# TRACKING SUBNATIONAL PROGRESS

## TOWARD CARBON NEUTRALITY IN THE U.S. AND CHINA

The California-China Climate Institute
November 2023

Berkeley Law | California-China Climate Institute

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## ABOUT THE CALIFORNIA-CHINA CLIMATE INSTITUTE

The California-China Climate Institute was launched in September 2019 and is a University of California-wide initiative housed jointly at UC Berkeley's School of Law and the Rausser College of Natural Resources. It is Chaired by Jerry Brown, former Governor of the State of California, and Vice-Chaired by the former Chair of the California Air Resources Board Mary Nichols. The Institute also works closely with other University of California campuses, departments and leaders. Through joint research, training and dialogue in and between California and China, this Institute aims to inform policymakers, foster cooperation and partnership and drive climate solutions at all levels.

## ACKNOWLEDGEMENTS

The authors would like to thank the following reviewers for helpful comments: Michael Davidson (University of California, San Diego), He Gang (Baruch College, City University of New York, Nina Khanna (Lawrence Berkeley National Laboratory), Hongyou Lu (Lawrence Berkeley National Laboratory), and Jim Williams (University of San Francisco).

# EXECUTIVE SUMMARY

The United States (U.S.) and China have set ambitious targets for carbon neutrality – reducing carbon dioxide ($CO_2$) emissions to net zero levels by 2050 and 2060, respectively. Implementation of policies to meet these targets will take place at a subnational level, within U.S. states and Chinese provinces. How can governments and non-governmental organizations track subnational progress toward carbon neutrality?

This report develops indicators and 2035 milestones for each indicator to track progress by U.S. states and Chinese provinces toward mid-century carbon neutrality goals. It builds on a 2021 report, Getting to Net Zero, which developed a framework for supporting coordination on carbon neutrality between the U.S. and China, including technology pathways, common milestones, and priority areas for dialogue, research and development, and international leadership.

The indicators in this report (Table 1, pg. vi) aim to balance simplicity and completeness, with publicly available data that can be regularly updated over time. They focus on two core transitions: (1) the transition from fossil fuel-dominant to non-fossil fuel energy systems, and (2) the transition to more carbon-intensive land use.

Table 1 includes two kinds of indicators: flow (adoption) and stock (fleet) indicators. Flow indicators track the flow of new infrastructure and equipment and may change relatively quickly. Stock indicators track changes in total energy mix and land use and will tend to change relatively slowly. In tandem, flow and stock indicators can provide a useful lens on the impacts of policy and the pace of nearer-term and long-term change. For most flow indicators, standardized, publicly available data are not yet available at a subnational level. National governments can play an important role in addressing this data gap.

The 2035 milestones in Table 1 are national milestones, consistent with either current national policy or studies of longer-term carbon neutrality pathways.1 Indicator values for each state and province will likely change at different rates, but changes should be directionally consistent with the 2035 milestones, and over time there should be greater convergence in indicator values among states and provinces. A key goal of tracking subnational progress is to identify the regions and sectors that may need more targeted support from national governments, in order to inform and adapt national policy.

The U.S. and China have very different economies, geographies, and energy systems. So why develop a common set of indicators for both countries? By developing common indicators, we can identify sectors and regions where each country is making faster or slower progress, as the basis for dialogue and coordination between national and subnational governments. A common set of indicators also can help to build confidence that states or provinces in the other country are making progress in energy and land use transitions.

Over the past two decades, the U.S. and China have both made significant progress in the initial stages of a transition to non-fossil fuel energy systems, though thus far the most visible changes have been in the electricity sector. In both countries, non-fossil fuel generation – renewables, large hydropower, and nuclear – now accounts for about 70% to 80% of new generation capacity. Between 2010 and 2020, the share of electricity generated from non-fossil fuel energy resources

1 Of these milestones, only "share of non-fossil fuel electricity generation in total generation" in the U.S. is explicitly tied to a specific national policy goal. The remaining milestone values are consistent with the results of longer-term decarbonization studies. See Appendix A for an overview of milestone calculations.

