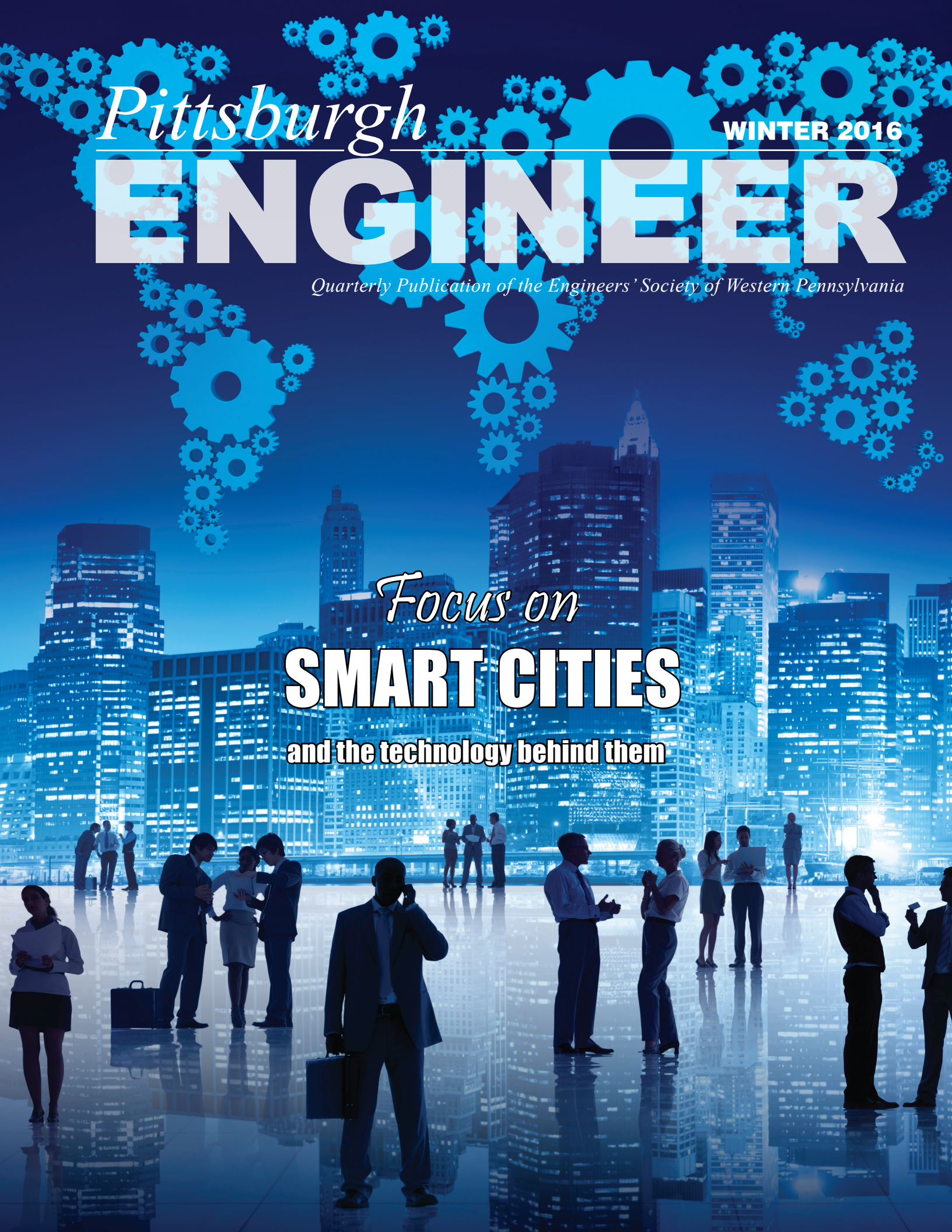




Pittsburgh

WINTER 2016

ENGINEER

Quarterly Publication of the Engineers' Society of Western Pennsylvania

Focus on
SMART CITIES
and the technology behind them

A nighttime photograph of a city skyline with a multi-lane highway in the foreground. The highway shows long-exposure light trails from cars, with white trails for headlights and red trails for taillights. The city skyline in the background includes several illuminated skyscrapers, one of which has a distinctive tiered top. A bridge with blue lights is visible in the mid-ground. The overall scene is a vibrant urban night scene.

Michael Baker

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Pittsburgh ENGINEER

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WINTER 2016

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Guest Editor's Column

By The Honorable Bill Peduto, Mayor - City of Pittsburgh

Innovation is in Pittsburgh's DNA. From the invention of the industrial processes that allowed steel to be affordably mass-produced to the scientific minds that created the vaccine for polio to the construction of the first leg of the nation's interstate highway system -- our city was built on innovation. That fire to create and build led to an explosion of industry and wealth, and a rapidly growing population from the early 1920s to the 1950s. In that period, Pittsburgh produced more than fifty percent of the nation's steel, held the second highest bank assets in the country, and was home to nearly as many corporate headquarters as Chicago and New York City. In 1950 our population was more than twice what it is today.

Pittsburgh also knows the seismic changes that innovation can bring better than nearly any other city in the United States. The collapse of domestic manufacturing in the 1970s and 1980s left the city a shell of its former self, hollowing out neighborhoods and decimating the tax base for a generation. To make matters worse, this economic collapse capped off a period of well-intentioned but sometimes counterproductive urban renewal in transportation and housing that cut highways and bridges through the hearts of vibrant, diverse communities and concentrated low-income residents in socially and economically isolated housing projects. In the course of a decade, Pittsburgh's trajectory flipped from unbridled growth to managed decline. However, through sheer force of will and a tradition of institutional coordination, Pittsburgh bent the curve of that trajectory and has today emerged as a national leader in education, healthcare, and advanced industries, and we have begun to reinvest in infrastructure for the next generation.

Today, we are on the cusp of a new revolution in transportation and information technology that has the potential to again reshape the urban environment and our way of life. Pittsburgh's new approach to transportation and "smart city" technologies

is called SmartPGH, which will place us on the leading edge of that revolution and allow us to adapt in ways that will avoid the mistakes of the past and improve safety, enhance mobility, and address climate change. Our critical transportation infrastructure can no longer be viewed as just a means of travel -- it must evolve into a resilient network that connects people to opportunity and accelerates innovation and data driven decision making.

SmartPGH is not just about the deployment of new technology for technology's sake. At the core of our approach is a people-first strategy prioritizing interventions that will improve the lives of those most in-need in our communities. For example, many residents are still without adequate transportation options or lack safe routes to access them, leaving them isolated and disconnected from opportunities that others Pittsburghers enjoy. The goal of SmartPGH is to deploy infrastructure and assets to address such challenges, while keeping people at the center of our strategy and planning at all times.

The first step to creating a truly SmartPGH is developing our network of key "Smart Spine" corridors -- layering environmental, communications, energy, and transportation infrastructure supported by an array of technology -- to improve connections between historically isolated neighborhoods and major centers of employment and educational and healthcare services.

The City of Pittsburgh's existing network of smart traffic signals will be significantly expanded, connecting the current real-time adaptive signal technology pilot area in East Liberty to the major job centers and transit hubs along our Smart Spines. Moving forward, these Smart Spine corridors and public buses, city fleet vehicles, and even bike share bicycles will be equipped with digital short-range communication (DSRC), creating an extensive connected vehicle environment. Initially, we will equip Port Authority of Allegheny County's entire fleet of 726 public buses to be fully optimized

when traveling the Smart Spine corridors, decreasing travel time, queuing time, and air emissions, and improving the transit experience for all riders. As additional public and private vehicles are outfitted with such technology, our entire transportation network will become fully optimized.

