Mercury (Hg) is a global threat to human and environmental health [1]. To address this global issue, the Minamata Convention on Mercury (MC) was agreed upon by 128 countries on 19 January 2013. China officially ratified the MC in August 2016. As the largest emitter of atmospheric Hg, China accounts for 30–40% of global Hg emissions [2]. Additionally, projection of the atmospheric emission of Hg in 2050 also indicates China’s significant contribution [3]. Whether there are major knowledge or policy gaps are key questions for not only the development of a Chinese Convention Implementation Plan, but also the overall success of the MC.

**Hg USE IN PRODUCTS AND MANUFACTURING PROCESSES**

The largest user of Hg in China is the Hg-containing catalyst used in the carbide process-based vinyl chloride monomer (VCM) industry. The total demand for Hg in the VCM sector was as high as 900 tons in 2014 [4]. China was aware of this issue and established a policy in 2010 to force the VCM industry to switch from high-Hg-containing catalyst (HMC) to low-Hg-containing catalyst (LMC) [5]. However, according to estimates, only ~40% of the production capacity had switched to LMC by 2014. Due to the increasing total production volume of VCM, even if China achieves 100% replacement of HMC by LMC, the VCM sector will still be the largest user of Hg by 2020. LMC is therefore only a temporary solution; China must invest in R&D to develop Hg-free catalyst, which is the ultimate solution for this sector to eliminate Hg in the production process.

Reducing Hg in products has also raised awareness in China since the
Hg EMISSIONS AND RELEASES

Human activity, especially the burning of fossil fuel and the smelting of minerals, has increased the emission and release of Hg into the environment, raising the amounts in the atmosphere, soils, fresh waters and oceans [1]. Figure 1 shows the relative contribution of Hg emission to the air in 2010. Since 2010, China has extensively reviewed and strengthened its atmospheric-emission standards, and Hg has been added as a targeted control element in most industrial-emission standards, such as those of coal-fired power plants, coal-fired industrial boilers, non-ferrous metal smelters, waste incinerators and cement clinkers. For example, the Hg-emission limit in flue gases from coal-fired power plants was revised in 2011 and set to 30 μg m⁻³, which is expected to be met by the power plants via the installation of wet flue gas desulfurization and dust collectors that provide synergistic Hg removal [7]. This standard is lenient compared to the US standard, which is measured in units of power output to encourage energy efficiency [8], but similar to the German standard [9]. However, the EU (including Germany) is currently developing a more stringent emission standard, and China may follow suit. According to estimates, China could achieve a limit of 5 μg m⁻³ by 2020 and aims to achieve a 3 μg m⁻³ limit by 2030 [9]. Creating a more stringent Hg-emission standard requires more than synergistic Hg removal alone, and dedicated Hg-control technologies, such as activated carbon injection and halogen-injection devices, must be installed. The additional cost of installing these technologies will be an important factor that determines when and how China plans to improve its emission standard. Other emission sectors will face similar problems, except for the industrial boilers. Building large factories is generally the most straightforward way to reduce the per-unit cost of air-pollution controls and promote the application of more advanced Hg-control technologies. However, this approach is not applicable for industrial boilers because these boilers are difficult to centralize due to the loss of steam pressure. A potential way to overcome this problem is to promote alternative cleaner energy sources, such as natural gas, which will also reduce the emissions of other pollutants.

Although Hg emissions into the atmosphere have been given considerable attention, Hg releases into the water and soil have been given less attention, except for a few contaminated sites in China. The release of Hg into the water and soil is a serious local problem given the scale of heavy-metal pollution in China. It was estimated that approximately 651 tons of Hg was release into the land and 84 tons into water in 2010 [10]. This amount is equivalent to the atmospheric emission, which was 633 tons [10]. Studies on Hg releases is still insufficient compared with atmospheric emission. Therefore, a soil- and water-release inventory similar to the atmospheric-emission inventory is urgently needed.

