PROGRESSES OF PROCESS ENGINEERING IN CHINA

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In the very last years, China is becoming very competitive in developing new processes and exporting them worldwide[1]. Traditionally China was importing technologies and not exporting. However, the situation is today different. China is becoming a competitive exporter of chemical processes. These successes are largely also well related to the success of Chinese Scientists active in the field having today a leadership of the advanced research project in membrane science and engineering as well testified by the manuscripts published in the Journal of Membrane Science and by the creation of Industrial Membrane Parks (as in Nanjing and in other part of the Country).

Typical examples can be considered:

1. Conversion of carbon dioxide and methane into synthesis gas. The process was developed by Shanghai Advanced Research Institute (SARI) with the support of funds provided by Shell. The viability of the process was demonstrated by Shanxi Lu'an Group.

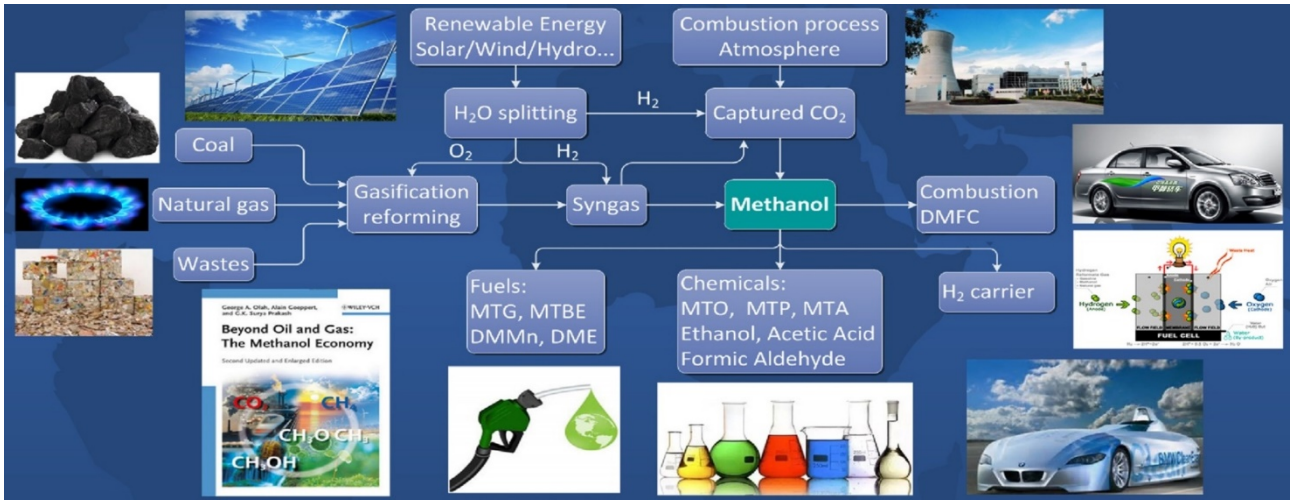
Process development labs at SARI seek, among other things, to reduce the carbon footprint of high-carbon fossil fuels. From 1.

2. Organic solvent nanofiltration (OSN) technology. Organic Solvent Nanofiltration (OSN) is an innovative and environmentally friendly membrane technology, which has a wide range of applications in the petrochemical, pharmaceutical, fine chemicals, and food industry. An example can be found in the collaboration between EVONIK and SINOPEC in OSN membrane technology[2]. In fact, in June 2017, the German specialty chemicals company Evonik Industries AG and the SINOPEC Beijing Research Institute of the Chemical Industry (BRICI) have signed a collaboration agreement to build a process development laboratory for Organic Solvent Nanofiltration (OSN) membrane technology. Evonik stated that new technologies developed at the lab will be marketed to chemical, food, and drug producers in Asia.
3. Zeolite membrane.

