

DAY ONE **PROJECT**

**Deploy a National Network of
Air-Pollution and CO₂ Sensors
in 300 American Cities by 2030**

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Summary

The Biden-Harris Administration should deploy a national network of low-cost, co-located, real-time greenhouse gas (GHG) and air-pollution emission sensors in 300 American cities by 2030 to help communities address environmental inequities, combat global warming, and improve public health. Urban areas contribute more than 70% of total GHG emissions. Aerosols and other byproducts of fossil-fuel combustion — the major drivers of poor air quality — are emitted in huge quantities alongside those GHGs. A “300 by ‘30” initiative establishing a national network of local, ground-level sensors will provide precise and customized information to drive critical climate and air-quality decisions and benefit neighborhoods, schools, and businesses in communities across the nation. Ground-level dense sensor networks located in community neighborhoods also provide a resource that educators can leverage to engage students on co-created “real-time and actionable science”, helping the next generation see how science and technology can contribute to solving our country’s most challenging issues.

Challenge and Opportunity

U.S. cities contribute 70% of our nation’s GHG emissions and have more concentrated air pollutants that harm neighborhoods and communities unequally. Climate change profoundly impacts human health and wellbeing through drought, wildfire, and extreme-weather events, among numerous other impacts. Microscopic air pollutants, which penetrate the body’s respiratory and circulatory systems, play a significant role in heart disease, stroke, lung cancer, and asthma. These diseases collectively cost Americans [\\$800 billion annually in medical bills](#) and result in more than [100,000 Americans dying prematurely each year](#). Also, health impacts are experienced more acutely for certain communities. Some racial groups and poorer households, especially those located near highways and industry, face higher exposure to harmful air pollutants than others, deepening health inequities across American society.

GHG emissions and ground-level air pollution are both negative products of fossil-fuel combustion and are inextricably linked. But our nation lacks a comprehensive approach to measure, monitor, and mitigate these drivers of climate change and air pollution. Furthermore, key indicators of air quality — such as ground-level pollutant measurements — are not typically considered alongside GHG measurements in governmental attempts to regulate emissions. A coordinated and data-driven approach across government is needed to drive policies that are ambitious enough to simultaneously and equitably tackle both the climate crisis and worsening air-quality inequities in the United States.

Technologies that are coming down in cost enable ground-level, real-time, and neighborhood-scale observations of GHG and air-pollutant levels. These data support cost-effective [mapping of carbon dioxide \(CO₂\)](#) and [air-quality related emissions](#) (such as PM_{2.5}, ozone, CO, and nitrogen oxides) to aid in forecasting local air quality, conducting GHG inventories, detecting pollution hotspots, and assessing

the effectiveness of policies designed to reduce air pollution and GHG emissions. The result can be more successful, targeted strategies to reduce climate impacts, improve human health, and ensure environmental equity.

Pilot projects are proving the value of hyper-local GHG and air-quality sensor networks. Multiple universities, philanthropies, and nongovernmental organizations (NGOs) have launched [pilot projects](#) deploying local, real-time GHG and air-pollutant sensors in cities including Los Angeles, New York City, Houston, TX, Providence, RI, and cities in the San Francisco Bay Area. In the San Francisco Bay Area, for instance, a dense network of 70 sensors enabled researchers to closely investigate [how movement patterns changed](#) as a result of the COVID-19 pandemic. Observations from local air-quality sensors could be used to evaluate policies aimed at increasing electric-vehicle deployment, to demonstrate how CO and NO_x emissions from vehicles [change day to day](#), and to prove that emissions from heavy-duty trucks [disproportionately impact lower-income neighborhoods and neighborhoods of color](#). The federal government can and should incorporate lessons learned from these pilot projects in designing a national network of air-quality sensors in cities across the country.

Components of a national air-quality sensor network are in place. On-the-ground sensor measurements provide essential ground-level, high-spatial-density measurements that can be combined with data from satellites and other observing systems to create more accurate climate and air-quality maps and models for regions, states, and the country. Through sophisticated computational models, for instance, weather data from the National Oceanic and Atmospheric Administration (NOAA) are already being combined with existing satellite data and data from ground-level dense sensor networks to help locate sources of GHG emissions and air-pollution in cities throughout the day and across seasons. The Environmental Protection Agency (EPA) is working on improving these measurements and models by encouraging development of standards for low-cost sensor data. Finally, data from pilot projects referenced above is being used on an ad hoc basis to inform policy. Data showing that CO₂ emissions from the vehicle fleet are decreasing faster than expected in cities with granular emissions monitoring are that policies designed to reduce GHG emissions are working as or better than intended. Federal leadership is needed to bring the impacts of such insights to scale on larger and even more impactful levels.

