WATER USE IN CHINA'S POWER SECTOR:

IMPACT OF RENEWABLES AND COOLING TECHNOLOGIES TO 2030

This brief examines the expected impact of China's power sector on water and climate in 2030. Building on plans announced at COP21 in Paris and earlier analyses by China Water Risk and IRENA[1], it assesses the impact of different options for China's power mix in 2030 on water use and carbon emissions. The analysis finds that a power sector transformation driven by renewables would also yield benefits in areas related to water. The magnitude of these effects reaffirms the importance of integrated water and energy decision-making in the power sector. Indeed, tomorrow's water resources should be considered as part of energy decisions today.

KEY FINDINGS

» **The power sector is exposed to, and contributes to, water stress in China.** Rapidly expanding thermal power generation has put a strain on limited water resources, accounting for almost 12% of national water withdrawals. Water stress is particularly acute in the northern provinces, which hold just a quarter of the country's renewable water resources but account for over half of national thermal power generation and over four-fifths of coal production and coal reserves. The same provinces host nearly half of China's sown cropland. Faced with growing risks for water and energy security, the sector needs long-term solutions to reduce water-intensity while meeting decarbonisation goals.

» **Renewable energy reduces water use as well as carbon emissions.** China's official Nationally Determined Contribution (NDC), or pledge to reduce carbon emissions, includes sourcing 20% of primary energy consumption from non-fossil fuels by 2030, compared to 11.2% in 2014. Much of this will happen by scaling up renewable power generation. Solar PV and wind technologies – key pillars of China's energy transition – use far less water than other generation methods. By using renewables to transform the power mix, adopting less water-intensive plant cooling technologies, and improving power plant efficiency, China has the opportunity to substantially reduce water use and carbon emissions

» **By 2030, the combination of renewables and improved plant cooling technologies can reduce water-intensity in Chinese power generation by as much as 42%.** Such a course could also reduce emissions-intensity by up to 37%. To realise these benefits, the share of renewables must increase in line with NDC objectives and the REmap options outlined by IRENA. A transition to less water-intensive plant cooling technologies is also needed to limit the growing water demand of China's power sector. Because of these interlinkages, energy policies and development strategies need to account for impacts on water resources.

[1] In 2015, China Water Risk published "Towards a Water & Energy Secure China" (CWR, 2015) which explored strategies towards water and energy security as well as provided an overview of water risk exposure across the power landscape. In 2014-15, IRENA published "Renewable Energy Prospects: China" (IRENA, 2014) and "Renewable energy in the water, energy and food nexus" (IRENA, 2015) which presented quantitative evidence of the water saving potential of renewable energy at a national and regional-level.