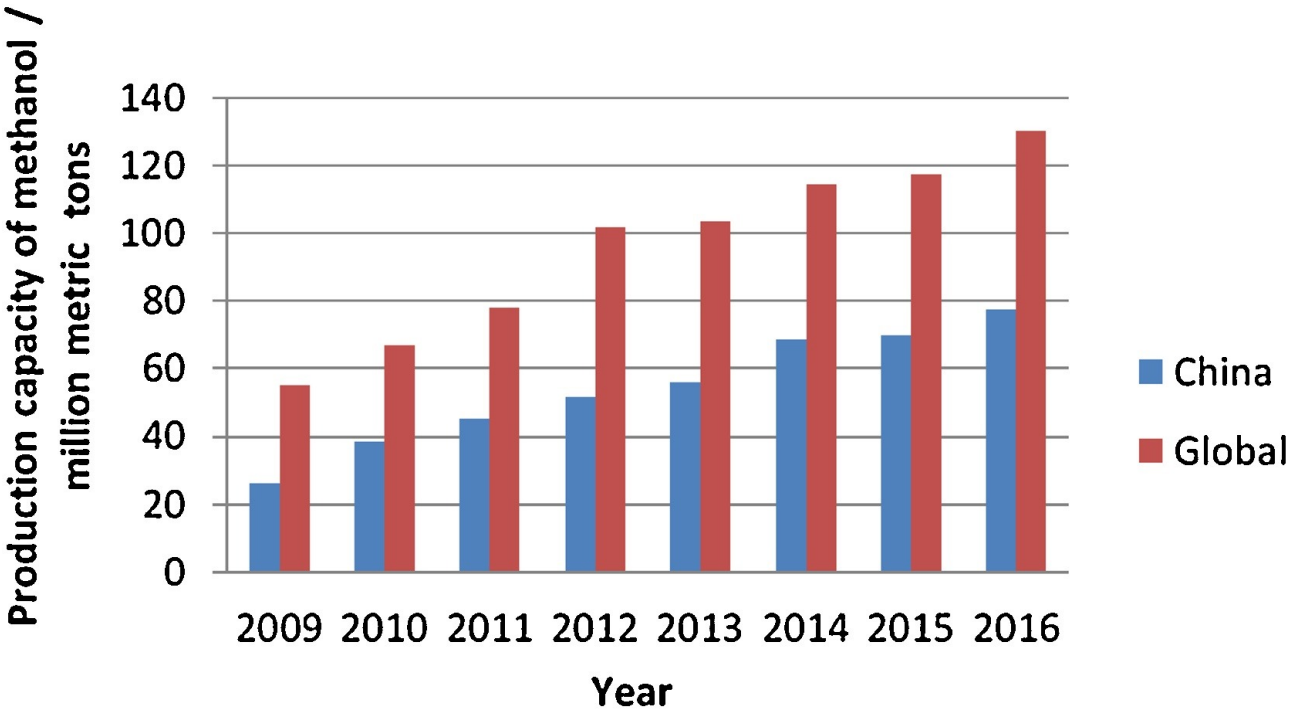
   An example can be found in the process, developed at Dalian Institute of Chemical Physics (DICP), using a zeolite membrane for dewatering.

On December 11, 2017, Prof. Yang's Group (full professor of DICP, Chinese Academy of Science) finished zeolite membrane separation system for dewatering of ethanol with scale of 100,000 T/a. The produced anhydrous ethanol meets with the requirements of GB/T678-2002 standard. The zeolite membrane used in the separation system was synthesized with microwave heating which was first developed by Prof. Yang's Group in 1999. This separation system is the largest zeolite membrane facility in the world.

