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3205 Walnut St, Philadelphia, PA 19104

Global Pathways to enable Innovative Materials Solutions for Urban Challenges

Synopsis

This symposium served as a starting point to look at urban problems around water, energy and air in three case study cities (Seoul, Korea; Grenoble, France; Philadelphia, PA, USA) and the potential roles that academic researchers in engineering and the sciences might be able to have in contributing to solutions to these problems. Hosted by the University of Pennsylvania, with the support of research partners from the Grenoble Innovation for Advanced New Technologies (GIANT) campus in France and Sungkyunkwan (SKKU) University in Korea, this symposium brought urban experts and practitioners to the stage to discuss municipal challenges with an audience of primarily engineering and science researchers and students, and some attendees from outside of Penn. For many in the audience, this was the first time they had the opportunity to hear directly from experts on urban needs and the successes and challenges of applications of technology towards these needs. As a first-step in thinking about how the often small-scale, pioneering, high-tech and expensive research programs of academic scientists might contribute to the very real, large-scale, often immediate, budget-constrained needs of cities, the symposium guidelines to the speakers were general and open. The idea was that this symposium would provide space to listen, to stimulate new thinking about the science/engineering urban interface, and to provide a foundation to continue conversations among the local and international research network and with city practitioners. The program, videos of the talks and biographies of the speakers are posted on the REACT website (https://react.seas.upenn.edu/event/react-at-penn-2020/). Several key takeaways of the symposium include those that are described below.*

The morning session of the symposium provided context on the urban settings of Seoul, Grenoble and Philadelphia. These "case study" cities are the locations of the home institutions of a network of science and engineering researchers and educators that developed out of the National Science Foundation's Partnerships in International Research and Education award that funds the REACT project based at the University of Pennsylvania (NSF Award #1545884). These cities have strong science, technology, research and higher education infrastructures. These three cities represent a range of population sizes (Grenoble: ~525,000; Philadelphia: ~1,584,000; Seoul: ~9,962,000), histories, geographies and socio-political landscapes. Speakers from each city provided insight into the roles technology has played in each city, in particular around the domains of water, energy and air.

Seoul, and more generally, Korea, uses a smart city strategy and technologies to assist with areas including crime control, transportation, waste management, reduction of energy needs and increased resilience to climate change. For example, advanced sensors have been used to detect water leakage in the municipal water distribution system, which decreased leakage loss to only 3%. New towns have become testbeds for smart technologies; for existing cities, which contain the majority of the nation's population, there is a major R&D initiative to assist in the transition to smart technologies and/or modernization of older technologies. An ageing population and making rewards of moving to smart city technologies equitable are two societal factors that shape policies and strategies. Increasing residents'

satisfaction with the smart technologies is an ongoing goal. To implement new technologies successfully, the speaker suggested having clear goals and vision, governing with inclusion (e.g., with local governments, private sector, citizens), and ensuring that the benefits be felt by most residents, including the underserved. Changing people's behaviors to support sustainable habits is important to the success of these programs. Constraints include the scale needed for implementation (which requires innovation and money), maintaining and upgrading the technologies over time, regulations (which often fall behind technologies), privacy and security, political and social factors (including intended users wanting to use services). [*Professor Kyung-Hwan Kim, "Smart Technologies for Urban Management: The Case of Korea"]*

Grenoble is the flattest city in France and has a wide variety programs aimed at sustainability, including ones that result in recovery of 90% of its waste. The city lies in a valley surrounded by three mountain ranges, which results in trapped air pollutants and air quality being a major concern. Energy consumption is decreasing mainly because of industry efforts, but drastic changes need to be made to meet carbon neutrality by 2050. Grenoble had the first air climate plan in France (2005) and since 2012, all metropolitan areas are required to have plans. The city's environmental footprint can be decreased in the areas of housing and real estate, transportation and food. Initiatives to reduce energy consumption include assistance for adding insulation to private buildings, promoting biomass, geothermal and solar energy sources and a thermal generating heating distribution network. Air quality initiatives include sensing, modeling, restitution and public education campaigns. The transportation system is going through a transformation with €2.2B of investment towards infrastructure (including a new electric cable car system by 2023), as well as policy and education initiatives. Water sources of Grenoble are mainly natural springs and ground water and are maintained (from source to distribution) by Grenoble Alpes Water. New developments (e.g., Presqui'ile) are under relatively rigorous directives towards carbon neutrality and sustainable living. *[Francine Papillon, PhD "Sustainable Development@Grenoble Alpes Metropolis"]*

