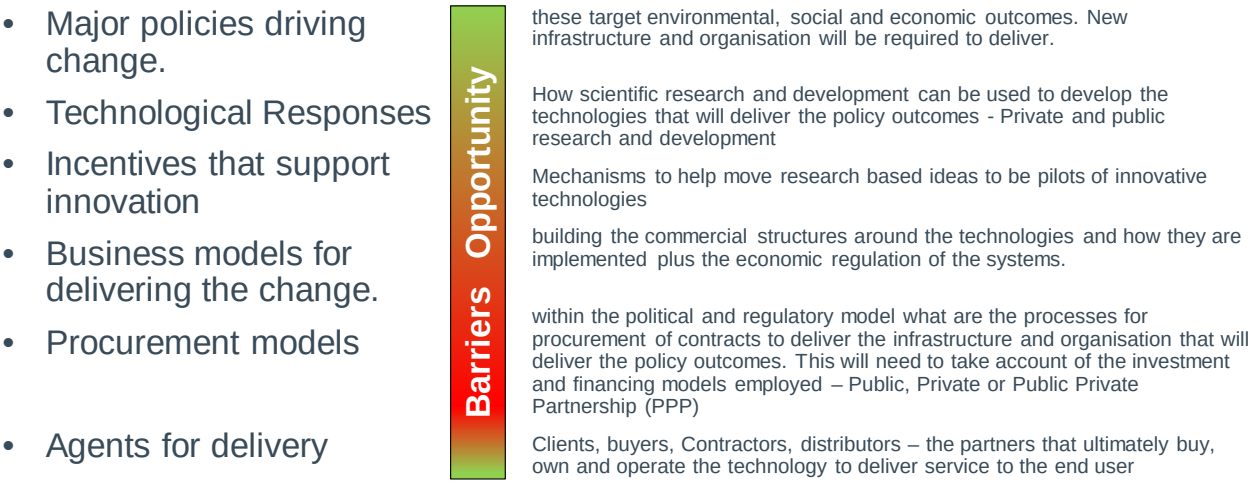


Figure 1- 4 Relationships between policy drivers, technology responses and the opportunities and barriers in the market

The rest of this report is exploring those opportunities, barriers and how to develop effective strategies in various market areas.

1.4. General barriers in water sector

When considering the market barriers this report primarily considers those affecting small and medium sized companies with technology that they are looking to market in China. For larger multinational companies the market barriers may be slightly different.

The following are some of the key barriers that will be encountered:

- Market understanding / language;
- Market / public acceptance of new technologies;
- Promoted / closed lists for imports and market access;

- Localisation of technology / understanding local standards;
- Certification and approval of technologies, licences to operate or issue designs;
- Identification of clients;
- Procurement routes;
- Business registration and banking;
- Reliable partners for distribution, installation, training and operation;
- Hiring of local staff or bringing foreign experts to China;
- IPR protection and copying;
- Company resources, skills, financial capacity and China strategy.

General information on doing business in China is available from member state trade missions, from Chambers of commerce and from the EU-China SME centre. The following is a selection of further information on these barriers and how they may be overcome for the water sector.

Market understanding:

EU companies have limited knowledge of the market in China and the opportunities there. European government sponsored programmes, such as the H2020 PIANO project, Innovation promotion centres, small business support, such as the EU-SME Centre and the EU in China Chamber of Commerce can help to provide information and a supportive platform for market investigation / entry. National trade fairs and conferences can also provide information, though good local contacts and support with language will be required.

Useful information can also be found on key in-charge authorities to understand the market of China water sector:

- Ministry of Housing and Urban-Rural Development of the PRC, http://www.mohurd.gov.cn/;
- Ministry of Water Resource of the PRC, http://www.mwr.gov.cn/;
- Ministry of Ecology and Environment of the PRC, http://www.zhb.gov.cn/;
- National Development and Reform Commission, http://www.ndrc.gov.cn/;
- National Energy Administration, http://www.nea.gov.cn/

Acceptance of new technologies

Both the consumers and the regulators need to accept new products. For some products, such as those using recycled wastewater there are resistances and disgust at using such water sources, the application of quality standards and public promotion exercises can help in overcome such barriers, but these are generally outside the reach of a European company to implement in China. Therefore, the business should understand well the regulations that are in place or are being brought in to manage market acceptance. Appropriate marketing, that is culturally sensitive and targets the correct media channels is essential and will require local partners or local staff leading.

“Not invented here” is also a common barrier to acceptance, either the product must be marketed explicitly as a special overseas high value product, or made to look and feel as local as possible so as to appear familiar and acceptable.

Closed industries

Not all areas of the Chinese economy are open to foreign industries, while others are actively promoted. The ‘Catalogue for the Guidance of Foreign Investment Industries’ published by the Chinese Ministry of Commerce (MOFCOM) sets out which industries are open, restricted or closed.

Most environmental and water services are open for foreign investment and there are some government departments set up specifically to encourage investment, but there are some notable exceptions under certain headings relevant to water and environment sectors[6]:

Restricted (Require a Chinese partner who holds the majority of shares):

Breeding of new strains of plant seeds;

Construction and management of urban gas, heating power and water supply and drainage pipe network with a population of 500,000 or more (Chinese partner shall hold the majority of shares).

[6] As of March 2017

Prohibited:

Research, development, cultivation and growth of China's rare and unique precious breeds, and production of related propagating materials (including tine genes in plants industry, husbandry and aquatic products industry);

Breeding of transgenic varieties of crops, livestock, poultry and aquatic fingerlings and production of transgenic seeds (seedling);

Fishing in the sea area under the jurisdiction of China and in-land waters of China;

Construction and management of nature reserves and internationally significant wetland areas;

Development of resources from wild animals and plants native to China and protected at national level.

Localisation of technology

Any product coming into or manufactured in China needs to comply with product standards (GB standards or ISO standards) which may be based on international standards or may be slightly or even very different compared to those in the EU. At the very least interfaces and instructions must be available in Chinese and sales and operational staff need to be able to communicate with the clients in Chinese. This may be best done through local partners. Assistance in these aspects can also be obtained from the EU SME Centre in Beijing, so it will not be covered further in this report.

Certification and approval of technologies

For many products and services, they cannot be used in China on Government or other projects unless they have been certified as effective by a relevant ministry technical institute, confederation or professional institute. The product will need to be piloted in a trial and experts who are eminent in their field invited to review the results to endorse the product as effective and genuine before it will find wider market acceptance. This is a process that varies from sector to sector, it may not be necessary for a one off import nor where the product is an effective substitute for an existing Chinese product but for innovative new technologies it can be a significant hurdle to overcome.

It used to be the case that for each sector there were designated technical institutes who had to be consulted for any certification process, In recent years this has become a more open and competitive process with different institutes vying for authority in each sector.

For the water sector one of the main institutes was China Water Enterprises Confederation (CWEC)[7] who can provide advice on certification.

There is also the China Compulsory Certification (CCC). This is a compulsory safety evaluation system that is applied to certain products that are imported, sold or used in China (more information and requirements per product can be found at www.cqc.com.cn). The system is regulated under the Administrative Regulations on Compulsory Product Certification. CCC approval is required for both products manufactured domestically and overseas. Goods that are covered under the CCC system may not be delivered, sold, imported or used in other business activities until they are certified and labelled with a CCC certification mark.

For products that are subject to compulsory product certification, the State will ensure that the product catalogue, the compulsory requirements, standards and conformity assessment procedures for technical specifications, the certification marks and the charging standards will be the same across China.

Products for importation are exempt of CCC if they are: for personal use; are samples that will be returned to place of origin, are components of a product that will be certified or will be exported, are components of equipment for the manufacture of goods that will be exported; are for repair purposes.

Identification of clients

Before there can be any hope of being able to establish a business and undertake marketing it needs to be established that there is a client or consumer who is going to be in a position to buy the product. This may seem obvious, but it can be quite difficult to establish who the ultimate clients are and who within client

[7] http://www.cda-ida.org.cn/en/

organisations will be the decision maker and at what point in a procurement process they should be contacted. If this cannot be established then the only option would be to engage with a government department who may be able to undertake preparatory work to establish conditions and situation in which the product can be commercially applied, if they think that the benefit would be great enough.

Procurement routes

Understanding of the procurement process of the water market is vital to successful market entry.

This is a large topic which is dealt with in section 1.5 on procurement.

Business registration, cross-border payment, legal processes

1. EU companies may export their products or transfer/license their technologies to China.

If not sold directly to Chinese end users, products have to be exported through distributors which gives very little control to the originators of the products as well as limited access to the market. Technology is the core competence of many EU companies trying to open the Chinese market thus they are advised to first develop a transfer strategy and protect themselves against losing control and ownership.

In fact in order to trade in China, many EU companies consider investment in China which gives them more access to the market due to the on-the-ground operation in China. In this case some sort of business registration will be required, among which foreign invested enterprises (FIEs) like wholly foreign-owned enterprises (WOFE) and joint ventures (JV) are the most common forms. You may find detailed information in this aspect from the guidelines and reports of the EU SME Centre at http://www.eusmecentre.org.cn/report/ways-enter-chinese-market and http://www.eusmecentre.org.cn/guideline/establishment-foreign-invested-enterprise.

With FIEs established in China, EU companies may have more options regarding their technology application in China. For details, please refer to the Centre's guideline on Technology Transfer Agreements with China at http://www.eusmecentre.org.cn/guideline/technology-transfer-agreements-china.

Below is an example for readers' reference.

Case Study: Belgian Tank and Boiler Producer

- A Belgian company designs, manufactures and distributes engineering solutions for hot water generation. The company decided to enter the Chinese market.
- Before entering China, the Belgian company applied to WIPO to register its trademarks and appointed China as a protection country. Therefore, the trademark was protected both in the EU and China.
- The Belgian company established a WOFE in Beijing with an investment of CNY 4 million.
- The WOFE also applied and obtained importation and exportation licences to import the products from its headquarters.
- The WOFE signed distribution and agency agreements with local distributors and agencies to sell products in China. Meanwhile, the WOFE also sells products through its own channels.
- With this business development, the Belgian company increased its investment as capital in the WOFE by CNY 3 million.

2. RMB is not a fully convertible currency yet. Cross-border payment from China towards EU companies for trade in products sale or technology transfer or between FIEs and their EU parent companies for investment contribution or dividend repatriation has to be made in convertible foreign exchanges thus involves the foreign exchange administration in China which is comparatively strict.

In China, foreign exchange administration is co-managed by two government organizations: the People's Bank of China (PBOC) and the State Administration of Foreign Exchange (SAFE). Both organizations have offices in all major cities and regularly share the same office space as well as occasionally some staff. SAFE is the key point of contact for all daily operations and issues in regard to China's foreign exchange

administration policies. Local SAFE offices have some room to interpret currency control regulations themselves resulting in a set of consistent national principles but inconsistent local regulations.

The administration is made by supervising flow of foreign exchange currency via two types of accounts: capital account and current account. Capital account items are strictly restricted, while current account items are much less restricted, daily administration of which is mainly entrusted to local banks through examining documents required. Payment for trade in products or technology or dividend repatriation is categorized as that under current account items.

However, even for the less restricted current account items, requirements for documents may vary in practice with the change of macro-economic policies in China. Practice may change often and abruptly without prior notification. It is therefore important to contact your local bank and SAFE office to understand what rules your different operations in China have to follow and to ensure strong local relationships as specific cases need specific solutions that need to be agreed on at a local level.

Foreign-invested entities (FIEs) need to establish at least 2 bank accounts: an RMB basic account and a foreign currency capital contribution account.

Companies registered in China including FIEs need approval from the transmitting Chinese bank to send foreign currency overseas. This requires a:

- written contract for the goods or services which is signed and dated by all parties
- formal written invoice for every required payment which is signed and dated by the European company in a form acceptable to the bank

It is advisable that both documents include a Chinese translation.

Chinese banks may ask for additional documents such as:

- proof of existence of the European company
- contract registered in accordance with Chinese law if payment is a royalty for a technology licence or similar agreement

Detailed information on payment issues can be found in the guideline of the EU SME Centre at http://www.eusmecentre.org.cn/guideline/payment-options-and-foreign-exchange-control-china.

Moreover, the anti-bribery and corruption regulations of China place many restrictions on the transfer of funds to overseas bank accounts. Rules which are there to stop illegitimate transfers of public money out of the country can also prove to be a major problem for legitimate business. This has been a major problem for foreign companies operating in China – even for payments to their WOFE in China and especially for transfer payments from the WOFE to the parent company. Though since late 2016 this has become a little easier as rules become more established – getting a contract and agreed payment terms with a Chinese client does not necessarily mean that the client will be able to pay on time or at all despite their best intentions.

In conclusion, the best practice and recommendations in relation to getting paid for export to China by EU SMEs will include the following:

- To carefully review the export contract and proactively check with banks regarding the documentation requirement and application procedure for payment
- To engage experienced importer and learn about importer status
- To learn the latest regulations and local practice of SAFE and banks for goods and service trade
- To discuss with banks to better understand the risk and benefit of proposed payment options based on the available bank products
- To engage a professional advisor to assist to conduct PRC tax implication assessment and go through relevant procedure with tax authorities if any

3. For relevant legal matters there are many firms specialising in supporting foreign enterprises in China. EU SMEs may also access the service providers' database of the Centre at http://www.eusmecentre.org.cn/service-providers where you will find a list of potential leads e.g. law firms in China.

Reliable partners for distribution, installation, training and operation.

The type of partners required varies based on the type of business that is being conducted:

- The simplest model would be selling a product manufactured in EU as an export item to consumers (domestic or trade), for this a distributer is required to help with import / customs, marketing, sales, installation, maintenance and customer service;
- More complex is setting up local manufacture of similar items for sale to market;
- Then there is sale of larger items of specialist equipment to industry or to infrastructure projects;
- Finally there is the process of fully engaging in the procurement processes for major projects, setting up PPP companies and delivering utility services to government clients.

For a consumer focussed product, e.g. a domestic water purification, heating and cooling appliance - this can be similar to other consumer products – find regional agents and distributers to put the product into shops or online portals, and follow-up with delivery, installation, maintenance etc. In this model it is often important to have multiple partners to cover different geographical areas. China is big and few companies have complete coverage. Having multiple partners can add to complexity but also adds resilience if one relationship runs into problems then the whole venture is not lost.

For more complex projects, supplying into government procurement processes then the partnering can become much more complex, requiring full business JVs which require very serious commitment to set up and manage.

The EU SME centre provides a lot of advisory material on this topic. Member State missions can also help in establishing partnerships and adding weight to negotiations which will be vital for big business partnerships and major infrastructure projects.

IPR protection and copying

Having Patent protection in Europe or US does not confer protection in China. You need protection specifically registered in China.

China is a first filed system so a Chinese competitor can see your product and international patent, then register something very similar in China before you register, then block you from sales in China or charge you license fees on your invention.

There are multiple levels of protection, each offering more comprehensive protection but taking longer to process (1 to 5 years) and requiring differing levels of disclosure:

1. Trademark;
2. Utility model;

3. Design patent;
4. Invention patent;

Protection has got better in recent years and there is less blatant copying going on but it is still a major problem. Trust of partners not to steal IPR is a serious problem. Until the registration process is complete you have no protection.

Once IPR is registered in China you do have protection and this lasts for the duration of the Chinese license starting from the date of registration. Thus, this protection lasts in China even if the original protection in the rest of the world has expired. This is good if you registered your own IPR in China first but can be bad if rival Chinese company registers your expired IP in China then sells against you in the rest of the world immune from challenge in China.

Many JV arrangements require the sharing of IPR on the products that are to be made, this is a legal requirement originating from government and a condition of getting business licenses.

This is an area needing specialist advice early in the process of bringing a product to China. Further details from EU IPR SME Helpdesk. http://www.china-iprhelpdesk.eu/

Company capacity

Any company that is considering entry to the China market must reflect if it really has the capacity and has planned carefully what it is going to do. There is no point in half-heartedly dabbling. There needs to be a plan of making some initial investigations into your particular market niche, reading and talking to people with experience, then if there is a good opportunity to make an initial visit to China. But the next stages of adapting a product to the Chinese market and finding the partners, networks and customers is a major undertaking which will require the commitment of a considerable amount of senior staff time and considerable expenditure. Building relationships and moving from introductions to contracts and then to doing real business take much longer than you would think and you need to be committed. Thus the company must build a strategy for market entry and ensure that their financing capital and revenues are sufficient to support the very expensive market entry phase.

Exit strategies

Depending on the type of product or service it may also be realistic to consider exit strategies. An innovative product may be successful for a while, but fairly soon, if it is doing well, local competition will develop. The choice is then whether you can innovate more and stay ahead, or bank the profits and sell up to a local partner. If the product has well protected IPR and has created a large new market together with a JV partner it may be possible to attempt an IPO in the local or international stock markets. This may be an ideal / dream exit strategy. The other way to counter local competition may be that, if manufacturing in China is to achieve lower costs, you move to selling more product out to overseas markets rather than continuing to try to beat local competition.

1.5. Procurement procedures

An important factor that companies wishing to participate in environmental-friendly product tender processes must know is that the government has certification systems that grant preferential treatment to companies that are approved and possess an Energy Conservation Certificate and China Environmental Labelling System. It is recommended that European companies wishing to participate in government tenders in this field obtain the certifications.

As there are already a number of players in the market, European companies may have an easier time entering China if they partner with a firm that is already well established. This partnership could take the form of a licensing agreement or through forming an alliance/ consortium to jointly bid for projects.

All levels of State authorities, institutions and social organisations are allowed to use fiscal funds to procure goods, projects and services that fall within the catalogue for centralised procurement.

There are two main types of government procurement – centralised and decentralised procurement. The difference between the two is that centralised procurement's scope is subject to catalogue for centralised procurement promulgated by people's governments at provincial level and above.

Procurement procedure for water projects in context of 5 year planning process.

In order to be able to get access to the China water sector it helps to have some understanding of how openly published policies and investment programmes are implemented as projects delivered by contractors and so how a European company might go about making the contacts necessary to get involved in such contracts. The government procurement system in China is open to foreign participation but foreign parties interested in the tendering for a bid must have an established Wholly Foreign Owned Enterprise (WFOE) or Joint Venture (JV) in China.

