Healthy Urban Environments (HUE) Initiative
Arizona State University

Project Update: Third Year, First Quarter, 2021
Date of Report: July 30, 2021

Project Overview

As outlined in the Healthy Urban Environments (HUE) Initiative proposal, ASU has launched HUE as a solutions-focused research, policy and technology incubator to rapidly develop, test and deploy heat-mitigation and air-quality improvement strategies and technologies. This will be accomplished through four project components: 1) research, solutions and innovation incubator; 2) communication, networking and solutions hub; 3) implementation and evaluation of new insight in real-world contexts; and 4) public, workforce and management education and capacity building. The schedule for delivery of each component as proposed is shown below; we will report on progress for each of these components separately in the following pages.

Project Summary: July 30, 2021

As we enter the third year of our Healthy Urban Environment initiative, attention has shifted towards implementation of solutions and institutionalization of approaches to ensure continued impact through deploying solutions, improving local thermal comfort and reducing air pollution exposure and continued economic advancement in the Phoenix region. Specifically, this report

- We provide details on new research and innovations selected for support during Year 3 of the HUE project
- We report how HUE has enabled the formation of the Arizona Heat Preparedness and Resilience workgroup to support local municipalities keep Maricopa residents heat-safe
- We detail the transition of our Photocatalytic NOx project from being directly supported by HUE to industry support from the Semiconductor Research Corporation to ensure industry adopts this promising technology; and
- We discuss how HUE, working with the City of Phoenix, developed the concept of Cool Corridors for the City of Phoenix to invest in retrofit of individual street segment in each City Council district to demonstrate the impact of a holistic approach to heat mitigation.

Tangible impacts of these HUE projects include the Arizona Heat Preparedness work to safely expand cooling center availability during the COVID-19 pandemic and the long-term collaboration with HUE and the City of Phoenix has resulted in a new effort within the City of Phoenix to staff an office specifically responsible for urban heat response. These are just the initial steps in what we hope will be widespread new employment in a variety of situations.

1. Research, Solutions and Innovation Incubator

Overview:
ASU will develop a research, solutions and innovation incubator to test novel heat and air pollution mitigation technologies; deploy field demonstration projects to quantify the heat and air quality mitigation effectiveness; and modeling projects to simulate the impact of heat and air quality mitigation approaches.

July 30, 2021 Status:

2021 New Cohort Announcement
HUE has recently solicited projects for our 2021-2022 cohort. We received 11 submissions from diverse groups. We selected a wide range of projects that aligned with our goals of advancing technology, deploying solutions and mitigating urban heat and air quality.

Waking Up Wall St: Creating a cool pedestrian thoroughfare in downtown Chandler, AZ
The idea of activating alleyways has been embraced as an urbanist strategy across the globe to reclaim public space for cities and to create more interconnected pedestrian networks. During the COVID-19 pandemic, alleyways were lifelines for restaurants looking to create additional outdoor seating that allowed for safe social distancing. As alleyways transform from dark, underutilized spaces frequented mostly by service trucks to vibrant arteries within cities that safely connect people and places, they help to create more livable communities. A majority of the robust alleyway activation projects are found in markets that do not face the same heat-related challenges that projects in metropolitan Phoenix will face, limiting applicability. The Waking Up Wall St. project will engage diverse stakeholders and community members to explore, demonstrate, jump-start, and showcase the implementation of a comprehensive alleyway activation approach that is unique to Maricopa County's hot, desert environment. The approaches developed through this project can be applied throughout metropolitan Phoenix, where there are many other alleys that could be used as year-round pedestrian corridors.

HeatReady Neighborhood
Impacts from extreme heat are particularly intense in communities with a history of disinvestment, low vegetation, populations with pre-existing health conditions, large presence of elderly, children, and low- income families. While hazard mitigation plans and climate action plans may include heat interventions, it is at the city or regional scale. Previous research revealed the need for community-based solutions that are contextually and culturally appropriate. This HUE project will develop a HeatReady Neighborhood that helps communities prepare for extreme heat emergencies and work towards long-term heat mitigation solutions that create more thermal comfort for its residents. The HeatReady Neighborhood rubric will optimize a community's assets or "heat resource shed" and be developed by community groups, neighborhood organizations, and community development corporations to guide neighborhoods in personal and collective emergency heat situations as well as to utilize evidence-based solutions in creating cool zones and pathways in anticipation of a hotter future

environment.