ENERGY AND WATER: THE INTERLINKAGES

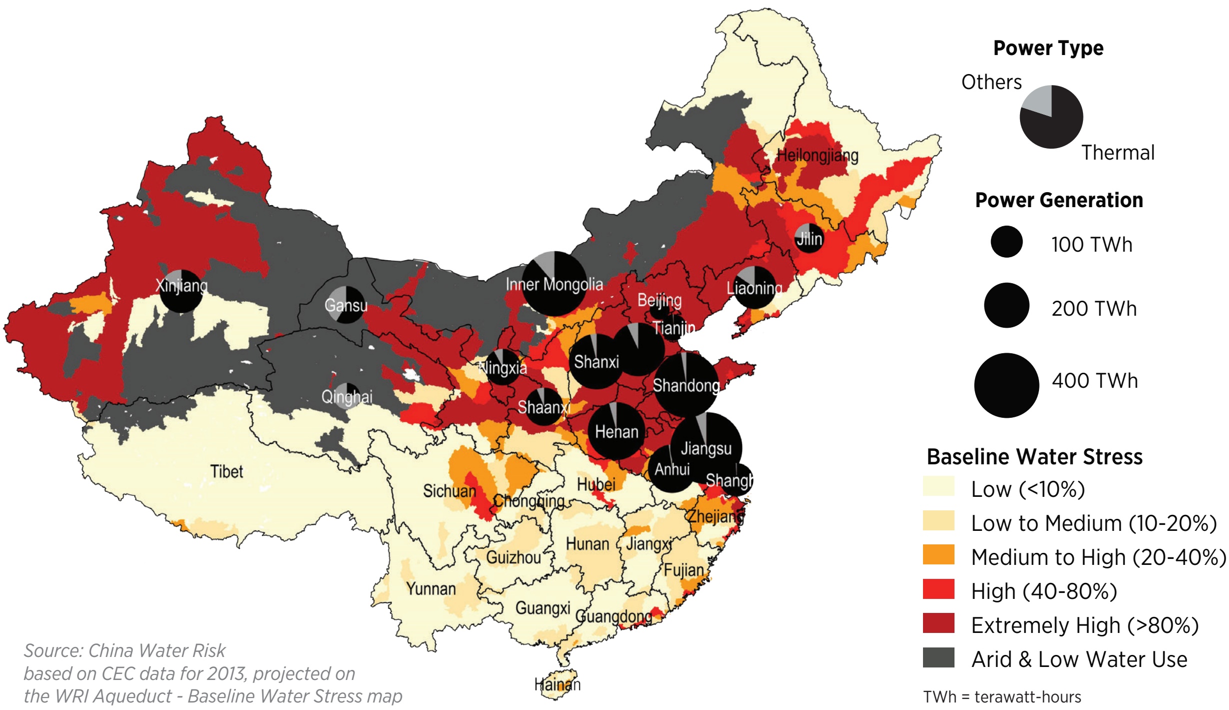
Accelerated economic growth has substantially increased energy demand in China. In the past decade alone, energy consumption has more than doubled. The growth in the power sector has been particularly rapid. Electricity generation capacity almost tripled from 2004 to 2014, rising to 1360 gigawatts. The trend is likely to continue over the coming decades, with the country's power demand expected to rise 65% by 2030 compared to 2013.

The power sector has traditionally relied on thermal power. Coal accounted for around 70% of electricity generated in 2014. This dependence is coming at a cost to the environment, including the health and welfare of people, as well as to natural resources such as water. Growing concerns over local air pollution have prompted the adoption of several measures. Many municipalities and regions, for instance, have decided to progressively shut down coal power plants and replace them with less polluting options. Similarly, water availability for power generation is also emerging as a major concern for the power sector. Producing electricity requires water for fuel extraction and processing, and for actual generation. Thermal power is among the most water-intensive options, as it requires vast volumes of water at each of these stages. In fact, the power sector currently accounts for nearly 12% of total national water withdrawals, second only to agriculture.

Coal and water resources are unevenly distributed across China's landscape. Northern provinces, for instance, hold only 25% of renewable water resources but account for 51% of thermal power generation, 82% of coal production and 86% of coal reserves. These water-stressed provinces are also the ones that are most reliant on thermal power (Figure 1). The concentration of coal resources and thermal power plants in these regions has two consequences:

- Increased risks to water supply for utilities. Nationally, an estimated 45% of China's power generation facilities are reliant on freshwater and are located in areas of high water stress (excluding hydropower). China's five largest power utilities are already facing retrofitting costs of as much as USD 20 billion to address water risks (BNEF, 2013).
- Intensifying competition for limited water resources with other sectors such as agriculture. The water-stressed provinces of the north are also home to nearly half of China's farmland leading to potential conflicts betwen sectors for water resources.

FIGURE 1: WATER-STRESSED AREAS AND THERMAL POWER GENERATION



Source: China Water Risk based on CEC data for 2013, projected on the WRI Aqueduct - Baseline Water Stress map

Given the growing complexity of the interlinkages between water, energy and food, and the challenges it poses for sustained economic development, different measures are being introduced. Central to this is the "Three Red Lines" – a series of water policies that set national and provincial quotas on water use and targets for the period ending in 2030. They consider total water use, efficiency, and ambient water quality (WRI, 2013). The 'Water-for-Coal Plan', announced in 2013, states that future coal base development plans should be made in consultation with bodies responsible for water in the provinces (CWR, 2013). These measures indicate that regional water availability in China is likely to influence the use of coal in the future. A growing trend towards less water-intensive power plant cooling technologies is also being seeing. Wet closed-loop and dry cooling are being preferred over the dominant once-through cooling for coal power plants given water accessibility challenges and policy changes.

China's actions have clearly moved beyond water savings to curbing absolute demand. The power sector can play a central role in this effort by:

» transforming the power generation mix towards less water-reliant energy sources;

» transitioning towards less water-intensive power plant cooling technologies; and

» increasing power plant efficiencies.