Open tenders can be found on a number of websites :

- http://www.ccgp.gov.cn/
- http://www.bidchance.com/index.html

There are also many provincial and municipal government websites. All levels of state authorities, institutions and social organisations are allowed to use fiscal funds to procure goods, projects and services that fall within the catalogue for centralised procurement. Bid process may be open or private. For some very large or politically sensitive projects such as Xiong'an New City the bid process is private and not open to foreign participation though it may be possible to sub-contract to a Chinese bidding consortium.

The following is an approximation of the process for water resources projects (similar processes would be in place for urban water utility projects, agricultural and industrial projects):

- The Water Resources Strategy is set out in policy by central government and indications are given of the expected level of financing;
- In consultation with the central ministry and technical advisors from research institutes, projects fitting this policy are prepared by local government with initial feasibility studies and costs. These Indicate how projects will contribute to the attainment of the various targets at national, regional and local levels and who will be responsible. Projects must match with specific plans such as flooding, irrigation, river rehabilitation;
- Each province collates plans for its cities and counties and passes list to central ministry for initial review;
- For selected projects more detailed feasibility studies may be done by ministry approved institutes (paid by province), for example GIWP;
- Projects then go to the water resources planning and programming department for technical assessment;
- List of projects approved to proceed passes to NDRC for financial assessment;
- List passes back to provinces - If funding is available then projects can commence with bidding process.

Central funding may be assigned for some projects prior to start, for others the central government will reimburse funds to the local government once the project is successfully completed. The Ministry of Finance has an important approval role in this. Where there is commercial scope for it then private sector investors will be sought to undertake the projects with private finance.

Following the general procurement procedure, the Ministry of Water Resources issued the "Provisions on the Administration of Bidding and Bidding for Construction Projects of Water Conservancy Projects", which apply to bidding and design activities such as surveying, design, construction and supervision of water conservancy construction projects and important equipment and materials procurement related to water conservancy construction. The provisions specified that the only two procurement method used for water conservancy projects are public tender or tender by invitation. The document also clarified for different kinds of water conservancy projects, what qualifications are expected for tenderers to enter the competition. http://ztb.jsxx.gov.cn/themes/read.aspx?newsid=3920

General procurement background

Procurement in China is primarily under the regulation of two national laws: the Government Procurement Law (GPL) and the Tender and Bidding Law (TBL), and local government procurement measures. All procurement activities, as the obtaining of goods, projects and services in the form of contracts for consideration, including by acquisition, lease, appointment, and employment, must work under GPL, with the exemptions of military, emergency and national security procurements, procurement with international loans, and procurement of mechanical and electrical products.

GPL and TBL have created two distinct procurement processes, subject to two distinct procurement laws for two distinct sets of goods and services. Below we outline the processes, procedures and key players for each of these systems.

GPL

The current effective China's Government Procurement Law (GPL) was revised in 2014.The goods and services governed by the GPL are generally limited in scope to such goods and services required by government and affiliated organisations for operational purposes only. Beneficiaries of this government procurement include central and sub-level ministries, schools, hospitals, institutes, etc., but not state-owned enterprises. Such goods and services frequently include office equipment and supplies, construction and upkeep of government buildings, purchases of government vehicles, IT for government departments, etc.

The complete list of goods and services subject to the GPL are listed in China's Centralised Procurement Catalogue. They form part of the government's annual central planning budget and are subject to the GPL and the GPL processes which are administered by China's Ministry of Finance (MOF).

Centralised procurement catalogue of both central government and level local government level and government procurement announcements on the website of Central Government Procurement Centre (CGPC) at www.zycg.gov.cn and website of each level of government procurement centre (GPC) such as Beijing GPC at www.bgpc.gov.cn Alternatively, they can be found collectively on the website of China Government Procurement Web authorised the MOF at http://www.ccgp.gov.cn/

However, the large "public works projects" or construction projects financed by the government or led by state-owned enterprises are not subject to the GPL. Instead, this much larger portion of the procurement market is governed by the Tender and Bidding Law (will be discussed in the next section "TBL").

1.5.1. Tendering and Bidding Law (TBL)

In addition to the Government Procurement Law, China's procurement processes are also governed by a second law — the Tendering and Bidding Law (TBL). Whereas the GPL applies to all items purchased through the government budget process, China's TBL, which was revised in 2017, outlines the tendering process to be followed by state-owned enterprises and private companies that receive government financing (either Chinese, foreign, or international such as the World Bank). These projects are generally referred to as "public works projects" and include large scale infrastructure projects such as power generation and supply, public transportation development, water and sewage plants, etc. China's NDRC oversees the implementation of this law. The market for goods and services falling under the Tender and Bidding Law is roughly eight to ten times the size of the market for which the Government Procurement Law applies. Projects under the Tender and Bidding Law are therefore generally of greater interest to private firms. Furthermore, unlike the GPL, TBL has no requirement for the use of industry catalogues. It is strictly within the remit of the purchaser to set the requirements. TBL allows for multiple procurement forms, it may be contracted by public tender, private tender or tender by invitation, competitive negotiation, single-source procurement, inquiry and other methods approved by the State Council regulatory authority for government procurement. Among these methods, public tender is considered as the default method for government procurement while the other five methods can only be used under prescribed situations.

Specific details for public tender of public works projects is generally more flexible under the TBL, making it less predictable and transparent, but it still follows a similar structural process as that outlined within the GPL, consisting of tender preparation, tender announcement, bid preparation, bid review and selection and winning bid announcement.

Sources for the announcements of projects will vary; however, www.chinabidding.com.en (EN version) is recognised as one of the most comprehensive websites for project announcements under the TBL.

The State Council Development and Reform Commission in conjunction with the relevant ministries and commissions of the State Council will set the standards for the specific scope and scale that a procurement is compulsory to undergo public tender. The State Council Development and Reform Commission direct and coordinate the bidding of the whole country, and carry out supervision and inspection on the bidding activities of all major national construction projects. Other ministries and commissions carry out provisions of relevant bidding activities in accordance of their divisions of responsibilities.

At provincial, municipal and county level, the development and reform departments also direct and coordinate the bidding activities in their respective administrative areas while other relevant departments in accordance with the stipulated responsibilities, supervise the bidding activities and investigate and punish

the illegal acts in the bidding according to law. Meanwhile, the financial department will supervise the budget implementation of the government procurement project and the implementation of the government procurement policy, and supervisory organ will supervise any relevant bidding activities.

Apart from supervision and regulation, as mentioned, local governments above county level can also publish the government procurement measures applicable within their jurisdictions. Local government procurement measures can be collectively found on the website of China Government Procurement at: http://www.ccgp.gov.cn/zcfg/dffg/ . For instance, in 1998, Shenzhen Special Economic Zone enacted its own procurement rules, under which public bidding is required for contracts to purchase goods or services excessing RMB100,000, and contracts to rent, repair and landscape excessing RMB200,000[8]. Understanding both national and local procurement measures is necessary for securing contracts in China. Meanwhile, successfully obtaining contracts in China can also mean working with various commissions, ministries and departments, to get guidance, certification and political support which may require significant effort over a number of years by foreign companies.

Projects under state-owned funds also undergo public tendering according to the law, which means fierce competition and involvement of other factors such as personal relationships, unless the project falls into the category of a special prescribed situation. One of those situations worth mentioning is the need to adopt a non-substitutable patent or specific technologies. A European company that enjoys the advantage of a proscribed patented technology can actively seek out and approach the client in order to establish an early involvement in the competition.

Meanwhile, China requires government procurement to be derived from domestic sources, with prescribed exemptions of military, emergency and national security procurements, which includes where the required goods, projects or services are not available in China, or are not available under reasonable commercial conditions and the objects of procurement are for use outside of China. This clause seems to pose serious challenges for foreign competitors, but the GPL does not define domestic goods, projects or services, and this rule applies only to procurement for government-invested projects that are within the scope of the GPL.

General procurement procedure

[8] http://www.ccgp.gov.cn/zcfg/dffg/shenzhen/201310/t20131025_3185003.htm

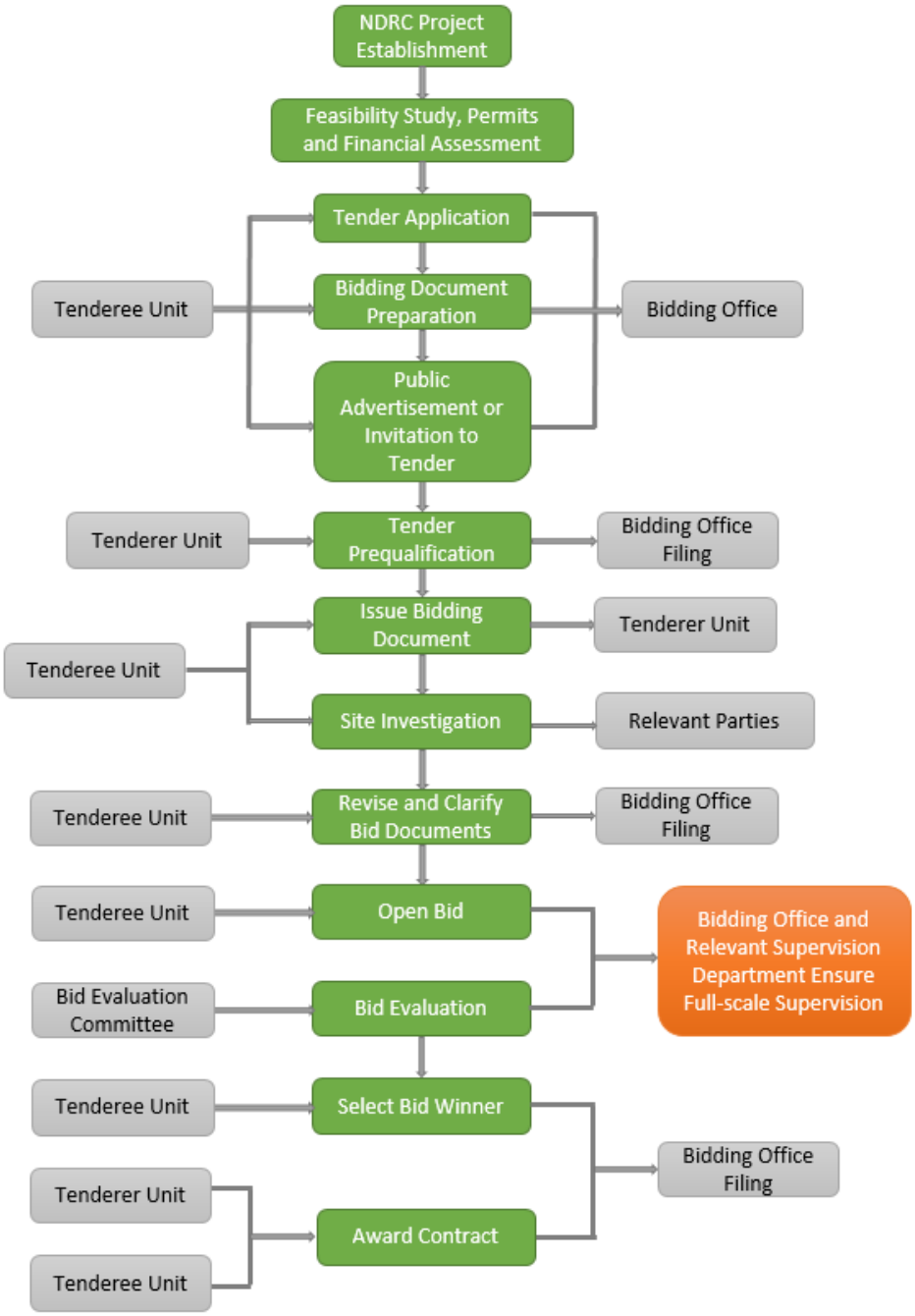


Figure 1-5 General procurement procedures

Timing aspects

Before starting the bidding process, the tenderee needs to ensure the project has approval and complete a series of filing processes. Then, after the bidding document has been prepared, tenderee unit will place public notice in newspapers, network or other media;

The tender notice should be published in the media for three consecutive days; the tender notice issued to the deadline for entry should be at least 5 days. Then tenderee, with the assistance of designated bidding agency, will assess tender prequalification (mandatory requirements) and issue tender documents to different competitors that meet these requirements. There may also be payment of fees;

According to the TBL, at least 20 days bidding time must be allowed from issuing bidding documents to submission of bids. For most bidding projects, it will also involve site investigation and the revising of bidding document before the bid actually opens. Then, under the full-scale supervision of the bidding office and relevant supervision departments, a bid evaluation committee will select a bid winner, after which, if no complaints occurred within 5 days, the tenderee may issue the letter of acceptance to the winning tenderer.

The tenderee and successful tenderer should sign the contract within 30 days of issuing the letter of acceptance. There may be presentations of bids by shortlisted tenderees with a panel of eminent experts appointed to join the evaluation committee. These experts are often selected from Academies of Science or are respected retired officials, they may be more conservative than the client when evaluation innovative solutions to a challenging brief.

Goods and Services:

For either goods, projects or services, the procurement procedure will show certain differences while still following the general procedure shown above.

Procurement procedure for goods

- Prepare preliminary equipment list and cost estimates;
- Prepare final equipment list and cost estimates;
- Prepare bidding documents;
- Advertise (specific procurement notice);
- Issue bidding documents;
- Receive and evaluate bids and select the lowest evaluated bidder (LEB);
- Award contract;
- Issue performance security;
- Deliver goods (at pot or site as specified in bidding documents);
- Install and commission;
- Acceptance certificate;
- Warranty period;
- Contract evaluation.

Procurement procedure for civil works

- Advertise qualifications;
- Receive prequalification information and data;
- Select qualified bidders;
- Prepare preliminary design, drawings and cost estimates;
- Finalise design, drawings and cost estimates;
- Prepare and issue bidding documents to selected qualified contractors;
- Receive and evaluate bids and select the lowest evaluated bidder (LEB);
- Award contract;
- Performance guarantee;
- Mobilize and gain access to site;
- Begin construction and take over site and works;
- Maintenance period;
- Contract evaluation.

Procurement procedure for consultation

- Develop a program and cost estimates for consulting services;
- Advertise for expressions of interest;
- Prepare RFP including shortlist, TOR and form of contract;
- Finalise consultation program, TOP and cost estimates;
- Invite proposals;
- Receive and evaluate technical proposals;
- Open and evaluate financial proposals;
- Approval of final report;
- Negotiate contract with consulting firm with highest score;
- Award contract;
- Bank guarantee;
- Mobilize and begin assignment;
- Carry out assignment;
- Performance evaluation.

Key market segments in water sector

The following table lists the six market segments in water sector and the potential in-charge authorities, which may vary depends on the nature of each specific project, to understand the development plan/trends and policies.

Key Market Segments	Sub-segments	Key In-charge Authorities
1 Urban Water	• Climate Change Adaptation, Local Rainwater Harvesting Solutions • Blue-Green Urban Development • Flood Risk Management and Dike Safety • Reinfiltration of excessive surface water to groundwater	• Ministry of Water Resource of the PRC • National Development and Reform Commission • Ministry of Housing and Urban-Rural Development of the PRC
2 Rural Water (rural areas and smaller cities)	• Agricultural Water Use, incl Irrigation • Water Supply for Rural Cities and Villages • Decentral Wastewater Management (Small-scale WWTPs) • Biological Wastewater Treatment • Groundwater Management, including Monitoring, Protection and Extraction	• Ministry of Ecology and Environment of the PRC • Ministry of Water Resource of the PRC
3 Water & Energy	• Small Scale Hydropower • Water Use for Fossil Energy Production (Coal, Shale Gas, Oil etc) • Large-scale Hydropower • Desalination	• National Energy Administration, • National Development and Reform Commission
4 River Basin Management	• River Basin Management and Planning • Water Quality Monitoring Equipment and Software • Restoration of Wetland, Lakes and Rivers • South-North Water Transfer Project	• Ministry of Ecology and Environment of the PRC • Ministry of Water Resource of the PRC
5 Waste Water Treatment – Water Supply - Utilities	• Large-scale Water Supply • Non-Revenue Water / Reduction of Water Leakages • Urban Wastewater – Construction of new WWTPs • Urban Wastewater – Upgrading of existing WWTPs	• Ministry of Ecology and Environment of the PRC • Ministry of Water Resource of the PRC
6 Industrial Water Use	• Water Use and Discharges, Fruit and Vegetables Production • Water Use, Food Processing (Diaries, Butcheries, Bakeries etc) • Water Use and Discharges, Non-food Processing (Paper, Textile, Steel, Electronics etc) • Water Use and WWTPs, Industrial Parks	• Ministry of Ecology and Environment of the PRC

Observations for EU SMEs

Chinese private enterprises are the key players in the construction market, with a group of large state-owned enterprises (SOEs mostly involved in infrastructure building) accounting for the rest. Foreign companies make up almost 1% of the Chinese construction industry. Western companies are mostly focusing on niche markets in which they enjoy a technological or brand advantage over local competitors. This limited exposure is the result of a series of factors, which can be summarised by the following categories:

- **Regulation**: in many construction industry subsectors, foreign or even recently established Chinese entities experience strong regulatory constraints. European companies, including architects, quantity surveyors, project managers and contractors, face legal barriers to entering the Chinese market,

preventing them from sharing their world-class expertise and cutting-edge technology with Chinese players;

- **Business practices**: As in many other Chinese sectors, business is often awarded by means of "personal relationship". Relationships are often more important than the quality of products and services. Business is to some extent promoted through practices that Western companies are unable to follow;
- **Price competition**: the Chinese construction market is still in the relatively early stages of development, and social structures do not foster quality considerations. Builders (very often local mayors or real estate developers) are keen to use their budget to build more and their focus is generally not on creating a better quality infrastructure.

For EU companies willing to be engaged in China's government procurement projects, it is suggested to go to the bidding website www.chinabidding.com.en to search project tender information by sector, including tendering announcement, issuing organisation, evaluation results etc.

The competition in water sector is fierce, but there are still opportunities for EU companies (Veolia, Atkins and Mott Macdonald are good examples), especially in certain niche areas such as specific precise instruments and equipment, project management and consulting, post-project management and maintaining etc.

