high," a source from water engineering firm Tritech told GWI. "Most of the market participants are not competing on technologies or cost, but more on their business relationship with local governments and state-owned developers."

A PPP-based financing model is encouraged in the 13th FYP for comprehensive environment treatment projects in rural areas. This works in Origin Water's favour since it has the China Development Bank (CDB) as its third biggest shareholder and has a design institute and engineering company as its wholly owned subsidiaries, giving it the power to secure PPP projects in-house by taking sole responsibility for financing, design and construction. "Rural wastewater treatment is a huge market with fierce competition," observed Liu.

Alignment with the trends of the PPP project model is of critical importance. Jiangxi JDL Environmental Protection (JDL), another integrated MBR specialist known for its patented facultative-anaerobic-adapted MBR technology, is now developing an ability to take on PPP projects through cooperation with SOEs. This system eliminates any sludge discharge by recycling it as a carbon source supply to increase the organic loading. "JDL is mainly engaged in rural decentralised wastewater treatment. Its business model has matured over the last two years by developing a close relationship with SOEs to participate in the PPP market," the GreenTech technical engineer told GWI. After shifting from the role of equipment provider for government procurement to PPP project developer, the company's revenue reached RMB213 million ($34 million) with year-on-year growth of nearly 100% according to JDL's first semi-annual report in 2017.

In order to compensate for the lack of experienced technical operators in rural areas, the containerised MBR systems usually include remote monitoring and control. The Compact Wastewater Treatment System is an integrated containerised MBR system designed by Origin Water specifically for underground wastewater treatment in rural and remote areas. Beside the traditional anoxic and aerobic membrane units, Origin Water also installs a remote control device for intelligent management. "We usually arrange one technical staff for a certain project, who is responsible for managing and operating our devices in several rural WWTPs through apps," Liu said.

Residential filtration taking off

Ageing and poorly maintained water supply systems that include old pipelines and water tanks can pose a risk to potable water quality before it reaches the taps. To further purify the tap water, small residential filtration devices are receiving growing attention, carrying much less cost than the construction of pipelines.

UF, NF (nanofiltration) and RO membranes are all commonly applied in the point-of-use filtration market with RO taking the largest share. The three filters are suitable for water with different chemical composition and physical properties. "UF or ultra-low pressure NF membranes are more appropriate in the south part of China where soft water is in the majority," Gao explained. "Whereas in the north where the water is hard, filters using NF or RO membranes will last much longer. For some areas of Hunan and the north part of Guangdong, NF membranes are a better fit because the water is heavily contaminated by metals there."

Litree is the leading player in the point-of-use (PoU) UF market, introducing the technology into the market in 1998. The company was responsible for providing up to 150,000m^3 of potable water for 73 million visitors to the Shanghai Expo in 2010 and became the leading PoU UF membrane manufacturer in China. Besides Litree, Origin Water is also attempting to penetrate the PoU market through its wholly-owned subsidiary Beijing Origin Water Purification Technology. "Consumers have a huge need for residential water purification. We have prepared for this part of the business for about six years, during which we also provided our membranes to some other brands as original equipment manufacturer for online sales," Liu told GWI.

The revenue of Origin Water's PoU water treatment business in 2016 was RMB233 million ($37 million), seven times that of 2012. "This market is focusing more on the product's filtering effect and business model, which is quite different from the municipal engineering projects where you have to convince both the governors and experts," Liu said. The DF membrane, a type of low operational pressure NF membrane, is the mainstream technology promoted by Origin Water for filters. "Compared with RO filtration systems our DF membrane has a much higher recovery rate of more than 80%," said Liu. Poten Environment, the Chinese project developer, is also trying to take a share of the PoU market through the acquisition of Canature Environment, which specialises in residential water purification, in late 2017. ■

Terminology

Ceramic membrane: membrane made from inorganic materials such alumina, zirconium oxide or silicon carbide.

Hollow fibre: configuration of a membrane where fibres are bundled together and potted usually at both ends. Most products have fibres with an inside diameter of less than 1mm.

Non-solvent induced phase separation (NIPS): the most common method to develop porous asymmetric membranes whereby a change in stability of a polymer solution is achieved by mass exchange in a non-solvent bath.

Polyethersulfone (PES): a thermoplastic polymer used to manufacture UF/MF membranes making them inherently hydrophilic and offers tighter pore size distribution than PVDF membranes.

Polyvinylidene fluoride (PVDF): a thermoplastic polymer used to manufacture UF/MF membranes that offer more flexibility than PES membranes and can better deal with a wider variety of feedwaters. Less inherently hydrophilic than PES.

Thermally induced phase separation (TIPS): an alternative, less common method to develop porous asymmetric membranes. Change in stability of a polymer solution is achieved by mixing with a solvent and high temperature, which is reduced to induce phase separation. TIPS membranes offer higher mechanical strength and narrower pore size distribution than NIPS products.

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> Liu An Bo, Origin Water