EXHIBIT V

UNIVERSITY OF SOUTHERN CALIFORNIA

UNIVERSITY OF SOUTHERN CALIFORNIA

USC Energy Institute

Improving Southern California Air Quality by Reconditioning Idle Oil and Gas Wells to Create Large-Scale Subsurface Energy Storage Systems for Renewable Power Sources

A proposal from the USC Energy Institute to:

Audi CO2 Cy Pres Settlement Fund

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USC University of Southern California

Executive Summary

Idled, orphaned, and abandoned oil and gas wells can play a significant role as we transition to a zero-emission energy economy. These well are a known source CO2 and other greenhouse gases. This proposed research program will work to repurpose these wells for large-scale subsurface storage of solar and wind energy. In doing so, the greenhouse gas emissions will be eliminated and these assets will be part of the zero-emission energy infrastructure. In California, most of these wells are located in densely populated and primarily low-income areas of Los Angeles County and the San Joaquin Valley. The elimination of these greenhouse gas emissions will also have positive impact on the health and wellbeing of these communities. With $3.113 million in funding, we will establish a three-year research and development program to address the engineering, technical and implementation challenges.

The Challenge of Emissions from Idle, Orphan, and Abandoned Wells

Since the late 19th century, Southern California has been a major oil-producing region (see Figure 1). Of the thousands of wells drilled, many have already been abandoned, and many more will be abandoned in the years ahead. Furthermore, many of the abandoned wells are in close proximity to populated areas.

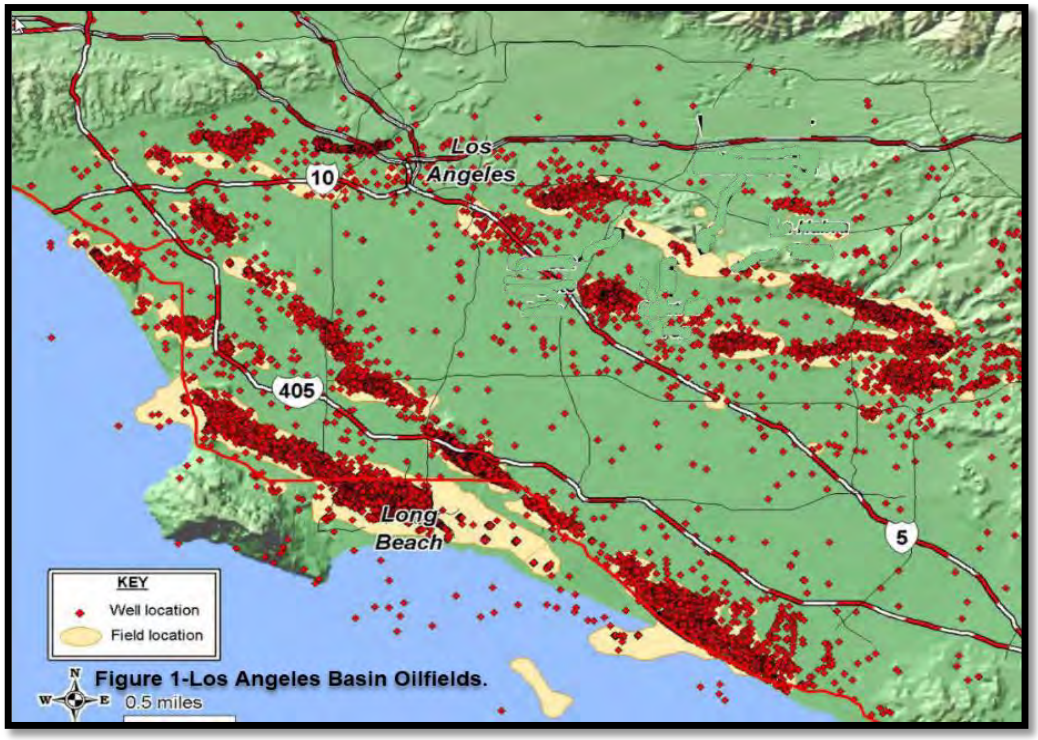


Figure 1-Los Angeles Basin Oilfields.

According to Reuters, the 3 million abandoned oil and gas wells in the United States emit close to seven million metric tons of carbon dioxide equivalents to the atmosphere

Methane leaking out of abandoned oil and gas wells in the United States and Canada is also a major contributor to climate change

In the State of California, there are more than 5000 orphaned oil and gas wells and an upward of 37,000 idle wells. Moreover, well abandonment is a costly process, and if a producing company is not capable of covering the cost, it becomes the sovereign state's responsibility to bear the abandonment cost. Moreover, improper abandonments can create a long-term emission risk. As such, a paradigm shift is needed for the long-range plans for the proper handling of idle oil wells.

Re-purposing Abandoned Oil and Gas Wells for Large-Scale, Emission-Free Energy Storage

Accelerated growth in renewable sources requires the development of large-scale, long-term energy storage capacity. New creative solutions will be required for storing the excess energy produced during peak output periods from variable renewable generation sources such as solar and wind. Such large-scale, long-term storage solutions can complement the use of batteries to overcome current limitations in terms of power capacity, depth of discharge, round trip efficiency, and long-term use. The proposed unique research project is intended to condition California idle oil and gas wells for environmental safety and use them as conduits to store energy in massive subsurface pore spaces of saline aquifers. Compressed air storage can offer long duration and high levels of storage compared to other options. The concept of using subsurface saline aquifers and conditioning of idled wells can be expanded to other states. The sensing and monitoring system can also provide environmental safety issues related to idle oil and gas wells.

According to California SB 100 and Executive Order B-55-18, all Utilities must provide 100% Green House Gas (GHG) free electricity by 2045. Also, California Renewable Portfolio Standard (RPS) Goals require 60% by 2030. Under this mandate, California Utilities will need the deployment of a significant level of energy storage to integrate renewable power such as wind and solar, which are intermittent. Large-scale solutions for energy storage need to match the required growth in variable renewable power generation sources. It is the goal of this project to demonstrate that subsurface storage solutions can offer major advantages and can be a large-scale, long-term storage complement to battery storage technology. They can offer a cost-effective and environmentally sound way to reach such subsurface sites and provide storage requirements. Our proposed research program simultaneously addresses both opportunities of reconditioning idle wells and creating massive subsurface sites for energy storage through a unique integrated solution.

Details of the Proposed Research Program

The proposed research program consists of two primary thrusts. The first is to address the growing problem of greenhouse gases sourced from orphaned, idle, and poorly abandoned oil and gas wells in Southern California. The second is to develop novel engineering solutions for reconditioning and re-purposing such wells to function as conduits to a) transmit compressed air to the pore spaces of subsurface saline aquifers and b) recover the compressed air on demand from driving surface hydraulic power turbines, thereby establishing a closed-loop, large-scale energy storage system.