An efficient way for EU companies is to approach Chinese bidding agents or winning bidders for cooperation.

Case Study- Green Tech[1]

- GreenTech is an example of an SME based on European water industry experience and technology which was established as a European–Chinese joint venture company with design and manufacturing based in China and only servicing the Chinese market.
- GreenTech is a "water only" technology and engineering company and specialises in membrane system technology. They produce more effective process designs and housings for membrane modules supplied by third party manufacturers (mostly leading EU companies).
- They apply technologies such as micro-filtration, ultra-filtration, nanofiltration and reverse osmosis in large water treatment systems for wastewater reuse (both municipal and industrial wastewaters) and drinking water. They design, manufacture, supply and install these systems all over China.
- GreenTech operates through a variety of contract approaches including equipment sales, EPC contracting, public-industry-private-partnerships (PIPP), and performance security programmes (PSP), in which the company analyses and upgrades client facilities, providing equipment and training as well as partially finances required investment in exchange for long-term returns.
- Over the years, they experienced steady growth which eventually became limited by their access to capital. Equity investments first from Abengoa water of Spain and then by BEWG of China (taking over from Abengoa) allowed the company to expand. It now acts as a part of the BEWG group of companies, this gives it some access to additional capital through BEWG and to BEWG projects across China (BEWG is China's largest water company).

Identify potential difficulties for foreign competitors to win contracts in China

- The difficulty of obtaining timely, accurate information about upcoming projects;
- Liaison with various commissions, ministries, and departments;
- A lack of understanding of projects' evaluation criteria;
- Fail to link national and local development strategies to project opportunities;
- The trend towards decentralisation of tender information - leading to higher costs and less transparency;
- Potential unfair implementation of public procurement awards.

On 17 January 2017 the State Council published the "Notice on several measures on promoting further openness and active utilisation of foreign investment (Guofa [2017] No. 5)" This circular aims to address some of the above concerns by, Article X, promoting standardisation reform, information disclosure and supervision as well as, Article XI, procurement reform promoting openness, transparency and fair

competition by treating foreign and local bidders equally in procurement of manufactured equipment and for government contracts. How effective this will be remains to be seen.

Restrictions on foreign enterprises when pre-qualifying for procurement processes

Apart from the GPL, in order to enter the Chinese market, EU companies providing engineering consulting services need to be aware of the Interim Provisions on the administration of foreign enterprises engaged in construction engineering design activities within the territory of the People's Republic of China issued by the Construction Commission. These require that the company hold appropriate licenses and grade certification as a provider of engineering services. The requirements for this are often to have a sufficient number of qualified and experienced engineer staff in local offices and a track record of successful projects **in China**. Of course, without the license it is not possible to gainfully employ such staff or such in country track record, thus this is a near insurmountable barrier.

A possible way around this is to acquire or form a JV with a local company that already has such certification and transfer that certification to the new entity, or to a partner with a design institute that does have the necessary certification to sign off designs and pass the drawings to them for approval before issue. The acquisition option poses serious financial and management challenges. However, it is not possible to continue to use their license unless you retain the requisite number of registered professionals and there are few examples of its being successfully done. The partnering option can work and is often done but can also lead to very difficult situations if there are disagreements between partners during the course of the project.

There has now been an introduction of a super-A licence for which allows design in all areas, although foreign companies are unable to obtain this.

These certification restrictions only apply to the final design stages, conceptual planning and design is not restricted and foreign companies can compete effectively in the conceptual and outline design stages of projects.

The limitation on engineering licenses plus local low price competition for detailed design effectively means that only the high level conceptual engineering and feasibility markets are open to foreign engineering firms or very specialised niches such as structural engineering of complex projects. Such services come mostly at the front end or bid stage of projects and are often provided for free by the local design institutes who are then “paid” once awarded the main detailed design contract. It is hard for foreign firms to engage in this process as they would have to put up a large amount of risk capital to enter the game. This stands for projects in China and for China outbound projects let directly or through PPP vehicles.

The final major market access issue was the lack of qualification recognition. Currently, the Institute of Structural Engineers recognises Chinese educational qualifications with a conversion exam. It is not the same for European qualifications, which are not recognised in China, therefore a lack of reciprocity.

1.6. Public Private Partnership

The water supply and wastewater treatment services of a lot of Chinese cities, particularly smaller cities, are provided by companies owned by local government. These have generally been derived from what were local government departments but have reformed as nominally financially and administratively independent entities. Normally, those companies have very limited access to finance and new technologies. Moreover, their human resource arrangements are often insufficient as they do not invest sufficiently in training and up skilling their employees. Local governments have therefore embraced the practice of introducing private sector companies to provide public water infrastructure and services on a term contract basis.

The first private sector water contracts in China were tendered in the late 1990’s with French multi-national company Veolia Environment being awarded an 18-year BOT contract for the Chengdu No. 6 plant in 1998. Following this there was rapid expansion of private sector water contracts in China, first in water treatment and then in wastewater treatment. China rapidly became by far the largest market in the world for private sector water ventures.

Initially all of the contracts were for BOT with private international water companies – with Veolia, Suez, and SAUR, Thames water being awarded the most. After the turn of the century, regional companies from Singapore, Hong Kong and Malaysia became more involved and international projects included more partnerships with Chinese companies. In 2002 the Chinese government changed the rules on fixed percentage return contracts and on paying for take or pay contracts when poor planning meant demand was lower than anticipated. This led to the exit of most of the international companies apart from Veolia and Suez. This coincided with an increase in Chinese companies taking on BOT contracts. From 2005 onwards,

there was a relaxation in the rules to allow variations on BOT to include concessions and management contracts for water treatment, supply networks and in some cases sewerage and treatment networks for joint venture companies. In the period up until the 2008 economic crisis this triggered a boom in both national and international investments in China's private water sector. Following 2008 the boom subsided markedly, especially for international companies for whom financing new ventures had become much more difficult. The current market in China is dominated by a few big local players who combine their utility business with financial services businesses. These are the likes of Beijing Capital, Beijing Enterprises Water Group, Sound Group etc. However, for new contracts there is an increasing diversity of bidders as the major Property and industrial / energy contracting companies seek to enter this space, so companies like PowerChina and China Communications Construction Corporation (CCCC) or event the massive China State Construction Corporation (CSEC) are entering and competing in this market. This has seen returns on investment for such contracts squeezed to very tight levels.

Increasingly for larger infrastructure projects there is a prohibition on foreign companies being able to control assets. The Catalogue for the Guidance of Foreign Investment Industries (published annually, here referring to 2017) requires certain projects involving foreign capital to be constructed through a Sino-foreign joint venture and the Chinese partner may need to hold a majority ownership. For example pipeline networks for gas, heat, water supply and sewage in cities with a population of not less than 500,000 must have Chinese parties holding a relative majority of shares in the company.

Though there are various policy and guidance documents, there is no specific law concerning the regulation of public utilities or private sector participation in the sector[9]. There are plans to issue a draft PPP law for consultation shortly (as of May 2018).

Chinese law does not require developers and contractors to adopt standard contracts. Construction contracts must however be recorded and filed with the local construction department where the project is located, in the required format for the locality. The uncertainty about the regulatory environment has restricted the efficient development of the sector. This is especially true for international companies who are reliant on a clear legal and contractual process to complete the required due diligence for major financial commitments, and are less able to define the security inherent in complex relationships with clients and local governments.

The government does not issue a mandatory model PPP contract, but the Ministry of Finance and the NDRC both released their own contract guidelines (to be used reference purposes only):

- Contract Guide for PPP projects (Trial), issued by the Ministry of Finance, on 30 December 2014, is an appendix to Notice of the Ministry of Finance on Regulating the Contractual Management of Public-Private Partnership (2014);
- Guide to General Contract for Public-Private Partnership projects (2014 Edition), issued by the NDRC on 2 December 2014, is an appendix to Guiding Opinion of NDRC on Public-Private Partnership (2014).

NDRC and MOF have each issued their own guidance for PPP procurement processes allowing for open competitions, invitational bidding, single source negotiations, and competitive negotiations.

Given increased local government debt, new forms of PPP are now evolving in China, especially build-transfer arrangements which also include additional land transfers and residential development approvals in lieu of payment for major infrastructure constructions. Put simply: you build a WWTW or road etc. and we give you some prime land you can build apartments on and then sell to pay for the infrastructure construction cost. It can be difficult for a foreign water services company to have the depth of local contacts required to exploit these new build – transfer opportunities.

There are other increasing tangible and intangible barriers for European companies to win water contracts in China. Local governments naturally favour granting water contracts to local companies, especially if owned

[9] Some important policy papers issued are "Accelerating the Marketization of Public Utilities" (No.272 Policy Paper of the MOC, 2002), the "Measure on Public Utilities Concession Management" (No.126 Policy Paper of the MOC, 2004), and the "Opinions on Strengthening Regulation of Public Utilities" (No.154 Policy Paper of the MOC, 2005). NDRC Notice on Effectively Implementing the Public-Private Partnership related Work in the Traditional Infrastructure Fields (Fa Gai Tou Zi [2016] No. 1744); MOF Interim Financial Measures on Public-Private Partnership Projects (Cai Jin [2016] No. 92); MOF Notice on Promoting the Work of Public-Private Partnership in the Field of Public Services (Cai Jin [2016] No. 90); NDRC Guiding Rules for Implementing Public-Private Partnership Projects in Traditional Infrastructure Fields (Fa Gai Tou Zi [2016] No. 2231)

by local government. Foreign companies therefore feel that water contracts often do not always go through a transparent and fair tendering process. The legal rights of the water services companies are not protected properly. It is often the case, particularly in less developed regions, that the service fee that is due to the services companies is not paid on time or in full. This can be caused by various factors but mostly it is because the government cannot collect enough treatment fees from the customers, due to their limited reach out to customers, or that the level of the fee was initially set too low so cannot cover the costs. Occasionally, the local government deliberately violates the contract, and uses the treatment fee collected from the customers for other purposes, instead of paying them to the services companies.

Other developments in the wastewater sector arising from 12th and 13th Five year plans are the massive increase in schemes to provide wastewater services to rural areas – small towns and villages let on a regional basis, the capital cost of which is heavily subsidised by local government but the operational costs will have to be met by the community, thus driving designs towards minimum OPEX solutions. These opportunities are difficult to be met by international companies.

The factors mentioned above have affected the willingness and penetration of international water companies to provide services in China. A more detailed analysis of the factors related to foreign PPP companies in China can be found at:

- http://www.sciencedirect.com/science/article/pii/S0263786309001215
- https://thelawreviews.co.uk/edition/the-public-private-partnerships-law-review-edition-4/1168039/china

As of December 2017, China is reported as running 14,220 PPP projects valued at 17.8 trillion yuan ($2.7 trillion)

1.7. Organisations and policies for innovation promotion

The Chinese government has taken steps to try to help overcome some of these barriers. The following are some of the organisations, policies and catalogues for encouraging international cooperation in the field of environmental technology. More details of these are given in the PIANO project report[10].

1.7.1. Organisations

Just as in Europe there are many innovation promotion and development organisations, in China there are lots of organisations at central, provincial and local levels who have an interest in finding technologies from around the world and bringing these to Chinese markets. Further information on these is provided in the EU-China PIANO Report Appendix A and from the referenced websites.

Key organisations include:

At state level:

- China-European Union Science & Technology Cooperation Promotion Office (CECO)[11];
- The Foreign Economic Cooperation Office (FECO)[12];
- The International platform for environmental technology (3iPET)[13];
- China Association of Environmental Protection Industry (CAEPI)[14];
- The MWR Science and technology promotion centre[15].

Some examples at province level:

- Jiangsu (Yixing) Institute of Environmental Industry (JIEI)[16];

At city level:

[10] See: Report WP3.2 Barriers Drivers and Strategies Appendix A, PIANO Project , http://project-piano.net/piano-documents/reports/

[11] http://www.cstec.org.cn/ceco/en/index.aspx

[12] http://en.mepfeco.org.cn/

[13] http://www.3ipet.cn/?f=index2&lan=en

[14] http://www.caepi.org.cn/index.html

[15] http://www.cwsts.com/

[16] http://www.jiei.cn/english/index.php/index/index.shtml

- Beijing Municipal Research Institute of Environmental Protection[17];
- International Technology Transfer Network (ITTN)[18];
- Tianjin Academy of Environmental Sciences[19,20];
- Chongqing Environmental Protection Industry Association (CQAEPI)[21].

1.7.2. Policies

Key policies for driving innovation and encouraging international cooperation:

Plan of introducing international advanced water science and technology ("948" project)[22]

In 2009, the Ministry of Water Resources issued the revised management regulation of the "948" project which promotes import of technology in relation to water conservancy, which including technologies promoting sustainable development of water conservancy industries, technologies promoting the saving, protection and optimal allocation of water resources, technologies enhancing the development ability of water conservancy equipment and innovation ability of water conservancy science and technology.

Implementation plan of major environmental protection technology equipment and product industrialization project[23]

In 2014, National Development and Reform Commission, Ministry of Industry and Information Technology, Ministry of Science and Technology, Ministry of Finance and Ministry of Environmental Protection jointly issued the implementation plan of major environmental protection technology equipment and product industrialization project. In order to accelerate the improvement of the technical level and supply capacity of environmental protection technology equipment and products in China, this plan is specially formulated to meet the needs of pollutant emission reduction and ecological environment protection in China as soon as possible. The plan involved five major tasks and pointed out the key technology and equipment it focus on, which possess higher potential of technology import and international cooperation.

1.7.3. Catalogues

There are catalogues issued by particular ministries which identify the specific areas of technology to be encouraged and then support programmes to enable the development internally and by international cooperation, of such technologies.

Catalogue of technologies and products whose imports are encouraged (2017 edition, draft)[24]

In November 2017, National Development and Reform Commission, Ministry of Finance, Ministry of Commerce revised the Catalogue of Technologies and Products whose imports are encouraged (2016), and formed the draft catalogue of 2017 edition. This catalogue includes a number of technologies related to water environmental protection, which means imports of these technologies are encouraged. These include membrane and desalinisation technologies, various sewage treatment technologies for high strength industrial wastewaters and municipal and industrial sludges, nutrient removal for urban wastewater discharges, restoration of highly polluted urban rivers (including insitu treatment) and energy recovery from urban and industrial wastewater.

Catalogue of major environmental protection technologies and equipment whose development are encouraged by the state (2017 edition)[25]

This catalogue divides the technologies whose development are encouraged into three categories, technologies to be developed, technologies to be applied and technologies to be popularized. For water environmental protection area, these technologies are much more specific - graphene/macromolecule composite-material permeable membrane concentration equipment, waste water treatment equipment for

[17] http://www.cee.cn/
[18] http://ittn.com.cn/?lang=en-us
[19] http://www.taes.org/english/
[20] http://www.sec-tj.com/
[21] http://www.cqhbcy.net/
[22] http://www.mwr.gov.cn/zwgk/zfxxgkml/201304/t20130428_963785.html
[23] http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757018/c3763307/content.html
[24] http://www.ndrc.gov.cn/zwfwzx/tztg/201711/t20171123_867550.html
[25] http://www.miit.gov.cn/n1146295/n1146592/n3917132/n4061768/c5992309/content.html

flue gas evaporation and microbubble ozone reactors. For each important technology and equipment in the catalogue, corresponding supporting institutes and enterprises are listed.

2. Agricultural water

- Agricultural Water Use: Irrigation, Nutrient management and budgeting
- Recycling Wastewater for Rural Cities and Villages
- Reducing surface and groundwater water pollution
- Groundwater Management, including Extraction, Monitoring, Protection against overdraft

2.1. Background on agricultural water

Agriculture in China has been operated on a quite basic and small scale with many individual peasant farmers working together in communes to coordinate the process of raising crops, mostly by hand with very low levels of mechanisation. The underlying principle being that only the government may own the land and the people may form communes through which they are assigned rights to operate plots of land, normally in a cooperative manner. This has resulted in each farmer having access to only a small area of land that generates low income, and limits the options for entrepreneurial development using land as collateral. Investment could happen through government planned schemes or at commune level where there is strong local leadership.

The rural population has been moving to the cities at a rate of around 2.67% per year[26] while total population growth has stagnated. The remaining rural population are increasingly either the very old or very young with fewer of them able to work their small plots effectively. As a result, the area of land under the management of remaining active farmers increases and so the opportunity for investment in mechanisation and systematic approaches, by a professional farming class, increases. The wealth aspiration of the rural population and educational levels now reached mean that they are able and motivated to transition to more advanced arrangements that will close the wealth gap with urban populations.

Changes to land policy since 2016 have allowed for the separation of farmland ownership rights, contract rights, and operating rights, which allows farmers to retain the rights to their allotted land if they choose to lease the land out to others (after moving to a city for example) without violating the no private ownership of land principles of the communist party. Thus, formerly grey or informal arrangements of migrated farmers to allow others to operate their land and pay them rent can now be formal arrangements. Thus there are agri-businesses developing, who operate larger areas of land on a contract basis. These commune enterprises are better able to invest in infrastructure for irrigation, intensification, greenhouses and mechanisation etc. There are also commercial enterprises establishing in farming communities developing equipment leasing businesses. These enterprises have greater resources to engage with suppliers of agricultural equipment (national and international), to buy in bulk and lease to the emerging farm operating enterprises. The more secure arrangements for rights transfers mean that a farmer or enterprise holding larger areas of land can afford to hire labour. It is also now possible for labour service enterprises to establish such as roving harvesting teams providing seasonal work to many different clients.

These changes are leading inevitably to some instability with some enterprises being set up without proper financial backing, frauds and failures, but overall this transformation represents an opportunity for greater international engagement in the Chinese agricultural system.

Irrigation is required in most areas. There are many large scale / regional irrigation schemes and long distance transfers of water. Even in water rich areas, rice growing and fish farming require management of standing water in the farming system. Thus water management is a very important part of farming in China with the ministry of water resources having an important role in the agricultural management system, combining water resources management with soil conservation.

The 2018 ministerial reorganisation has moved the agricultural water and soil management functions of MWR, together with many of the agriculture planning functions of the Ministry for Agriculture into the new

[26] Analysis of Rural and Urban population statistics 2006 to 2016 from https://www.statista.com/statistics/278566/urban-and-rural-population-of-china/ matched with annual total population rise of 0.5% and migration rate of 2.66%.