GAPS AND THE WAY FORWARD

Although China has obtained extensive knowledge of the Hg problem that can serve as a basis for MC implementation, there are still important gaps that are not sufficiently addressed by the existing policies (Table 1). The following knowledge and research gaps should be addressed in a timely way:

(i) China should enhance the R&D on affordable Hg-free alternatives for products and catalysts, promoting the best available techniques/best environment practices (BAT/BEP) in relevant industries to reduce Hg emission/release;

(ii) China needs to establish an integrated inventory for Hg-material flows to keep track of the Hg supply and trade in the society and movements in air, water and soil;

(iii) China must develop a reliable and affordable Hg-monitoring system to fulfill the reporting obligation under the MC.
Although facing numerous challenges, China has already shown great determination in reducing its mercury pollution. China is now developing its National Implementation Plan for Minamata Convention; all of the above-mentioned issues will hopefully be addressed sufficiently. Law enforcement will then become the key to ensuring a successful implementation of the Plan. China needs also to be prepared for the effectiveness evaluation that will be conducted no later than six years after the MC enters into force to check the performance of the MC.

SUPPLEMENTARY DATA
Supplementary Data are available at NSR online.

FUNDING
This study is funded by the Sino-Norwegian Cooperation Project on Mercury—Capacity Building for Implementing Minamata Convention. S.W. also acknowledges support from the Major State Basic Research Development Program of China (2013CB430001) and from the Collaborative Innovation Center for Regional Environmental Quality. Y.L. would like to acknowledge the support from the Opening Fund of the State Key Laboratory of Environmental Geochemistry (SKLEG2017915).

Yan Lin¹, Shuxiao Wang², *, Eirik Hovland Steindal¹, Hua Zhang³, Huan Zhong⁴, Yindong Tong⁵, Zuguang Wang⁶, Hans Fredrik Veiteberg Braaten¹, Qingru Wu² and Thorbjørn Larsen¹
¹Norwegian Institute for Water Research, Norway
²State Key Joint Laboratory of Environment Simulation and Pollution Control, School of Environment, Tsinghua University, China
³Norwegian Environment Agency, Norway
⁴State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, China
⁵State Key Laboratory of Pollution Control and Resources Reuse, School of the Environment, Nanjing University, China
⁶School of Environmental Science and Engineering, Tianjin University, China
⁷School of Environment & Natural Resources, Renmin University of China, China
*Corresponding author.
E-mail: shxwang@tsinghua.edu.cn

REFERENCES
1. United Nations Environment Programme. Global Mercury Assessment 2013: Sources, Emissions, Releases, and Environmental Transport. Geneva, Switzerland: United Nations Environment Programme, 2013.
2. Zhang L, Wang S and Wang L et al. Environ Sci Technol 2015; 49: 3185–94.
3. Streets DG, Zhang Q and Wu Y. Environ Sci Technol 2009; 43: 2983–8.
4. Lin Y, Wang S and Wu Q et al. Environ Sci Technol 2016; 50: 2337–44.
5. Ministry of Industry and Information Technology of China. Hg Pollution Control Plan for VCM Industry Using Carbide Process. Beijing, China: State Council of China, 2010.
6. China Council for International Cooperation on Environmental and Development. Special Policy Summary of Mercury Management in China. Beijing, China: China Council for International Cooperation, 2011.
7. Wang S, Zhang L and Wu Y et al. J Air Waste Manage Assoc 2010; 60: 722–30.
8. United States Environmental Protection Agency. Mercury Air Toxics Standards MATS. Washington DC, United States: United States Government, 2012.
9. Ancora MP, Zhang L and Wang SX et al. Energy Policy 2016; 88: 485–94.
10. Hui M, Wu Q and Wang S et al. Environ Sci Technol 2017; 51: 222–31.

*ASGM, Artisanal and Small Scale Gold Mining.