Philadelphia is working towards these key objectives: reducing carbon emissions, reducing traffic deaths, and eliminating use of landfills and conventional incinerators. The city's goals include reducing carbon emissions by 80% and 100% carbon-free electricity by 2050. The municipal energy master plan outlines cutting the city's energy use by 20% and moving to 100% renewable electricity for city facilities by 2030, building a solar facility and installing solar panels on city buildings, initiating a new high-speed bus line to reduce car traffic, and updating building codes for reduced energy usage. Technologies that would help these efforts include: organic solar cells that are cheaper, lighter, and customizable; better batteries to store energy; better insulators; electric car/charging advancements. Challenges include social/behavioral ones (e.g., getting people out of their cars). For clean air, the airport, regional transit system and city fleets have upgraded vehicles to hybrid, electric and compressed natural gas. Technologies used for and useful for reducing traffic deaths include speed cameras, interactive maps for users to report unsafe conditions, LED street lights, improved street marking materials (functionality and durability), safety warnings for cars (e.g., backup cameras, impact softening materials) and streets (e.g., pedestrian warnings). For more sustainable waste management, the city is supporting small scale composting systems, running programs to donate surplus food to food pantries, supporting zero waste events (e.g., Philadelphia marathon) and a plastic bag ban. Useful technologies would include systems to track materials through the supply chain and help promote a circular model, more environmentally friendly construction materials, ways to process or reuse materials (e.g., when a building is destroyed),

sensors to improve internal building temperature regulation (and decrease energy usage), innovations to deal with ageing buildings efficiently and cost-effectively. In addition, although not related to energy, water or air, two important city challenges for Philadelphia are gun violence and asbestos/lead in school buildings. Innovation from scientists towards solutions to tackle these problems could also offer tremendous contributions. *[Anne Fadullon, Philadelphia Challenges with Potential Materials Solutions]*

The symposium's afternoon session started with "**Integrated Adoption & Adaptation of Multiple New Technologies, Plans, Policies, Behaviors, & Finance for Urban (Nexus) Challenges**" *[Joshua Sperling, PhD, National Renewable Energy Laboratory]*. This session used Dr. Sperling's own pathway as the base for sharing a diversity of convergent research project examples. Urban X was defined as "X" being a variable that could be many things (e.g., sustainability, resilience, energy, water, infrastructure, etc.). Urban "Nexus" science was described as science co-designed by different stakeholders in an information environment and around these characteristics: engagement of the community and stakeholders, quality data-research, inspiration of new thought and action leadership, design of change without profit-motives, assessment of effectiveness of strategies to prioritize next actions. The model of prioritizing human-scale benefits for emerging technologies was shared (how does it affect people's behaviors and decisions; how do we include people into the research, research questions, and make results accessible; how do we improve lives now and more immediately). The human-centered focus led to additional system-level benefits (e.g., reducing emissions) and defining external mission statements around sustainable, healthy, resilient cities. For effectiveness of these Nexus projects, the importance of doing this work with a group of researchers and practitioners from multiple disciplines (and ones that conventionally interact infrequently, e.g., social scientists with engineers with city designers) was stressed. An important theme in the different kinds of domestic and international projects that were highlighted in this session was reducing disparities and increasing equity in urban habitats.

In the second afternoon session, Kleinman Center for Energy Policy's Angela Pachon, led a discussion around **facilitation of new technology-based solutions in urban habitats**. Panelists Howard Neukrug (Water Center at Penn), Christopher Puchalsky (City of Philadelphia) and Kyung-Hwan Kim (Sogang University; Vice Minister of the Ministry of Land, Infrastructure and Transport of the Republic of Korea from May 2015 to June 2017) discussed specific examples of cities using technology to address their needs, best practices for upgrading aging infrastructure, deployment of new technologies, funding and scale of support. Technology readiness level, the role of crises in provoking change, limited budget and many competing city needs, agile and visionary leadership, incentives/disincentives of civil servants, politics and regulations, industry engagement and scale and expense of projects were factors that all contributed to the complexity and uniqueness of particular scenarios. There were also specific examples of how city leadership and managers engage with each other to share best practices and encourage innovative solutions. When asked to connect to "materials innovations" panelists mentioned energy efficient and responsive windows that meet building codes, self-healing pipes, and reduction of biofilms that create energy loss in sewage heat exchanges.

**This Symposium Synopsis was generated by REACT organizers; any errors, misinterpretation or misrepresentation are completely the responsibility of REACT.*