Ministry for Ecology and Environment. New institutional arrangements are currently being developed[27] at provincial, county and city levels that will reflect this new ecological civilisation focussed structure.

More intense and high capital horticultural systems are being constructed, especially in closer proximity to cities or in urban / rural settings. Production of crops under green housing has greatly increased. 'Sponge Cities' and green infrastructure solutions are developed in new urban areas and so the opportunity increases for higher value systems where food production becomes a part of the urban infrastructure together with the provision of ecosystem services. Dual purposes such as urban recreation and green space provision can allow much higher infrastructure investment than pure food production.

The ecosystems services provided by the rural areas are formally recognised with various payment for ecosystem services pilots and very wide spread tree planting and forestation programmes which have transformed the landscape, reversed desertification in many areas and changed the balance of income of farmers from just production to a balance of production and service.

There is increased treatment of wastewater and availability of higher quality tertiary treated effluent which can be used for irrigation in urban settings. The spread of wastewater treatment to rural towns and villages also means that new sources of useable water are becoming available. The financial arrangements for such rural treatment works are very different to those for large municipal works. The operation comes under the village / commune / enterprise responsibility and the technology and the business model must be appropriate to that.

Water resources scarcity is driving regulation to protect groundwater and to consider management of natural recharge and installation of artificial recharge schemes to prevent further loss of resources. Regulations are also starting to curb the recent massive expansion of private / commune owned tube wells for groundwater abstraction which had contributed to the over exploitation of aquifers and abandonment of larger scale regional irrigation infrastructure.

To understand the role of the innovative technologies in the agricultural sector and their context in terms of opportunities, barriers and strategies we should consider the main elements of the water and nutrient cycle in the production system in the context of the economics of creating wealth by maximising valuable products and minimising production costs. Investment in infrastructure and technology is required to move to higher value production and minimise environmental impact and costs.

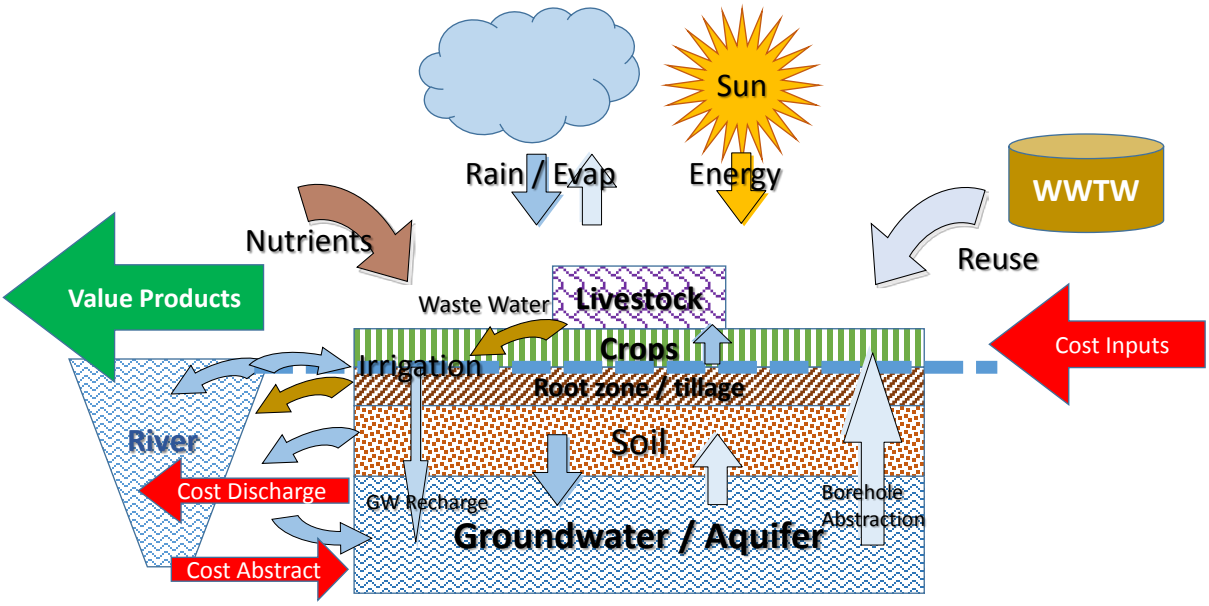


Figure 2-1 Adding value to agricultural water and nutrient cycles

[27] Interviews by PIANO team with MWR Development Research Centre (DRC) 27 March 2018, in Beijing, provided information on current changes and institutional arrangements but the uncertainty meant that a planned full workshop on agricultural water management could not be arranged.

Agriculture in China is moving to a more intensive mode of production, especially in areas closer to cities. There is the need to attain higher yields and optimise inputs of water and nutrients to minimise waste and negative environmental impacts, while ensuring adequate food supply (Kahrl et al., 2010)[28]. There is a widespread over exploitation of water resources, especially groundwater, and a need to increase recharge of available aquifers and to protect these resources against subsidence and pollution. There is also the need to integrate the increasingly intensive farming methods into the needs of developing a sustainable water resources, water quality and soil management system. Some parts of the cycle are regulated by government, setting standards and imposing tariffs for water use or pollution discharge. Currently in China's agricultural sector the costs of abstractions and discharges are relatively small and not fully enforced. There is also political and educational pressure to improve economic and environmental performance.

The intensification is most dramatically seen in the changes in livestock farming moving in just a few decades from villagers keeping a few animals as part of their mixed farm system to a global scale industry. China is now the world's largest producer of meat (48% of world total pig meat, and 12% beef and veal and 14% poultry in 2016 (USDA web query 2017)[29]. Most meat production in China has moved to intensive indoor rearing with western automated production methods being adopted. However, prices are still considerably higher in China than in US and Europe due to less efficient production techniques, leading to rapidly increasing imports to meet market demand (Gale, 2017)[30]. The demands for animal feed are driving much of the arable crop production and associated irrigation while the water demand of the confined animal raising facilities and the slurry and wastewater emissions have important water resources and soil and nutrient management impacts.

Water resources scarcity is driving regulation to protect groundwater and to consider the management of natural recharge and installation of artificial recharge schemes to prevent further loss of resources. Water resource abstraction fees apply to the use of water from rivers and groundwater (NDRC, 2013)[31]. Though these have been relatively low in the past they have risen sharply in recent years, especially for groundwater abstraction, so drive investment in water saving. However there is a difficult balance between keeping fees low enough that they do not make lower income farms unviable, and high enough that they are of significant to larger , higher income farmers. Penalties for pollution discharge have also increased. However, in China's agricultural sector the costs of abstractions and discharges are not fully enforced. Some progress in improving river water quality and protecting groundwater is evident in recent years but is slow despite massive investments ($100's billions) and systematic planning and reform under the five year planning system (MEP, 2017)[32]. Under the MEP and MOF 2015 Document 90 guidelines on implementing water pollution and control by PPP list: Livestock wastes, non-point pollution and rural wastewater, remediation of groundwater environment are among priorities for investment projects to meet performance targets.

Large state owned enterprises are now entering the agricultural and rural environment market. For example Sinohydro, part of the massive PowerChina Group have established a rural water technologies business to develop treatment and irrigation systems for rural enterprises. CASIC –China Aerospace Science and Industry Corp have set up divisions bidding for rural wastewater treatment and rural sustainable drainage contracts. Large SOEs also look to form partnerships with technology suppliers from overseas to extend their technical competence and gain technical advantage over local competition.

2.2. Market analysis

2.2.1. Opportunities

Investment in monitoring systems, linked to models for better crop management and water efficiency. Use understanding of plant condition and soil condition to accurately measure and budget nutrient and water requirements.

As farming becomes more intensive and soils are worked harder to produce more crop and achieve higher revenue per area so there is a need to ensure that the nutrients added to the field are appropriate, are in

[28] Kahrl, F.; Li, Y.; Su, Y.; Tennigkeit, T.; Wilks, A.; Xu, J. Greenhouse gas emissions from nitrogen fertilizer use in China. Environmental Science & Policy 2010;13:7

[29] USDA web query: https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery 2016 data comparison of China and World Total production. Accessed October 2017

[30] Gale, F. (2017). China's Pork Imports Rise Along with Production Costs. US Economic Research Service, USDA

[31] NDRC and MWR, 2013. Decision 29 on Bulk water pricing according to water scarcity of different regions

[32] MEP, 2017: The Water Pollution Prevention and Control Plan for Major River Basins (2016-2020) http://english.sepa.gov.cn/News_service/news_release/201710/t20171027_424220.shtml

balance between chemical and organic components with the soil biome. That appropriate ploughing / tilling, planning and harvesting techniques are employed and that quantities are tailored to the specific crops and conditions. Monitoring and modelling systems can increase the yield and revenue and so justify investment in infrastructure. Maybe some savings in consumption of fertilizer inputs.

- Moves to intensive and urban area farming and of higher value horticultural crops on more complex rotations increases the market for such systems;
- Regulations about diffuse pollution reducing nitrogen and phosphorous runoff will provide additional drivers for such solutions. In the MWR "Three red lines", Red Line for total pollution is supposed to include nutrient runoff, though not yet well defined. Certain areas of the country include nutrient sensitive zones (e.g. Lake Tai) where additional controls to nutrient runoff apply or are being piloted.
- The crop's need for water and for nutrients varies spatially and temporally. Correctly matching inputs to needs can increase yields, improve resilience to droughts and reduce the inputs required and the runoff and environmental impact of irrigation return waters and runoff;

- In addition to the monitoring of water quality parameters and of the plant and soils parameters and models there are geophysical parameters that are vital to evapotranspiration calculations and as inputs to water and nutrient balance models appropriate to crops, soil type and setting and meteorological conditions;

- As more and more WWTW in China have tertiary treatment added to them under regulatory and economic drivers, so there is increasing availability of recycled water as a resource. There are driving regulations and policies to increase the availability of recycled water. As WWTW are being constructed in rural areas so the availability of high quality re-usable effluent increases.

The water companies receive revenue from government for producing the effluent to set standards[33] they can attain additional revenue if they are able to sell that water to agricultural sector to pay for infrastructure and ultimately return profit. This would require raising from Class 2 effluent (Municipal discharge GB18918) to either Class 1A or to Surface water Class 4 (GB3838) or the Agricultural re-use standard (GB20922)

2.2.2. Barriers

Barriers related to nutrient management

- Farmer understanding: Education of the problems of incorrect nutrient balance and that there are solutions;
- Cost: the revenue from the market value of crops and the incremental improvement in yield and reduction in input costs needs to exceed the cost of the system;
- Regulations that penalise excess nutrient runoff and provide subsidies for reduced runoff need to be enforced and understood;
- Regulatory frame work, if weak will not drive change;
- Localisation of technology;
- Scaling market: sell to individual farmers, to village communes or to local government organisations / departments or at a province / national level;
- Implications of different tilling strategies on technology requirements – No tilling may require expensive drilling systems. Low levels of mechanisation of farming can greatly limit options compared to approaches in EU.

Barriers related to use of recycled water

- Public acceptance of the direct use of recycled water in irrigation;
- Cost of infrastructure of conveyance of recycled water to irrigation systems;
- Reliability of supply of recycled water;
- Undeveloped regulatory framework for the recycled water in agricultural context – standards and protocols for what to do with rejected water.

2.2.3. Strategies to overcome barriers

- Acceptance: the presence of monitoring and control systems will help ensure contaminants don't get through;
- Cost: more intensive farming method – greenhouses, year round rotations, GM crops etc will increase the revenue that can be generated per area of land, dependent on having sufficient water

[33] Environmental Quality Standards for Surface Water (GB3838-2002), MEP; The reuse of urban recycling water-Water quality standard for farm irrigation (GB 20922-2007); Discharge standard of pollutants for municipal wastewater treatment plant. (GB 18918-2002)

supply;

- Reliability of supply: demonstrating compliance with standards, identifying problems early and fixing. Understanding of the sources of wastewater and continuing availability in times of drought;
- Regulation and contracting: regulations and standards for recycled water exist (REFs see EU-China decentralised water reuse report) and are being updated (DRC add latest). PPP contracting arrangements are becoming more widespread and sophisticated – see UKTI PPP Training materials.
- Farmer training supported by local government, integrated with training in sustainable farming practices and appropriate crop selection. Government assistance in conveying market information of suitable crop selections in areas;
- Pilot projects and examples to demonstrate the situations in which investment into different levels of such systems will yield significant savings;
- Strengthening of regulatory framework (draw from some EU expertise?);
- Technology manufacturers to work through central government partners in China to find local partners (private sector and government) to help with the localisation of their technology, set up distribution and support networks;
- Would need some strategic support to agricultural universities and institutes to help with the localisation of the technologies and approaches;
- IPR issues through localisation process.

3. Municipal water management

- Water treatment systems
- Water Networks
- Consumer water saving systems
- Desalination / water recycle to source
- Wastewater treatment
- Sludge management
- Sponge Cities – Decentralised treatments and integrated urban catchment / green infrastructure
- Climate Change Adaptation, Urban Development

3.1. Background on urban water

Urbanisation and economic development has driven investment in urban water systems. The market is now quite mature and conventional centralised water supply and wastewater treatment systems are present in all large cities and most smaller to medium sized ones too. Administratively urban water is managed on a municipal basis with each city responsible for water and wastewater provision.

The water supply and wastewater treatment services of a lot of Chinese cities, particularly smaller cities, are provided by companies owned by local government. Normally, those companies have very limited access to finance and new technologies. Moreover, their human resource arrangements are often insufficient as they do not invest sufficiently in training and upskilling their employees appropriately. Since the start of the 21st century they have therefore embraced the practice of introducing private sector companies to provide public water infrastructure and services on a term contract basis. These "private" companies are in many cases actually state owned, but they act largely as though they were private in the context of a public private partnership systems.

13th Five Year Plan targets and drivers.

There are specific targets in the 13th Five Year Plan for water consumption and water quality. Most significantly, the plan aims to reduce water consumption by 23% from 2015 levels by 2020. China will also develop and upgrade urban sewage facilities. Water quality is targeted to improve through 2% reductions in chemical oxygen demand and ammonia nitrogen emissions. Wastewater treatment rates are set to increase to 95% in urban areas and 85% in non-urban counties.

This represents a significant increase in the quality and standard of wastewater treatment in urban areas and the extension of basic treatment to more rural areas. Much of this is also driven to improve source water quality and so achieve better quality drinking water by that means. There is also a move towards water eco civilisation and sponge cities solutions by which water treatment and storage are incorporated to urban green infrastructure design at local levels, this drives demand for very small package treatment solutions.

3.2. Discussion of market sectors

3.2.1. Water treatment systems

Though 97% of the urban population have access to centralised water supply, in 2005 less than half of this supply met the full set of water quality standards based on 35 measurements specified in 1995 (GB 5749-1995), leading to low public confidence in the quality of tap water. In new standards (GB 5749-2006, effective July 2012) covering 106 measurements (comparable with international WHO standards, were introduced to try to increase public confidence. National census data from 2011 published by the MOHURD shows that water from waterworks has a standard compliance rate of 83%, whereas the tap water standard compliance rate is only 79.6%. This indicates significant improvement there is limited public confidence in tap water quality.

98% of water treatment plants in cities above county level are based on simple conventional treatment processes such as coagulation sedimentation, filtration and disinfection, which is not sufficient to purify contaminated source water. Only a few plants in first tier cities use advanced treatment technologies such as ozone treatment and activated carbon to remove trace contamination. Traces of pesticides, pharmaceuticals, heavy metals and industrial discharges are present in many source waters and are not removed fully by conventional treatment.

The limited public confidence in drinking water quality means that it is normal practice to use bottled water, water cooler kegs or in house water purification devices domestically for drinking and cooking water. At the very least to boil water before consumption. This has created a large market in China for domestic water purifiers, heaters and coolers.

Great effort is needed to improve the quality of the source water to prevent contamination rather than treat after. In August 2016 MEP announced a commitment to push local governments to invest over RMB 430 billion in 4800 schemes to improve the quality of drinking water sources[34]. Wastewater treatment plants in source areas must also be upgraded to the 1A standard. Thus, water treatment should consider both the source protection and the treatment processes.

In Europe there is increasing attention being paid to integrated catchment solutions to problems of water resources quality and failure to meet river water quality targets. This is a focus on the removal of pollution at source in the catchment before it enters the watercourse. Changes to farming and livestock management (pesticide management, contour ploughing etc.), measures to prevent excessive algal growth and better management of the river channel, flow and morphology to encourage healthy, self-purifying ecosystems to develop can significantly reduce water treatment costs and meet environmental quality targets. There has been extensive research and investment to develop models and codes of practice for this type of management which could be adapted for China.

Observation of water and wastewater treatment plants run by major companies around China suggests that most have a degree of online monitoring, DSS and SCADA control systems with control rooms where the main process parameters can be seen and adjusted. Overseas manufactured components in these (e.g. Hach etc) are common though local manufacturers are increasingly competing and showing systems at trade fairs.

Though there was a large amount of involvement in construction of water supply plants for the major cities of China in the period 1998 to 2010, with companies such as Veolia, SUEZ and Thames Water building many works through BOT programmes the sector is now dominated by domestic companies. In this mature market it is harder to find niches.

3.2.2. Water and wastewater networks: pressure and leakage management, modelling distribution and collection networks, river modelling

Loss of water in the distribution networks is a waste not only of water but also energy used for the production of that water. Higher water pressure leads to greater leakage from pipe networks and higher probability of sudden bursts. Better pressure management, with the goal of achieving consistent pressure sufficient to match demand requirements which change through the course of the day, can greatly reduce over- and under-pressure and so reduce leakage, prevent bursts, reduce the risk of contamination of the supply and save energy. Higher efficiency pumps can also save significant amounts of energy.

Analysing the problems of supply networks and designing solutions can be most effectively done with the assistance of network modelling tools. EU SMEs have expertise in the integrated analysis of water supply networks and the design of pressure management and novel leakage detection and repair technologies. Such companies could work with Chinese industry associations to match their products to the clients and partners in China.