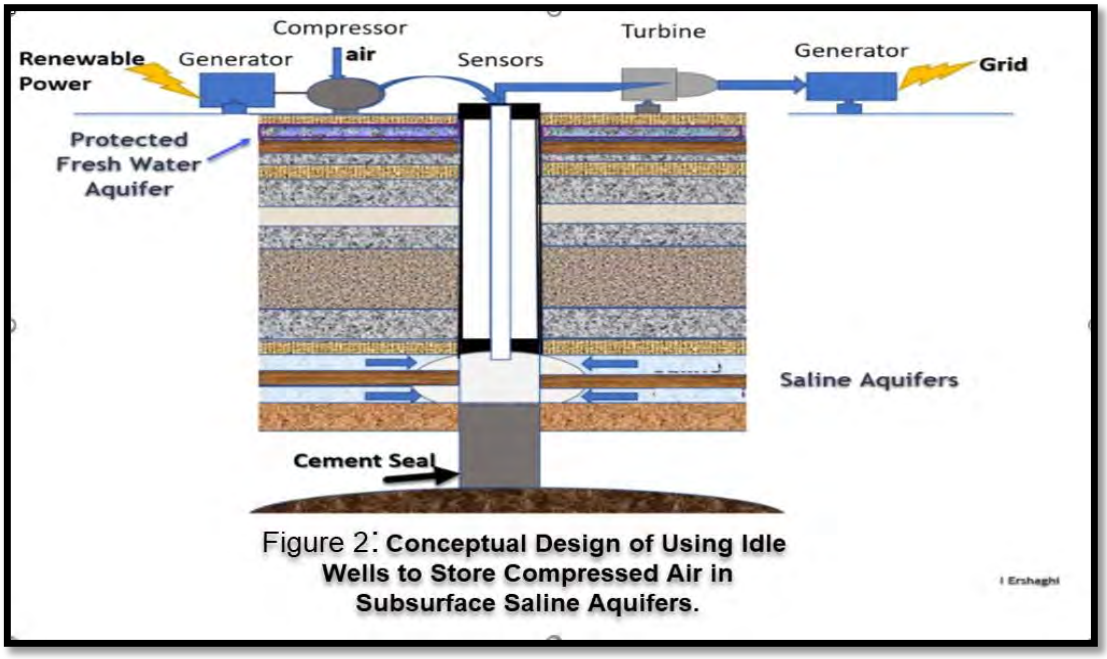


Figure 2: **Conceptual Design of Using Idle Wells to Store Compressed Air in Subsurface Saline Aquifers.**

This approach also allows for the long-term maintenance of well integrity for emission control through the continuous real-time monitoring of the state of the wells. Figure 2 shows a schematic of the system to create a large-scale subsurface energy study utilizing a re-purposed idle well to connect the surface electrical power grid to the saline aquifer storage by injection and production of compressed air. Through a combination of pilot-scale laboratory measurements and overall system simulations, the target end-to-end energy efficiency is 70%. Preliminary economic modeling shows that at this level of

efficiency, the cost of supplied stored energy will be approximately $0.05 per kilowatt-hour, including amortized capital. Costs at this level are well below those of other electric energy storage systems, as the proposed system eliminates the cost of drilling new wells.

Project Impact

This initiative will provide significant and lasting impacts in two areas. The first is reducing or eliminating the potential negative environmental and air pollution impacts of abandoned oil and gas wells. Second, it will support the development of the large-scale energy storage systems required for the continued expansion of renewable energy sources required for transformational decarbonization.

In summary, with the funds requested for the proposed program at the USC Energy Institute, a unique research effort will be launched that will leverage the existing expertise and research capabilities of the engineering staff in the USC Viterbi School of Engineering. In this proposed project, we will also utilize several previously developed advanced sensing and monitoring technologies at USC. Once the program is established, additional sponsors will be recruited to expand the effort and create the basis for large-scale commercial deployment. The deliverables will be transformative and can

Substantially contribute to cleaner air, free from greenhouse gases in Southern California and eventually to other parts of the state and to other states.

Specific Information on the Proposed Research Program

The proposed research study will have a timeframe of three years. The principal investigator brings more than 18 years of executive leadership of multi-disciplinary research teams. Supporting him will be contributions from engineering staff and graduate students in engineering. The engineering staff working with the principal investigator will bring in expertise in geomechanics and reservoir engineering, environmental sciences, geohydrology, and subsurface imaging, computer engineering, materials science, and electric power systems.

The main research questions and the research plans to address those issues are summarized below:

1) Subsurface Studies and Screening Methodologies:
Question: How would the technological advances in subsurface reservoir characterization be extended to develop the screening criteria for site selection?

We plan to develop methodologies for rapid evaluation and modeling of regional geologic and geohydrology studies in Southern California using information available from CALGEM (a state regulatory agency) and the industry.

2) Emission Reduction from Re-Engineering of Orphaned and Idle Wells:
Question: Rather than burdening the operators and the state with the cost of well abandonment and taking the risk of potential leakage in the future, what technologyadvances can be developed to re-purpose these wells and make them as conduits to store compressed air in subsurface aquifers?

Our research will focus on the development of new materials as permanent composite liners that can provide a protective measure for the old steel pipes and perforations when exposed to the repeated cycles of compressed air and the presence of oxygen. Additionally, we will work on the development of alternative and advanced materials to conventional cement-based technologies for providing earth-stress compliant permanent and effective seals to minimize leakage of greenhouse gasses from orphaned and idle wells to the atmosphere.

3) System Monitoring, Control, and Integration:
Question: What advantages can the re-purposing offer monitor gas emissions on re-purposed wells with potential extension to sites of previously abandoned wells? We propose utilizing advanced sensing, control, and distributed power technology to monitor both the environmental and operational performance of wells, subsurface geologic formations, and surface systems. Some of these systems (such as PTG for distributed power) have been previously developed and field-tested by USC. Proper system integration will be essential to materially reduce the costs and time to implement the proposed subsurface storage systems at scale.

4)Technology Transfer, Education, and Program Management:
Question: How would the result of the research be communicated to policymakers, industry, academia, and the students that will lead to the building of demonstration and actual plants and reshape the expertise of the graduating students?

We intend to conduct primary knowledge transfer workshops once a year. They will be free to the participants from regulatory agencies, the public, and representatives from electric utility companies. The goal is to share information from the research work and the progress made from the proposed research effort. An important supportive goal of the program is to expand our current engineering curricula to provide education and training in subsurface engineering for energy storage and advanced well re-engineering and abandonment technologies.

Research and modeling results published in the form of the annual reports will also be presented at national conferences of the Society of Petroleum Engineers (SPE), American Institute of Chemical Engineers (AIChE), other professional societies, and energy industryforums. The scheduled workshops will also serve as a knowledge source for the public and regulatory agencies.

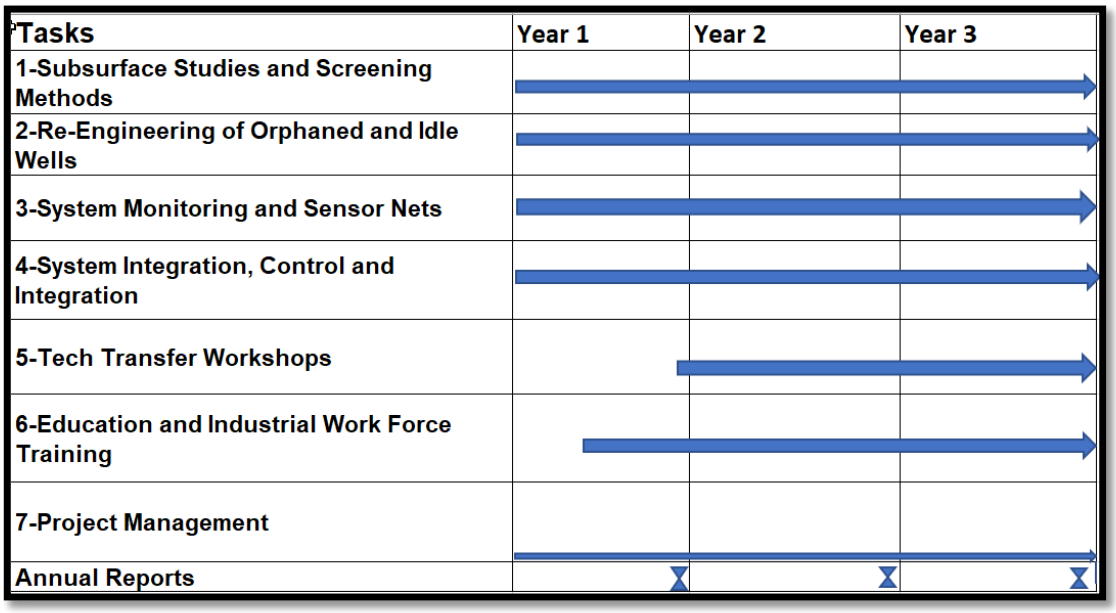
Program Funding:

One of the main goals of this innovative project is to prove the concept and gain the interest of electric utility companies as they consider solutions for the storage of renewable energies.Our comprehensive approach to this project will enable us to develop blueprints neededto build demonstration sites. The complete research program, as outlined above, will require many tasks and focus areas and an estimated total funding level of $3,112,186—over three years. We have summarized below the categories of envisioned tasks and deliverables with this budget.