Building a Targeted Real-Time Warning System to Prevent Indoor Heat Deaths
In Maricopa County, and many other jurisdictions across the United States, a significant portion of heat-related deaths occur because of indoor exposure. Yet there are no explicit public programs or systems designed to detect extreme heat indoors and trigger appropriate and timely response actions. This project seeks to develop, build and test a real- time, targeted, knowledge-sharing platform that would issue alerts when dangerously hot conditions are measured inside one's home. These alerts would trigger wellness checks by neighbors, family members, or other support personnel, and ultimately help connect vulnerable residents to a larger network of resources and assistance. The goal of the project is to interrupt the causal pathway from unexpected or unknown dangerous heat to severe heat-related illness and/or heat- related death with technology-triggered interventions.

Crowdsourced Heat and Indoor Air study
Maricopa County and the Phoenix area in particular are relatively unusual as people stay indoors for long periods of time in summer months because of the heat. Additionally, the air exchanges between the inside of houses with the outside are limited because of energy considerations and the nearly universal use of air condition systems. Only very limited observational work exists in Maricopa County limited to special populations while overall there is no observational database on indoor/outdoor pollution ratios and the impact of heat. This project will follow a crowdsourced, "citizen science" approach to identify and correct knowledge gaps on indoor exposure to air pollution and heat, as well as the relationship between indoor and outdoor pollution levels in Maricopa County. The project will use students (high-school and college) as "citizens" and provide them with air pollution and temperature sensors to make the measurements in their homes (and school/work environments) and collect data in their neighborhoods. To expand the impact of this project, science education curricula will be developed and distributed based on the findings of this project.

Mesa CARE Resilience Hub
Urban heat is a growing public health crisis in Maricopa County. Vulnerable populations, especially the elderly, children, those with pre-existing conditions, individuals with low socioeconomic status, and minorities are especially at risk for heat related illnesses. These risks are amplified by landscape level differences. This project will create a CARE (Community Asset Resource Enterprise) Campus Resilience Hub that supports all residents and will respond to heat and air quality challenges during the summer, emergencies, and recovery times while addressing inequalities and their root causes. Further, and more importantly, building this Resilience Hub will build community capacity, shift power dynamics, increase the shared health of the community, and provide access to relief services in emergency situations.

Online Decision-Making Tool for Active Shade Management
In the desert Southwest, shade is one of the most important urban design features to lower Mean Radiant Temperature (MRT) and increase outdoor thermal comfort on hot sunny days. The impact of shade on people is localized (dependent on the shadow), site-specific, and context-dependent (impacted by surrounding urban form). It varies diurnally and seasonally by

shade type (engineered vs. natural), orientation, and ground surface cover. This project will develop a web-based simulation tool that generates shade performance curves for arbitrary shade types, locations, dates, and times of day. This tool will translate empirical findings into usable science by making comprehensive shade assessments accessible at no costs to City staff, developers, and the general public in Tempe, the Southwest, and across the nation. The hands- on, web-based decision-making tool will allow users to assess the thermal comfort impacts of customized, site-specific shade interventions for active shade management.