Sewage collection systems are another key component of the urban drainage networks and have dual sanitation and urban flood prevention functions. Urban flooding has become a high-priority issue especially after the severe floods in Beijing in 2011 and 2012. In Europe, solutions to such issues would be designed with the assistance of sewerage network modelling tools (e.g. InfoWorks, Mouse and Microdrainage) and the application of sustainable urban drainage solutions (SUDS), technologies that EU SMEs could also provide in China. Some European software companies are active in China, but they have only a limited capacity to deliver the entire consultancy necessary to produce the models and train local government clients. In Europe, consultancy companies usually specialise in the delivery of such solutions, using the software packages as a tool. This business model is harder to establish in China as the clients tend to be interested in the software, but not the accompanying consultancy. On top of that, there is still often the need to develop and modify the software to fit specific local Chinese requirements, which is hard to do without access to the underlying code.

[34] http://english.mep.gov.cn/News_service/news_release/201608/t20160811_362178.shtml

River flood modelling using numerical computational methods is relatively underdeveloped in China as there is a highly developed physical modelling capability. Like urban network modelling, computational river modelling has great capacity for growth in China once there is acceptance of the methods, certification of the results and sufficient data collection and sharing.

The Chinese approach of total pollution load allocation for river basin water quality modelling is completely different to the approach taken in most European countries and requires entirely new modelling methods to be implemented. The development of such approaches was fragmented between MWR and MEP. The 2018 bringing together under MEE of River basin management, river water reach water quality objectives and industrial, municipal and agricultural discharge management opens the way to much better integrated pollution management systems. Such models can be key to the successful implementation of an effective water resources protection monitoring, planning, permitting and enforcement regime.

Local companies and universities are developing their own versions of available software, often based on the freely available US EPA models, such as EPANET, SWMM and HEC-RAS. Though these are still inferior to the best European companies have to offer they will eventually catch up and, unless companies can establish their reputation and market position fairly rapidly, it will become difficult for late entrants.

Though a very interesting and intellectually challenging market, network modelling in Europe followed a fairly rapid path from specialist research tool for academics and specialists to commodity product produced by well-trained and organised teams of technicians competing fiercely over narrow margins. There is the danger that in China this development would be even quicker once such modelling will be made a requirement. Therefore, EU SMEs in this sector would have to be able to constantly maintain an innovation advantage over local rivals.

Leakage

Leakage from water mains is a serious problem in China with high losses, especially from older pipelines made from cement and rusting steel pipes. There are large programmes to replace pipes with modern HDPE and other longer lived materials. The 13th five year plan targets to reduce from more than 15% in 2015 (though many placed much higher than this) to 12 % by 2017 and 10% by 2020. This opens markets for various leakage detection technologies either ground based (such as listening, ground radar and Doppler shifts) or remote sensing – using satellite data to detect the effects of leakage. Also for flow control, district metering and pressure management; and for pipe repair technologies. These are often systems that can be supplied to local clients as imported systems without complex procurement issues. Trade fairs can be an effective way to make contacts for such products.

3.2.3. Consumer water saving devices and point of use devices

These are filters, membranes and ion exchange filters with or without water heating and water cooling for domestic use. Some of these have already established sales and distribution in China which can be done via trade fairs to make contacts with agents and distributors. These devices can be sold directly as exports through distributors or with a local manufacturing partners. It is advisable to build a network of distributors to cover geographic spread and increase resilience of the business in case of difficulties with one of the partners. Online sales through Alibaba or JD.com are increasingly important in such sectors.

3.2.4. Desalination

The 12th Five-Year Plan set a target of 2.2 million m^3/day of new desalination capacity to be added in China by 2015. This is seen as a key part of the plans to meet rising water demand, especially in the coastal east of the country. A number of plants were constructed, mostly using reverse osmosis (RO) technology, but the regulated low price of water is a major barrier for urban water supply since the energy cost of RO-produced water is much higher than the possible sales price. There are also issues of demineralised water causing corrosion and water quality acceptance issues in water supply networks in some areas. As a result, even where constructed the utilisation of desalination is very low, acting as an emergency supply only. Much more work is required to improve the strategic planning and contracting conditions for desalination if this is to meet the ambitious targets for growth[35].

In the 13th five year plan the same target of 2.2 million m^3/day of desalination capacity was retained, though now with a delivery date of 2020, but little prospect of being met. This reflects some of the problems in the roll out or desalination in China.

[35] See http://chinawaterrisk.org/resources/analysis-reviews/desal-in-china-trends-opportunities/ for introduction to Desalination situation in China

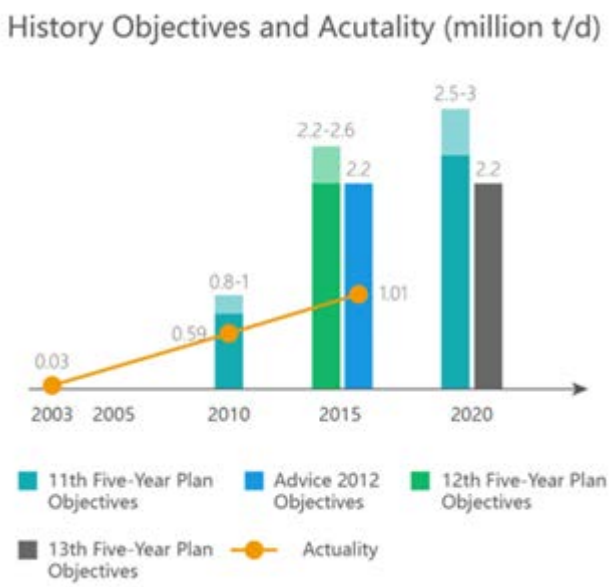


Figure 3-1 Desalination targets and actual achievement (after http://www.umoregroup.com/project.aspx?id=2097)

The lower energy consumption of newer RO processes and of membrane distillation processes utilising waste heat from thermal power plants could greatly reduce the cost of desalinated water. But China still lacks these technologies for efficient desalination, opening up a five to seven year window for EU companies to enter this market with an advantage over local competitors. China is rapidly developing its membrane production capacity and technology. Though RO is still uneconomical in urban water supply, there is a massive and well establish market for RO technologies in the industrial sector, for example for process and boiler make-up water production in the power sector, and in chemicals and food and beverages.

There is potential to use more efficient and robust RO for small scale decentralised water supplies in sponge cities or rural treatment plants treating brackish or recycled water. For these skid mounted package plants have great appeal if they can be produced to an appropriate price point.

3.2.5. Wastewater treatment

According to MEP[36], there were 4,436 wastewater treatment works (WWTW) in China in 2014 with total design capacity of 171 million m^3/d and typical operation capacity of 135 million m^3/d. This has increased from about 1200 WWTP in 2007 and by 2018 will be significantly greater, likely 30% more since 2014.

1,347 billion people, and associated industry, in China produce around 68.5 billion tons of sewage per year (equivalent to 188 million tons per day). This was expected to rise to 78.4 billion tonnes per year in 2015[37].

Based on those data, China has the world's second-largest sewage treatment capacity after the United States. Wastewater treatment generally consists of primary, secondary, and sometimes an advanced treatment process, with different biological, physical, and chemical technologies (Batt et al., 2007). At present, many sewage treatment processes are used in WWTPs in China, including conventional activated sludge treatment, anaerobic–anoxic–oxic (A2/O), anaerobic–oxic (A/O), sequencing batch reactor (SBR), oxidation ditch, etc.

For wastewater, around 80% of households in main urban areas have sewerage connected to some form of treatment, with about 28% receiving secondary level treatment and less than 1% receiving tertiary treatment. In rural areas the situation is very different, with about 40% of people having no access to improved sanitation in their homes.

The targets in the 13th plan five year are for urban wastewater treatment to reach 95 % coverage and county level treatment to reach 85% coverage (up from 90% and 82% respectively at the start of the period in 2015). All wastewater treatment systems will also need to comply with the new 1B standards under

[36] GWI, Asia Pacific Report 2017.

[37] Ministry of Environmental Protection of the People's Republic of China. National Report on Environmental Quality of 2012. http://www.zhb.gov.cn/gkml/hbb/qt/201306/t20130604_253201.htm

GB18918-2002 and about 600 will need to upgrade to the highest 1A standard for reuseable water. There will also need tens of thousands of new rural treatment plants. The expected capital investment is a total of $20 billion in new systems: $ 3 billion for upgrades to 1A; $2 billion for upgrades to 1B and $4 billion for new capacity in urban areas and the remaining $11 billion for new rural capacity. The whole system, existing and new capacity, will cost about $10 billion per year to operate[38].

There was a target for 20% wastewater reuse by 2015 which, though there has been a great deal of investment in wastewater recycling, is very far from being met with just 1% to 2% currently directly reused.

Thus the extension of secondary treatment to smaller cities and urban peripheral areas and the upgrading of main treatment works to higher levels especially to enable greater re-use and recycling of wastewater are major areas for investment.

3.2.6. Water pricing

A barrier to efficient water sector development in China has been their notoriously low water pricing. To address this a set of decisions by the State Council and National Development and Reform Commission (NDRC) on water pricing has demanded that ministries, provinces and municipalities shall: 1) achieve full cost recovery of water services by user charges, 2) introduce progressive water prices in urban areas[39]; and 3) introduce bulk water pricing based on a water scarcity principle[40]. These have resulted in substantial increases in water charges in recent years on a city by city basis.

The water tariffs are collected by the water company on the basis of mostly consumer metered readings. The price that the company is allowed to charge is set by the local government taking account of various lines of advice and directives. The water company collecting the tariffs or the local government will then pay the wastewater treatment company per m3 for water treated.

The Price Department of Development and Reform Bureaus are responsible for the setting of water tariffs, not the water industry itself or an independent economic regulator. NDRC have tended to enforce low tariffs. They have a responsibility to balance ensuring affordable access to water to poorer members of society, keeping general inflation in check and avoiding restricting investment opportunities in the water sector. However, water prices have risen sharply in recent years to go some way to meeting water resource constraints, water quality objectives and environmental quality requirements.

Stepped tariffs by volumetric use have been introduced to encourage water saving. The water price in China is still dramatically lower than in Europe. For example for Beijing the water tariffs (residential) are on stepped ladder fee basis[41].

- 0-180 m3 per year 5 RMB/m3 (€0.68)
- 180-260 m3 per year 7 RMB/m3 (€0.95)
- >260 m3 per year 9 RMB/m3 (€1.22)

These include in them a water resources fee of RMB 1.57 and a wastewater fee of 1.36 RMB

Non residential, commercial and industry, tariffs are significantly higher RMB 9.5 (normal industry) to 160 RMB / m3 - up to $22 per m^3 for special industries (e.g. health Spa).

Price for recycled water not to exceed 3.5 RMB / m3

The water resources fees are very dependent on the source and the region so in areas where ground water is very depleted and at risk, higher water resources fees will apply. Surface water abstraction is generally lower. Water may also be bought from long distance transfers (e.g. South North Transfer canal) but this is often more expensive.

The wastewater tariffs paid to the water company are also on a sliding scale by which they will be paid more for reaching higher discharge standards. Moving up from Class 2 to Class 1B to Class 1A each results in a step increase in tariff to compensate for the investment required. Generally the increase is slightly more than the incremental investment required and therefore it is more profitable to upgrade plants to meet higher standards.

[38] GWI, Asia Pacific report 2017, p 1535

[39] NDRC, MWR and MoHURD, 2012. Planning Notice 1618 on Implementation of Progressive Water Tariffs. NDRC, 2013: Guidelines on Promoting Water Pricing Reform in Urban Areas", NDRC, December, 2013

[40] NDRC and MWR, 2013. Decision 29 on Bulk water pricing according to water scarcity of different regions.

[41] BJ Municipal Government Jan 2018 prices. http://www.bjwater.gov.cn/bjwater/300817/300819/749062/index.html

The Price Bureaus do not have direct responsibility for the outcomes of their decisions on the water industry and have to work within national directives on economic inflation management, however the price bureaus are subject to oversight by the senior officials (such as mayor) and the officials have primary responsibility to meet their party cadre performance assessment indicators. Once these indicators have water resources and environmental quality metrics in them then there is serious attention paid to setting the prices to balance the economy, the environment and the need to maintain resilience in the water supply, encourage investment and not put the water company out of business while transitioning to a transparent rule of law system.

However, If the tariffs paid to the water and wastewater companies can be shown by the water company not to meet their reasonable investment and operating costs they are periodically able to negotiate with the local government for balancing payments to be made. This is a very delicate and political process but the amount of these balancing payments can be considerable and mean that despite the very low official rates it is possible to operate a water enterprise profitably. It can prove more difficult for foreign owned providers of water services to obtain such balancing payments.

These payments can also be very important in the water re-use and recycling market. The official way in which this market is supposed to work is that a water company should be able to sell water that meets the higher recycling standards (Class 1 A or the even higher GB3838 Class 4 standard) to consumers who will pay a higher rate than the wastewater discharge tariff. e.g. as above RMB 3.5 /m3 instead of the RMB 1.36 /m3 but this is much cheaper for the consumer than buying fully treated water at 5+ RMB/m3. In Beijing there has been massive investment in the production of recycled water and pipe networks to take that water to the bulk consumers who will pay for it. These may be industrial water users e.g. cooling water for industrial processes, or municipal users such as road washing, irrigating parks and supplementing urban water features and rivers / canals. However the reality is that in Beijing the “recycled” water is produced by Beijing Drainage Group (BDG), who operate most of the wastewater treatment plants and the vast majority of it is sold to Beijing Water Authority (BWA), who are responsible for the management of water resources in the region, flows in the urban rivers and canals and the drinking water supply. Only a tiny proportion is actually sold direct to industrial users. Beijing Water Authority are also the main regulators and collect the water tariffs from the users and pay BDG for the wastewater treatment. Officially BWA should be paying BDG a recycled water rate for the water that is treated to a high enough standard to be piped some distance from the treatment plant outfall and used to supplement river flows. However the cost to BWA of paying a full rate would be unsustainable and so in reality they pay just the normal wastewater discharge rates and then make up the “lost” income to BDG through the periodic balancing payments on the basis of open book accounting.

These sort of arrangements can work because BWA is a local government department organisation and BDG is an independent, but still state owned enterprise able to raise finance like an independent company but both organisations are still subject to the cadre assessment, discipline procedures and mediation by the party (CPC).

3.2.7. Sludge management

From the 68.5 billion tonnes of wastewater about 34 million tonnes a year of sludge will be produced[42] of which only about 25% receive proper treatment[43]. Most of the sludge is mechanically dewatered and then dumped to landfill. Reports of illegal dumping of sludge are common. Over the past years, sludge policies and technical guidelines have been issued by Chinese authorities. In 2010, MEP issued a regulation requiring all WWTW to have proper treatment and disposal facilities by August 2012 including the standards to be met [44]. However, local governments do not always know exactly what their responsibilities are relating to sludge treatment and the lack of clear indications for financing and tariff allocations prevent them from making the right decisions in order to facilitate the growth of the market and to meet government targets. The wastewater treatment equipment market in China is now largely served by local suppliers, but there is much lower capacity in sludge treatment technologies and so a greater opportunity for foreign firms to enter this part of the market.

There is a special tariff levy for wastewater treatment, but this is insufficient to also cover sludge treatment. situation. The final treatment and disposal of sludge is the responsibility of the local government and not normally the WWTP owner. The WWTP is required to process sludge normally to be a dewatered cake at 25% dry solids and to transport this a certain distance to the municipal sludge treatment / disposal facility if one exists. Due to the unclear responsibility, missing of core policies and unsolved tariff problems, many

[42] Report on Sludge Treatment and Disposal Market in China, 2013. http://zt.h2o-china.com/report/2013/2013wncz_report/index.html

[43] War on Sludge, China Water, 19th August 2014, viewed 25th April 2015, http://news.h2ochina.com/html/2014/08/130241_1.shtml

[44] Waste Water Treatment Project Technical Specification of Anaerobic/Anoxic/Oxic Activated Sludge Process (HJ 576-2010), see http://english.mep.gov.cn/standards_reports/standards/Catalogue_Standards/201101/t20110113_199825.htm, for lists of relevant environmental regulations

enterprises are not willing to treat sludge, and the investors must take a wait-and-see attitude resulting in a failed market

Sludge is a very difficult and hazardous material to handle, being noxious, often corroding and contaminated with pathogens and toxins. It is generally seen as a waste material that is expensive to dispose of. Yet, it can represent a valuable resource filled with energy and nutrients that can be utilised and recycled with the appropriate investments in infrastructure. Such utilisation of sludge as a resource is still a big challenge in China as it is still lacking mature and reliable technologies that attract appropriate investment.

Sludge is only a valuable resource that can be re-used in agriculture so long as there is sufficient control of industrial discharges to sewers to ensure that the sludge does not become contaminated with toxic chemicals or heavy metals which are generally impossible to remove later in the treatment stages. Therefore improved trade discharge management to sewers is vital to being able to safely reuse, dispose of and realise value from sewage sludge and this factor must be carefully considered when assessing potential projects.

The 13th five year plan calls for treatment of sludge to increase to 70%. This will require massive investment in treatment facilities and represents an opportunity for the supply of effective sludge disposal systems, especially those for sludge to power.

The sludge treatment sector has been one of the greatest areas of success for European companies, able to bring proven technologies from the mature EU market to the very fast growing and technically inexperienced Chinese market. The Norwegian company CAMBI has successfully formed a partnership with Beijing Drainage Group and the CAMBI thermal hydrolysis process has been added to all the major sludge processing centres in Beijing.

Case Study- CAMBI

- CAMBI is a medium sized company from Norway that developed a Thermal Hydrolysis treatment for municipal sludge prior to digestion
- The dewatered sludge is heated by steam at high pressure at 150-170 ^{o}C in batches in pressure vessels for 20 to 30 minutes, it is then cooled and passed on to normal digestion vessels for biological anaerobic digestion.
- The heat treatment breaks down the cellular structure of the sludge, releasing the digestible material and also completely sterilising of pathogens
- This results in much easier and faster digestion with much higher biogas yields and less residual sludge. The digested sludge is easier to dewater and safe to use on agricultural fields. It is easier to recover phosphorous and nitrogen from the water extracted from the sludge processed in this way.
- Over the last 15 years CAMBI installed this process in many plants in the UK (18 sites) and elsewhere in Europe. Japan and recently USA. This developed and refined the process.
- CAMBI have a joint venture company with Beijing Drainage Group (BDG), an SOE who provide most of the drainage and wastewater treatment and recycling for Beijing City, and more recently some other cities.
- 4 very large plants have now been built in Beijing and more have been contracted for Shanghai and Chongqing. These are amongst the largest sludge treatment plants in the world.
- CAMBI provide the engineering and process expertise to BDG, local manufacturers produce the pressure vessels, piping, M&E etc and local contractors construct the plants which are then operated by BDG.