Budget Requested	Year 1	Year 2	Year 3	Total
Engineering Salaries and benefits	837,400	862,522	888,398	2,588,320
Tech Transfer Workshops	5,000	5,000	5,000	15,000
Materials and Supplies	35,000	40,000	30 000	105,000
Sub Total	877,400	907,522	923,398	2,708,320
Overhead	131,610	136,128	138,510	406,248
Total Budget	1,009,010	1,043,650	1059526	3,112,186

Program Timeline

Under the budget requested, Tasks 1-4 will take three years to complete. Task 5, the Tech Transfer activities, will start at the end of the first year. Task 6, the educational component and design of a new academic course, will also start in the middle of the first year. Project management will be continuous during the proposed research activities.



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UNIVERSITY OF SOUTHERN CALIFORNIA

Microbial Greenhouse Gas Consumption Research Center

Microbial Greenhouse Gas Consumption

A proposal from the USC Dornsife College of Letters, Arts and Sciences to:

Audi CO2 Cy Pres Settlement Fund

Dr. Jan Amend, Principal Investigator

USC University of Southern California

Executive Summary

Many microorganisms can 'breathe' greenhouse gases, thereby destroying them. While much can be learned from sequencing DNA, a fundamental tenet of microbiology remains, *to know it is to grow it!* However, scientists can currently only grow—and thereby study in necessary detail—a tiny fraction of all microbial species. Here, we propose a 3 to 4-year, $3 million research center to identify and characterize naturally occurring microbes that are able to consume the three most harmful greenhouse gases: carbon dioxide, methane, and nitrous oxide. We will hunt for these novel greenhouse gas-consuming microbes in a wide range of pristine and impacted environments on land and in the oceans, and then apply an array of laboratory techniques to bring them into culture and optimize them for potential commercial use.

Introduction

Microorganisms account for the overwhelming majority of biodiversity in the ocean and on land. Many of these organisms have the capacity to consume greenhouse gases, including the three most problematic ones: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Furthermore, these organisms occur in most pristine natural environments, as well as in those impacted by human activities. Understanding and harnessing this microbial power could lead to novel solutions in the fight to mitigate climate change. While much can be learned about an organism's biochemical machinery by DNA (genome) sequencing and other means, scientists must be able to grow these organisms at a scale suitable for experimentation. To date, this is limited to only 1-5% of all microbial species. Two fundamental reasons for these shortcomings are that most of microbiology a) relies on very few sources for new cultures (e.g., human gut, fecal matter, agricultural soils) and b) mostly uses standard laboratory methods that prioritize fast growth over diversity in the type of growth. There is incredible potential for identifying new microbes that might be capable of consuming greenhouse gases on a larger scale if scientists target new and different microbe-rich environments and study them using innovative laboratory techniques.

Scholars at the University of Southern California (USC) are leading the way in this effort. For example, the NSF-funded Center for Dark Energy Biosphere Investigations (C-DEBI) focuses on the discovery of microbial life below the ocean floor, in the rocks and sediments that blanket 70% of the Earth's surface. In addition, the NASA-funded Life Underground Astrobiology Center at USC targeted novel life forms in the continental subsurface biosphere. As a third example, a multi-departmental collaboration recently initiated a pilot study to search for new microbes that synthesize new beneficial natural products. To build on these and other pioneering investigations and take the next leap, we propose an interdisciplinary research center with the following goals:

1. ***Isolate and characterize thousands of novel microorganisms that are naturally capable of converting greenhouse gases into innocuous waste products***
2. ***Experimentally select a subset of "super microbes" and engineer novel cultivation reactor systems to speed up and scale up greenhouse gas consumption***
3. ***Create and manage a collection of pre-screened greenhouse gas-consuming microbes available for purchase to be used worldwide in research and for industrial purposes***

We believe that a) diverse but poorly studied environments are ideal hunting grounds to find new microbes, b) novel and diverse ways of growing and cultivating them will yield numerous greenhouse gas-consuming organisms, and c) these microbes have the potential to be employed in creative ways to consume greenhouse gases.

Background on greenhouse gases and the Microbes that can Consume them

Carbon dioxide (CO_2) makes up about 80% of greenhouse gas emissions in the US and the world. Marine phytoplankton are often ignored or forgotten in efforts to curb global warming, yet these single-celled organisms use photosynthesis to process as much CO_2 as all land plants combined—around 10 gigatons per year. After CO_2 (and water vapor), methane (CH_4) is the most abundant greenhouse gas in Earth's atmosphere, with a global warming potential about 25 times that of CO_2. Archaea, one of three major branches on the 'tree of life' (along with Bacteria and Eukaryotes), are capable of consuming methane and they are the only organisms that can produce it. It is, in fact, archaea in the guts of cattle that produce the methane generated in the meat and dairy industries. Third on the greenhouse gas list is nitrous oxide (N_2O), which is 300 times more potent in trapping atmospheric heat than CO_2. As with carbon dioxide and methane, certain bacteria and archaea have the biochemical machinery to produce or destroy this nitrous oxide.

Current estimates put the total number of microbial species at about 1 trillion, or more than 99% of all life on Earth. Owing to these staggering numbers, but also driven by ever-changing conditions in the atmosphere, oceans, rocks, sediments, and soils over billions of years that they have been evolving on Earth, bacteria and archaea have developed far more diverse biochemical machineries than plants, animals, or fungi; and this combination of species diversity and evolutionary history for microbes translates to immense capabilities to consume gases. However, only a tiny fraction of all bacteria and archaea have, up to now, been grown in the laboratory and therefore readily used in biotechnology, including efforts to remove methane, nitrous oxide, and other greenhouse gases. In most ecosystems, organisms that currently cannot be grown in the

laboratory vastly outnumber those that can, but as mentioned before, researchers must be able to cultivate microbes to best use them in greenhouse gas mitigation. Our center seeks to dramatically improve these opportunities.

Research Plan

The paucity of bacteria available for research, and also the dramatic expansion of known archaeal diversity and their underrepresentation in culture collections, make this a very opportune time to fund a center that combines science and engineering research on microbial greenhouse gas mitigation. Funding will also help bridge the "valley of death", the gap between government-funded foundational research and marketable technological innovations. The proposed research pipeline, described in more detail below, consists of the following: a) collecting samples from numerous and diverse environments, b) cultivating microbial colonies and optimizing their growth, c) engineering and implementing the 'scaling up' from test tubes and petri dishes, and d) ultimately marketing environmentally beneficial organisms.

Sample collection. Bacteria and archaea are globally ubiquitous, but most of those currently studied and well understood come from human or animal hosts, agriculture, and other easily sampled systems. We will focus this study on samples from decidedly different environments including, but not limited to, organic-rich marine sediments, coral reefs, the abyssal (deep) ocean, methane seeps, hydrothermal systems, continental hot springs, sites of acid mine drainage, gold and base metal mines, engineered wastewater/water treatment systems, and effluent impacted aquatic environments. USC scholars already have collections of water, soil, sediment, coral, rock, and biofilm samples from recent expeditions, but we will expand these with additional field campaigns. We will also make use of our extensive network of collaborators to complement our own samples.