Revitalizing and Reimagining Outdoor Play and Learning Environments
Overexposure to heat, ultraviolet (UV) radiation, and traffic-related air pollution (TRAP) are significant health concerns, and although preventable, deaths due to these exposures persist across U.S. populations. Children have heightened sensitivity to heat- related illnesses, thermal burns, asthma, and UV skin damage due to these interconnected exposures. Children's heat illness is a significant concern for public health agencies, emergency responders, and hospitals, with over 950 emergency department visits for heat in Arizona for children aged from 2008–2018. Moreover, 10.9% (>174,000) Arizona youth have asthma, with many public schools located immediately adjacent to major transportation corridors (e.g., 30 Phoenix schools are within 1⁄3-mile of a major highway). The COVID pandemic has also exposed the importance of outdoor classrooms; however, these spaces must be environmentally safe and conducive for their intended use. This project will extend and amplify the existing efforts at Paideia Academies, which would benefit from additional resources to ensure that long-term air quality and microclimate monitoring can continue. It also aims to enhance these measurements with new data collection related to water use, soil temperatures, and evaporation, as questions around water often arise when heat solutions using re-greening are posed.

Unlimited Potential
Metropolitan Phoenix ranks in the top five US cities for asthma-related deaths with approximately 8% of the population living with the disease. In its 2019 State of the Air report, the American Lung Association ranked Phoenix 13th out of 217 cities across the country for highest daily particle pollution and seventh for high ozone days out of 228 metropolitan areas. In south Phoenix the effects of asthma for children, families, and communities are exacerbated by poor air quality and complex factors related to racial and ethnic disparities. This project aims to engage, educate, and empower members of the South Phoenix community and help them understand the interconnection of asthma, pollution, and climate change.

2. Communication, Networking and Solutions Hub

Overview:
Arizona State University (ASU) will convene workshops to share mitigation approaches, initiate new inquiries to expand on urban heat and air quality improvement strategies, and provide summative reports on relevant community strategies for interventions for urban heat and air quality.

July 30, 2021 Status:

The Arizona Heat Preparedness and Resilience workgroup is actively supporting municipalities, health departments, non-profits, academia and the faith community to keep Maricopa residents heat-safe and thermally comfortable as we experience the second heat season coupled with the COVID-19 pandemic. This group started the heat season by hosting the Fifth Annual Arizona Extreme Heat Planning Workshops along with NOAA, the National Weather Service and Arizona Department of Health Services. Many Healthy Urban Environments projects were highlighted as promising or best practices for tackling extreme heat. Recent speakers at the bi-monthly meetings include the local utilities, SRP and APS, the Morrison Institute, and the Arizona Department of Economic Security.

The Arizona Heat Preparedness and Resilience workgroup is also gaining national attention, especially by NOAA/NWS, as they are looking for best practices in engaging the public with their weather products. The co leads have been invited to the planned NOAA Climate/Equity Roundtable on Heat Risk. The Aspen Global Change Institute is hosting the Western Adaptation Alliance, a consortium of cities and counties across the inter mountain west that are interested in climate adaptation and resilience and have invited the Arizona Heat Preparedness and Resilience workgroup steering committee to highlight how heat risk is managed in our area. Meetings will continue to be twice per month until October 2021 and they are opened to any entities that are actively involved in managing extreme heat issues.

3. Implementation and Evaluation of New Insights in Real World Context

Overview:
ASU will test new solutions developed as part of HUE; conduct surveys and in-depth interviews with community members; and enable Technology Transfer and Intellectual Property licensing on all projects sponsored by HUE.

July 30, 2021 Status:

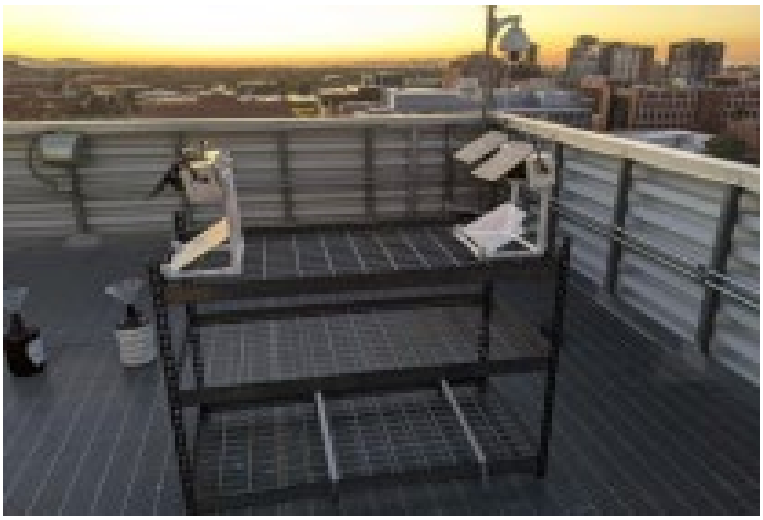

Figure 1: Field Testing Photocatalytic NOx removal approach on the ASU Tempe Campus