### Table 1 | Indicators, Recent Indicator Values, and 2035 Milestones

| SECTOR | INDICATOR | 2020 VALUE | | 2035 |
|---|---|---|---|---|
| | | U.S. | CHINA | U.S. |
| **ENERGY SUPPLY** | | | | |
| **Electricity Generation** | Share of new non-fossil fuel capacity in total new generation capacity (3-year moving average) | 79% (2019-2021) | 67% (2018-2020) | >90% |
| | Share of non-fossil fuel electricity generation in total generation | 40% | 32% | >95% |
| **Centralized Heat Supply** | Share of non-fossil fuel energy in total centralized heat supply | N/A | 2% | N/A |
| **ENERGY CONSUMPTION** | | | | |
| **Buildings** | Share of heat pump sales in total water heater and furnace sales | N/A | N/A | 80% |
| | Share of non-fossil fuel energy in residential and commercial final energy consumption | 51% | 61% | 70% |
| **Industry** | Share of non-fossil fuel energy in industrial final energy consumption | 22% | 32% | 45% |
| **Transportation** | Share of zero-emissions vehicle (ZEV) sales in light-duty or passenger vehicle sales | 8% (2022) | 22% (2022) | 80% |
| | Share of ZEV sales in heavy-duty or freight truck sales | < 1% (2022) | 7% (2022) | 60% |
| | Share of non-fossil fuel energy in transportation final energy consumption | 5% | 7% | 20% |
| **LAND USE** | | | | |
| **Forest Area** | Annual increase in forest area as a share of total land area (percentage points per year, %/yr) | 0.1%/yr (2007-2017) | 0.3%/yr (2010-2020) | 0.1%/yr |
| | Annual increase in forest volume per forest area (cubic meters per hectare per year, $m^3$/ha-yr) | 1.1 $m^3$/ ha-yr (2010-2020s) | 1.7 $m^3$/ ha-yr (2010-2020) | 1.0 $m^3$/ ha-yr |
| **ECONOMY-WIDE** | | | | |
| **Energy Intensity** | Reduction in energy consumption per unit real gross domestic product (GDP) | 33% (2000-2020) | 36% (2000-2020) | 43% (relative to 2020) |
| **$CO_2$ Intensity** | Reduction in energy-related $CO_2$ emissions per unit real GDP | 44% (2000-2020) | 38% (2000-2019) | 70% (relative to 2020) |

| | |
|---|---|
| **Flow indicator** | (green) |
| **Stock indicator** | (beige) |

**Sources and notes:** See Appendix A for a detailed description of how milestone values were calculated. Sources for most historical values can be found in corresponding sections of the report. ZEV sales shares are shares of electric vehicle sales from the International Energy Administration (IEA) (2023). These data include plug-in hybrid electric vehicles (PHEVs), which are not zero emitting, not other zero emitting vehicles, such as fuel cell vehicles. The U.S. does not have a significant centralized heat supply, and thus we do not report this indicator for the U.S. Several flow indicator values are "N/A" because data are not publicly available. We report the forestry metrics in total, rather than per year, later in the report; use of the per year values here enables comparison with historical values rose from 30% to 40% in the U.S. and from 19% to 32% in China. Regionally, the largest increases in the share of non-fossil generation between 2000 and 2020 were in areas with higher quality wind resources: the midwestern U.S. and northern China. More recently, however, large declines in the cost of solar generation have led to greater regional convergence in the share of new non-fossil generation capacity in China, a trend that is likely emerging in the U.S. as well.

The energy consuming sectors – buildings, industry, and transportation – present a more nuanced story. In China, the share of non-fossil fuel energy use in buildings and industry grew rapidly over the last decade, driven by a combination of environmental policy and technological change. In the U.S., non-fossil energy shares in buildings and industry were relatively flat; likely a consequence of low natural gas prices and limited federal and state policies to encourage fuel switching. Neither country has made significant progress in reducing the share of fossil fuel consumption in transportation, despite more than a decade of national biofuel policies, more stringent national vehicle emissions standards, and state and provincial efforts to support alternative transportation fuels.

The geography of changes in state and provincial fossil fuel consumption, energy intensity, and $CO_2$ intensity reflects the different social, technology, and resource challenges that the U.S. and China face in transitioning their energy systems to non-fossil fuel energy sources. In the buildings sector, for instance, northern urban areas in China have extensive district heating networks, whereas southern urban areas and most rural areas lack centralized heat supply. China's challenges for increasing the share of non-fossil energy use in buildings will be to (1) develop non-fossil heating solutions for rural and southern urban areas and (2) decide whether to develop non-fossil energy sources for district heating or to electrify building heating in northern urban areas. In the U.S., by contrast, there is very little district heating, and most fossil fuel heating in urban and rural areas is supplied by natural gas and oil products. The largest challenge for increasing the share of non-fossil energy use in U.S. buildings will be to develop reliable and low-cost ways to electrify heating in colder northern regions.

Sustained progress over the next 15 years will be critical for putting the U.S. and China on a trajectory to meet their mid-century carbon neutrality goals. In the transportation sector, for instance, will emissions standards, government programs, and incentives be enough to drive rapid adoption of electric vehicles (EVs) and growth in the share of non-fossil fuel energy in transportation? Will the growth of non-fossil fuel generation be enough to ensure that transportation electrification actually leads to significant reductions in $CO_2$ emissions? The indicators in this report provide a comprehensive, yet still tractable, means of gauging subnational progress over the next decade.

The value of tracking progress toward carbon neutrality in the U.S. and China together, rather than doing so separately, will increase over time as both countries face and overcome a range of regional challenges: land constraints on renewable energy development; renewable integration challenges in regional electric grids; technology, political, and economic challenges in industry; building electrification in colder areas and electrification of heavier industries; adoption of non-fossil fueled transportation modes in logistical hubs; and difficulties in reconciling economic development and land conservation. By monitoring the U.S. and China in tandem, cooperation between the two can focus on regions that face comparable challenges – for instance, land constraints in the northeast U.S. and China's coastal provinces may mean that both take a more distributed approach to renewable energy development. Regionally targeted bilateral cooperation can help to promote convergence in indicators among states and provinces over time.