A national network of hyper-local GHG and air-quality sensors will contribute to K-12 science curricula. The University of California, Berkeley partnered with the National Aeronautics and Space Administration (NASA) on the [GLOBE](#) educational program. The program provides ideas and materials for K-12 activities related to climate education and data literacy that leverage data from dense local air-quality sensor networks. Data from a national air-quality sensor network would expand opportunities for this type of place-based learning, motivating students with projects that incorporate observations occurring on the roof of their schools or nearby in their neighborhoods to investigate the atmosphere, climate, and use of data in scientific analyses.

Scaling a national network of local GHG and air-quality sensors to include hundreds of cities will yield major economies of scale. A national air-quality sensor network that includes 300 American cities — essentially, all U.S. cities with populations greater than 100,000 — will drive down sensor costs and drive up sensor quality by growing the relevant market. Scaling up the network will also lower operational costs of merging large datasets, interpreting those data, and communicating insights to the public. This city-federal collaboration would provide validated data needed to prove which national and local policies to improve air quality and reduce emissions work, and to weed out those that don't.

Plan of Action

The National Oceanic and Atmospheric Administration (NOAA), in partnership with the Bureau of Economic Analysis, the Centers for Disease Control and Prevention (CDC), the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), the National Institute of Standards and Technology (NIST), and the National Science Foundation (NSF) should lead a \$100 million **“300 by '30: The American City Urban Air Challenge”** to deploy low-cost, real-time, ground-based sensors by the year 2030 in all 300 U.S. cities with populations greater than 100,000 residents.

The initiative could be organized and managed by region through an expanded [NOAA Regional Collaboration Network](#), under the auspices of NOAA's Office of Oceanic and Atmospheric Research. NOAA is responsible for weather and air-quality forecasting and already manages a large suite of global CO₂ and global air-quality-related observations along with local weather observations. In a complementary manner, the “300 by '30” sensor network would measure CO₂, CO (carbon monoxide), NO (nitric oxide), NO₂ (nitrogen dioxide), O₃ (ozone), and PM_{2.5} (particulate matter down to 2.5 microns in size) at the neighborhood scale. “300 by '30” network operators would coordinate data integration and management within and across localities and report findings to the public through a uniform portal maintained by the federal government. Overall, NOAA would coordinate sensor deployment, network integration and data management and manage the transition from research to operations. NOAA would also work with NIST and EPA to provide uniform formats for collecting and sharing data.

Though NOAA is the natural agency to lead the “300 by '30” initiative, other federal agencies can and should play key supporting roles. NSF can support new approaches to instrument design and major innovations in data and computational science methods for analysis of observations that would transition rapidly to practical deployment. NIST can provide technical expertise and leadership in much-needed standards-setting for GHG measurements. NASA can advance the STEM-education portion of this initiative (see below), showing educators and students how to observe GHGs and air quality in their neighborhoods and how to link ground-level observations to observations made from space. NASA can also work with NOAA to merge high-density ground-level and wide-area space-based datasets. BEA can develop local models to provide the nonpartisan, nonpolitical economic information cities will need to inform urban air-policy decisions triggered by insights from the

sensor network. Similarly, the EPA can help guide cities in using climate and air-quality information from the sensor network. The CDC can use network data to better characterize public-health threats related to climate change and air pollution, as well as to coordinate responses with state and local health officials.

The “300 by ‘30” challenge should be deployed in a phased approach that (i) leverages lessons learned from pilot projects referenced above, and (ii) optimizes cost savings and efficiencies from increasing the number of networked cities. Leveraging its Regional Collaboration Network, NOAA would launch the Challenge in 2023 with an initial cohort of nine cities (one in each of NOAA’s nine regions). The Challenge would expand to 25 cities by 2024, 100 cities by 2027, and all 300 cities by 2030. The Challenge would also be open to participation by states and territories whose largest cities have populations less than 100,000.

The challenge should also build on NASA’s [GLOBE](#) program to develop and share K–12 curricula, activities, and learning materials that use data from the sensor network to advance climate education and data literacy and to inspire students to pursue higher education and careers in STEM. NOAA and NSF could provide additional support in promoting observation-based science education in classrooms and museums, illustrating how basic scientific observations of the atmosphere vary by neighborhood and collectively contribute to weather, air-quality, and climate models.