Microbial cultivation. Much of microbiology uses standard laboratory techniques that are optimized for fast growth and high biomass yields. However, to identify radically different organisms that thrive on methane or nitrous oxide, we can't rely on the status quo. USC researchers have pioneered many laboratory cultivation strategies to extract key organisms from environmental samples. Some of our laboratory strategies mimic as closely as possible the conditions found in nature. For example, seafloor methane seeps are home to many methane-consuming microbes, but to grow them in the laboratory researchers may need to bubble methane through sediment grains at high pressure and low temperature. Many natural environments are characterized by steep gradients in temperature, light, fluid flow, nutrient availability, acidity, or other. To 'convince' organisms from such systems to grow in the laboratory, scientists can't use static conditions and may need to employ specialized gradient chambers where experimental conditions change—in some cases dramatically—with time. Nitrous oxide is a typical byproduct in the natural, but complex nitrogen cycle. To target the microbes responsible for consuming nitrous oxide, we must optimize experimental conditions for this specific step in the cycle, to the exclusion of the other steps.

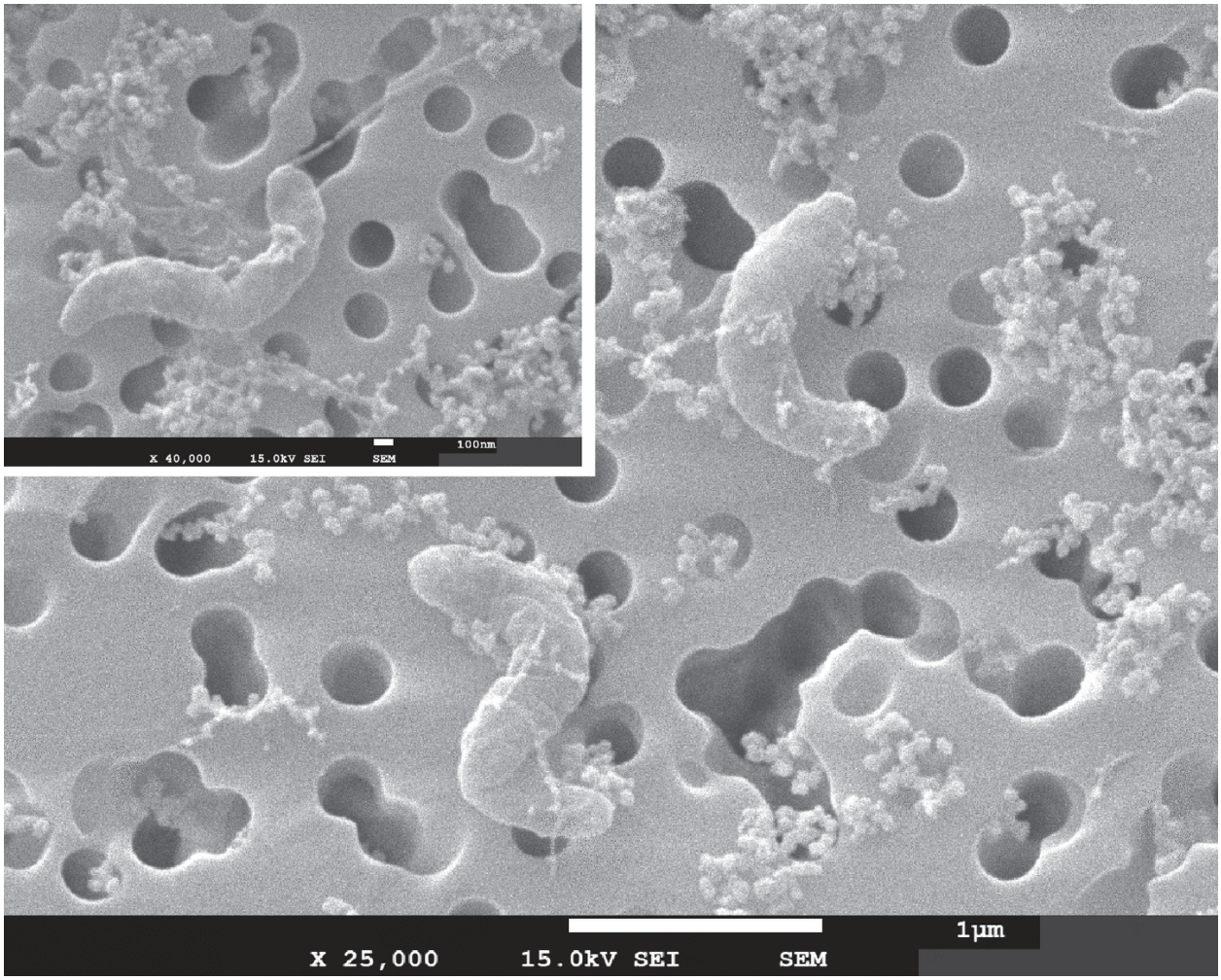
Engineered bioreactors. To optimize and ultimately market bacteria and archaea capable of greenhouse gas consumption, we must scale up operations from the test tube or petri dish to large volume vessels or bioreactors. USC is a leader in this field, with several biophysics and environmental engineering labs focused on designing bioreactors that permit the use of different gases at elevated pressures. A particular advantage of some of these reactors is that methane-consuming (oxidation) and nitrous oxide-consuming (reduction) organisms can be grown simultaneously (co-culturing), with one organism benefitting the other which leads to greater efficiencies in methane and nitrous oxide removal.

Marketing. A select group of novel "super microbes" will be deposited in culture collections, where they will be available for purchase by the global research community. This is analogous to special chemicals, reagents, lubricants, enzymes, catalysts, gas mixtures, and other compounds developed in research labs and then made available for societal benefit. While 'native' organisms (i.e., in their original form) cannot be patented, genetically modified versions as well as the cellular processes can. A long-term goal, but one that is beyond the scope of this 3-4 year project, is to use the most efficient greenhouse gas-consuming archaea and bacteria to drastically reduce methane and nitrous oxide emissions from meat and dairy farms, wastewater treatment and power plants, and other point sources.

A Research Center at $3 Million

We propose establishing a research center at USC with the goal of identifying, growing, and optimizing new microbes capable of efficient conversion of greenhouse gases to innocuous waste products. Such a center can be launched with an initial investment of $3 million, with several key deliverables. Additional and/or future funding would enable us to scale up the range of tested environments, expand the experimental conditions to be tested, and enable us to operate a variety of larger scale reactor systems.

At the $3 million level, USC researchers could test a) environmental samples currently stored in our laboratories, b) samples to be provided to us by a network of close, international collaborators, and c) newly collected samples from separately funded field excursions. From these three sources, we will have access to rare samples from exotic, methane-rich or nitrous oxide-containing environments, including Arctic tundra, seeps in Monterey canyon, the deepest hydrothermal system in the Gulf of California (Pescadero Basin), and large-scale farms and cattle ranches. We will first use artificial growth media and state-of-the-art cultivation approaches at small (i.e., laboratory) scales. Subsequently, this will be expanded to engineered reactor systems with larger volumes and greater automation, permitting more frequent and more detailed testing to find optimum solutions. ***We estimate being able to run and screen 1,000-2,000 growth experiments***, isolate and partially characterize several hundred greenhouse gas-consuming microbes, and develop optimal growth conditions for a handful of 'super microbes'. Time and resources permitting, we would then employ co-cultures, where consumption of both methane and nitrous oxide could occur simultaneously and hence far more efficiently.