In addition, the City of Pittsburgh is moving forward with an LED smart streetlight conversion of nearly 40,000 lights beginning with those along our Smart Spine corridors. This conversion will create an energy savings of 60% and the streetlights themselves will be capable of collecting and transmitting data and improving safety for users of all modes of transportation -- particularly pedestrians and cyclists. The wealth of new data from fixed and mobile assets and the administrative and legal structure to freely access it -- through our Western Pennsylvania Regional Data Center -- will provide the ideal environment for data-driven decision making as well as a foundational platform for the development of applications, decision-support tools, and research in an open marketplace. Transit optimization along the Smart Spines connecting low and moderate income neighborhoods to the job centers of Downtown and Oakland will provide disproportionate benefits to Pittsburgh's most disadvantaged residents.

With these efforts, the City of Pittsburgh will integrate pre-existing and new networks and create systems-of-systems that will allow Pittsburgh to accelerate our work to improve safety, enhance mobility, address climate change, and enhance opportunity. Indeed, SmartPGH lays the groundwork for a truly 21st Century vision: a connected city that provides efficient, affordable, safe, and clean access to jobs and services to all of our residents. We're learning from the past, and evolving from who we once were. With our hardworking ethos and our spirit of innovation intact, we know that if it's not for all, it's not for us.



Bill Peduto

THE PITTSBURGH 2030 DISTRICT:

Voluntary Building Performance at Scale

by: Angelica Ciranni, LEED AP O+M

An internationally recognized, locally driven, voluntary initiative, the Pittsburgh 2030 District encourages business owners and facility managers in the Downtown and Oakland neighborhoods of Pittsburgh to work collaboratively toward aggressive 50% reductions in energy use, water consumption, and transportation emissions (below baselines) by the year 2030. Part of an international 2030 Districts Network, the Pittsburgh 2030 District is a public-private partnership convened by Green Building Alliance (GBA) --and the largest such District in North America. Participants include 143 Property, Community, and Resource Partners, all committed to the measured building performance goals of the 2030 Challenge.

When creating the Pittsburgh 2030 District in 2012, GBA leveraged the goals of Architecture 2030 to develop a comprehensive, place-based initiative that measurably transformed a large collection of existing buildings into a

sustainable community via an innovative, visible, large-scale initiative unique to Pittsburgh. The boundaries in Downtown and Oakland are small enough to manage effective implementation, but large enough to inspire work beyond these business districts. Building on the best elements of existing downtown and sustainable community initiatives, the 2030 District model adds critical performance criteria to establish healthy, high performance practices and measures on a community scale, while providing a replicable model for other downtowns and neighborhoods in Western

Pennsylvania and around the world as they work to save money, increase building operational efficiency, and positively contribute to the global climate change challenge.

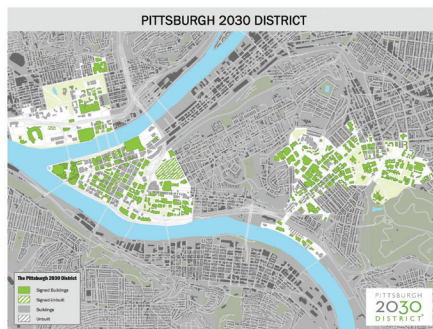
Can properties create stronger downtowns by working together towards 50% reductions in energy consumption, water use, and transportation emissions by 2030? The Pittsburgh 2030 District emphatically answers, "Yes," with improved indoor air quality, reduced resource use, increased asset value, solid returns on investment, stronger community fabric, and growing national reputation. Along the way, Pittsburgh's existing buildings have been able to voluntarily join the green building conversation in a way that recognizes past efforts to create efficient properties, with

ongoing peer-to-peer education that helps property owners improve the region's economic competitiveness today, in the

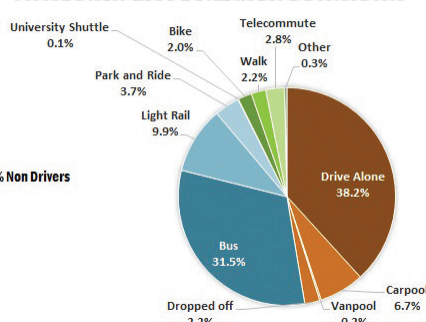
Community, and Resource Partners to reach those targets. A 2030 District is a tangible, quantifiable, place-based, and goal-oriented method for making the building sector part of the solution for climate change. Downtown Pittsburgh and Oakland are existing communities with both common and unique concerns and opportunities. By working together, participants have created an evolving forum for strategic and collaborative discussions about building performance, but also about group purchasing, neighborhood concerns, district energy, transportation system challenges and solutions, and more.

Replication

Across North America, 2030 Districts are forming to meet the 2030 Challenge goals for energy, water, and transportation emissions reductions. Established in August 2012, Pittsburgh was the third of 15 established 2030 Districts in North America. Total commitments across these 15 cities include over 296 million square feet.



PITTSBURGH 2030 BUILDINGS: DOWNTOWN



year 2030, and beyond.

At its core, the District is built on a model that balances environmental concerns with economic prosperity and community needs through collaboration and resource sharing. Engaging directly with property owners and managers, partners make a simple pledge -- commit to the goals of the 2030 Challenge and work together with other Property,

The Pittsburgh 2030 District is the largest 2030 District in the world to date -- in fact, 25% of the square feet and 25% of the Property Partners committed in the entire 2030 Districts

Network are right here in Pittsburgh! In 2 of Pennsylvania's 3 largest downtowns, 101 Property Partners have committed 482 buildings, for a total of 76.3 million square feet. Community and Resource Partners (42 nonprofits, professional organizations, utility providers, and Business Improvement

Districts) support their efforts. The Pittsburgh 2030 District has commitments from 84% of the existing building square footage in Oakland and 64% of the square footage in Downtown Pittsburgh, for a combined total square footage commitment of 70% of what's possible. Buildings committed to the initiative include many types of owners and uses, including large office buildings, local and federal governments, sports teams, colleges and universities, historic buildings, healthcare institutions, cultural amenities, and national corporations.

Energy

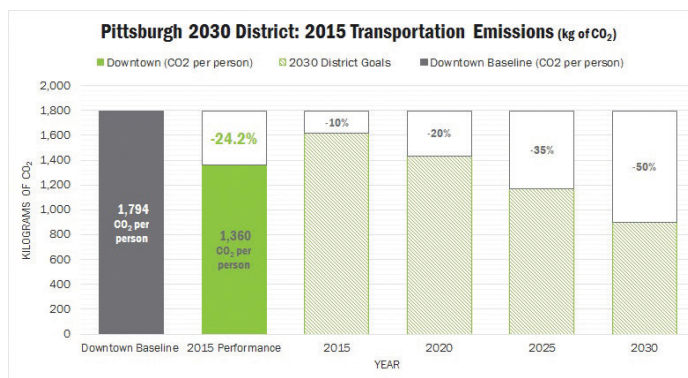
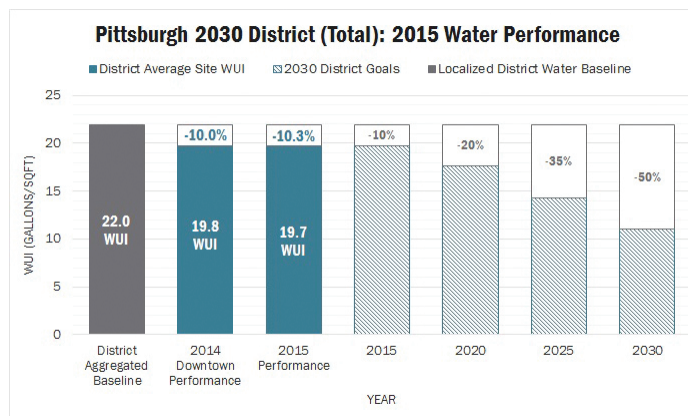
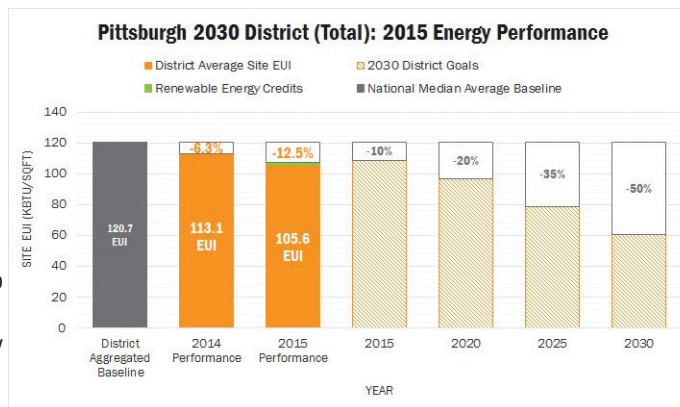
Working with each Property Partner, a property-specific energy use intensity (EUI, annual energy use in kBtu per square foot) baseline using EPA ENERGY STAR's Portfolio Manager and the 2003 Commercial Building Energy Consumption Survey (CBECS) is established. Each baseline is a measure of the national median average for that building use type, taking into account current use, operational characteristics, and Pittsburgh's climate zone.

