# Supplementary material: Description of study area

*Los Angeles water and energy overview*

Infrastructure and technology Los Angeles county has a population of approximately 10 million and a total area of 12,310km2 [1]. It has a semi-arid, Mediterranean climate with an average annual precipitation of 362mm, of which 92% falls between November and April [2].

Los Angeles is heavily dependent on imported water transported long distances (i.e. from the Colorado River, State Water Project, and Los Angeles Aqueduct). Climate uncertainty in California and across the southwestern US is a significant concern for Los Angeles' water sector. Recent drought has led to the over-pumping of groundwater, and increased temperatures, more variable precipitation, and greatly reduced snowpack retention are expected to reduce water availability to Los Angeles' long-distance water supplies [3]–[6]. These impacts are increasingly making Los Angeles' existing supplies less resilient, pushing water providers to act to secure more reliable alternatives.

In the context of California's recent drought, the need to increase water supplies in the region is recognized at several levels of governance ranging from the State's Water Resources Control Board (SWRCB) [7] and the Governor's Office, to the recent federal level programs within the US Department of Energy (e.g. the Water Security Grand Challenge) [8], all of which explicitly incentivize local water reliance strategies. The impact of drought on the region's water and energy systems is unquantified, but appears to be burdensome as increasing local water sources will be energy intensive (see [9] on advanced water recycling), while expected flow reductions in environmental waters will diminish energy supplies generated through hydropower [10], [11].

California has made a commitment to reduce greenhouse gas (GHG) emissions to 40% below 1990 levels by 2030, in which specific targets such as 50% renewable electricity production, 50% reduction in petroleum use in vehicles, energy efficiency and carbon sink are included [12]. The most recent Senate Bill No. 100 [13] further requires that eligible renewable energy resources and zero-carbon resources supply 100% of retail sales of electricity to California end-use customers and 100% of electricity procured to serve all state agencies by December 31, 2045 .

Los Angeles's energy supply is varied, with a single dominant municipal utility, the Los Angeles Department of Water and Power (LADWP) serving roughly 40% of the population, with two investor-owned utilities (Southern California Edison and Southern California Gas Company) capturing most of the remainder. Though distinctly managed, these agencies together are facing a sector-wide challenge of reduced energy sales as California's "green" policies encourage more renewable energy sources—in particular, behind-the-meter solar. These same policies, driven by public environmental concern and California's global role as an environmental leader, are one of the most crucial factors influencing both the water and energy sectors.

*Beijing water and energy overview*

Beijing has a population of 21.7 million [14] and a total area of 16,410 $km^2$. Located at the temperate semi-arid and semi-humid monsoon climate zone, the average annual precipitation is 585 mm and the total annual water resources is 3.74 billion $m^3$, with nearly 75% of precipitation mainly concentrated in the summer flood season [15].

The Chinese government's "three-red-line" policy, introduced in 2011 with long-term goals for 2030 and five-years targets along the way, will strongly influence future water decisions with strict and ambitious goals for consumption, efficiency, and quality [16], [17]. These decisions will need to be carefully implemented as they compound on Beijing's already severe water supply limitations. Due to the city's large population and relatively limited hydrologic catchment area, water supplies can be challenging to maintain, and its scarcity is often seen as a critical restraint in the sustainable development of its economy and society [18]. Beijing's water supply is varied and predominantly consists of locally sourced groundwater and recycled water, with some long-distance imports (45%, 26%, and 22% respectively) [15]. These latter two supplies are energy intensive [19]–[21]. Based on current trends, it is expected that the share of groundwater will decrease, and the share of recycled water increase in the future, while imported water may slightly increase [22], [23].

Similarly to water, regional "red lines" have been introduced by the central government to reduce energy use, and in particular, to regulate coal use for power generation and industrial use [24]. In 2016, 80% of power generation and 56% of industrial energy use [25]. Most directly, this has implications for Beijing's power mix, but it also notably influences the water sector in regions of the country that mine coal and use it for producing electricity, two water intensive processes [26]. In 2016 the majority (86%) of the electricity produced in Beijing was derived from gas fired power plants [27], the remaining being from coal-fired power plants [27]. In 2017 however, coal power generation was phased out in Beijing to improve air quality. Like Los Angeles, the city's energy supply is highly dependent on outside sources. Beijing imports 96% of its primary energy supply from other provinces – mostly Hebei, Shanxi, and Inner Mongolia in the North of the country – or countries through a regional distribution network [28]–[30].

To increase energy security and improve air quality, Beijing has also set up energy conservation goals independently from water related targets, through controlling energy consumption, adjusting its energy structure to increase energy efficiency and improve air quality, and setting emissions reduction targets. By 2020, the city expects to achieve much of this latter target by further developing its utilization efficiency to match other developed countries, by capping total energy consumption (at 5 billion tons of standard coal equivalent), by controlling energy intensity (energy consumption/10000 Yuan output value), by increasing renewable energy production to meet 8% of total demand, and by providing 95% of its demand using clean energy.

Overall, the main drivers of change in Beijing are the strong push by the central government to improve resource efficiency in the wake of resource scarcity (especially water) in the country, with the underlying logics being about ensuring continuous economic growth and when it comes to water insecurity, to guarantee development and avoid potential instability [31]. Climate change mitigation and adaptation is not a strong driver currently, although it might become more relevant in the future and encourage a stronger drive for collaboration between the water and energy sector, which is currently missing.

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