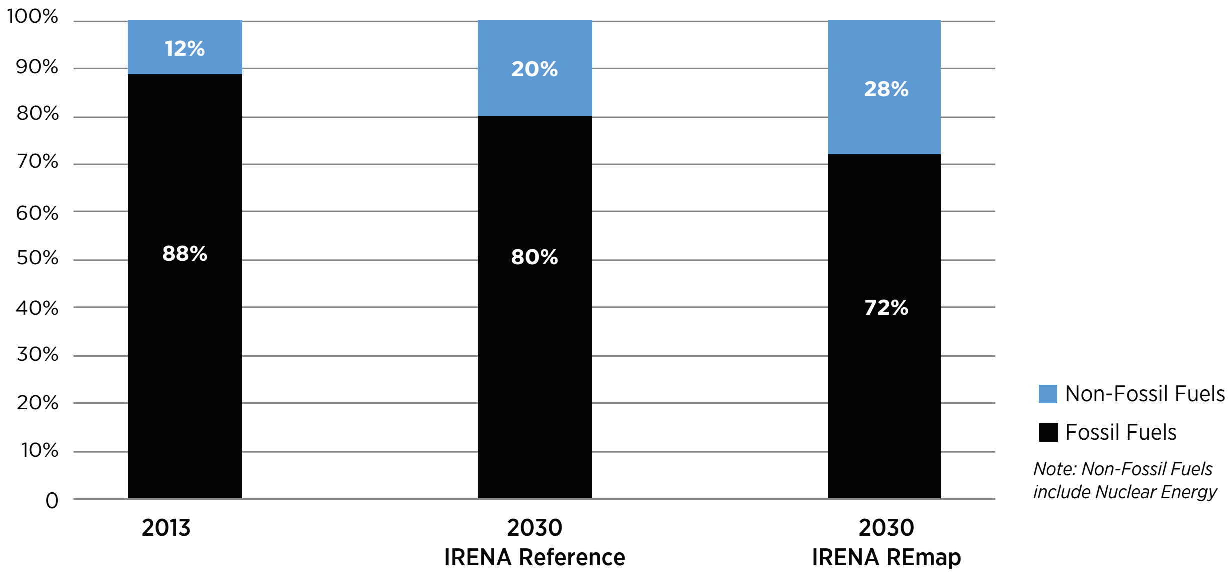
These measures are not independent of each other, and will need to be implemented together. This brief focuses on power sector transformation, showcasing how increased renewable energy deployment to address climate change can at the same time contribute to reducing stress on water resources.

RENEWABLE ENERGY LIMITS ENVIRONMENTAL IMPACT

Renewable energy is a key pillar of China's strategy to limit the environmental impact of the power sector. China leads the world in the deployment of renewable energy technologies and has set ambitious targets. In its official NDC, China committed to source 20% of its primary energy from non-fossil fuels by 2030, including renewable energy sources and nuclear energy (UNFCCC, 2015).

In its *REmap* analysis for China, the International Renewable Energy Agency (IRENA) formulated two options for the energy sector's development to 2030: the reference case and the *REmap* case. In the former, 20% of primary energy is seen to be sourced from non-fossil fuel sources[2]. The *REmap* case envisages an even greater share for renewable energy, thus increasing non-fossil fuels share to 28%. This is an increase that is both technically and economically feasible (IRENA, 2014) (Figure 2).

Figure 2: Share of non-fossil fuels in China's primary energy (2013-2030)