For the 2015 performance year, 266 properties (57.7 million square feet) shared their annual energy consumption. Each property's total energy consumption was aggregated to provide progress figures for 2015. The total reported square footage represents 85% of participating properties.

The District EUI is the total site energy consumption reported (6,093 million kBtu) divided by the total square footage of aggregated properties (57.7 million square feet). This results in an average site EUI of 105.6, which represents a 12.5% reduction from the baseline – exceeding the 2015 reduction goal of 10%. Equivalent to 868 million kBtu avoided, this energy use is roughly equivalent to the annual energy use of 6,353 homes, 14,673 passenger vehicles, or 69,697 metric tons of carbon dioxide.

Large office buildings are making significant progress toward the 50% energy reduction

goals, with 26 office buildings larger than 200,000 sq. ft. reporting data for 2015. As a cohort, these properties were 28% below the baseline, with 77% operating at or below the 2015 reduction target of -10%, and 62% already achieving the 2020 energy reduction target of -20%. Several buildings in this use-type still have significant opportunities available for savings, with 12% of the buildings performing at the 2003 national median average.



Water

Unlike energy, a national water use intensity (WUI, annual water use in gallons per square foot) does not exist for the commercial building sector. Between 2012

and 2014, the Pittsburgh 2030 District worked with the Pittsburgh Water and Sewer Authority to establish a District water baseline for the Downtown boundary using historic water consumption information. A year later, the Oakland-specific water baseline was developed and integrated into the existing Downtown water baseline, creating a localized water baseline with 15 different use-types.

For the 2015 performance year, 177 properties representing 60% of committed square feet shared annual water consumption with a result of a site WUI of 19.7, representing a 10.3% reduction below the baseline. This is a reduction of 91 million gallons below the baseline – the annual water use of 624 homes or the equivalent of 1,244 Point State Park fountains.

Transportation

In partnership with the Southwestern Pennsylvania Commission (SPC), GBA determined a Pittsburgh 2030 District transportation emissions baseline for Downtown Pittsburgh. The modeled baseline established an average mode split by person trips and associated emissions from commuter transportation to and from Downtown Pittsburgh. SPC's "Regional Travel Demand Model," which estimates commuter trips into and out of the District's Downtown boundary from the 10-county Southwestern Pennsylvania region, specified air emissions impacts for each mode of transportation.

The Make My Trip Count (MMTC) commuter survey, conducted in September and October 2015 by GBA, Pittsburgh 2030 District, and 10 other regional transportation stakeholders, asked respondents a series of questions related to zip code of residence, destination location,

and mode(s) for making the commute to and from work or school. More than 20,710 responses were successfully completed and analyzed for measured performance against the modeled SPC baseline.

The survey was imperative to determining Pittsburgh 2030 District's transportation emission reductions. The SPC-modeled baseline serves as the measure from which the Pittsburgh 2030 District will reduce transportation emissions in the form of CO₂ per person annually, with each mode having specific CO₂ emission levels.

The MMTC Commuter Survey recorded 9,598 Downtown responses, of which 7,801 responses are from buildings committed to the Pittsburgh 2030 District. Key takeaways from the comparison of the SPC and Pittsburgh 2030 District mode splits include fewer single-occupant vehicle/carpool trips (47.4%) and more bus (31.5%), light rail (9.9%), and bicycle trips (2%) compared to the baseline (expected vehicle trips: 58.4%, bus: 29.4%, light rail: 7.1%, bicycle: 0.4%).

In the 2015 Progress Report, the Pittsburgh 2030 District reported emissions against the baseline for commuters traveling to Downtown 2030 District committed buildings only. The Pittsburgh 2030 District Downtown boundary demonstrated a reduction of 24.2% below the baseline, surpassing the goal set for 2020. Reductions achieved in the Oakland boundary will be published in a future Progress Report.

Indoor Air Quality

The reduction goals in energy, water, and transportation emissions are common across the 2030 Districts Network, and Districts are welcome to select a fourth metric on an issue of regional importance. Focusing on indoor air quality (IAQ) in District buildings, GBA and the Pittsburgh 2030 District partnered with the University of Pittsburgh's Mascaro Center for Sustainable Innovation to determine a standard protocol for IAQ measurement, tracking, and benchmarking.

Six Property Partners participated in a 2014-2015 IAQ pilot, which included on-site

testing, HVAC equipment evaluation, and follow-up recommendations for improvement. This approach supports development of a scalable IAQ protocol, which will be standardized for the entire District, and will eventually be adopted by other 2030 Districts within the 2030 Districts Network worldwide.

The testing protocol was modeled on the EPA's *Building Assessment Survey and Evaluation*. Each evaluation included a site visit, selection of a target study area and monitoring location, characterization and sampling of the building, and data analysis. An occupant satisfaction survey was also administered. Participants in the initial pilot program included academic, large office, nonprofit, and municipal government buildings.

Continued Growth, Expansion, & Market Penetration

In 2016, the Pittsburgh 2030 District continued to add new Property Partners from across the established boundaries, while also expanding the Downtown boundary to include additional portions of the Northside. The biggest policy news related to building performance, however, was the passage of building benchmarking legislation by Pittsburgh City Council.

This City of Pittsburgh legislation requires owners of nonresidential buildings over 50,000 square feet (or portions of mixed use buildings with at least 50,000 square feet of nonresidential space) to submit complete whole building energy and water usage to the city on an annual basis. In October 2016, Pittsburgh became the 17th city to adopt a legislated building benchmarking approach, following similar requirements in effect in many U.S. cities, including Philadelphia, New York City, Austin, Boston, San Francisco, Seattle, and Washington D.C.

The City will publish annual building benchmarking information online, allowing owners, tenants, prospective buyers or lessees, and the general public to view energy and water usage. This increased transparency allows businesses and individuals to

make informed choices related to building specifications while also providing a method for tracking building efficiency and monitoring for maintenance needs. GBA will assist property owners and building managers in complying with the legislation and offer dedicated training on the use of Portfolio Manager. As privately-owned buildings disclose their data for the first time in 2018 for the 2017 performance year, the Pittsburgh 2030 District will evaluate the potential for including those performance figures in its annual Progress Report.