Prior HUE work has demonstrated the ability for a titanium oxide coating applied to glass to photocatalytically remove NOx from air in laboratory-controlled conditions. NOx – the sum of gas-phase concentration of nitric oxide (NO) and nitrogen dioxide (NO2) – is important to local air quality as a precursor to ground-level smog formation. To investigate the

feasibility of this approach to be deployed in real-world situations to simultaneously remove air pollution and produce clean electricity, a field pilot scale study was performed on the ASU campus in Tempe.

The field testing consisted of deploying small glass panels (8x12 inches) each coated with different photocatalysts that have been shown to photocatalytically remove NOx from air in laboratory experiments. In addition, uncoated panels were used as controls. The field testing was performed on the roof of the ISTB4 building at ASU's Tempe campus. Initial tests used NO2 sensors to quantify the difference in gas-phase pollutant concentration above treated and untreated panels to determine the removal of NOx from the atmosphere as is shown in Figure 1.

However, because of variability in the concentration of NO2 over time, it was determined that measurement of the oxidation product of the photocatalytic reaction NOx– nitrate ion deposited to the glass surface – was a more precise approach to determine the effectiveness of the catalyst. The nitrate formed was quantified using ion chromatography in our lab in ISTB4.

For the field testing, we conducted multiple exposures of untreated glass panels (control), one panel coated with titanium dioxide by a local business (commercial coating) and two panels using different commercially available photocatalysts that were coated in our lab in ISTB4 (P25 coating and FN1 coating). All field testing was successful in showing an increase in nitrate formation on the glass panels treated with the photocatalyst when compared to the control panel, showing successful NOx removal in environmental conditions. To obtain a quantitative value of how this approach might scale to larger deployments, the flux of NOx removal was calculated showing the amount of nitrated formed normalized by the time of exposure. The average nitrate formed per day during our pilot field studies can be seen in Figure 2. The amount of nitrate formed during exposure varied between catalysts with the commercially available FN1 coating showing the greatest nitrate removal.

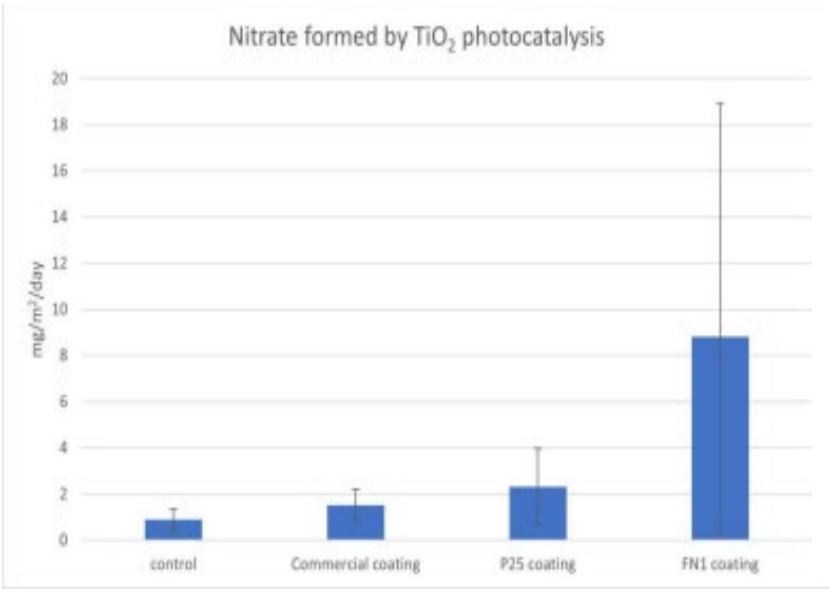

Figure 2 The average nitrate formed per day during the field demonstration

While there is significant variability in the amount of NOx removed between each of the runs during the ambient field testing, part of this variability can be explained by changes in concentration of NOx in air as well as changes in relative humidity. During controlled laboratory testing, it was shown that humidity directly influenced the effectiveness of photocatalytic removal of NOx by oxidation to nitrate.