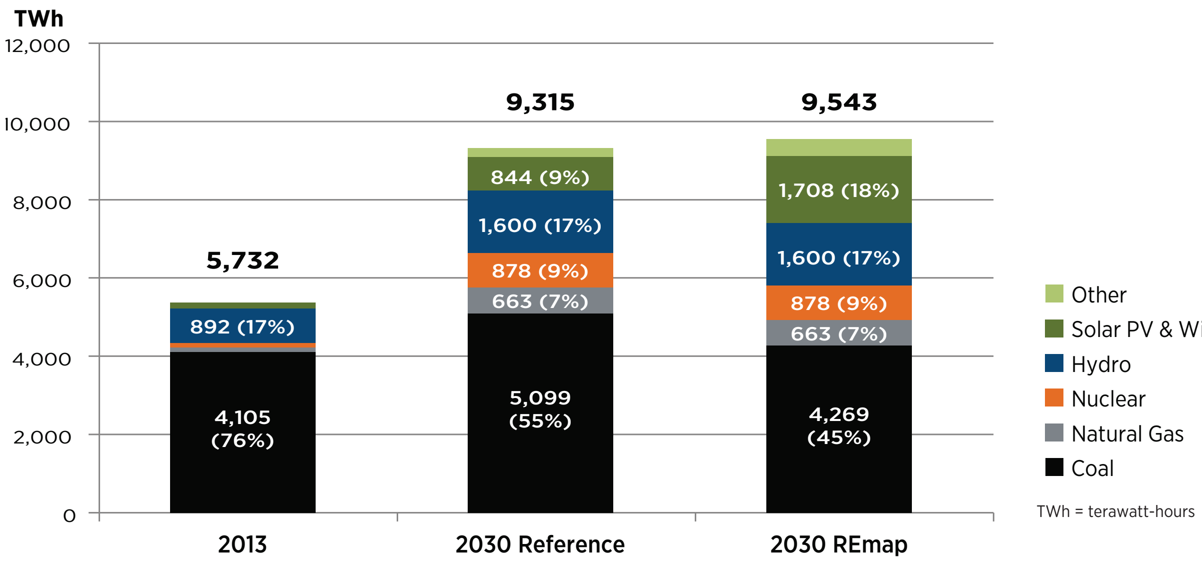


Source: NDRC, IRENA

[2] *China's NDC commitment is not directly comparable with the reference case given differences in methodologies adopted by the Chinese National Bureau of Statistics and IRENA.*

The increased share of non-fossil fuels in the *REmap* case comes from a greater penetration of renewable energy, in particular in the power sector (Figure 3): it would reach 39% of power supply, compared with 29% in the reference case. As a measure of comparison, the value in 2013 was 19%. This increasing share of renewable energy, together with other measures, will help reduce carbon emissions as well as the water use intensity of electricity generation.

Figure 3: China's power generation mix (2013-2030)