Regardless of shape, size, or use, from the Fort Pitt Blockhouse to the U.S. Steel Tower, GBA and its very many Pittsburgh 2030 District partners continue to diligently work towards the goals of the 2030 Challenge, proving that they can be achieved, maintained, and surpassed, while celebrating many milestone achievements along the way. The Pittsburgh 2030 District is proving that measured building performance facilitated in concert with a supportive learning cohort can be motivational, inspirational, and reach many far beyond those within District boundaries in quest for more efficient, high performing, and healthy buildings.

Endnote: In 2015, the Pittsburgh 2030 District received the International Downtown Association's (IDA) Achievement Award for Economic and Business Development and in 2016 received both the Pennsylvania Environmental Council's Western Pennsylvania Environmental Award and the Pennsylvania Department of Environmental Protection's Governor's Award for Environmental Excellence.

About the author...

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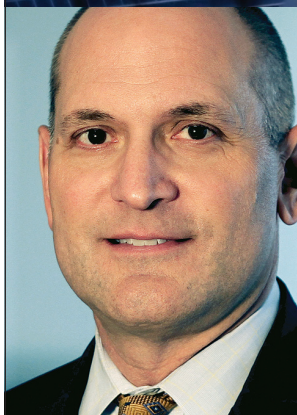
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What's Next?

Ben Morris is a Senior Manager, Operations Strategic Planning for the Duquesne Light Company

What is the technology that will be impacting your industry most dramatically in the next five years?

Duquesne Light Company is the City of Pittsburgh's electric utility, providing transmission and distribution service to approximately 587,000 residential, commercial, and industrial customers across a service territory encompassing the majority of Pennsylvania's Allegheny and Beaver counties. DLC is focused on becoming a next generation energy company by implementing such smart grid technologies as distribution automation, smart meters, microgrids and Distributed Energy Resources (DER), Advanced Distribution Management Systems (ADMS), and synchrophasors. While each of these technologies represent important smart grid applications for Pittsburgh, DLC's smart meter deployment will have the broadest impact on our customers by providing them access to their energy usage and giving them tools with which to manage it.

How is Pittsburgh poised to take advantage of the new technology?

DLC's smart meter deployment plan, which includes the exchange of all residential, commercial, and industrial customer meters, is scheduled for completion in 2019. Major functionalities enabled through the new meters include the ability to record hourly usage data, communicate bi-directionally with the meter, participation in time-of-use rate programs, provide remote connect and disconnect services, provide customers the tools to make more informed decisions on their energy consumption (e.g. high-bill alerts, consumption comparison reports, etc.), and configure meter parameters remotely. As a result, DLC's new smart meters are expected to offer many benefits for our customers.





Being a Smart City Without Being Designated a Smart City

By: Jeffrey J. Kupko, P.E., PTOE

This past summer, the United States Department of Transportation (USDOT) announced the winner of their Smart City Challenge competition and its \$50 million award to Columbus, Ohio. Ultimately, 77 cities applied for the designation and the initial list was narrowed to a shortlist of finalists, with Pittsburgh being one of the top seven applicants. Michael Baker International, a global leader in engineering, planning and consulting services, collaborated with the City of Pittsburgh's Smart City application team and consulted on the systems engineering and other technical aspects of the pursuit. A significant amount of planning, brainstorming, and proposing went into the application, but not being selected by the USDOT begs the question: What's next for a Smart City that is not dubbed a "Smart City"?

What is a Smart City?

The first step in moving forward is defining what a Smart City is, should be or could be. According to USDOT, the challenge was created to help one city define what it means to be a "Smart City" and become the country's first city to fully integrate innovative technologies – self-driving cars, connected vehicles, and smart sensors – into its transportation network. However, this definition is, while very future-focused, is too bound by technology. The definition of a Smart City may be much different to a developing nation where satisfying a need for

clean running water or access to healthcare may be the primary goal.

Carnegie Mellon University recently hosted Transportation Camp PGH – an event that is held in various cities with an attendee-led agenda and well-received lack of PowerPoint presentations – where the question was posed: What exactly is a Smart City? The event included a diverse group of attendees from engineers, bicycle and pedestrian advocates, transit profes-

Any good business is built around the customer at its core, and a city should be no different

sionals and riders to hedge fund managers and local residents. The discussion did not necessarily go to technology or "smarts" but rather focused on outreach and meeting the needs of the city.

Before any analysis can be done, a city needs to recognize that its citizens are to be viewed as customers. Any good business is built around the customer at its core, and a city should be no different. To serve its customers, a city must focus in the following "smart" areas:

Data

A Smart City uses data to backup decisions, but not necessarily using technology for that data. Surveys count as data, so it could be as simple as asking community stakeholders questions. The data collected is used to make informed and justifiable decisions.

Each person has the potential to be a data point with valuable information. There is certainly value in collecting cell phone origin-destination data or swipes of transit cards as well. How a city utilizes and maximizes the data available to it is the first step in becoming a Smart City.

Demand

The simplest way to find out what a city is not providing to its customers is to ask people what they would do and where they would go. What is the demand for routes or access that does not currently exist? A significant portion of the decisions made in transit today are based on the way the system operated yesterday. A Smart City can determine where the demand truly lies, rather than the induced demand influenced by existing stops and routes.

The role of a Smart City and a transit system should be to connect employment centers with population centers; essentially, as a way to get people to work so they have better avenues for opportunity. As economies shift, both of these center could shift so a transit system has to be able to adapt.

The worst thing a Smart City could do is allow itself to be vendor-driven with solely off-the-shelf products. The city needs to determine what the customers want and then find a way to meet it through existing means or with a technology solution. Further, mobility is a service that must be guaranteed by a city because a city that can get around is better off in quality-of-life, economy and equity.



Columbus has developed a very strong partnership between government, public utilities, the private sector and philanthropy that helped articulate a vision for providing services to those underserved centers within the communities.

The good news is that all is not lost for Pittsburgh. The City applied for a follow-up grant

USDOT that was related to the Challenge and was awarded \$1 million in funding for its Smart City initiative. They are in the process of creating a Department of Mobility and Infrastructure to guide planning decisions and focus on the needs of the community. The Mayor's Office has been largely focused on how technology can aid the city. This is a great first step on building the skills to advance Smart City initiatives for the City and it demonstrates a commitment to improving the lives of residents.

Ultimately, Pittsburgh hasn't been labeled as a Smart City according to this particular challenge, but it certainly isn't a dumb city either. The innovative thinking and efforts placed into the challenge have shifted the way the City of Pittsburgh moves forward with its planning and solutions to the challenges ahead. And that's good for the customer.

Equity was a strong focus in the Smart City Challenge between the seven finalists and from U.S. Transportation Secretary Anthony Foxx and with good reason. Our transportation system has failed those of lesser incomes, minorities and alternate mode customers as we designed for the automobile. This tied into President Obama's Ladders of Opportunity initiative to make transportation more inclusive. A Smart City also develops a plan to train its workforce for current needs and adapt as those needs change.

More importantly, a Smart City looks beyond how many cars it can squeeze through a traffic signal cycle. It finds ways to provide the homeless with access to transportation, it modifies routes to pick up expectant mothers for doctor's appointments since the demand for that route lasts for nine months with that person, and it utilizes technology to reduce carbon emissions for healthier city living; it is a people-first city.

Aspects of a Smart City that came out in Transportation Camp PGH were that a city should reconnect communities that are underserved and reach out to the community and find the problems and issues. It's no

Pittsburgh hasn't been labeled as a Smart City according to this particular challenge, but it certainly isn't a dumb city either.

secret that the interstate system planning severed communities from the vibrant and economic centers within a city, and this is echoed with transportation decisions made today. Transit doesn't serve the people that need it most due to barriers.