One concern when using photocatalysts is that they will become less efficient at removing NOx from the atmosphere over time. In Figure 3, the average nitrate flux from one of the photocatalytic panels is shown for commercial coating tested sequentially over time. The results show that while there is significant variation in the amount of nitrate on the panel over the duration of field testing, this variability is likely due to changing environmental conditions such as ambient NOx concentration, relative humidity or solar insolation which drives the chemistry. The data is promising in that it shows no trends towards decreasing concentration which means coatings should be durable enough for extended operation in the field.

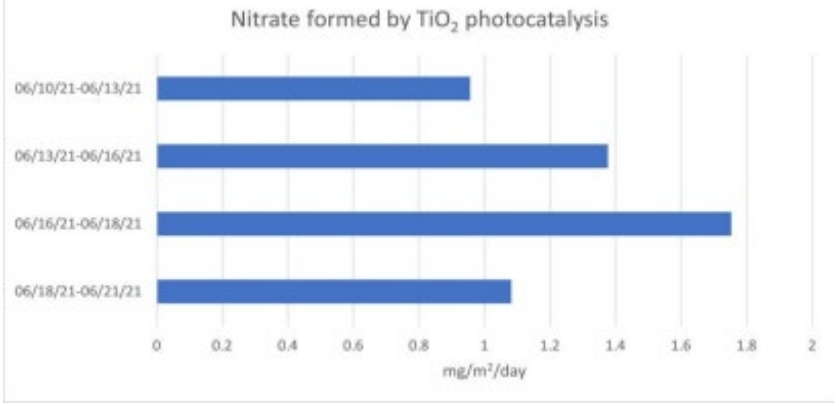

Figure 3 Average nitrate flux from one of the photocatalyst panels over time

Currently, we are using concentrations of NO_x measured by the Maricopa County Air Quality District to understand what fraction of gas-phase NO_x that comes into contact with the panels is removed by reaction to determine if improved mass transfer can increase the amount of NO_x removed by bringing more NO_x into contact with the catalyst or if improved catalyst chemistry can remove more NO_x by converting a larger fraction of NOx that comes into contact with the panel.

Finally, to ensure that this promising technology is integrated into industrial approaches to mitigate air pollution, funding for an additional three years of technology development and industry scale up of this promising technology. This funding – secured from the Semiconductor Research Corporation (SRC) – will both ensure continued advancement of the technology, scale-up of approach to industrially relevant approaches, and economic advancement through deployment.

4. Public, Workforce, and Management Education and Capacity Building

Overview:
ASU will enable capacity through development and implementation of workshops aimed at stakeholders and community members; create online modules to be integrated into existing ASU outreach programs; and develop material for new workforce training programs.

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Work completed over the past quarter for the "Measuring the urban canopy and cool corridors" HUE project has focused on the development of strategic goals and prioritization criteria for Cool Corridors in the City of Phoenix. Cool Corridors were emphasized over the past quarter to respond to the City's 2021-2022 operating budget, first proposed in spring 2021 and formally adopted on July 1, 2021. The budget includes a dedicated Cool Corridor investment that will support the planting and maintenance of approximately 1,800 trees each year across a total of nine prioritized one-mile street segments. The first Cool Corridor installation is scheduled for the 2021-2022 planting season.

Our HUE-supported research team has been collaborating with City of Phoenix staff, the city's Urban Heat Island and Tree Shade Subcommittee (UHITS), and the Arizona Department of Health Services, to develop recommendations and work plans that will guide Cool Corridor selection, implementation, and subsequent monitoring and evaluation.