Scanning electron micrograph of a novel marine bacterium capable of converting the greenhouse gas carbon dioxide. This organism was recently isolated by USC researchers (Savoie et al., 2021, *Environmental Microbiology*).

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UNIVERSITY OF SOUTHERN CALIFORNIA

Expanding the Urban Canopy for More Resilient Cities

USC University of Southern California

A proposal to *Audi CO2 Cy Pres Settlement Fund* to support

Expanding the Urban Canopy for More Resilient Cities: The USC Urban Trees Initiative

PUBLIC EXCHANGE

USC Dornsife
College of Letters, Arts and Sciences

Executive Summary

Access to green space can save lives: a 2020 study found that one in four lives currently lost during heat waves in Los Angeles could be saved with cooling measures such as planting trees. Unfortunately, low-income Angelenos who are at highest risk of exposure to climate threats live in the most tree-poor areas of the city. The USC Urban Trees Initiative partners experts in advanced mapping technology, air quality experimentation, and landscape architecture with the City of Los Angeles Department of Public Works to grow an equitable urban canopy in vulnerable neighborhoods of LA. **With $2.7 million over three years, the project team will expand on pilot work done in 2020 and 2021 to build a greening blueprint for areas of South and East LA, establish a forest laboratory site to monitor and optimize tree performance by planting 385 trees with community organizations, and collect and analyze data to better clarify the potential of using trees to mitigate air pollution and extreme heat.** Ultimately, the USC Urban Trees Initiative presents a vision for climate justice driven by innovative data and meaningful engagement with residents.

Challenge & Opportunity

Climate change poses serious environmental health threats in urban environments. Extreme heat and poor air quality are threats to general health, pregnancy outcomes, brain development in children, cognitive function in adults and chronic diseases (i.e., diabetes and cardiovascular conditions).[1] Urban environments further exacerbate these issues because of the ways that asphalt and concrete roads and other infrastructure absorb heat from the sun, causing surface temperatures and emissions to rise. This "urban heat island" effect makes air pollution more hazardous to urban populations. Urbanization also creates more impervious surfaces, limiting groundwater recharge. More than half of the global population now lives in urban centers, and the UN predicts that urban populations will grow to 68% of the world's population by 2050.[2]

Urban tree cover mitigates heat island effects by lowering ground temperatures, sequestering carbon, and removing air pollutants. There is growing evidence that trees support good physiological and mental health and reduced mortality. Trees are the most cost-effective way to mitigate the impacts of climate change and the heat island effect. However, the tree cover in Los Angeles has declined in recent decades[3] and unfortunately, communities of color and those with low incomes are disproportionately more likely to live in areas with less trees and therefore less shade and worse air quality.[4]

This inequity is what motivated the launch of the Urban Trees Initiative at the University of Southern California in 2020.[5,6] In partnership with the City of LA's Department of Public Works and first-ever City Forestry Officer, the team studied a 5-square mile area on the Eastside of LA (Fig. 1) with 57,000 residents to clarify the opportunities and constraints for improving green infrastructure. The pilot study inventoried the presence of urban forest on public and private lands and tested the effectiveness of arid climate tree species to absorb pollutants and provide cooling. Working with community members and policymakers, the research team developed a blueprint to illustrate how strategic planting of tree species in specific locations could provide the most efficient and effective removal of particulate matter and effective cooling.

As a result of the pilot study, the multidisciplinary team of USC experts in the spatial and earth sciences and landscape architecture delivered criteria and a vision to the City of LA in April 2021 for where, what kind, how many, and in what configuration trees could be added within the study area to provide greater shade and improve air quality. This knowledge will help the City of Los Angeles meet the commitment established in its City Sustainability Plan (also known as LA's Green New Deal) to plant 90,000 new trees and pursue a 50% increase in land area covered by tree canopies in neighborhoods with the greatest need.[7]

This proposal seeks to continue this important work, at greater scale, directly reaching 387,000 more LA residents. However, the impact does not stop at the city's borders. LA's arid climate, urban infrastructure, and reliance on automobiles make it an ideal testbed for conducting these experiments and deepening the global body of knowledge around trees' impact on air quality and health. LA is an established leader on climate and urban policy, including as a voice in organizations like C40. This makes the city well-placed to establish models for adoption in cities around the world hoping to mitigate the effects of rising temperatures and poor air quality. We can apply what we achieve in LA worldwide.

The overarching theme of our work is that urban trees can help to mitigate air pollution and urban CO_2 emissions and provide cooling to largely underserved communities. But to do this in a way that maximizes the effectiveness of public resources will require the research and team we are proposing here. **Below we breakdown our proposed workplan in two phases that will be executed consecutively over the course of three years.**

PHASE 1

Build and test a greening blueprint to support vulnerable communities in LA suffering from extreme heat and poor air quality

The work proposed here represents a significant expansion of the initial study completed in our pilot project in 2020-2021 and some preliminary analyses done in summer and fall 2021 in east and south LA. With additional resources, we will scale up to focus on larger areas of east and south-central LA (Fig. 1), which represent some of the most vulnerable neighborhoods in the city. These new areas will add 387,122 residents and 27 square miles and, like the pilot project, focus on parts of the city with sparse green cover and high levels of near-roadway traffic pollution.[8]

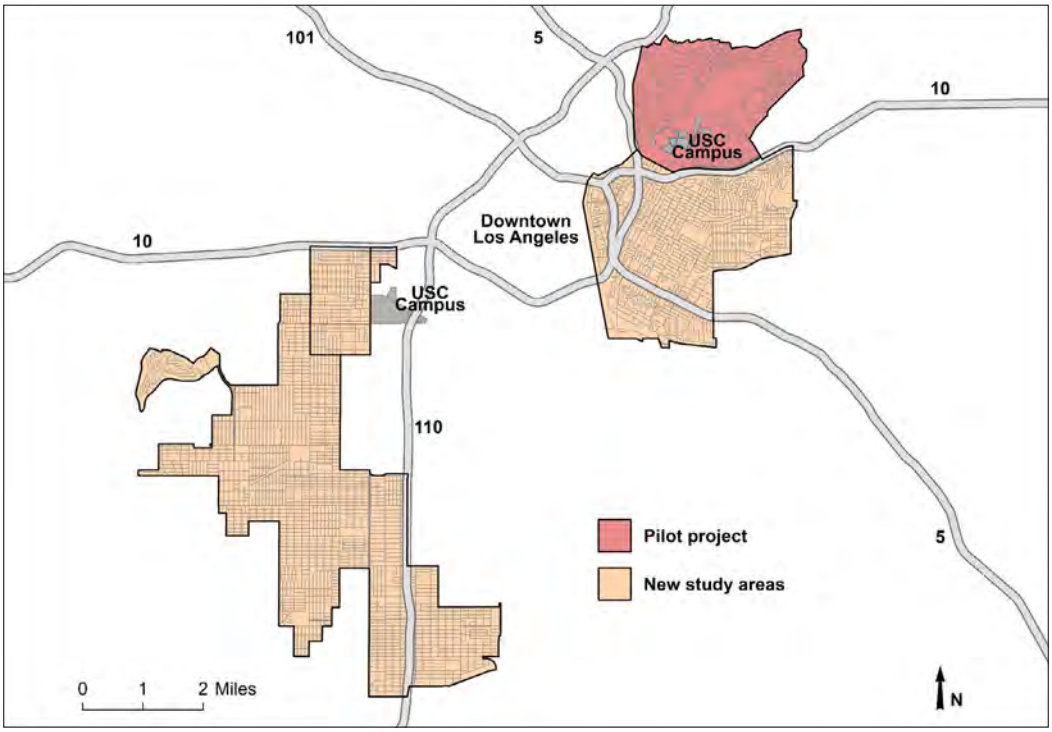

Fig. 1: LA communities targeted in this project

Using a similar methodology to that developed in our pilot project, the team will do the following in phase 1:

- **Categorize every tree** on public and private property to add to the city's tree inventory, including tree species, existing canopy cover, and potential levels of shading and heat reduction.
- **Conduct intensive data analysis** to determine the locations of vulnerable residents in highest need of additional canopy, and locations where trees would contribute to the shading of buildings.
- **Analyze the "air cleaning" potential of trees**, focusing on which species of trees from the new City of LA preferred trees list, at what density and in what configurations, would provide the greatest benefit to residents.
  - Build and deploy portable sensors to assess the rates at which various tree species capture particulate matter on their leaves.
  - Analyze air quality improvements for differing tree configurations (i.e., single trees, street trees, clusters of trees, and trees within several contiguous city blocks).
- **Engage community members and organizations** to understand their greening needs, priorities and preferences, building on relationships established in our pilot project.
- **Develop models and visualizations** to test and communicate the potential benefits of trees planted in streets, parks, and schools based on the data generated in earlier steps.