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Columbus placed a strong emphasis on connecting to all communities, specifically those that have been left behind. Ultimately, their proposal identified that there is a direct link to lack of transportation and poverty

Jeffrey J. Kupko, P.E., PTOE is an Assistant Transportation Program Manager for Michael Baker International



Adaptive Traffic Signals

ADAPTIVE TRAFFIC CONTROL SYSTEMS RESPOND TO REAL-TIME CONDITIONS



By: Doug Smith, E.I.T.

In a decade where tech start-ups are racing to make everything in our lives a personalized, on-demand service, driving up to red light after red light can feel like an irksome relic of the 20th century. And it's not an uncommon experience: even many of the region's busiest corridors rely on 5-year-old data and 50-year-old computers to balance green time and coordinate flows at adjacent signals. Special events, land developments, or simple timekeeping errors can render previous optimizations useless, or worse. But like many emerging ITS applications, innovations in signal technology are showing their potential to reduce maintenance costs while improving system performance. Locally and nationally, agencies that have traditionally retimed traffic signals two or three times a decade, or only in response to customer complaints, are installing systems that make adjustments on a second-to-second basis, and with minimal user input.

What distinguishes such "adaptive" traffic control systems is their agility in responding to real-time conditions. A conventional signal will try to hold the green light for approaching traffic, but if it is to remain in sync with its neighbors, it must stay within a fixed network schedule based on a shared "cycle length" -- the amount of time it takes to serve all movements at a signal. Adaptive signal systems can tweak that cycle to accommodate demand, or do away with the cycle altogether. While these changes are not as visible as other improvements, they can drastically alter driver experience.

Development

Adaptive signal systems, still gaining public awareness, have actually been in development since the 1970's. Initial efforts focused on refining the rigid schedules of conventional

timing plans: rather than switch at a certain time of day, signals would match current traffic conditions to the closest predefined template. This method (known as pattern matching, or traffic-responsive plan selection) proved either too slow or too disruptive, and adaptive research went in a different direction. However, that did not stop the advancement of the traffic-responsive model; today, even many of the cheaper signals on the market include a refined version of this feature by default.

Other early attempts focused on custom adjustments at isolated intersections. Again, most signals sold today can adapt in isolation, using "dynamic maximum" timings that give more leeway when traffic gets heavier than expected. This can reduce the need for

**TRULY ADAPTIVE SYSTEMS...
FOCUS ON COOPERATION
BETWEEN INTERSECTIONS,
AND THEY ADJUST MUCH MORE
THAN JUST GREEN TIMES**

manual retiming, but it doesn't allow a corridor or network of signals to work together. Since it has become such a common feature, most agencies would no longer use the term "adaptive" for this functionality.

Truly adaptive systems, pioneered in Australia and the United Kingdom in the 1980's, focus on cooperation between intersections, and they adjust much more than just green times. They may constantly repartition a network into different subgroups, and change the order in which competing movements are served. Some systems can even specifically minimize transit times or emissions, depending on an agency's priorities. Though each system has its own methodology, they all aim to provide

the best possible timings for the traffic currently moving through a network.

Applicability

Before proposing adaptive signal systems, agencies should be aware of their limitations. Adaptive technology will not add actual capacity, as would the addition of through or turning lanes. In a very congested network, benefits may be most noticeable in the off-peak hours. At the other extreme, low-traffic areas may not be a cost-effective application. And locations with significant pedestrian volumes crossing wide intersections can limit the flexibility that gives adaptive systems their advantage.

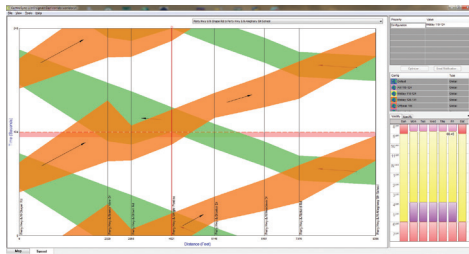
One suggested application is the network surrounding an event venue, where irregular traffic surges may otherwise require manual police control. Adaptive control is also recommended for major suburban arterials that serve as detours during incidents on parallel freeways; police departments are generally not able to dispatch officers to the multitude of signals that line such a corridor.

Adaptive systems can be added to most locations without replacing much signal equipment. Still, since they are more responsive to real conditions, it is crucial that their detection systems stay operational. Before a system is installed, all detectors must be functioning, and responsibility for maintenance must be agreed upon.

Local Experience

Cranberry Township, PA, with some funding from PennDOT's Green Light-Go initiative, has recently started expanding an Econolite Centrac's Adaptive network, reporting positive results thus far. Like conventional signals, Centrac's uses a fixed cycle length, determined by time of day or pattern matching. The system

can actively change green time allocations and the timing offsets between intersections. As a municipality that's historically prioritized signal retiming, Cranberry may not see as big a difference as more neglected areas. However, their proactive maintenance of signal equipment will help the system to stay online and work optimally.



Rythm Engineering adaptive traffic systems

InSync, by Rhythm Engineering, was first introduced to the region at eight signals on Perry Highway (US 19) in Wexford Flats, PA, a largely commercial suburban arterial, as part of a PennDOT widening project in 2013. Positive feedback prompted a second InSync system, recently activated along William Penn Highway (US 22) in Monroeville and Murrysville, PA.

InSync dispenses with most typical signal parameters to model coordination through an arterial as two separate, directional “green tunnels,” which are each regulated based on demand. The system can change which movements are served together, and in what order they proceed.

Though InSync has worked well, it seems best suited for small daily fluctuations. It keeps timings within a reasonable range based on initial setup, which may neglect more major shifts; for instance, the Wexford Flats system was configured during the summer, and the school entrance had to be recalibrated in the fall. As with conventional signals, the video detection and communications do not always work flawlessly. For William Penn Highway, we selected InSync's Fusion system, which can combine its own cameras with our preferred detectors for more

reliable detection.

SURTRAC (Scalable URban TRAffic Control), developed at Carnegie Mellon University, was first deployed in 2012 at nine signals in Pittsburgh, PA's East Liberty neighborhood, where it reportedly achieved travel time reductions of 25%. The City has since expanded the network to include 50 signals around the pilot area. The system is also being expanded to two signals on Bigelow Blvd, as part of a PennDOT betterment project.

SURTRAC uses a decentralized approach, in which each signal optimizes itself while being informed by radio communications from upstream intersections that provide advance notice of incoming traffic. Unlike most adaptive strategies, which emphasize a linear arterial, SURTRAC caters more to grid-like networks.

As with InSync, SURTRAC has seen issues with detection and communications. Due to its urban context, it has also received criticism for optimizing performance measures for motor vehicles. With the pedestrian push button telling the system only that there is at least one person waiting to cross, it's impossible to factor pedestrians fully into the equation. Upgrades in video detection of pedestrians may allow systems to obtain more detail on how many pedestrians have been waiting, and for how long.

With several adaptive systems now running effectively, PennDOT District 11 has more extensions and additions on deck. McKnight Road, a heavily commercial suburban arterial parallel to I-279 and I-79, is a prototypical candidate for adaptive control, and connects Pittsburgh to the InSync corridor in Wexford Flats. A project already underway on McKnight is bringing the InSync system south to 15 signals along this strip. Likewise, the InSync installation on William Penn Highway will be extended in 2018 to all 14 signals in the western section that parallels I-376 through Churchill, Wilkins, and Monroeville.

The frequently congested Sewickley Bridge, in Sewickley, PA, has suffered from persistent timekeeping issues at the cluster of three signals on Ohio River Blvd, a suburban principal arterial. An adaptive system funded under PennDOT's Green Light-Go program will work to address this issue, in addition to allowing more flexible timings.

Adaptive technology will also be added in Bridgeville and South Fayette on PA Route

50, a suburban commercial arterial straddling an interchange with I-79. This system will partially fulfill traffic mitigation needs for the nearby Newbury development, and will also receive funding from Green Light-Go.