HUE researcher David Hondula is a member of the UHITS subcommittee and contributed scientific expertise and ASU scholarship to help the subcommittee develop Cool Corridors Program Policy Recommendations in spring 2021. The Recommendations were unanimously approved by UHITS, and subsequently, by the city's Environmental Quality and Sustainability Commission, who communicated the recommendations to City Council. The recommendations span four categories: (1) Cool Corridor Definition; (2) Cool Corridor Prioritization; (3) Community and Stakeholder Engagement; (4) Evaluation and Accountability. ASU researchers will continue to support activities that align with these recommendations through summer and

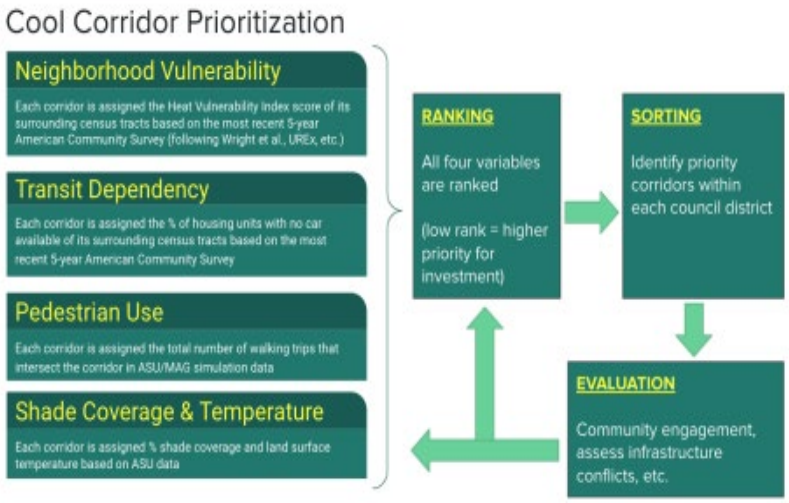

Figure 4 Proposed Cool Corridor prioritization criteria

fall 2021, ahead of the planned installation. Figure 4 illustrates the currently proposed Cool Corridor prioritization criteria. These criteria will help identify one street segment in each City Council district and one additional segment for the initial installation. ASU researchers supported by HUE are compiling relevant data, creating the prioritization index, iteratively adjusting the index based on stakeholder feedback, and providing appropriate visualization tools.

The HUE Cool Corridors project team also made progress over the past quarter in compiling data and preparing visualization tools to support Phoenix staff and City Council's decision-making process for Cool Corridor selection. The most significant achievement was completion of the set of candidate street segments for the Cool Corridors prioritization index, which involved manually editing the city's GIS street layer to align with program objectives. The creation of this new GIS layer also enabled the team to identify present-day "best case" examples of Cool Corridors, which helped the project team and partners discuss and refine Cool Corridor definitions and goals. The project team created an ArcGIS online web map and dashboard to serve as the primary visualization platform for Cool Corridor selection. The web map and dashboard are currently designed as internal resources to help city staff learn about variability in heat-relevant land cover data and social variables at a high spatial resolution and deliberate about priority street segments in a systematic, data-informed environment. Increased capacity among city staff will ideally lead to improved short- and long-term decision making with respect to cooling resource allocation. In the future, the web map and dashboard can be adapted for broader public dissemination, such that non-profit and community-based organizations can most effectively complement city actions. More coordinated and accelerated tree planting efforts will create additional labor demand, for installation, maintenance, and evaluation, which may ultimately produce new jobs within and beyond city government.

Finally, our team members collaborated with city staff, the Arizona Department of Health Services, Trees Matter, and Unlimited Potential to submit a funding proposal to the Centers for Disease Control and Prevention's Building Resilience Against Climate Effects (BRACE) program. The $900,000 proposal would support a significant enhancement of community engagement, public education, and evaluation activities connected to the City of Phoenix Cool Corridors initiative and the City's broader urban forestry initiatives. A funding decision is expected by September 2021.