This work will provide a blueprint for the City of LA's Department of Public Works to address the needs of the communities based on scientific research and intensive data analysis. The research will equip LA to target its resources to meet its goal of increasing tree canopy in areas of highest need and mitigating climate threats for residents. Our goal is to provide the scientific and socioeconomic footing to shape and support the preferred tree planting scenarios. Our findings will be conveyed through reports and briefings to city officials, on our Public Exchange project page, in public talks and presentations and within mainstream scientific publications.

PHASE 2

Develop tools and best practices for sustainable, resilient urban forests that protect residents from extreme heat and air pollution for decades to come

Increasing the urban canopy will only be an effective tool for climate resilience if the trees thrive. There are many unknowns about how trees will fare in worsening drought and extreme heat conditions.[9,10] To manage urban forests effectively, policy-makers and urban planners need to understand best practices in a variety of conditions. The work in phase 2 will build on the work in phase 1 by collaborating with the City of LA and community organizations to plant **385 trees**. In one larger site, we will create a controlled test environment, gathering real-time data on water use, the shading of buildings, and tree performance. In phase 2, we will also extend the air quality monitoring to trees near pollution sources, such as heavily trafficked freeways and roads.

The design and installation of soil water sensors at our test site will help us to assess the availability of water for urban trees. This aspect of our work will include mapping groundwater levels, effective recharge areas and precipitation as well as soil moisture on a neighborhood scale and documenting tree physiology as a function of water supply, so we can predict how these trees will behave under warming and drying scenarios. This information is critical if we are to establish sustainable and resilient urban forests in large cities like LA.

With an award this large, we think it is important to give back to the community. We will share the cost of the 385 new trees with the City of LA. While their funds will cover the trees themselves and the infrastructure improvements where necessary, our funds will go to tree "establishment" (i.e., watering and maintenance over three years, including 99 site visits per tree), monitoring, and community engaged design (see budget attached). This cost-share will enable the city to **double** the number of trees planted at targeted sites within our study zones. This will have a large impact since we have already shown how small increases in canopy can dramatically increase shade. As an example, we estimated in our pilot study that planting only 20 new trees on a section of Barbee Street, in the Lincoln Heights neighborhood, could generate an 800% increase in shade cover (Fig. 2).

Fig. 2: Proposed street tree planting on Barbee Street

We will create a grants program in collaboration with the City of LA for local non-profits to lead tree establishment efforts. Our team already has strong partnerships with local groups, such as Northeast Trees and the Koreatown Youth and Community Center, which have extensive experience executing planting and engaging community members in greening projects. In partnership with the City of LA and these non-profit partners, we will use sites, species, and design models and visualizations completed in phase 1 and 2 to engage communities and install trees that will provide increased shade as well as provide controlled environments for further data collection. The grants program will create approximately **12 jobs** in our study zones, supporting much-needed workforce development to care for the expanding urban forest.

The USC-City of LA team will accomplish the following in phase 2:

- **Establish an urban forestry grants program**.
- **Engage communities in design workshops** led by non-profit partners.
- **Plant 385 trees** in the 2022-2023 planting season in collaboration with the City of LA.
- **Collect data on the ability of trees to improve air quality near pollution sources,** such as heavily trafficked freeways and roads.
- **Collect data on soil moisture and tree performance** to test configurations, densities and species effectiveness, and inform strategies for using water more efficiently to sustain tree health in warming climates.
- **Build tools for policymakers and practitioners** to guide site selection and best care practices for establishing a sustainable and resilient urban forest that serves the local residents.

This work will lead to the planting of 385 new trees, the establishment of an instrumented forest laboratory site so we can monitor and optimize soil moisture and tree performance, and the collection and analysis of data to better clarify the potential of using trees to mitigate air pollution and extreme heat. The small grants program and design workshops will empower local residents and the tree planting and maintenance will support workforce development.

The work proposed in phases 1 and 2 will take 3 years to execute and cost $2.7 million (see budget attached).

Leadership Team

John Wilson is a Professor of Architecture, Civil and Environmental Engineering, Computer Science, Preventive Medicine and Sociology and the Founding Director of the USC Spatial Sciences Institute.

Will Berelson is a Professor of Earth Sciences, Environmental Studies, and Spatial Sciences at USC.

David Galaviz is the Associate Vice President for Local Government and Community Partnerships at USC.

Melinda Gejer is a Service Coordinator within the Bureau of Street Services (StreetsLA) at the Department of Public Works for the City of Los Angeles.

Rachel Malarich is the first City Forest Officer within the Department of Public Works for the City of Los Angeles.

Esther Margulies is an Associate Professor of Landscape Architecture in the USC Master of Landscape Architecture + Urbanism program.

Kate Weber is the Director of the USC Dornsife Public Exchange, which connects USC faculty with public and private partners to work collaboratively on social impact projects.