Frequently Asked Questions

1. Has something like the “300 by ‘30” initiative been tried before?

Recent improvements in sensor technologies are only now enabling the use of dense mesh networks of sensors to precisely pinpoint levels and sources of GHGs and air pollutants in real time and at the neighborhood scale. Pilot projects in the San Francisco Bay Area, Los Angeles, Houston, Providence, and New York City have proven the value of localized networks of air-quality sensors, and have demonstrated how data from these sensors can inform emissions-reductions policies. While individual localities, states, and the EPA are continuing to support pilot projects, there has never been a national effort to deploy networked GHG and air-quality sensors in all of the nation’s largest cities, nor has there been a concerted effort to link data collected from such sensors at scale.

2. If the proposed sensor networks will be inherently local, then why does the federal government need to get involved?

Although urban areas are responsible for over 70% of national GHG emissions and over 70% of air pollution in urban environments, even cities with existing policy approaches to GHGs and air quality lack the information to rapidly evaluate whether their emissions-reduction policies are effective. Further, COVID-19 has impacted local revenue, strained municipal budgets, and has understandably detracted attention from environmental issues in many localities. Federal involvement is needed to (i) give cities the equipment, data, and support they need to make meaningful progress on emissions of GHGs and air pollutants, (ii) coordinate efforts and facilitate exchange of

information and lessons learned across cities, and (iii) provide common standards for data collection and sharing.

3. Is there precedent for this initiative in other countries?

A pilot project including a 20-device sensor network was led by U.S. scientists and developed for the City of Glasgow, Scotland as a demonstration for the COP26 climate conference. The City of Glasgow is an active partner in efforts to expand sensor networks, and is one model for how scientists and municipalities can work together to develop needed information presented in a useful format.

4. Where will the sensors come from?

Sensors appropriate for this initiative can be manufactured in the United States. A design for a localized network air-quality sensors the size of a shoe box [has been described](#) in freely available literature by researchers at the University of California, Berkeley. Domestic manufacture, installation, and maintenance of sensors needed for a national monitoring network will create stable, well-paying jobs in cities nationwide.

5. Which organizations are already working in this space?

Leading scientific societies Optica (formerly OSA) and the American Geophysical Union (AGU) are spearheading the effort to provide “actionable science” to local and regional policymakers as part of their [Global Environmental Measurement & Monitoring \(GEMM\) Initiative](#). Optica and AGU are also exploring opportunities with the United Nations Human Settlements Program (UN-Habitat) and the World Meteorological Organization (WMO) to expand these efforts. GHG- and air-quality-measurement pilot projects referenced above are based on the [BEACO₂N Network](#) of sensors developed by University of California, Berkeley Professor Ronald Cohen.

6. What about methane (CH₄) sensing?

Methane is a powerful greenhouse gas emitted from many natural and anthropogenic sources. Methane sensors with the needed capabilities are currently too expensive to incorporate into the proposed sensor network nodes. However, researchers are investigating improved methane sensing techniques with an eye to bringing down the technical and cost barriers. Methane sensors can easily be integrated into the sensor network nodes later as their cost decreases.

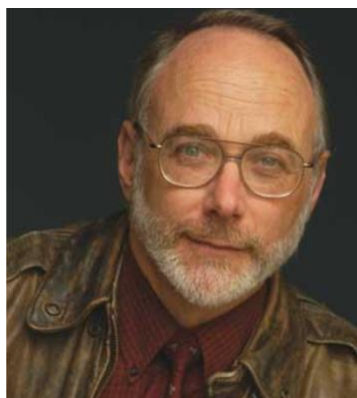
About the Authors



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[Raj Pandya](#) is the Director of the American Geophysical Union's (AGU) Thriving Earth Exchange, a program that connects scientists and communities, especially historically excluded communities, and helps them work together on projects that advance community priorities. He is interested in how the sciences can be more participatory, how inclusivity contributes to innovation and relevance, and how the sciences can be allies in advancing justice. Dr. Pandya chaired the National Academies committee on "Designing Citizen Science to Support Science Learning," and has served or is serving on advisory boards for the Cornell Lab of Ornithology, Public Lab, the Citizen Science Association, the Anthropocene Alliance, the Denver Institute for Science and Policy, ISET International, and the Science and Research subcommittee for the City of Denver's Sustainability Advisory Council.

About the Day One Project



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