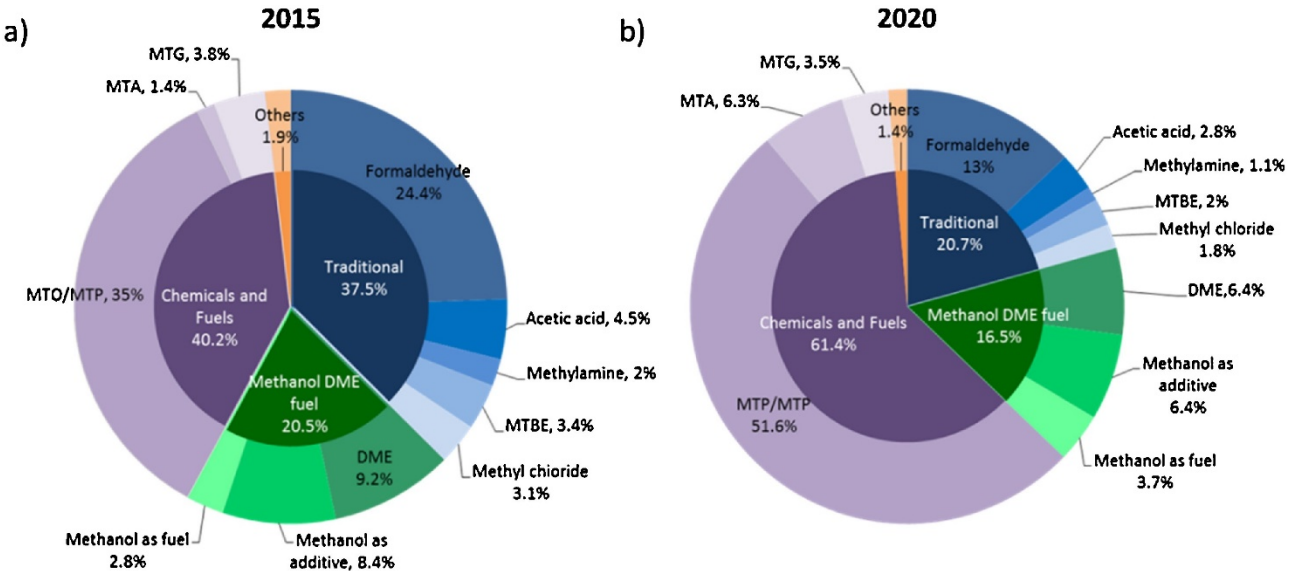
4. Catalysis (and in particular industrial catalysis), for example for producing ethanol from acetic acid, methanol, and synthesis gas. In recent years, China has developed in the very recent years a series of clean coal technologies to transform black-dirty coal into clean fuels and chemicals[3]. An example can be found in the Shenhua Group, the largest coal company in China that is leading the commercialization of modern clean-coal technologies for value-added chemicals and clean transportation fuels, in which CO_2 is captured in the process and ready for carbon capture, utilization and storage. In the last decade, industrial plants for coal-based methanol production and conversion are prosperous. With the development of renewable H_2, methanol production could be realized by CO_2 hydrogenation to transform into "Methanol Economy", the sustainable energy development system.



Methanol production and uses. From 3.