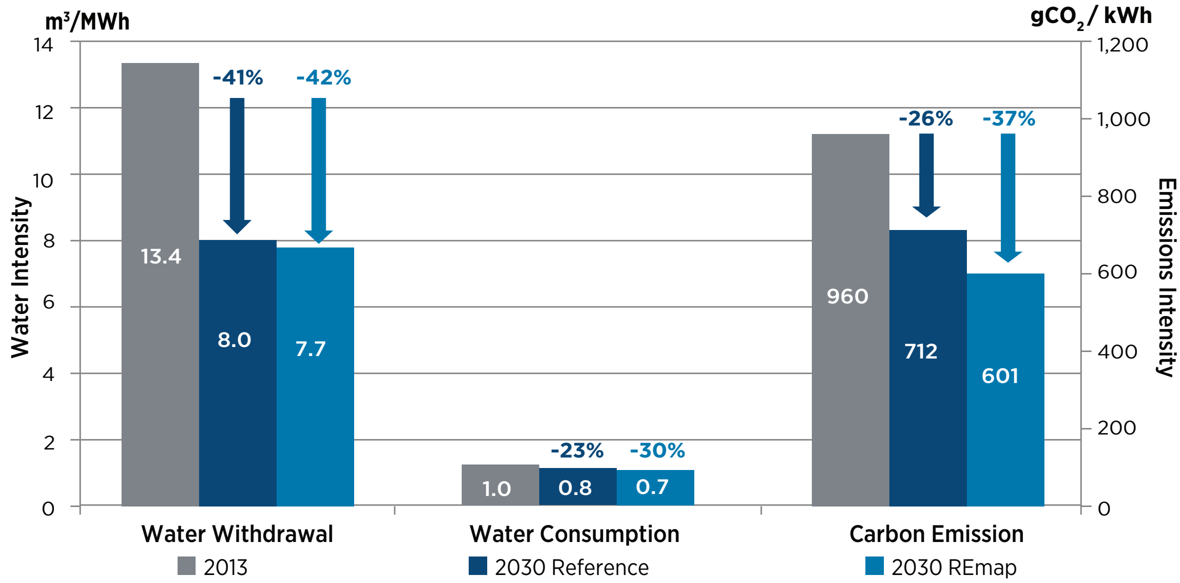
Source: CEC, IRENA

RENEWABLES AND IMPROVED COOLING CAN REDUCE WATER- AND CARBON-INTENSITY BY ABOUT 40%

During the power generation phase, some renewable energy technologies, such as solar photovoltaics (PV) and wind, require far less water than conventional thermoelectric options where substantial water is needed for cooling. Concentrating solar power has higher operational water needs, but recent projects globally have shown that application of dry cooling, similar to those in conventional plants, could reduce water use. Recent analysis has found that renewables could help simultaneously achieve water and carbon savings in China (WRI, 2016). To quantify these benefits, an analysis[3] of different options for the power sector in 2030 was conducted (Figure 4):

- Reference case: Water withdrawal intensity would decrease by 41% and consumption intensity 23%[4]. Carbon intensity would fall 26%.
- REmap case: Water withdrawal intensity would decrease 42% and consumption intensity 30%. Carbon intensity would fall 37%.

Figure 4: Water and carbon intensity of power generation (2013-2030)



Source: China Water Risk based on IRENA's REmap options

MWh = megawatt-hours; gCO_2 = grams of carbon-dioxide; kWh = kilowatt-hours

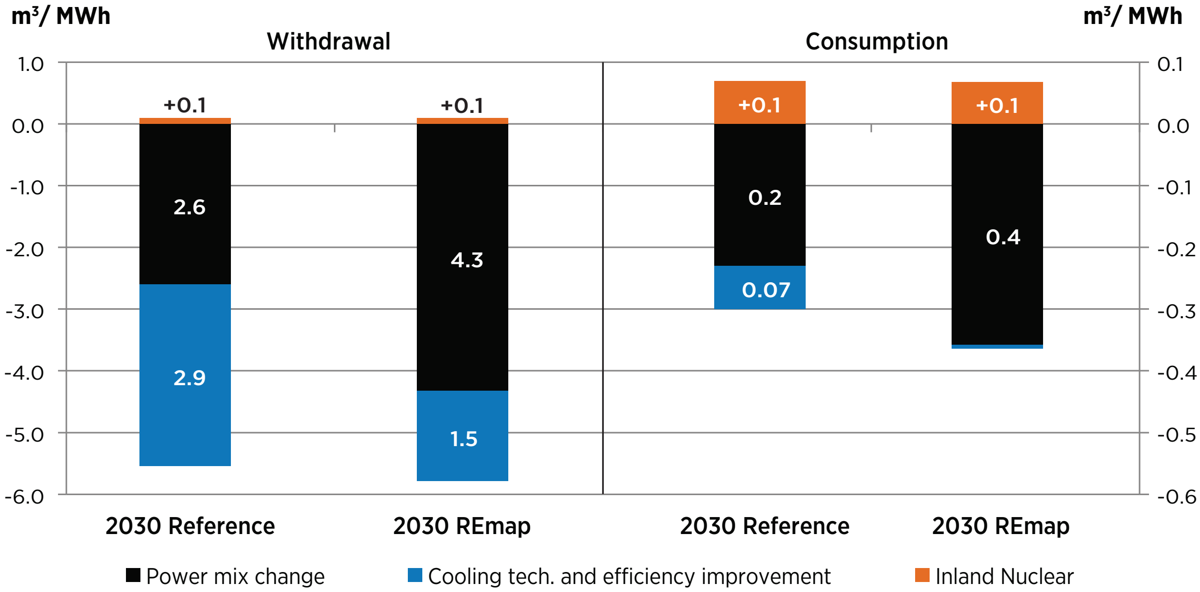
The above estimates account for shifting trends in power plant cooling technologies, as devised in existing policies, for both renewable and non-renewable power plants, such as adopting dry-cooling technologies (which are significantly less water-intensive) for coal plants in water-stressed regions, and wet closed-loop methods elsewhere. The sharp decrease in water withdrawal intensity results from the choice of cooling technologies (in particular the absence of once-through cooling in new coal-fired plants) and the change in power mix towards renewables and natural gas. At the same time, the important reductions in consumption intensity are predominantly a result of increasing the share of renewable energy (Figure 5). Between 2030 Reference and 2030 REmap, reductions in withdrawals are lower since growth in solar PV and wind in large part offsets dry-cooled coal power plants, reflected in the continuing decrease of emissions intensity.