Outlook

Adaptive signal algorithms should see incremental progress in the future, with upgrades to existing software as well as new brands with different strategies. Advances in the reliability of detection and communications equipment will be just as important.

The ability of connected and autonomous vehicles to cooperate with conventional traffic signal operations has been a hot research topic, and adaptive signals could bring even greater benefits. As connected vehicle technology penetrates the market, it can enhance the accuracy and reach of data being used by an adaptive system. Meanwhile, data from a grid-oriented system could help to inform route choice by sending recommendations to drivers or their GPS devices. With enough market share, autonomous vehicles and adaptive signals might someday work together to minimize stops by adjusting both driving speeds and signal timings.

PennDOT plans to continue adding adaptive signals throughout the region, and Green Light-Go will keep funding these systems along critical and designated corridors on state highways. In future years, Western Pennsylvania's less urban areas will likely receive adaptive technology and see some of the benefits that Pittsburgh and its suburbs have enjoyed.

Although adaptive signal technology still shows room for improvement, our experience suggests that today's systems, applied properly, can be a valuable tool for adapting to the less certain side of traffic, from everyday incidents to incremental growth.

About the author...

Doug Smith, EIT, is a Civil Engineer in the Signals Section of PennDOT District 11-0, where he has worked for 3 years. He obtained a B.S. in Mathematics from Grove City College in 2011 and an M.S. in Transportation Engineering from the University of Pittsburgh in 2013. Doug thanks Phil Mutunga, Dan Fedio, Melissa McFeaters, and Marty McKinney for contributing their experience to this article.



Six BIG Benefits of Smart Lighting Solutions

By Charlie Nobles

What if police officers could use street lighting capabilities to keep the public safer and even deter crime? Or if utilities could save thousands of dollars on energy costs simply by more effectively managing power loads to street lights based on the time of evening? And what if data and analytics could help save municipalities hundreds of hours spent diagnosing, finding and repairing problems with outdoor lighting?

Thanks to smart lighting, these futuristic advancements are no longer just “what ifs.” They’re a reality.

The emergence of the Internet of Things (IoT), Big Data and advanced communication networks are ushering in an era of unprecedented innovation. Municipalities are rethinking the potential for using existing and future investments in technology and infrastructure to improve the lives of residents. And, considering that outdoor lighting consumes 19 percent of global energy use and can take up to 40 percent of a city’s energy load, there is a huge opportunity for municipalities and utilities to harness new smart solutions to reduce excesses and produce new revenue streams.

Streets, parking lots and public gathering locations have become more inviting spaces in the midst of urban growth. This article explores six key benefits of smart lighting in creating safer and more interconnected communities.

Grid Operations Get an Upgrade

Did you know that there are electrical systems available that can provide access to real-time data, allowing users to better manage their grid? New lighting control solutions provide real-time insights on voltage levels, outages and overall power quality. Improved monitoring also ensures quick alarms and even quicker dispatch so users can solve lighting problems faster and more efficiently.

Whether you’re working with a utility, co-op or municipal system operator, a sunrise/sunset management feature offers a variety of benefits. Users can dim lights in areas that aren’t active and brighten others for a big public event or retail business hours. Flashing capabilities can also alert the public of a safety issue. Bottom line: citizens get a better experience and greater sense of security.

“Businesses want to locate in smart communities because being a part of a progressive city says good things about their brand.”

Lighting professionals now have the solutions to better manage functions from one central control. That puts them in the driver’s seat to precisely control lighting levels and energy use, schedule maintenance, dispatch repair crews and better focus resources. In fact, electrical system operators can pinpoint potential problems and proactively address customer needs, even before reports come in.

Next-Gen Public Safety Solutions

Street lights help pedestrians and drivers see better and be safer at night. They provide a more secure feeling in neighborhoods and assist police patrols.

Now police officers responding to suspicious activity can flash or brighten street lights from patrol car laptops. Emergency dispatchers can also improve response times by flashing the street lights in the location of a reported incident. In high crime areas, communities can create “safety zones” where lighting levels are increased to deter criminals.

While street lights are not the complete answer for reducing crime, many commu-

nities have reported improvements after increasing lighting in key areas. According to a review by the Campbell Collaboration spanning four decades of street lighting intervention in the U.S. and U.K., crime decreased by 21 percent in areas that improved lighting, compared to similar areas that did not. Researchers believe improved lighting signals increased surveillance, deterring potential offenders.

For retail, office, health and education campus applications, upgrading to smart lighting also means that parking lots and exterior areas get the right level of lighting based on the time of day and level of traffic. This gives guests a greater feeling of security and staff more lighting control.

Control the Network, Maximize Revenue

Street lights are shifting to LED, which is reducing energy use and generating savings—as much as 60 percent or more, according to a recent Ameresco report.

Some communities have retrofitted lights instead of installing smart lighting controls. As a longtime vendor of smart lighting solutions, we let customers know that this move increases future deployment costs and extends the upgrade payback period. The right lighting control solution can extract more value out of the existing legacy fixtures, while also enhancing the value in moving to new LED fixtures. Our VantagePoint® Lighting Control Module easily plugs into all National Electric Manufacturers Association (NEMA) standardized socket fixtures—a simple upgrade that allows users to manage both LED and legacy bulbs.

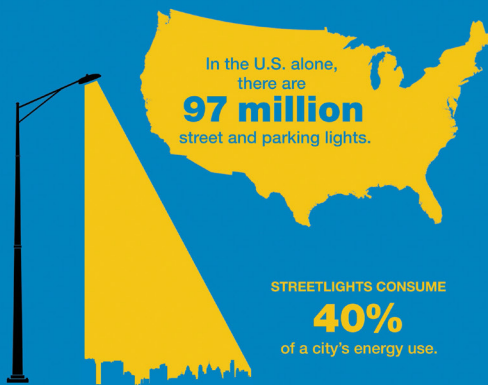
Good for Economic Growth

Businesses want to locate in smart communities because being a part of a progressive city says good things about their brand. Plus, smart cities attract technical professionals and members of the creative class,

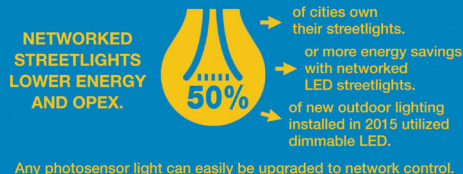
A smart lighting network means a smarter city.

SENSUS
Nothing's out of reach

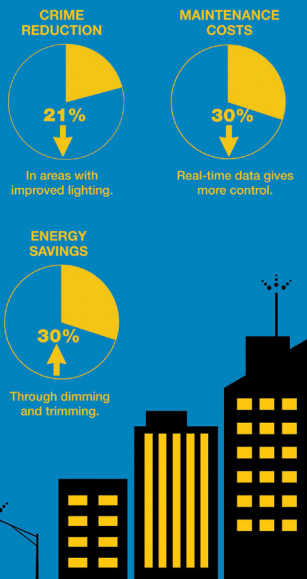
A spotlight on energy.



Cities are seeing the light.



Smart and sustainable lighting benefits.



Sensus VantagePoint lighting solution, your gateway to a smart city.



VantagePoint™ module + FlexNet™ communication network + Analytics software =

A smart solution that provides real-time insights to achieve greater control, energy savings and reduced costs. It also creates a pathway to other infrastructure solutions such as smart water, smart grid and smart gas.

VantagePoint enables a city to:

- Monitor voltage levels in real time.
- Identify outages for intelligent dispatch.
- Flash/brighten lights.
- Control lights in target areas.
- Location-aware asset management.
- Aggregate energy consumption data.

INCREASE SAVINGS:

Day burners occur on 5% of fixtures.
\$29 or more in savings per fixture annually.
Each bucket truck roll can cost \$150+.