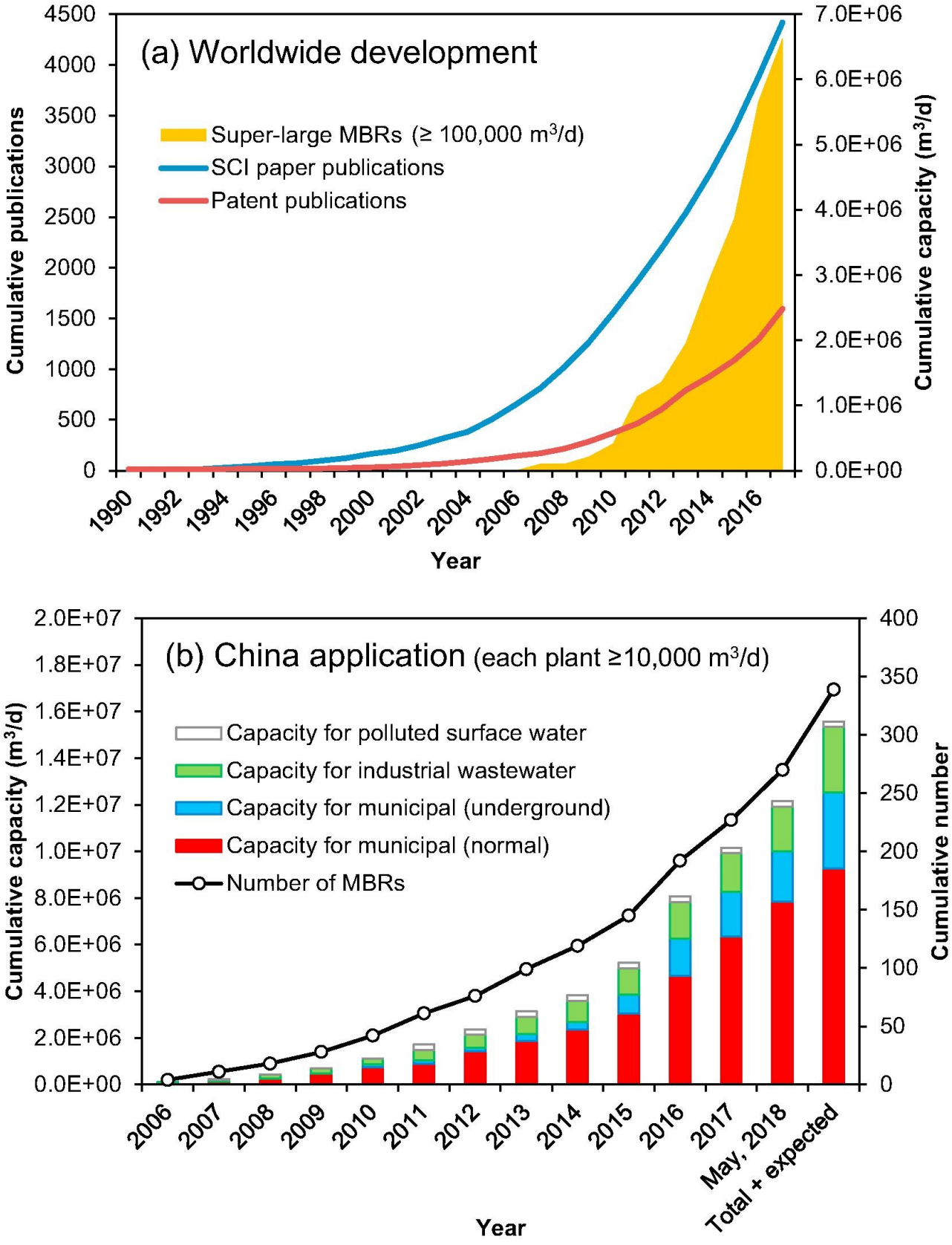
Production capacity of methanol between China and global 2009–2016. From [4]



China's methanol production in 2015 and 2020 (projected) and its sharing ratio in each derivative. From 3.