Sludge is difficult to handle, hard to separate solids from water, and produces gases, and when dry dusts, that can be both toxic and explosive. There are a large range of sludge treatment technologies. These tend to vary in the temperature that operate at and the amount and state of water that they use (liquid, steam, super critical) and the presence or absence of oxygen. Figure 3-2shows some of the range of processes possible

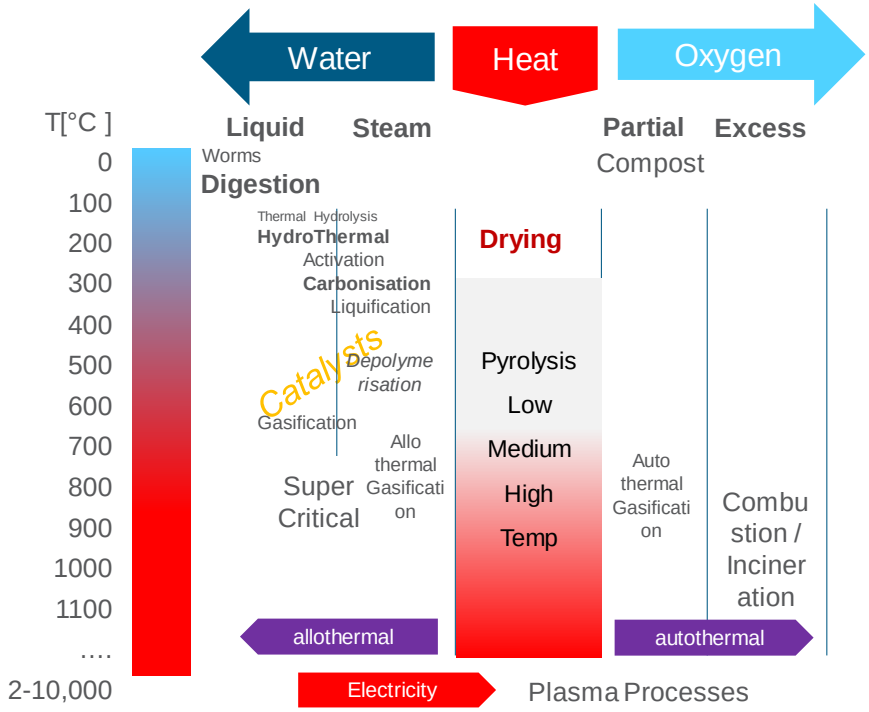


Figure 3-2 Range of hydrothermal sludge treatment processes

There are many sources of sludge (agricultural, municipal, industrial) and the possibility to combine with other solid wastes such as straw, food waste, wood chips, minerals etc. to produce a huge range of products from soil conditioner, to oil, coal, biogas and mineral fertilisers rich in phosphorous and nitrogen. Some of the processes are:

- Liquid disposal – sludge farms;
- Dewatering – thickeners, beds, belts, centrifuges, presses;
- Stabilisation – lime, heat;
- Digestion – anaerobic – biogas yields (35°C);
- Composting - farm or food waste, worms;
- Drying – rotary thermal, hot beds;
- Incineration.

Energy use and recovery is an important aspect of sludge processes. Though the dry solids in sludge may have high energy content they are likely to start as only a few percent of the material, separating from the water can require more energy than may be recovered. There are therefore a range of different biological, and physical processes that may be employed to extract chemical energy as a gas, liquid or solid which can be easily separated from the water. For highly toxic industrial wastes high temperature incineration or even super high temperature plasma treatments may be used, but the energy yields on these are often poor and the combustion gasses may need complex cleaning before release.

- Sludge conditioning – blending, enzymes, biome, worms, physical / sonic / heat;
- Thermophilic digestion (55°C);
- Thermal hydrolysis (150-170 °C);
- Hydrothermal carbonisation (170-250°C);
- Pyrolysis (low O_2) / gasification (Mid O_2) / incineration (high O_2) (300-1000°C);
- Plasma.

These different temperature treatment processes have different advantages and disadvantages that affect their commercial viability. Overall there is a development of more of the higher temperature processes that allow for circular economy solutions to be implemented.

Process	Advantage	Disadvantage
Thermal Hydrolysis	Greater Biogas Disinfection, faster, Easy DW	Liquid sludge remains
Hydrothermal Carbonisation	P + N recovery Biochar, 15 bar	No Gas Does not treat Lignin
Hydrothermal Gasification	Syngas / Oils	V High Pressure Catalysts
Pyrolysis	Syngas, Mixed feeds Ash products – recover NP.	Needs fuel Need Drying
Gasification	Syngas, Self fueling Ash products – recover NP.	Less Gas
Incineration	Complete destruction, just ash	Low energy yield Air emissions

The hydrothermal carbonisation (HTC) process is one example of this. This is similar to thermal hydrolysis, in that the dewatered sludge goes into a steam pressure vessel, but at higher temperature and pressure for a bit longer, the result is the complete transformation of the sludge into a carbonaceous material, bio-coal, which can be easily separated from the liquid portion which is very concentrated in recoverable P and N compounds for making mineral fertilisers. No digestion stage is required. The bio-coal can be used as a combustible fuel directly or as a soil conditioner / fertiliser or it can be converted to activated carbon and used in wastewater treatment processes for polishing effluent.

HTCcycle (previously AVA Green) have developed such a process as a start up and are in the process of marketing this in China as an alternative to the CAMBI process.

When transferring sludge treatment processes from Europe to China a degree of localisation will be required to adjust to different sludge compositions and levels of sand etc that may be found in Chinese sludge.

3.2.8. Asset management

These major water companies such as Beijing Water Enterprises, Sound Group etc, have rapidly increasing inventories of assets and are developing more advanced asset management systems. Most of the maintenance is still done in fairly manual labour-intensive ways. There is great interest in introducing more advanced automated systems and predictive strategic asset management solutions. However, the low labour costs mean that even the most efficient state of the art cost saving methods used in the EU could be more expensive to run, let alone install, compared to current practice. With rapidly rising labour costs and more labour safety and protection this equation is shifting and there is increasing potential for intelligent asset management offers.

3.2.9. Water recycling: centralised / decentralised wastewater treatment and reuse, sponge cities, membrane treatment

The 12th Five-Year Plan set ambitious targets for recycling water which in most regions of China were very far from being achieved this has been relaunched under the 13th FYP. Both centralised and decentralised schemes need to be implemented to improve the situation.

In centralised schemes, the effluent from a major wastewater treatment works (WWTW) undergoes tertiary treatment (normally involving some form of membrane treatment) and disinfection and is then piped through a separate pipe network to be used for purposes tolerant of lower quality water – urban green space irrigation, toilet flushing or industrial cooling for example. The WWTW is generally located at some distance from the water users, so extensive and expensive pipe networks and pumping are required. Currently, the provider of the recycled water can expect to be paid 25%-75% of the water tariff for fresh water supplies in China[45]. Thus centralised treatment is currently only practical in very dense large cities such as Beijing. However, there is still considerable room for improvement in tertiary treatment systems for recyclable water,

[45] http://www.waterworld.com/articles/wwi/print/volume-26/issue-3/regulars/creative-finance/mbr-technology-propels-china-into-water.html

opening up opportunities for EU SMEs with the right technology on offer. In the last 2 years some $400 million of contracts for water reuse systems were let in Beijing city alone.[46]

A more promising approach is decentralised treatment and reuse. Here, wastewater – either grey water or foul water – is collected and treated locally at building- or community-level and then re-used locally. This is ideally coupled with rainwater collection and harvesting as well as storage systems to balance out supply and the varying demand.

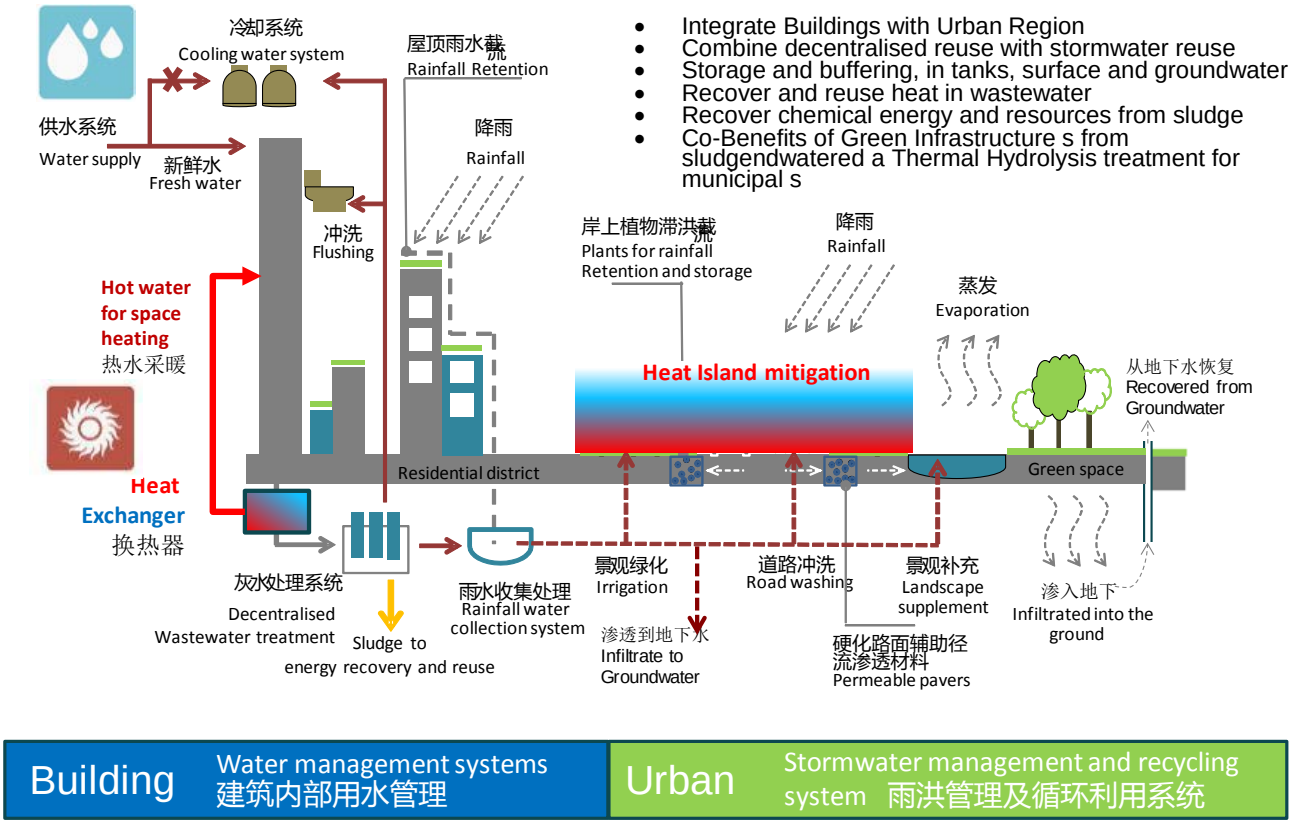


Figure 3-3 Integrated sponge cities solutions for buildings and urban spaces.

Decentralised wastewater reuse is most effective when integrated into new developments such as eco cities from the start. As such it is primarily a feature of urban planning and design to be applied in combination with low-carbon buildings, integrated transport and ecological landscaping to create more resource-efficient and liveable cities. This type of integrated thinking and design is something that Europeans excel at and there is a well-developed market for international urban planning, architecture and landscape architecture in China.

Government policy and regulation to increase recycling will encourage cities to consider constructing decentralised wastewater reuse schemes, but they will only be sustainable when there is a clear economic incentive for the owners to invest in and maintain them, preferably because it is generating positive returns or because of long-term government subsidies or incentives such as take-or-pay tariffs. Increasingly PPP models are being applied in China to incentivise sound financial planning and limit government exposure to project risk.

Recently many decentralised WWTW schemes have been constructed in China applying advanced packaged membrane bioreactor and membrane filtration plants, however there is still room for the development of more advanced and effective systems utilising European technology and innovation. Companies such as Beijing Origin are now leading in the deployment of membrane treatment systems in China.

Chinese urban eco-city planning – "Sponge Cities"

"Ecological Civilisation" and "Beautiful China" are key government policies announced at the 18th Party Congress in 2012. These require that new urban developments are planned to incorporate resource efficiency at the design phase, buildings to be energy- and water-efficient and the landscaping of

[46] Global Water intelligence project tracker

cities to also provide functional ecosystem services. These have now been codified in the MOHURD "Sponge Cities Guidelines" and the MWR "Water Ecological City Construction Evaluation Guidelines"[47].

The Sponge Cities" concept has become the Chinese equivalent of Sustainable Urban Design (SUDs) in Europe or Low Impact Design in the USA. However, Sponge cities is a wider concept than just drainage management and green infrastructure, taking in water capture, storage (including groundwater recharge) and reuse; rehabilitation of degraded urban water courses; wastewater recycling and reuse and the general improvement in liveability of cities.

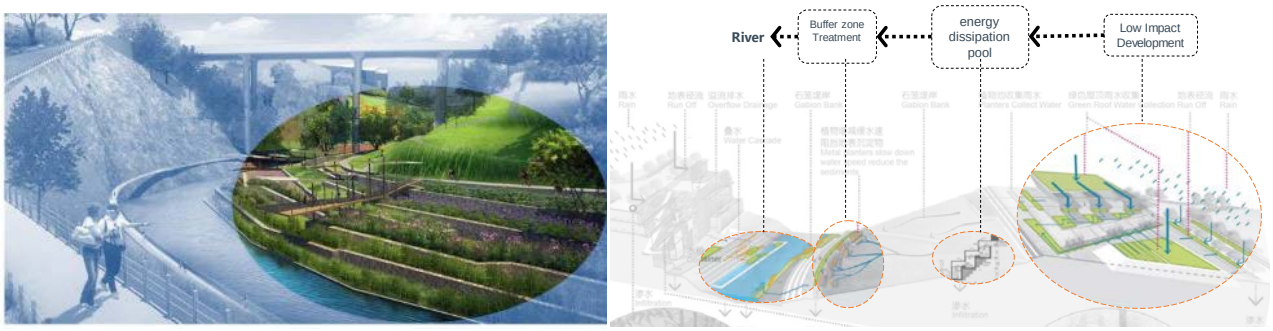


Figure 3-4 Sponge cities and black river restoration

All new urban developments must now incorporate best practices in low carbon design, renewable energy and resource efficiency. 30 pilot cities have been identified in which the approaches and technologies are to be developed and demonstrated. This opens many opportunities for European planners, designers and engineers to develop innovative integrated designs incorporating many of the features of decentralised water systems, recycling sustainable drainage, river and lake rehabilitation and in situ treatment with ecological landscaping. European firms experienced in developing integrated solutions for energy, water, transport and solid waste management and recycling, as well as seeing past the limitations of entrenched procedures to implement a circular economy will have an advantage. The sponge cities programme was rolled out in late 2015 with the announcement of 16 pilot cities for the sponge cities concept with substantial central government funding ($70 million per city per year) to support these. In 2016 a further 14 cities were added.

Figure 3-5 Location of sponge Cities Pilots

[47] Water Ecological City Construction Evaluation Guidelines SL / Z 738-2016, MWR

While there was no obligation for the first 16 cities to employ PPP models, the government is requiring some element of private finance in all 14 of the new projects. China's Ministry of Finance (MOF) reports that 12 sponge city PPP contracts, worth a total of RMB46 billion ($7 billion), have either been recently awarded or are under preparation.

Bundling WWTPs into sponge city PPPs is a new way of enhancing the environmental and financial benefits. In the past two years, the scope of PPPs in the water sector has expanded exponentially, with many projects now including a number of environmental services which do not have a revenue stream attached, such as river remediation, landscaping, and drainage services. This is happening even where projects are not in official "Sponge Cities" pilot areas.

This opens opportunities to provide green infrastructure solutions at a design or technology supply level either directly to the municipal governments or more likely to the companies bidding for the contracts to deliver the sponge cities projects. These may be national level companies specialising in water PPP projects such as Tsinghua Holdings Ltd, BEWG, China Everbright, Beijing Capital etc or local companies with close connections to the municipal governments. These companies will have to partner with construction contractor companies for project delivery and often also design consultants. This is different from the normal WWTP or water supply PPP contract competitions which are normally bid by a single company. This refelects the more complex nature of Sponge Cities projects, requiring urban construction and urban planning as well as water infrastructure experience.

Examples of recent awards are the Sanya Sponge City PPP project on Hainan Island, at $575 million won on 6th December 2016, by a consortium comprising Jiangsu Zhingnan Construction, Beijing Urban Construction, and China Wuzhou Engineering[48].

A project open for RFP as of April 2017 is the $238 million Shenzhen Guangming New District Sponge City[49]. The bidders for this are (to give an indication of the sort of company targeting such projects):

1) Architectural Design Institute of China Jingye Engineering Corporation/China Metallurgical Construction Engineering Group Co., Ltd. (CMCC);
2) Shenzhen Water/Shanghai Municipal Engineering Design Institute/China Railway 15th Bureau Group;
3) PowerChina Water Environment Management Technology/HydroChina ZhongNan Engineering Corporation/STECOL Corporation (a PowerChina Subsidiary contractor);
4) China Water Group/China Railway 11th Bureau/China Railway SIYUAN Survey & Design Group;
5) China Water Environment/China Construction Third Engineering Bureau/China Northeast Municipal Engineering Design & Research Institute;
6) China Everbright Water/China Construction Eighth Engineering Division Corp./Tianjin Municipal Engineering Design & Research Institute;
7) Beijing Origin Water/China Construction Fifth Engineering Division Corp./Shenzhen Municipal Design & Research Institute;
8) BEWG (China) Investment/China Construction First Building Group (subsidiary of China State Construction Engineering Corporation Limited).