Media Coverage of Pilot Project

To Offset Climate Change, Scientists Tout City Trees and Ultra-White Paint

Improving Health on L.A.'s Eastside with Trees

City of LA partners with USC on Urban Trees Initiative

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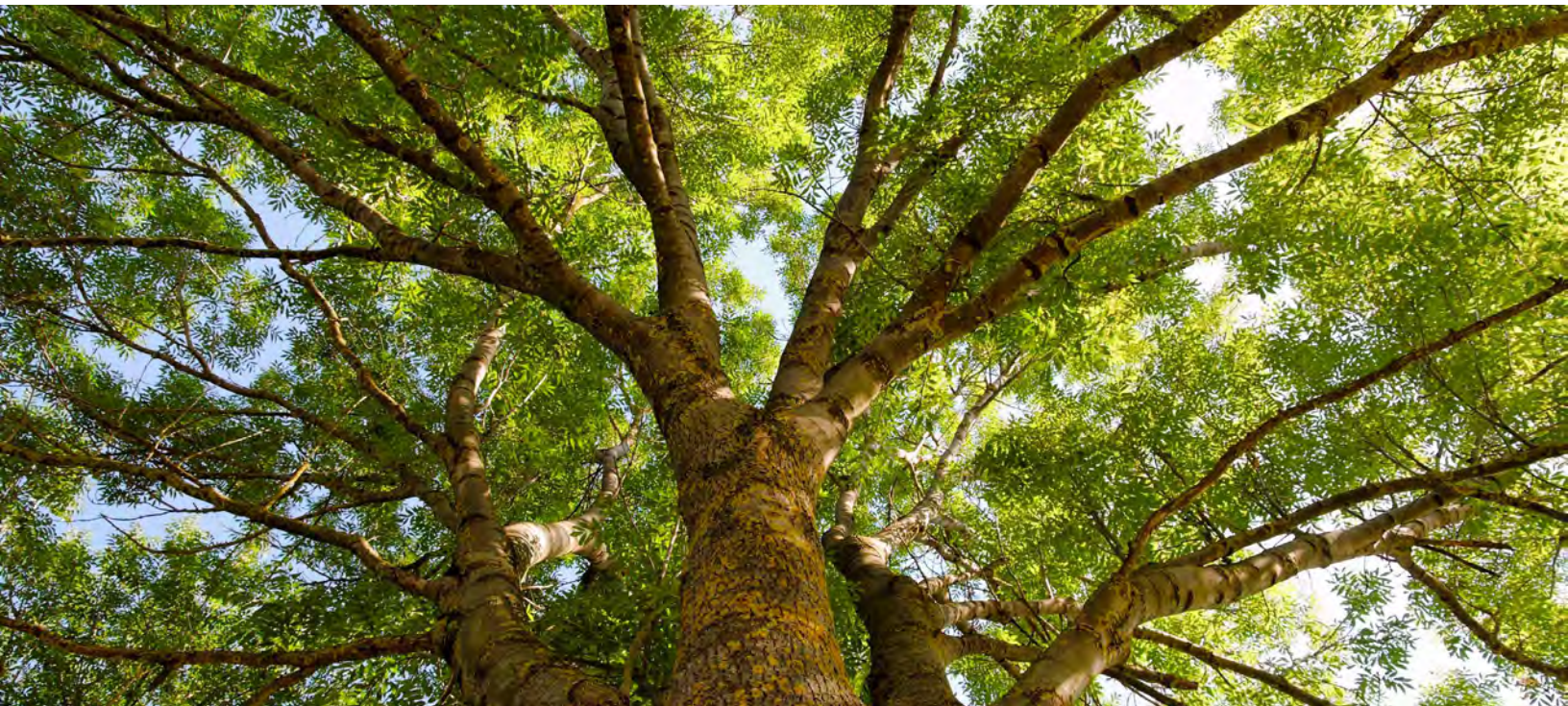
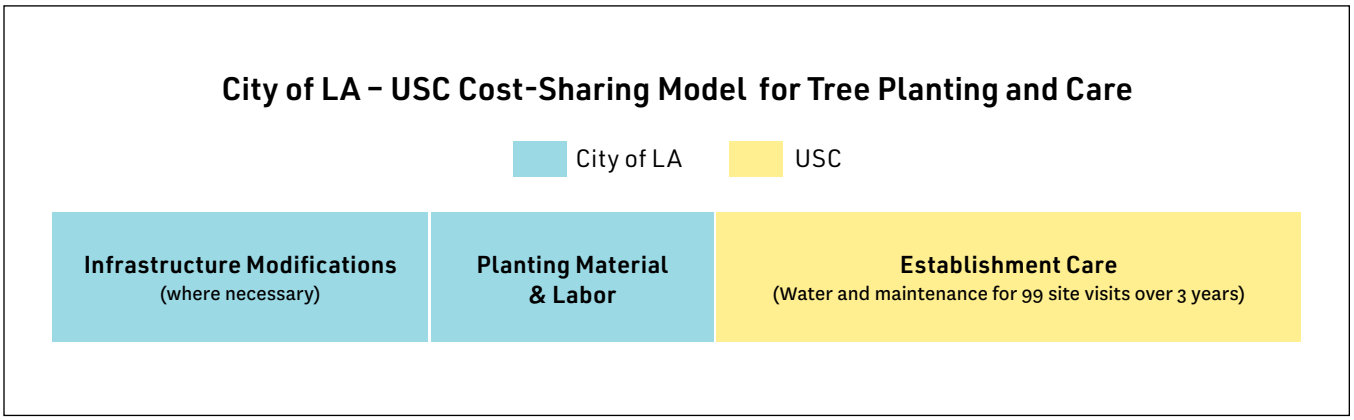


Appendix A

Budget Summary

	3 years
Personnel	$1,786,260
Community Engagement	$250,000
Equipment and Supplies	$123,740
Trees Installation and Care	$540,000
Grand Total	$2,700,000



Appendix B

Letters of Support

CITY OF LOS ANGELES
CALIFORNIA

ERIC GARCETTI
MAYOR

OFFICE OF THE
BOARD OF PUBLIC WORKS

DR. FERNANDO CAMPOS
EXECUTIVE OFFICER

200 NORTH SPRING STREET
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http://bpw.lacity.org

June 16, 2021

I am writing to express enthusiastic support for the attached proposal from the *USC Urban Trees Initiative*, submitted by the University of Southern California.

I have been working closely with the USC team since August 2020, along with colleagues from the Los Angeles Department of Public Works. The strong partnership that we have built is helping us answer key questions about how to deploy trees to most efficiently protect residents from harmful air pollution and extreme heat in the poorest areas of the city. The city has limited scientific research capacity to inform our greening efforts and to measure the efficacy in reducing air pollution levels. This work directly supports a priority goal of the City of Los Angeles, which is to increase tree canopy in the areas of greatest need by at least 50 percent by 2028.

The work our USC-City of Los Angeles team has done since last August lays the groundwork for this proposal. Together, we have:

- Engaged communities with nearly 60,000 residents to understand their needs;
- Refined a methodology for prioritizing tree planting focused on areas in greatest need of shade and air pollution mitigation;
- Conducted promising early research on which Southern California tree species are most effective in mitigating air pollution, as well as initial designs for tree groves that act as "air pollution sponges"; and
- Produced initial design renderings to guide city planning.

With additional funds, we would *immediately* and *significantly* expand the scope of this collaboration to focus on a larger geographic area, including expanded scientific research on tree species and air quality, and community-engaged urban forestry design, tapping the expertise of local non-profits. The new air quality research will fill a very important gap in the body of

knowledge in urban forestry in the Southern California climatic zone. Further, the funds would act as a multiplier to supplement the limited resources we have within the city for tree planting, allowing us to significantly expand the number of trees we can plant in areas of highest need. **This work will positively affect the lives of hundreds of thousands of low-income residents at risk from poor air quality in our nation's second largest city.**

The Office of City Forest Management and the Department of Public Works strongly value this partnership and know it will be a success because we have already built a close collaboration with USC and completed a pilot from which we learned a great deal. I assure you that we have full support from our agency leadership as well as other leaders within the city, many of whom are impressed at what this collaboration has achieved in a short time.

Thank you for your consideration and I am happy to answer any questions you may have.

Best Regards,

Rachel Malarich
City Forest Officer
City of Los Angeles

Kevin de León
Councilmember, Fourteenth District

June 30, 2021

I am writing to express support for the attached proposal from the *USC Urban Trees Initiative*, submitted by the University of Southern California.

It is my honor to serve as the Councilmember representing the 14th District of Los Angeles. As our city emerges from the pandemic, we must be mindful to build a healthier, more equitable, and more resilient community. Creating additional green spaces and improving air quality is a priority for my team so that we can protect our citizens, young and old, from extreme heat and worsening air pollution we know is coming due to climate change.

The scientific analysis conducted by the USC researchers in collaboration with the City of Los Angeles on the Urban Trees Initiative is imperative to the success of green infrastructure projects. The pilot phase of the initiative provided a detailed blueprint for the community of El Sereno, and the new proposed research will expand the work further into the community of Boyle Heights. These two neighborhoods in my district have some of the poorest tree canopy coverage in the city and thus community members are at risk of suffering adverse health effects from extreme heat and air pollution exposure in the coming years. The health and quality of life of our communities are of the utmost concern to my office. Significantly scaling the number of trees we plant to shade our streets and homes will be essential to keeping Angelenos healthy in the coming decades in the face of climate change.