Sensus is helping cities reach farther.

SENSOR USAGE ON LIGHTPOLES:

- Air quality
- Gunshot detection
- Weather
- Image/motion
- Traffic

This need-driven use of street lights reduces energy demand and significantly cuts carbon dioxide emissions. Street lights can also host monitors to help measure traffic density, control traffic lights and even guide vehicles to available parking spaces. It's a win-win.

Looking to the Future

As outdoor lighting continues to unlock the benefits of a Smart City, our communities will grow to become more interconnected. With just a single networked module, light poles can become smart assets that monitor everything from weather and air quality to traffic—even detecting and assisting police in locating the source of gunshots.

And finally, for municipalities and utilities alike, Big Data means big savings. The need for smart lighting analytics has the capability to join energy, water, communications and transportation systems. More data means more opportunities to impact essential services for those who live, work and play in urban communities.

The future is evolving in ways we could never have predicted. With advances in smart solutions and analytics, we will continue to evolve and technology innovation promises to bring new insights that offer more efficiency and responsiveness in our communities.

About the author...

Charlie Nobles is Marketing Director for Lighting Solutions and leads all related marketing and commercialization efforts. He has a Bachelor of Engineering and a Master of Mechanical Engineering and Control Theory both from Duke University.



Charlie also holds an MBA from Kenan-Flagler Business School at the University of North Carolina at Chapel Hill.

a boon for recruiting qualified candidates.

Smart lighting solutions tackle a variety of challenges for cities and utilities. They reduce energy consumption, save money, enhance the quality of life and improve safety. They also create a better sense of place, with the use of color, motion and lighting levels for special celebrations, the holiday season, and even in arts and cultural districts.

Smart and Sustainable lighting

With increased environmental awareness comes the need to reduce energy consumption and greenhouse gas emissions in our cities. Smart lighting provides a natural solution over street lights, which consume a significant share of the electricity used by most municipalities. Smart lighting allows electrical systems to make decisions to meet actual conditions. There's no longer a need to have lights at maximum capacity from sundown to sunrise.

ESWP Member News

More than 75 firms are represented in the Corporate Member program of the Engineers' Society of Western Pennsylvania (ESWP). Memberships are available at 3 levels: Gold, Silver and Bronze. Gold members are entitled to 14 memberships that can be exchanged by employees; Silver, 9; and Bronze, 5 — annual dues are \$2400, \$1700, and \$1000 respectively. In addition, ESWP Corporate Member Firms may add 2 additional individuals in our Under-35 age category at no additional cost. More information can be found at eswp.com. Please contact the ESWP Office (412-261-0710) for additional details.

NEW! For Government Employees (full-time), Individual Membership Rates are now \$50.00!

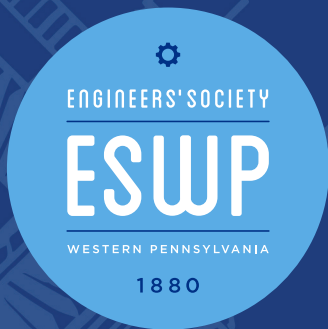
Membership in ESWP comes with a long list of benefits! From our continuing education opportunities earning you Professional Development Hours (PDHs), to the business networking events in our Executive Dining Room, there is something for everyone in your organization. Also, ESWP is helping the next generation of engineers with student outreach programs, giving you the opportunity to participate in many rewarding programs.

ESWP Gold Corporate Member Firms



ESWP Silver Corporate Member Firms





THIS YEAR, AT ESWP

Our Mission

Advance the engineering profession and position Western Pennsylvania as a Center for Engineering Excellence and Innovation

Objectives

Seek and prepare the next-generation of engineers

Offer professional development and networking opportunities

Collaborate on engineering matters of regional and civic importance

Highlight achievements from a diverse spectrum of engineering and related fields

Strategic Initiatives

PROMOTE ESWP AND POSITION THE SOCIETY FOR SUCCESS

- Raise awareness and grow membership
- Increase use of the Engineers' Club
- Develop and distribute exceptional publications

PROVIDE WORLD-CLASS PROFESSIONAL DEVELOPMENT

- Deploy exceptional conferences
- Offer educational and networking events; highlighting innovative technologies and industry best practices
- Provide professional outreach and services to affiliated technical societies

DEVELOP AND SUPPORT FUTURE ENGINEERS

- Mobilize and activate our young members
- Collaborate with local universities
- Promote and participate in STEM (Science, Technology, Engineering, and Mathematics) activities

Belonging to ESWP

Whether you're an individual or a business, an engineer, student or other professional – you'll enjoy a variety of benefits with our affordable annual memberships

Dining at the Engineers' Club

ESWP is located in the stately Pittsburgh Engineers Building, in the heart of downtown Pittsburgh. Our location and award-winning cuisine make it the perfect lunch club for professionals looking for both distinction and affordability.

The perfect facilities – available for your next lunch, banquet or meeting

THE EXECUTIVE DINING ROOM & THE VAULT

- Lunch Served M-F from 11:30AM-1:30PM
- Reservations not required, but appreciated (especially for larger parties)
- Can accommodate banquets & meetings: Breakfast, Lunch and Dinner
- Full audio visual capabilities with Wi-Fi enabled
- The vault serves as an intimate dining room for up to 12 guests

THE BOARD ROOM

One of our most popular rooms, the Board Room is traditionally set conference style and can accommodate 20 people comfortably. Natural lighting makes the room comfortable for meetings and conferences, along with the full range of AV services.

THE MAIN DINING ROOM

The Main Dining Room, our largest room, is located on the second floor of the Pittsburgh Engineers' Building. It can be set with different table configurations for meetings, conferences and social events, along with the full range of AV services. The room can accommodate 25-125 people.

Our Annual Awards Banquet

For more than 130 years, members and friends of the Engineers' Society of Western Pennsylvania have gathered to celebrate engineering, and recognize the best and brightest stars in the profession. Awards presented include:

- The Metcalf Award – Our Lifetime Achievement Award

- Project of the Year Awards – Presented for engineering excellence in categories of Transportation, Technology, Sustainability, & Commercial
- Engineer of the Year

STEM Outreach

ESWP is dedicated to encouraging the “next generation” of engineers, through innovative, enjoyable, and hands-on learning opportunities, and other activities, such as the Members College Scholarship.

Original programs such as our Design Lives Here program, the ACE Mentor Program, and the nationally renowned Future City Competition offer students the opportunity to learn by doing, alongside professional engineers, mentors, and teachers.

Pittsburgh ENGINEER Magazine

ESWP publishes the quarterly Pittsburgh ENGINEER magazine, covering interesting and timely topics on all engineering disciplines.

ESWP Sponsored Conferences

INTERNATIONAL WATER CONFERENCE® (LOGO)

The ESWP-sponsored International Water Conference® is the world’s leading technical conference on industrial water and waste water treatment. For more than 75 years, attendees from around the world have attended this international event.

INTERNATIONAL BRIDGE CONFERENCE® (LOGO)

Since 1983, ESWP’s International Bridge Conference® attracts a world-wide audience for technical presentations, tours, seminars and exhibits. Held in the City of Bridges, the IBC now attracts more than 1,500 attendees annually.

PA BROWNFIELDS CONFERENCE (LOGO)

Since 1995, ESWP has been committed to the cleanup of environmentally impaired industrial sites. Originally titled the ‘Industrial Site Recycling Conference’, this event preceded the term “brownfields”.

Who is part of ESWP?

ENGINEERS

A multi-disciplined community of more than 850 members and more than 400 different firms

NON-ENGINEERS

Associate members from healthcare, finance, law, insurance, government

AFFILIATES

Home to more than 30 different technical & professional organizations, providing administrative support services

Affiliated Technical Societies

In addition to calling ESWP “home”, Affiliated Societies enjoy many other membership benefits as described here. You can learn more about our affiliates by clicking on the link to their website, or contacting the officer currently listed with their respective association.