3.3. Market analysis

3.3.1. Municipal water: opportunities

- Water Treatment: rising standards, some investment via PPP, mature market – decentralised systems;
- Networks: leakage detection, water quality monitoring, modelling;
- Desalination: municipal market static, limited growth in last 5 years. More growth in industrial sector, new, lower energy use technology could change the balance towards desalination;
- Wastewater treatment: rising standards, massive investment via PPP, mature market – rural and decentralised systems – integration to green infrastructure and ecology;
- Sludge treatment: growing investment, developing regulatory framework, at take off – integration to energy systems and solid waste management;
- Sponge cities: moving beyond just pilots. PPP and land swap / urban planning drivers – integrated green infrastructure – volume drivers, multiple benefits;

[48] https://www.globalwaterintel.com/global-water-intelligence-magazine/project-trackers/sanya-sponge-city-ppp-project-hainan-province

[49] https://www.globalwaterintel.com/global-water-intelligence-magazine/project-trackers/shenzhen-guangming-new-district-sponge-city

- The integration of green infrastructures into urban planning and design was pioneered in Europe and is now being implemented on a massive scale in China.

3.3.2. Barriers

- The core aspects of Water supply and wastewater management are well understood and established in China, only in niche and specialised areas can EU companies stand out. Major areas are blocked for example aeration equipment is now on a restricted list;
- SOE / private sector companies are now fully established in the core urban water and wastewater treatment and supply markets. There is now little scope for EU business to directly engage in the main urban water business or to bid successfully against local players;
- Though it is rising, the low water price for water supplied and low rates for wastewater treatment provision remains a barrier to entry;
- The political means available to local companies to negotiate around low tariffs to get to extra payments is complex and sensitive and much more difficult to engage in for foreign companies;
- As for the agricultural water section monitoring, modelling and design of control systems remains an area of opportunity and faces the same barriers as listed there.

3.3.3. Municipal water: strategies

- Direct sales;
- JV manufacture;
- Partnerships with major SOE water enterprises – technologies and consultancy;
- Acquisition by Chinese SOE;
- Planning, design, modelling;
- Integrated thinking – part of wider urban infrastructure – water, energy, food, environment – sludge and wastewater as part of circular economy. Urban sustainable drainage features and river restoration / wetland as part of the urban ecocity planning.

4. Industrial water management

- Clean (source) water production, treatment, distribution and saving systems
- Water reuse, recycle and recovery systems
- Wastewater collection, treatment and disposal
- Water Use and WWTPs, industrial parks

4.1. Background on industrial water management

The management and treatment of industrial wastewater is the main focus of "The Action Plan for Prevention and Treatment of Water Pollution" released in 2015.

For industry the main drivers are the tighter Environmental Protection Law (EPL) which came into effect 1 January 2015. EPL instigates increased transparency and monitoring while rewarding compliant enterprises and companies in the environmental protection industries with financial incentives such as tax breaks, non-compliant enterprises will face heavy penalties such as shutdown. The previous caps on fines for industrial pollution have been removed and under the new Minister for Environmental Protection, Chen Jining, their has been strong political support to the enforcement of the changes with high profile penalties and aggressive action against polluters.

Other measures in the EPL include holding companies who produce fraudulent Environmental Impact Assessment reports that declare pollution industrial processes to be compliant, can be held jointly and severally liable together with the enterprise itself for consequential costs. Local government officials are also to be held accountable for compliance with environmental protection objectives as part of their annual performance reviews.

The new EPL in combination with the Water Ten Plan make are the main new weapons for China in its war on pollution. Major polluting industries are the first to be hit, with smaller factories without qualified water treatment facilities to face shutdown by 2016. This is building further on waves of closures of pollution Town and village enterprises during the 11th and 12th FYP periods, but the processes are becoming more structured and rule based, where before they were more political or arbitrary.

Larger companies are targeted for technological upgrades and are forced to adopt clean production methods. They will need to comply and consequently spending on water technologies will increase.

Many smaller factories are unable to bear the costs involved in treating wastewater to high standards. Consequently, more and more smaller factories will be forced to move into industrial parks with communal water treatment facilities, making this an increasingly relevant niche market.

With currently 3,300 industrial parks, less than 50% are estimated to have centralised treatment plants. This is due to change: all industrial parks are required to install centralised treatment facilities and online monitoring systems by the end of 2017 (end of 2016 for the more developed regions of Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta).

EPC contracting of treatment processes

Many industrial processes require clean make up water and pre-treatment of wastewater before discharge into municipal sewer systems or directly into rivers. The scale of projects for industrial customers are usually well suited to SMEs and there are a number of companies in China providing turnkey solutions for industry through engineer-procure-construct (EPC) contracting either directly or through partnerships or JVs with local companies. In January 2015 the government issued a policy promoting the outsourcing of industrial effluent treatment to 'professional third parties'[50]. This is aimed to ease access to private financing for investment in industrial water treatment and energy saving.

It is easier to enter this market if you are able to take on and manage the finance and risk aspects of an EPC contract. The client base for these projects would be state-owned enterprises (SOEs) and private industry rather than local government. Funds are more likely to be immediately available to finance industrial water infrastructure where such investment is critical to sustaining a profitable production process, unlike in the municipal sector where the cost of providing treatment is purely a cost burden for the respective city.

[50] Opinions on Promoting the Third-party Treatment of Environmental Pollution, effective 14 January 2015. http://www.gov.cn/zhengce/content/2015-01/14/content_9392.htm

13th Five year Plan Targets and drivers.

The management and treatment of industrial wastewater is the main focus of "The Action Plan for Prevention and Treatment of Water Pollution" released in 2015.

4.2. Market analysis

4.2.1. Industrial water: opportunities

- Real enforcement at last;
- Clean Source: rising standards, investment via PPP, mature market – decentralised systems;
- Reuse: tightening regulation on water use efficiency. Developing infrastructure to market;
- Wastewater treatment: rising standards, massive investment via PPP, Mature market but much scope for further innovation;
- Coal to chemicals – massive scale, complex, ZLD requirement, 154 in operation, 69 in construction (GWI);
- Industrial parks.

Most of the factors for industrial water development are similar with municipal water but generally on a smaller scale for typical industrial plants for manufacturing, food processing etc. However certain industries require very large scale water and wastewater treatment systems. These represent significant opportunities for the largest European companies and for smaller companies working with them.

4.2.1.1. Pulp and paper

The tightening requirements for compliance with discharge standards place huge financial burdens on industrial plants, especially smaller, older infrastructure. For example in the pulp and paper sector there used to be many thousands of small town and village enterprise level pulp and paper mills turning agricultural wastes such as straw as well as timber into paper products. As the requirements for pollution control have tightened it became impossible for small plants to incorporate black liquor treatment for the wastes from timber or straw to pulp processing and so many switched to re-processing wastepaper to make recycled paper products – a much less polluting activity – but now even that has stopped and all of the paper is produced in far fewer very large plants that incorporate full waste management facilities.

This means that before trying to develop and market a solution to a particular industrial discharge problem it is essential to understand the political direction. See case study on Bio Regional.

Case Study- Bio Regional

- Bioregional is a medium sized environmental services company in the UK who developed an efficient black liquor treatment process for small scale pulp and paper mills and looked to take to market in China around 2010.
- They Identified hundreds of medium sized mills struggling to meet discharge standards and causing serious pollution problems.
- They developed the MiniMill which use a fluidised bed to run a gasification process to produce syn gas to use as fuel to power the mill (5MW) and recover sodium hydroxide for re-use in pulping. They piloted a proof of concept MiniMill in UK.
- Though a little complex and expensive for town and village enterprises this process had great potential and there was significant interest in buying from several medium sized mills in China.
- However, Government policy changed to closing all polluting local mills and replacing with a few very large, hi tech, regional pulp and paper mills that meet all discharge standards.
- Thus the potential market for the Mini Mill was effectively snuffed out.

The lesson from this is that there are opportunities for European manufacturers of large scale pulp and paper (black liquor) treatment processes, but very little for smaller scale suppliers.

4.2.1.2. Coal to chemicals

China has limited gas and oil reserves but a great deal of Coal. In the presence of catalysts at high temperatures and pressures coal can be combined with hydrogen to form hydrocarbons such a methane, petroleum and, with the addition of some oxygen, methanol and other chemical feedstocks (e.g. olefin, dimethyl ether, monoethylene glycol). The hydrogen can be derived from water. These are complex processes that work on very large scales. China has embarked on a massive programme of constructing coal to chemicals and coal to gas plants with the capacity to exceed all other domestic sources of gas and oil production. These plants are mostly located close to the main coal sources in the arid North west of the country. The water use is very high, there is also the potential to generate huge quantities of wastewater. However, the government has decreed that these plants must be Zero Liquid Discharge (ZLD) and cause no water pollution impact.

Many of the processes required to achieve this require advanced membrane separation systems and associated evaporators to produce pure water and solid salts as re-usable materials. The presence of contaminants in the process streams such as heavy metals and sulphur compounds can be challenging for the longevity of such systems. Much innovation and development is therefore required. Many European companies such as Siemens and BASF are heavily involved in the development of the coal to chemical treatment processes and the associated water recycling in partnership with the state-owned operators and contractors. The plants must be large to be able to economically incorporate the required water and air emissions technologies, so there are minimum size requirement 2 billion m^3/yr for coal to gas and 1 million t/yr for most coal to oil and coal to chemicals plant. As of 2016 there were 154 plants in operation, 69 under construction and 69 planned for construction. This is a new industry with just a few pilot plants a decade before.

Note that coal to chemicals and coal to gas is generally classified as gas and chemicals production rather than coal consumption and therefore may not be included in the coal production figures of China. This is a very inefficient and energy consuming process. The scope for the addition of carbon capture and storage to such plants is very significant if the right incentives are put in place. Given the incredibly rapid development of the sector it is possible to see that the right CCS technology could find rapid take up in this sector.

4.2.1.3. Power sector

After years of building dozens of major new coal power stations every year and shifting to more efficient super and ultra-critical boiler technologies, with, in the water scarce areas of the country, dry cooling systems, China has greatly slowed the construction of new thermal capacity in response to climate change and emissions concerns and Paris Agreement. There has also been the wide spread installation of flue gas desulphurisation, low NOx combustion systems and dust removal systems to reduce the air pollution impacts of existing as well as new plants. More than 90% of plants are now fitted with emissions control systems and a very large market developed for the supply of new and retro fit systems. This is now largely saturated.

The existing plants are required to be more water efficient and to reduce wastewater discharges. This does open some opportunity for the provision of water treatment technologies in the Chinese power sectors. However, this sector, like the air emissions sector, is dominated by a few major SOEs. If they can be persuaded that a treatment technology is superior to what they have locally then there is a possibility to enter this market, but it is quite mature and dominated by established players. Licensing and release of IP to a JV company is a likely requirement. With dramatic reductions in the rate of construction of new thermal power plant in China in recent years there will be intense competition from existing players for the remaining contracts.

4.2.1.4. Membrane separation technologies

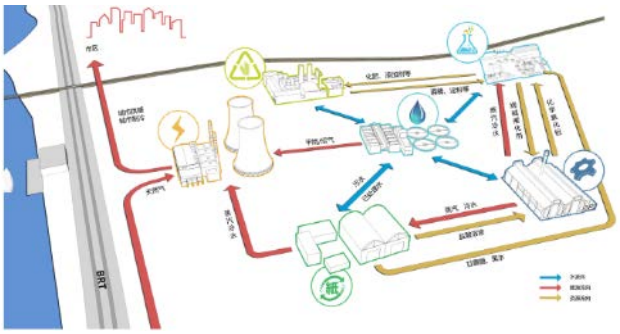
One of the most intense areas for development of water treatment technologies is in membrane separation, micro, ultra and nano filtration and reverse and forward osmosis systems.

For the filtration systems the key areas of advance are in the development of ceramic membranes and there is very strong interest where effective ceramic membrane systems can be demonstrated with much higher robustness and capacity to be aggressively backwashed and chemically cleaned to allowing for longer membrane life and offsetting higher initial costs.

There are now many local manufacturers of polymer membranes in China, especially targeting the commodity sectors of industrial treatment, but there is still strong niches for suppliers of high quality or special function systems.

4.2.1.5. Industrial parks

Most municipal planners are now trying to locate all heavy industry and many light industries in industrial park zones with specific and suitable infrastructure available to them. This can include centralised water, wastewater and solid waste management facilities. The combination of these can greatly enhance the opportunities for circular economy solutions, utilising the waste energy and materials from one process as a valuable source for a different operation. It can also lead to lower emissions to the environment and more sustainable industry.



After Atkins ELC planning methodology 2013

The provision of environmental services for the industrial parks may be let as a single or as multiple PPP contracts and can provide opportunities for European companies, most likely in partnership with local companies, to implement innovative circular economy solutions at scale.

4.2.2. Industrial water: barriers

- Like water supply and wastewater mature - only in niche and specialised areas can EU companies stand out – but lots of niches;
- SOE / private sector companies are well established;
- Discharge standards and engineering / HSSE standards are different requiring significant modification of designs;
- Plant or industrial park owners often try to build and operate complex water and wastewater management systems themselves rather than procuring from competent suppliers;
- Procurement procedures may favour local companies

4.2.3. Industrial water: strategies

- Partnerships with Major SOE water enterprises – technologies and consultancy;
- Acquisition by Chinese SOE of smaller EU companies that hold promising technologies for deployment at scale in China;
- Planning, design, modelling, clean tech auditing;
- Integrated thinking – part of wider urban infrastructure – water, energy, food, environment – circular economy;
- Targeting the provision of specialist wastewater treatment in large industries and industrial parks applying innovative and efficient processes to deliver greater value to owners;
- Develop capacity and partnerships to bid for and deliver as a part of PPP procurement of industrial water management services.

5. River basin management and flood control

- River basin flood management
- River training at basin scale, including water resources surface / ground and soil plus morphology
- River basin monitoring
- River basin management and planning
- River basin water quality / pollution management
- Wetlands restoration
- Urban flood management

5.1. Background info of the river basin management market

The River basin management sector is led mostly by local government departments, the main drivers are national policies for water resource management, water quality protection and flood management. Local government officials are responsible for meeting targets on water resource management and water quality as a part of their official performance reviews. This motivates them to find solutions at a local level that will help meet these objectives. Though this can motivate to solve problems at source with urban and industrial wastewater treatment, because an official is responsible for the water that is passing through their area they are also motivated to put in place in river treatment solutions that would not be seen elsewhere in the world. Rivers passing through urban areas are also major focusses for redevelopment as attractive features leading to increasing property values – to achieve this extensive river restoration is required.

Solutions, such as river monitoring networks, need to integrate over regions and there is a strong preference for locally sourced solutions. Other areas such as flood control embankments, dams, irrigation channels, river training works and inter-basin transfers are very large investments but most of this is relatively low-tech earth moving and construction which is difficult to access as a foreign company. Thus it is in the development of modelling and decision support systems that the bulk of innovations are focussed. These are the areas where foreign expertise is able to add most value by the optimisation of investment plans that will meet the performance indicators.

Economic losses from flood damage are very significant and more sophisticated risk analysis and quantification of flood risk in relation to insurance valuation and resilience planning can show high returns. This is an area where European expertise can be of high value.

Despite significant rises recently water resources fees are at a fairly low level and collection not always enforced, as a result the water resources management sector is dependent on government subsidised projects. This can make market access difficult for private and foreign companies. The dams sector is now very mature in China with little further to add from foreign experts. The earth moving and construction activities of major national projects are generally closed to foreign contractors. For modelling and decision support systems, though there is demand for products there is not a lot of money available to pay for them and copying and IPR loss is a high risk. Thus strategic partnerships with Government institutes will be required to access most of these markets and to gain acceptance of products.

There are major initiatives in wetlands restoration, recognising the vital ecological role that large areas of wetland played before they were largely drained for agricultural and urban development. Many of these are now being restored, especially along the lower reaches of the river Yangtze, the Yellow River delta and for the new administrative city of Xiong'an where there is a major restoration programme for the Baiyangdian wetlands area.

Urban flood management is generally led from the municipal government level and is now more focussed on Sponge Cities solutions for lower level flood events and also deep tunnel sewer solutions to take the flows from larger storm events. These have to integrate closely with the river basin flood management. The proper integration of such solutions requires modelling with computer simulations to understand the many interactions and the leading software systems, for this are provided by European suppliers. There is also experience from the construction of major sewer tunnels in Europe – such as the Thames Tideway Tunnel – than can be of great value to the planned projects in China.

From a policy perspective, major drivers are the Three Red Lines policies for water resources allocation, pollution load allocation and water efficiency. These set national targets for total use that are then allocated

down to province, county, city and village / enterprise levels. There are huge challenges in consistently quantifying these factors. However, this is a very different approach to that taken in Europe and most other parts of the world. The sort of environmental impact planning and regulatory support services that have developed in Europe would have to be heavily adapted and changed to work within these different contexts.

The recent reorganisation of ministries and the establishment of the Ministry for Environment and Ecology has significantly changed the reporting lines for the river basin organisation such as the Yellow and Yangtze river basin commission who will now report to MEE rather than to MWR. This could also prompt changes in the way that water resources and pollution loads are allocated and administered.

5.2. Market analysis

5.2.1. River basin water: opportunities

- Water resources shortage and regulation – Water Quantity Red Line for resource allocation;
- Water quality. – Total Load Red Line and pollution control action plans;
- Modelling and monitoring systems, SCADA controls;
- Long distance transfers;
- Wetlands restoration.

The key areas for opportunity in river basin management for European companies can be in the implementation of systems for monitoring, modelling and controlling water resources, water quality and flood or drought risks in river basins. The application of remote sensing, environmental monitoring equipment and data processing to understand in real time the situation and changes. The development of modelling systems to interpret data, test scenarios and support decisions. The implementation of those decisions through control systems. This is the basin level SMART water solution.

For European companies to engage in this area will require close working with Chinese institutes and companies. Great care will be required to negotiate the terms for technology and data sharing and access.

