Pursuing carbon neutrality and water security in China

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China has promised to become carbon neutral before 2060 and has coupled this ambitious target with stringent limitations on industrial water use by 2030. An international team of IIASA researchers and

Chinese colleagues explored the effects of simultaneously pursuing these goals.

Man-made carbon dioxide (CO_2) emissions need to fall by about 45% from 2010 levels by 2030, and reach "net zero" by mid-century to give the world a chance of limiting the warming of the planet to 1.5°C above pre-industrial levels and avoiding the worst impacts of climate change. China, which is currently the world's biggest emitter of CO_2, is one of a growing number of countries to have officially committed to achieving carbon neutrality by 2060, with a key focus on decarbonizing its industrial sector. In addition, due to severe water scarcity experienced in the country, the Chinese government has imposed stringent limitations on industrial water use by 2030, as China's industries not only account for half of national CO_2 emissions, but also for more than 20% of water withdrawals. The effect that emission reductions will have on industrial water use, however, remains unclear.

To shed light on this issue, IIASA researchers and Chinese colleagues used a model incorporating a self-developed, high-resolution provincial water use inventory based on enterprise census data covering over 140,000 enterprises in 31 Chinese provinces from 1998 to 2015. The new inventory was then used to develop an industrial water-use module to project the country's future multi-sectoral carbon emissions, economic indicators, and industrial water use under a business-as-usual scenario (without a carbon neutrality target) and under a carbon neutrality scenario (with a carbon neutrality target). The results of the study have been published in the journal *One Earth*.

"We used a computable general equilibrium model—a type of economic model that uses real economic data to estimate how an economy might react to changes in policy, technology, or other external factors—to identify synergies and risks over time and across regions in 31 Chinese provinces. This sets our analysis apart from previous studies that focused

more on water withdrawal from the energy sector, but neglected water-intensive industrial sectors, or only covered water use in a single region," explains study author Hancheng Dai from Peking University in China.

The study's results show that becoming carbon neutral will save 24% of China's industrial water use in 2060 and help to achieve the strict industrial water use targets in 22 out of 31 provinces studied. At a provincial level, it is however possible that 9 of the 31 provinces will struggle to meet water-use targets in a carbon-neutral future, unless more coordinated climate-water strategies are put in place. In addition, the researchers found that if inter-provincial industrial relocation occurs, water use could actually rise in certain provinces, reducing the water-saving potential.

"Different emission reduction expenditures and capacities have the potential to reshape industrial competitiveness and structure, eventually causing some industries to relocate to other regions. This can result in undesirable outcomes in terms of emission reduction and water use. At present, it is however uncertain whether the achievement of China's 2060 carbon neutrality goal would motivate industries to move, and how this might affect water savings and the ability of industries to meet water use targets," notes study author and Deputy Dean of the College of Environmental Sciences and Engineering at Peking University, Yong Liu.

Pursuing carbon neutrality also creates a number of co-benefits from key sectors. Notably, five energy- and/or water-intensive sectors, including power generation, light industry, chemicals, mining, and metal smelting and products, contributed to the bulk of national co-benefits, accounting for 48%, 14%, 13%, 9%, and 9% of total water savings in 2060, respectively.

"It will be important for regional governments to utilize and promote the

co-benefits originating from the key sectors to fulfill more environmentally friendly water resource allocation while achieving carbon neutrality. The saved water use can, for instance, be returned to natural water bodies like rivers and lakes for ecological purposes. There is no doubt that the co-benefit effects will contribute to the development of an ecological civilization," says study lead author Xiaoyu Liu, also from Peking University, who started this work as a participant in the IIASA Young Scientists Summer Program.

Due to the diversity of industry structure and differences in the availability of water resources between provinces, there are both opportunities and risks for Chinese industry in pursuing a carbon neutral future. Achieving the carbon neutrality target may, for example, enable 8 and 12 provinces to achieve the industrial water target set by the Chinese government in 2030 and 2060, respectively, mostly in northern China. The co-benefits produced by carbon neutrality are however not sufficient for the achievement of targets in 14 and 9 provinces in 2030 and 2060, respectively, mostly in the southern and northwestern regions of China.

"While risks are created by industrial restructuring and consequent spillover effects across and inside provinces, water use management that only relies on water-use intensity control and co-benefits from reducing carbon emissions is not enough to achieve China's overall water-use goals. This once again highlights the importance of imposing restrictions on total water use, especially for water-scarce provinces. On the other hand, it might also be beneficial to consider reducing the water use cap for areas rich in water resources, as too strictly limiting water use in these areas could hamper local economic development," says study author and IIASA Water Security Research Group Leader, Taher Kahil.

"The findings of our study facilitate a better understanding of the water-energy nexus in the context of meeting ambitious climate targets and

show that the integrated management of water and industry is efficient and can promote sustainable development. It also accentuates the need to formulate more coordinated policies, including more stringent regulations and advanced technologies, that can maximize synergies in addressing climate and water challenges," concludes IIASA Biodiversity and Natural Resources Program Director, Yoshihide Wada, who was also one of the study authors.

More information: Xiaoyu Liu et al, Achieving carbon neutrality enables China to attain its industrial water-use target, *One Earth* (2022). DOI: 10.1016/j.oneear.2022.01.007

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