Reducing withdrawals through changes in cooling technologies, however, translates into a trade-off between water and climate. Dry cooling reduces water withdrawals drastically, but comes at a cost for plant efficiency. This translates into higher costs as well as greater fuel use and emissions to generate the same electricity. An optimisation of costs and emissions is beyond the scope of this brief, although such efforts are being undertaken by such institution as the World Bank, for instance (World Bank, 2015).

[3] Hydropower has been excluded from this analysis given that evaporative losses can often not be attributed entirely to power generation. Water could be used for multiple purposes, including irrigation, water supply and flood control. As for nuclear power, all plants are presently located in coastal areas relying on seawater for cooling. There are plans to build inland nuclear plants which is reflected in the analysis. The analysis does not account for water use in fuel processing or equipment manufacturing. The detailed methodology is available at: www.chinawaterrisk.org/resources/research-reports

[4] Withdrawal is defined as the total amount of water taken from a source. Consumption refers to withdrawals that are not returned to the original source.

FIGURE 5: FACTORS IMPACTING WATER INTENSITY OF POWER (2013-2030)



Source: China Water Risk based on IRENA's REmap options

MWh = megawatt-hours

POWER DEMAND OUTPACES SAVINGS IN WATER AND CARBON

China's electricity demand is expected to continue to grow, which means that absolute increases in water use and carbon emissions will be difficult to avoid. Reducing the water and carbon-intensity, therefore, is particularly important to minimise the absolute increases in water and carbon to the greatest extent possible.

In the reference case, water withdrawal is seen increasing 3% by 2030, representing an additional 2.3 billion m^3 of freshwater withdrawn annually. Water consumption would increase by 1.9 billion m^3. But adopting the *REmap* options would slow this growth and create a savings of 0.6 billion m^3 of water withdrawn annually, and 0.5 billion m^3 of water consumed relative to the reference case.

REmap options would create an even bigger impact on carbon emissions. In fact, the reference case would result in a 29% increase, whereas adopting REmap options would limit it to 11%. Without growth in renewable power generation, the absolute levels of water use and carbon emissions will rise much faster.

TODAY'S ENERGY CHOICES MATTER FOR TOMORROW'S WATER RESOURCES

There is growing recognition of the water-energy nexus and the development challenge it poses. Several strategies have been implemented to decrease water use and reduce emissions. The evidence presented in this brief points to the additional benefits of renewable energy for reducing water use in the power sector.

Further penetration of renewable energy is, therefore, key to allow a cost-effective, secure and environmentally-sustainable expansion of the power sector. Accelerated renewables deployment in the power sector, as has been the hallmark of China's energy transition, can help alleviate pressures on scarce water resources as well as deliver reduction in carbon emissions. By the same token, it will also help address local environmental impacts and reduce the exposure of the power sector to water risks. In fact, regions facing water-stress are also the ones with substantial wind and solar potential. The transition towards a more diverse power mix must also be accompanied by the adoption of newer, more advanced power plant cooling technologies that are suited to local conditions.

Energy decisions inevitably effect water, and water availability can be a limiting factor in choosing energy-sector options. Today's decisions have long-term impacts: the average lifespan of power plants could be several decades. Therefore, today's energy decisions should take into account tomorrow's water resources. Renewable energy, with the potential to reduce both water use and carbon emissions, must play a key role in China's energy future.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METHODOLOGY AND REFERENCES

Details about the methodology used in this analysis can be found online at www.chinawaterrisk.org/resources/research-reports

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ABOUT CHINA WATER RISK

China Water Risk is a not-for-profit initiative dedicated to addressing environmental and business risks arising from China's urgent water crisis. China Water Risk aims to foster efficient and responsible use of China's water resources by engaging the global investment and business communities, civil society and individuals.

ABOUT IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy.

ACKNOWLEDGEMENTS

The brief benefited from valuable feedback from: Diego J. Rodriguez, Anna Delgado and Antonia Sohns (World Bank); and Henning Wuester, Sakari Oksanen, Paul Komor and Deger Saygin (IRENA).

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