The huge South – North water transfer is just one of many such major inter-basin transfer schemes in China. More are under construction. However these are state controlled strategic engineering contracts and presently the scope for international business involvement is limited.

For the many wetlands restoration projects at municipal levels there is significant scope for International cooperation on methods of ecological integration and development. Urban watercourses and wetlands areas are considered as important components of new ecological civilisation development projects. This is a major change from a decade or so ago when such features were being systematically drained and removed. The bigger strategic schemes will be more restricted in the openness to international cooperation.

Rural Enterprise cooperatives may play an increasing role in the local provision of flood protection, water resources and diffuse pollution control measures. Suppliers of relevant equipment may be able to build networks of links to these potential clients.

5.2.2. River basin water: barriers

- Government controlled, incumbent institutes and organisations;
- Low revenues very price competitive – based on agricultural and rural income levels;
- Low levels of automation;
- Some national government initiatives, but these focussed on inter basin transfers and industrial pollution control.

5.2.3. River basin water: strategies

- Partnerships with government institutes, SOE water enterprises or larger rural enterprise collectives;
- SMART water technologies: monitoring, modelling and control systems;
- Integrated thinking – Integrated river basin management, integrating river management and urban development;
- Targeting urban rivers – black river restoration.

6. Water for energy

- Small scale hydropower
- Large-scale hydropower
- Water use for fossil energy production (coal, shale gas, oil etc)
- Preserving natural ecosystems – minimise impact of hydropower on environment
- Novel energy production systems – thermal, wave etc

6.1. Background info on water for energy

"Hydropower Thirteenth Five Year Plan", released in November 2016, proposed that future hydropower development should follow the principle that hydropower development should be prioritised in the mainstream areas while environmental and ecological protection should be prioritised in tributary areas. Hydropower development in small and medium-sized watersheds should be strictly controlled to retain the essential habitat and ecological health in those watersheds. Still, Minister of Water Resources, Chen Lei, pointed out that in recent years, the global resource crisis, environmental degradation, climate change and other issues have become increasingly prominent. The development of green energy has become the general consensus of the international community. Hence, Chinese government still acknowledge that small hydropower, as a green renewable energy, is an important basis for developing countries to develop their economies, increase employment and improve people's livelihood. The Plan also points out, during the 13th Fiver-Year period, water to energy sector would need an investment of approximately RMB 500 billion, in which large and medium-sized conventional hydropower stations account for about RMB 350 billion, about RMB 50 billion for small hydropower stations, and about RMB100 billion for pumped storage power station.

6.2. Market analysis

6.2.1. Water for energy: opportunities

China's energy sector continues to grow. The electricity production capacity is the largest in the world at 1770 GW in 2017, having grown some 7.6% from 2016. Most of this, 62%, is still thermal fossil fuels. While there is still growth in the fossil fuel sector since 2016 there has been a moratorium on the construction of new coal capacity in most areas of China and a shift of investment to renewable energy while continuing the moderate pace on the nuclear build programme.

Type	Capacity		Growth	Production	
	GW	%Total	2016-17	TWh	%Total
Total	1770		7.6%	6495	
Coal	1100	62%	4.3%	4663	72%
Hydro	341	19%	2.7%	1190	18%
Nuclear	35	2%	6.5%	248	4%
Wind	164	9%	10.5%	394	6%
Solar	130	7%	69.0%		

Table 6.1 Power capacity by source, annual growth and total Production in China[51]

The amount of energy (MWh) produced by any given capacity of generation (MW) varies enormously with solar on only about 15%, wind 22%, while nuclear typically runs at by far the highest rate of 90% with coal and gas technically able to also achieve >80% but due to dispatching controls and demand matching typically manage about 43% and 37% respectively in China. Hydropower in China typically returns about 43% capacity factor[52]. As the amount of intermittent renewables increases so the need for more sophisticated load balancing and storage in a fully interconnected Grid increases. This requires massive investment in moving from a centralised grid distributing power to match demand to a network of producers and consumers balancing generation and demand across a smart grid system.

[51] https://www.enerdata.net/publications/daily-energy-news/chinas-installed-capacity-grew-76-2017-nearly-1800-gw.html
[52] See: Towards a water & energy secure china, China Water Risk, 2015

6.2.1.1. Hydropower

The 13th Five-Year period sets out ambitious investment for the water to energy sector RMB 500 billion of which:

- Large and medium-sized conventional hydropower stations RMB 350 billion;
- Small hydropower stations RMB 50 billion;
- Pumped storage power station RMB100 billion;

The 13 FYP states the intention that conventional hydropower should be installed on the main streams of rivers, while small scale and ecological hydropower should be employed on tributaries.

For large scale hydropower schemes the market is very mature and China is now the world's leading builder of large dams and hydropower systems. In 2017 China had some 341 GW of hydropower capacity, having added 9.2 GW in 2017, down from a 2014 peak of 30 GW of new capacity. The target is to reach 380 GW of capacity by 2020. The long term target for 2050 is some 500 GW of hydro power, though more than 100 GW of this may be pumped storage.

China is exporting this expertise around the world and is leading the construction of many projects in Africa, South America and central Asia etc. This is through leading power companies such as Sinohydro, Gezhouba, and 3 Gorges power company and associated design and research institutes. As such it is a major competitor to EU companies in international markets and there are only very limited opportunities to access the market inside China. Greater opportunities may lie with working with Chinese companies in 3rd countries.

The small hydropower sector is still under developed. Though there are many small local generating systems around China, as rural electrification was the starting point of the hydropower programme in the mid 20th century, they have been technically unsophisticated and built without much consideration to ecological integration. There is thus much room for innovation and integration to wider river restoration projects. This is also an area where smaller companies with an innovative product can enter the market. The very large investment levels in this as yet immature sector set out in the 13th FYP means that there will be strong demand for proven products and services.

As China transitions away from primarily coal power production to more renewables (solar and wind) so unpredictable variations in the rate of generation increase the need for power storage in the grid system. More significantly, the change in the thermal power generating units from older sub-critical to more efficient super and ultra-critical steam generator systems operating at higher temperatures and pressures also dramatically reduces the flexibility in the system as these have very restricted ranges of duty and cannot easily be switched on or off without incurring high risk of damage to the plant and long maintenance shutdowns.

Some of this required load balancing can be achieved by varying release rates from conventional hydropower, but pumped storage is an effective solution where the appropriate geological conditions permit. China has by far the greatest capacity in pumped storage with some 28 GW of operating capacity in 2017 and plans to expand to 90 GW capacity by 2025 of which some 60 GW is under construction or planned. This compares to the current EU Pumped storage capacity of some 18 GW.

Load balancing and exchange is also provided by the construction of a more interconnected ultra high voltage grid system.

6.2.1.2. Thermal power

There has been a moratorium on expanding coal capacity in most areas of China since 2016[53]. However there are still projects in pipeline under construction, though the construction programmes have been slowed, this is still in the 100 GW capacity. The aim is a cap on total coal capacity of 1100 GW by 2020. New plants are in part replacing inefficient old sub-critical plant with the latest high efficiency plants fitted with full emissions control. Power companies are allowed to build new capacity if they can demonstrate that the workers in the decommissioned plant are fully compensated for early closure. Thus the Chinese power industry is still very active and Chinese power companies represent 80 to 90 % of the world market for advanced coal combustion power generation systems.

The cooling water consumption of the more efficient plants is less, since they convert more of the heat to electricity. In arid areas of China the plant must be of a dry cooled type to consume less water. The

[53] https://www.sourcewatch.org/index.php/China%27s_2016/2017_Restrictions_on_Development_of_Coal-Fired_Power_Capacity

emissions control systems for NOx and SOx removal, now fitted on 90% of plants, will normally produce large quantities of wastewater. Though the air emission control systems market is very mature, for the resulting waste water management systems there is still scope for development. The treatment standards and processes for this still require further definition and development and could represent an opportunity for EU process designers and systems suppliers. The water efficiency and discharge control systems of the power sector generally represent a less mature sector of the energy market. The likely tightening of wastewater discharge control by the regulators will drive investment in better wastewater treatment systems across large stocks of infrastructure. There are currently many restrictions on third parties being able to provide water management services in power plants, resulting in the power companies undertaking the process design and operation themselves (often inefficiently) rather than contracting to competent organisations. The reforms to procurement set out in 2017 circular No.5 of the State council may help to open access for international companies to get fair access to the contracting of such contracts.

Thermal power plants have an important impact on total water resource use in their region, whether returned as warm water after direct cooling or evaporated in cooling towers in indirect cooling systems. Understanding and modelling the interactions between water resource allocation and management and power development is an important part of development planning in China. Studies by UK FCO in 2016 indicated that the way in which withdrawals and consumption of water by the power sector were counted was very inconsistent. A direct cooled power station will actually consume a similar amount to a dry cooled station but would withdraw and return to the river vastly more water. Evaporative cooling is the main reason for consumption of total resources, and the amount consumed per MWh produced falls significantly for larger installations.

6.2.1.3. Wave, wind, geothermal integrated renewable solutions

Hydropower provides some 20% of China's electricity needs, meanwhile China has been making the largest investments in wind and solar power of any nation in the world, but these still only constitute 5 and 2% respectively of the total production. Note the lower utilisation of wind and solar capacity – since they only work in sunshine or wind the actual level of production is much lower than the capacity relative to other sources. Though there are plans over the coming decades to add some 1000GW or more of solar and wind capacity, the impact of this on the total energy mix is less than the addition of much smaller capacity nuclear or thermal sources. Thus, there is still far to go before the addition of renewables has significant impact on the whole power balance and water use.

For geothermal energy, China has the greatest capacity of any county in the use of direct heating (and cooling) of buildings by geothermal energy and the 13th FYP has plans to greatly expand that. China has relatively mature technologies in the exploitation of shallow geothermal capacity for direct use but there is still much scope for improved efficiency and for wider implementation. The use of geothermal energy for high temperature steam and power production is very limited and un-developed with just 25 MW of capacity nationally. Though there are regions with favourable geological conditions there is far to go to create the regulatory and political environment that will favour such development. International cooperation could speed the development of this sector[54].

There is demand and interest in water energy nexus area – especially recovery of heat and kinetic / electrical energy from water systems. This can include heat pump systems to take heat from rivers, sewers and for in building recovery and re-use of heat. Fitting of microgenerators in water distribution systems where pressure reduction is required – to extract this as local electrical energy.

Wave energy extraction is still under developed in China. There have been pilots of systems based on EU derived prototypes and some international cooperation, but not yet at scale. Likewise tidal stream technology is being investigated with considerable potential, especially in the Zhezhian Zhoushan Island area where very strong currents run close to shore. As yet this is not close to a commercial level. Chinese investors were heavily involved in prototypes for the Swansea tidal lagoons in the UK, but eventually were not able to make commercially viable.

6.2.1.4. Demand management – the power grid and the water grid

The water supply and wastewater treatment system is a major energy user and has significant capacity to be a balancing factor in a smart grid system. Many energy intensive functions such as pumping water to service reservoirs can be scheduled to happen when there is excess power available on the grid. The provision of extra storage capacity of water in the water supply network can be a proxy for the storage of energy.

In coastal areas where there is a water shortage desalination may be considered as a source of water, and as desalination systems have become more efficient and more robust in recent years so this is becoming

[54] https://www.sciencedirect.com/science/article/pii/S0960148118302672

more feasible. However, the energy demand still makes this a relatively expensive source for freshwater. In a situation where solar and wind renewable power is much cheaper and more abundant desalination can become more attractive and, if designed specifically to operate under variable loadings, can act as a balancing demand factor and use the produced water as an effective store of energy.

Technical solutions that allow for greater integration of the water cycle with the energy cycle could find massive scale application in China.

6.2.1.5. China outbound

There are currently more than 200 coal power plants under construction by Chinese power companies in 31 countries outside of China[55]. China is the main builder of big dams around the world, most solar panel cells used anywhere in the world are manufactured in China and increasing proportion of wind turbines are produced in China and China controls most of the rare-earth metals required for the construction of high efficiency turbine generators and many battery technologies.

For companies that have products related to the water aspects of the energy cycle there are compelling reasons to engage with Chinese power development companies.

6.2.2. Water for energy: barriers

- Government controlled, incumbent institutes and organisations;
- Need contacts at local levels;
- Central only for very big or international projects.

This sector is dominated by major hydropower dams and increasingly by micro-hydro power and run-of-the river schemes. This is a mature industry in China where more and bigger dams are constructed than anywhere else. Having worked in the past with international hydropower experts, local Chinese producers are now able to meet most of the market needs.

6.2.3. Water for Energy: Strategies

- Partnerships with government institutes or SOE water enterprises;
- Partnerships with local and regional companies;
- Monitoring and modelling;
- Integrated thinking – Integrated energy and water use with river basin management and water resources allocations;
- Ecological restoration, fish passes etc;
- Energy production process wastewater treatment processes;
- China outbound – working with Chinese energy companies on overseas projects.

[55] https://instituteforenergyresearch.org/analysis/coal-dead-china/

7. Conclusions

Water security is critical to sustainable growth in China and the government is greatly increasing investment in the sector. The water resource scarcity and pollution issues represent both considerable risks to economic growth and opportunities for growth by providing solutions. China wants to access best international practice that can be demonstrated to turn risk of loss into potential for growth, but there are many knowledge, language, culture, IPR and financial barriers to overcome. There are complex planning and procurement procedures for foreign companies to negotiate and certain areas of the market will be inaccessible.

As the previous sections have shown, Europe has to offer a number of technologies with a potential for application in China. However, a foreign SME (or company) cannot easily contact and sell products to Chinese clients who would have the capacity to buy and implement their technology. A good local partner is required which in practice may be difficult to achieve. Further, to be successful, EU Companies will have to find the niches in which their expertise and premium technology are valued and there are clients with the financial resources to procure their services. If you get it right, the opportunities will outweigh the challenges.

The two main strategies for partnering for foreign SMEs are either finding distributors for direct sales and support or finding strategic partners who are involved in the PPP infrastructure projects and will incorporate the European technology to these projects. Distributors tend to be geographically based, therefore a foreign company may need to strike agreements with several different companies across China. A good route to finding distributor partners are trade fairs. Ideally the distributor should be able to provide installation, support and maintenance services as well as sales.

The policy driven solutions will most likely be implemented through demonstrations and pilots at local and regional levels delivered to local government tenders by PPP contractors. The foreign SME therefore needs to identify companies who are involved in tendering for these projects and demonstrate to them, that a consortium bid that incorporates their technology would be able to deliver better value and is more likely to win. Their role would most likely be as a sub-contractor to a consortium partner or possibly a JV partner. Certain central government agencies can be helpful in making such contacts. Innovation promotion centres in the EU and member state missions can also help as can member states water partnerships and networks.

For innovative technologies that will challenge standards or require integration of different departments and industries the foreign company may want to also build close relations with relevant Government research or technical institutes. These often play an advisory role to government and can introduce the innovations to policy makers, planners and those preparing procurement programmes. It may be necessary to get high level acceptance of the innovation before it will be possible to move to actual sales.

Before fully engaging with any partners the foreign SME should take action to register any intellectual property in China, in accordance with guidance from the EU IPR helpdesk. Even if registered internationally IP and trademarks should be separately filed in China. The foreign SME will need to identify the situations in which their product or service may be applied and prepare the case of how it will add value. They should also research the local standards for water, wastewater and recycled water quality, or for groundwater as appropriate to ensure that they are able to operate to the appropriate standards. Targeting the appropriate partners would also mean targeting the areas of China where their particular solution will have greatest application depending on the climate and development levels. This may also affect the practicality of engaging exclusively with one partner or having to negotiate multiple relationships in different regions.

When engaging with potential commercial partners consideration will need to be given to the localization of the technology to meet local standards and documentation in Chinese. Local universities and institutes may also be able to help with this. Most important will be to understand what the contracting situations are that the foreign SME and their local partner would be targeting and how they are to prepare the joint proposals.

In all cases the provider of the technology must be able to demonstrate the business case for customers to adopt their solution rather than the status quo or cheaper local alternatives by quantifying the added value provided either through innovation or quality, reliability, and efficiency.

In summary, to successfully obtain a foothold in China EU water sector companies will have to adapt their products and business processes to fit the local culture and market. We have identified the following proven strategies to achieve this:

1. Understand the market and the procurement processes – who are the real clients and key partners and which actions need to be taken at which stage of the procurement process; from profile raising and intelligence gathering to positioning, partnering, tendering and the delivery of projects;

2. Match the product that the company is selling (be it services, expertise or technology) to the needs and expectations of the clients – these are likely to be quite different to typical European client expectations. This will mean doing research and listening very carefully to what potential clients are demanding;
3. Map the revenue streams of the clients and the supply chain – make sure that the company is entering the deal at a point at which clients have revenue available with which to pay the company;
4. Companies will have best chances of successful entry in niche, emerging or high-risk areas of the market;
5. Keep the product simple so that clients can easily understand its purpose and function;
6. Adapt, tailor and package the product to comply with local standards and market prices. This may mean adapting any patented IP to fit local conditions;
7. It will be very difficult to find success in commodity markets where your costs will inevitably be higher than the local competition's. Define a premium product that still offers good value in the longer term; If done successfully, it is possible to achieve very high margins in China – potentially higher margins than in the EU;
8. Though the greatest skill that Europeans have is the ability to efficiently manage complex integrated systems, this can be very difficult to explain to Chinese clients who are likely to be used to the more compartmentalised Chinese approach to operations. Therefore, express yourself in simple terms;
9. Have strategies to protect your IPR, either by filing for patents or maintaining secrecy;
10. Assume that any IP-related secrets you bring to China will be compromised, as both data security and trust can be low in China. Therefore, keep essential trade secrets offshore wherever possible;
11. Acquire knowledge of the financing options available to support the growth of your business. If finance is required, ensure you have staff who fully understand Chinese banking and accounting procedures;
12. Understand the reforms to the procurement regulations and the actions now available to push for fair access to bidding processes;
13. Invest in building relationships with technical, business and financial partners and exercise due diligence.

Entering the China market requires commitment of time, resource and energy. Prepare, plan and budget. If not serious about it then don't waste efforts dabbling.