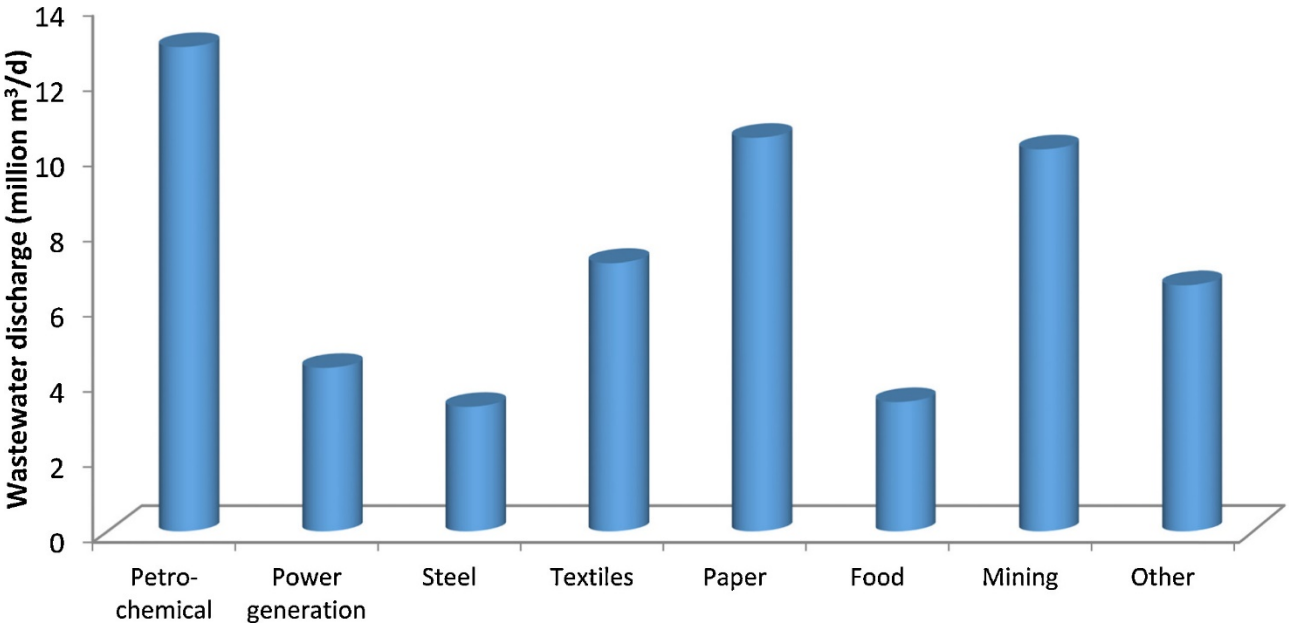
It is very interesting for membrane engineers that the contribution of membrane systems in the various cases mentioned is very important. Similar situation can be mentioned for various other systems such as:

- Membrane bioreactor (MBR) where China has contributed with about ¼ of published papers and more than half of super-large MBRs[5]



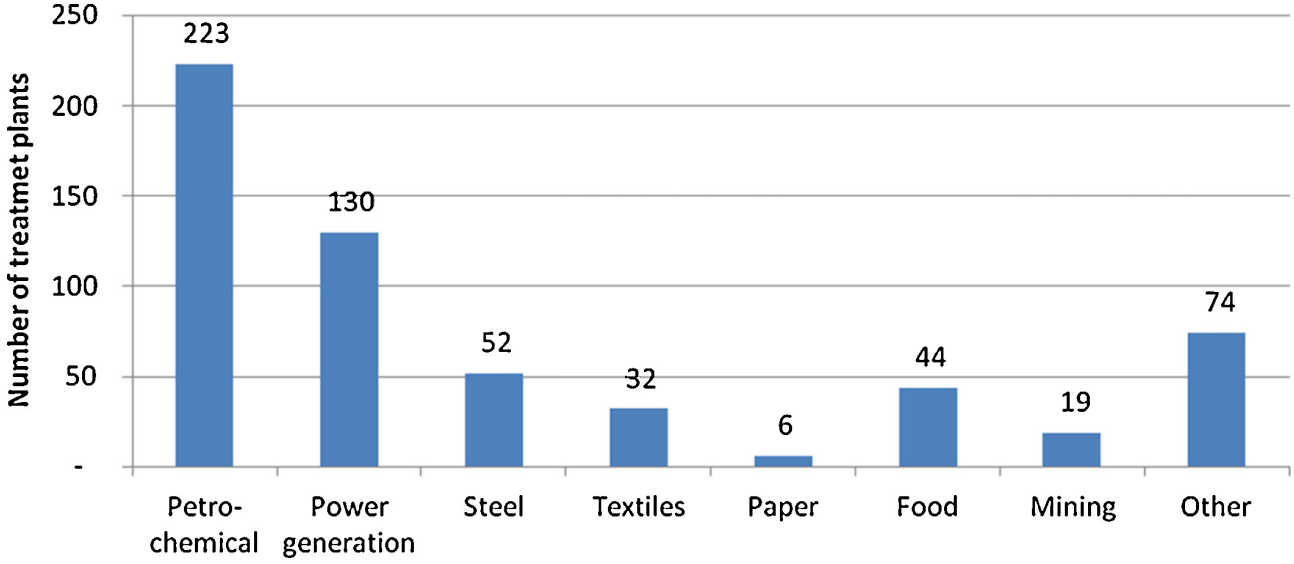
(a) Worldwide development of MBR paper publication, patent publication and engineering application; (b) development of large-scale MBR application in China. SCI-Expanded paper publications and patent publications were searched in the database of ISI Web of Science using the code of: TS = ((membrane bioreactor) AND ((water treatment) OR (wastewater treatment))). Data of super-large MBRs around the world were obtained from "The MBR Site" (http://www.thembrsite.com/, accessed 5 June 2018). From 5.