The Urban Trees Initiative has already laid the foundation for meaningful engagement with residents of my district. During the pilot phase, the team held multiple community meetings with local leaders, business owners, and non-profit organizations to understand their needs and

priorities around green infrastructure. My office attended a community town hall about the Urban Trees Initiative and can confirm that attendees expressed overwhelming support for adding trees to our city streets, parks, and school campuses.

It is with the strong support of my residents that I ask you to please consider investing in the Urban Trees Initiative and the work being done by USC and our colleagues in the Department of Public Works. The proposed project would significantly and positively impact the residents of our 14th Congressional District.

Thank you for your consideration.

Best,

KEVIN DE LEÓN
Fourteenth Council District, City of Los Angeles

GILBERT A. CEDILLO

COUNCILMEMBER

FIRST DISTRICT

June 28, 2021

I am writing in support of the attached research proposal from the **USC Urban Trees Initiative,** submitted by the University of Southern California.

It is my priority to advocate for more equitable policy on behalf of underserved communities. Our city, and my district in particular, suffer disproportionately from poor air quality. In 2018, a USC analysis found that Lincoln Heights in my district had the third poorest air quality of any neighborhood in Los Angeles. Thankfully, trees play a vital role in mitigating the unintended consequences of urbanization and development, while enhancing the quality of life for residents.

The **USC Urban Trees Initiative** studies not only where to plant trees to improve health outcomes for our community, but also what types of trees would be the best "air pollution sponges". This type of innovative research is the result of a strong partnership between scientific experts and public practitioners at the City of Los Angeles. The city alone cannot conduct air quality experiments and measure the efficacy of trees in reducing air pollution levels, and the USC team benefits from our deep roots within the community. This partnership and expanding this research will ensure tree planting decisions are producing community health and well-being in my district.

I am confident that if funded, the proposed project would have a significant positive benefit to the everyone in my district. Your support of this funding request will allow USC and city staff to further build innovative strategies to mitigate air pollution and provide better quality of life in Los Angeles.

If you need any additional information, please contact my staff Jose Rodriguez at 323-550-1538.

Sincerely,

Gilbert Cedillo

Gil Cedillo
Councilmember, First District

CITY HALL 200 N. Spring St. Room 470 Los Angeles CA 90012
Tel: (213) 473-7001 • Fax: (213) 473-7462
HIGHLAND PARK FEILD OFFICE 5577 N. Figueroa St. Los Angeles CA 90042
Tel: (323) 550-1538 • Fax: (323) 550-1579

CURREN D. PRICE, JR.

Los Angeles City Councilmember

THE NEW 9th

June 25, 2021

I am writing in support of the attached research proposal from the *USC Urban Trees Initiative*, submitted by Dr. John Wilson (PI), with Dr. Will Berelson, Esther Margulis, and Ms. Kate Weber at the University of Southern California.

As the representative for the Ninth Council District of Los Angeles, I remain committed to raising the living standards of all residents in my district and have placed great emphasis on improving parks and green spaces all over CD9. As I stressed during my "Clean & Green" campaign, trees not only beautify our neighborhoods, but provide shade that generates numerous benefits to health and well-being. My office is well aware that the adverse effects of climate change will burden our most vulnerable communities first, and finding mitigation strategies for rising heat and air pollution in Los Angeles is a top priority.

The research proposed by the project team would use geospatial mapping tools and air quality sensors to identify areas of greatest need within a section of CD9. This information is invaluable to help identify priority locations for future tree planting decisions and to start engaging residents around green infrastructure projects. The communities I have the privilege to represent are among those most vulnerable to the effects of climate change, including poor air quality and urban heat island effect. This is of serious concern as USC research indicates that only about 41% of South L.A. residents have air conditioning compared to 68% for average L.A. residents, and 64% of South L.A. households live below the poverty line compared to 37% of average L.A. households. Adding to our urban canopy is one of the most cost-effective mitigation tactics that will help us meet the challenges of climate change and ensure we build healthy, resilient neighborhoods across CD9.

I stand in strong support of the partnership between the USC research team and the City of Los Angeles Department of Public Works as they determine where to invest in underserved areas of greatest need.

Thank you for your consideration.

Sincerely,

CURREN D. PRICE Councilmember, 9th District

City Hall - 200 North Spring Street, Suite 420 - Los Angeles, California 90012
District Office - 4301 South Central Avenue, Los Angeles, California 90011

June 29, 2021

I am writing to express support for the attached proposal from the *USC Urban Trees Initiative*, submitted by the University of Southern California in partnership with the City of Los Angeles.

C40 is a network of 97 cities from across the globe that are committed to addressing climate change at the local level. We support cities through increased collaboration, knowledge sharing, and measurable action to ensure we deliver on the most ambitious goals set out by the Paris Agreements and by our own city governments.

The front lines of global crises are increasingly our cities. Home to more than half the world's population, the climate crisis poses significant challenges for urban environments such as extreme heat and air pollution, exacerbated by the urban heat island effect. A coalition of over 35 Mayors, including Los Angeles Mayor and C40 Chair Eric Garcetti, have committed to providing clean air to residents as part of the C40 Clean Air Cities Declaration. Taking action on these declarations requires the type of innovative cross-sector research partnership that the Urban Trees Initiative proposes.

This partnership between USC and the City of Los Angeles is an exemplary model of a collaboration that brings together scientific research expertise, city policymakers and community groups to guide the ambitious City of Los Angeles goals to increase urban canopy in areas of most need. Nature-based solutions can provide critical shade to cool surface temperatures and can mitigate urban air pollution. But to gain full advantage of these benefits, urban greening projects should be data-driven and guided by scientific analysis. The research that the USC-City of LA team has already done and is proposing to expand not only helps the City of Los Angeles prioritize greening projects in geographic areas in areas of need, but also seeks to fill key gaps in the scientific literature (such as the effectiveness of different species of trees in mitigating air pollution) and examine what makes our urban forests resilient.

Many other global cities are prioritizing adding to their urban tree canopies. We believe the work that the USC-City of LA team is doing can be shared with other cities as a set of best practices, thus magnifying the global impact of the initiative. C40 looks forward to seeing the results of this work and working with the City of Los Angeles and USC in sharing it with partner cities in our network.

Thank you for your consideration.

Best,

Iyad Kheirbek
Director, Air Quality Program
C40 Cities

North East Trees
Bringing Nature Back

June 29, 2021

I'm writing to express my strong support for the attached proposal from the *USC Urban Trees Initiative*, submitted by the University of Southern California.

North East Trees (NET) is a community-based, grassroots, environmental non-profit with deep roots in many Los Angeles communities, including El Sereno and Boyle Heights. For nearly 30 years, our organization has involved community members and fellow non-profits in urban greening and habitat stewardship. We pride ourselves in working in communities that are especially vulnerable to substandard air quality, excessive heat, and other impacts driven by pollution and climate change. As part of our core mission, we prioritize training and hiring youth of color from the communities we work in to ensure they gain skills in entry-level positions within the park and conservation industry.

It was with pleasure that we started meeting with the USC research team during the first phase of their project from August 2020 to April 2021, and we look forward to subsequent phases and increased community outreach and involvement. The Urban Trees Initiative, especially the first-of-its-kind research on the carbon sequestration potential of various local tree species, is relevant to the work of our non-profit and our ongoing projects. The next phase of research the USC team proposes will address knowledge gaps that our arborists are so keen to fill and provide important data to make our environmental efforts more competitive for grant funding. Pleased to be part of first phase

We look forward to building upon our strong partnership and collaborating on new greening and tree planting proposals with the Urban Trees Initiative team.

Thank you for your consideration.

Best,

Mark Kenyon
Executive Director
North East Trees