- Large scale plants based on ultrafiltration in paper and textile industry. One of the motivations is because in China, the top four wastewater discharge industries are petrochemical, paper, mining and textiles:



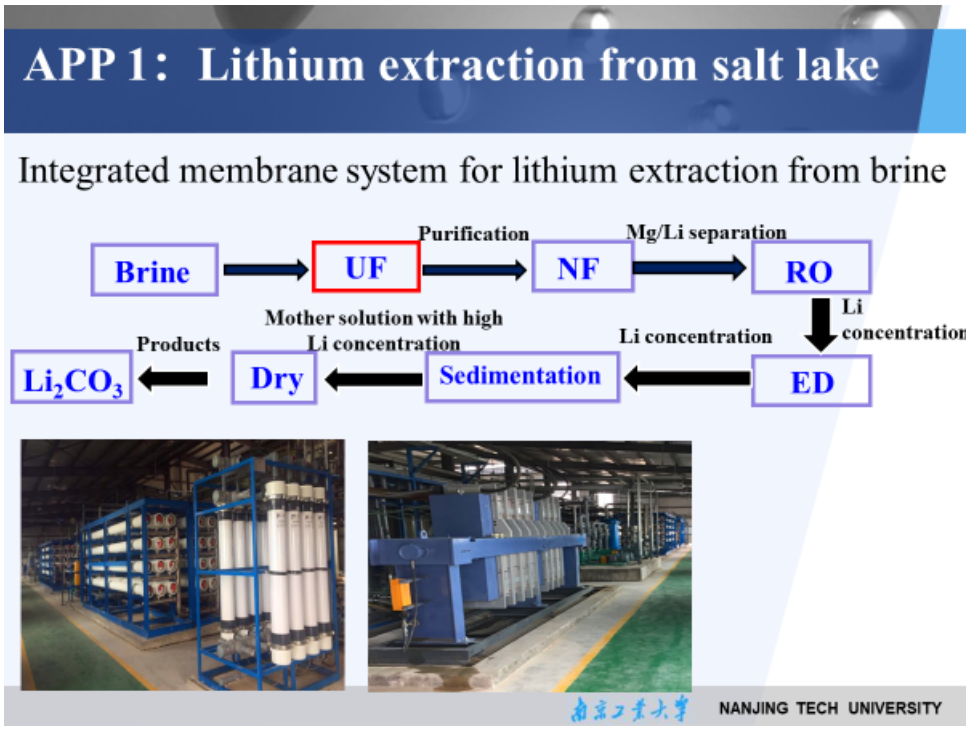
Industrial wastewater discharge for different industries. From [6]

From the perspective of the number of membrane plants, petrochemical, power generation, and steel industries account for the majority. The following figures demonstrates the number of membrane plants in various industries.



The number of membrane plants applied in different industries. From [7].

Approximately 70% of the membrane plants are employed in petrochemical, power generation, and steel industries: 38%, 22%, and 9%, respectively. Textiles, paper, food, and mining grasp 5%, 1%, 8%, and 3% of all membrane plants, respectively. 13% of all membrane plants are used in other industry.



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