The following professional organizations are just some of the Affiliated Technical Society members of ESWP.

- ASCE – American Society of Civil Engineers
- PMI – Project Management Institute
- PSPE – PA Society of Professional Engineers
- SAME – Society of American Military Engineers
- SWE – Society of Women Engineers

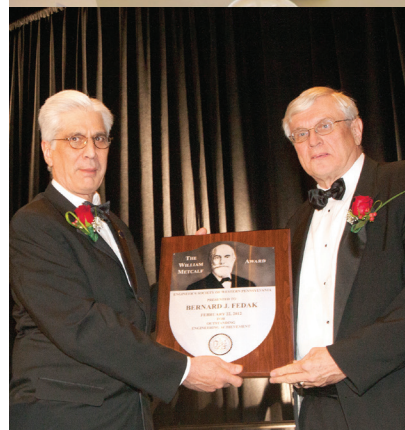
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ESWP Bronze Corporate Member Firms



Western Pennsylvania Smart Transportation Deployments from Carnegie Mellon University

Stan Caldwell, Courtney Ehrlichman, Chris Hendrickson, Raj Rajkumar and Richard Stafford

**Traffic21 Institute and Technologies for Safe and Efficient Transportation University Center
- Carnegie Mellon University**

Carnegie Mellon's Autonomous Vehicle Driving in Western Pennsylvania

With support from the Henry Hillman Foundation, Carnegie Mellon launched the Traffic21 Initiative in 2009 to develop intelligent transportation innovations that would help place Western Pennsylvania at the forefront of twenty-first century transportation systems¹. The Traffic21 Initiative was founded as a multi-disciplinary endeavor with emphasis on local partnerships and technology deployments for testing and demonstration. Current partnerships include the City of Pittsburgh, the County of Allegheny, the Pennsylvania Turnpike Commission, the Pennsylvania Department of Transportation and a co-operating consortium of over sixty agencies, companies and non-profit organizations. These partners work with over sixty Carnegie Mellon researchers.

Several transformative technologies are now affecting transportation. Driver assist automation and communication technologies have become commercial options on many vehicles. Both Carnegie Mellon and Uber are demonstrating highly automated vehicles in Western Pennsylvania. Data analytics have led to new information applications and services, including navigation aids such as Google Maps and new mobility services such as Lyft and

Uber. Alternative fuel vehicles are available for sale and becoming more common, with competition among natural gas, bio-fuels, electricity from the power grid and hydrogen for fuel cells.

Even the first generation, partial automation driver warning systems on vehicles are having an impact on safety. These systems warn drivers of possible forward or rear collisions and of drifting outside of travel lanes. A recent Carnegie Mellon study found that reduced crash frequencies and crash severity with the new systems result-

ed in social savings larger than the cost of installing the automation technologies². We would all benefit if these warning systems were universally used, especially as the technology improves. If properly managed, the new transformative technologies can make transportation safer, less expensive and more effective.

There is also a renewed focus on accommodating multiple modes of transportation and in insuring equitable provision of transportation opportunities. Biking and walking are low emission, low impact and active

modes of travel that deserve encouragement. Shared ride services can reduce congestion by eliminating numerous single driver vehicles on the road. In partnership with transit agencies, new mobility services can be used to aid access to employment, education and social services.

A few examples of past and current transportation technology deployments from Carnegie Mellon can give some indication of these new opportunities for Western Pennsylvania.

ParkPGH is an application



Traffic21 and University Transportation Center T-SET Leaders Stan Caldwell, Raj Rajkumar, Courtney Ehrlichman, Chris Hendrickson and Richard Stafford.

showing the real time availability of parking lot spaces in downtown Pittsburgh³. It was developed by the Pittsburgh Cultural Trust in partnership with Alco Parking, Pittsburgh Parking Authority, Carnegie Mellon researchers, CMU spinoff Deeplocal, and the Pittsburgh Downtown Partnership with support from the Benter and Hillman Foundations. Researchers hope to extend the system to include on-street parking availability.

TIRAMISU is an application showing real time location of transit buses and availability of seats⁴. Users can reduce their waiting time for buses. Initially, information in Tiramisu was crowd sourced from users. Now, the Port Authority of Allegheny County provides bus locations from onboard sensors and has their own application for real time bus tracking.

SURTRAC is an adaptive traffic signal control system that incorporates video and radar vehicle identification, communication among intersection controllers, and real time signal scheduling response to traffic volumes and incidents. Fifty intersections in Pittsburgh now have Surtrac traffic controllers, with more deployments planned. Researchers are hoping to extend the system to include video recognition and scheduling for pedestrians as well as communication with vehicles to improve system performance.

RoadBotics is a newly formed spin-off that detects and analyzes road conditions using smartphone sensors⁵. Developed in the Robotics Institute, the technology can detect cracks, potholes⁶, stop signs, lane markings, retroreflectivity as well as snow conditions using computer vision and machine learning. Portions of the technology were piloted with the City of Pittsburgh, Cranberry Township, North Huntingdon, and PennDOT.

The Pittsburgh Connected Vehicle Testbed is a new initiative for technology deployment. Carnegie Mellon's automated Cadillac vehicle already communicates with 35 traffic signals in Cranberry Township and Pittsburgh's East End. As noted above, plans are in place to introduce additional vehicle communication with the SURTRAC



Traffic 21/PennDOT Workshop on Vision 2040: Implications of Connected and Automated Vehicles for PennDOT Operations

traffic signal controllers. Researchers are also investigating communications between signals and bicycles, pedestrians, busses and freight vehicles within the communication testbed.

Traffic21 also has more work underway to improve transportation infrastructure management, including inexpensive identification of light rail track and bridge deterioration.



Traffic21 and Technologies for Safe and Efficient Transportation are headquartered at Carnegie Mellon University.

Technologies to identify distracted driving are also being researched actively. Video facial monitoring and posture changes can be indications of distraction. Recent increases in fatal vehicle crashes are regularly linked to increased distractions in driving.

Initial work in the Traffic21 Initiative led to award one of only five USDOT National University Transportation Centers (UTC)

- Technologies for Safe and Efficient Transportation National UTC for Safety. This center is operated in parallel with Traffic21 and in partnership with the University of Pennsylvania in Philadelphia. More recently, Carnegie Mellon launched the Metro21 Initiative, using the same research strategy as in Traffic21 but applied to a broad range of urban systems. In addition, Carnegie Mellon has been awarded a new 2016 National University Transportation Center for Improving Mobility of People and Goods. As a result, the initial transportation technology deployments in Western Pennsylvania are being expanded in geographic scope as well as into other urban systems. But we still hope to keep Western Pennsylvania as a leader in developing new transportation technologies.

About the authors...

Stan Caldwell, Courtney Ehrlichman, Chris Hendrickson, Raj Rajkumar and Richard Stafford (pictured on p. 17) are with the Traffic21 Institute and Technologies for Safe and Efficient Transportation University Center - Carnegie Mellon University

Acknowledgements: Support from the Henry Hillman Foundation and the USDOT University Transportation Center grant, award No. DTRT12GUTC11 are gratefully acknowledged.

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- 1 See the Traffic21 Institute website for more information: <http://traffic21.heinz.cmu.edu/>
- 2 See Harper, Corey D., Chris T. Hendrickson, and Constantine Samaras. "Cost and benefit estimates of partially-automated vehicle collision avoidance technologies." *Accident Analysis & Prevention* 95 (2016): 104-115.
- 3 See <http://www.parkpgh.org/>
- 4 See <http://www.tiramisutransit.com/#reloaded>
- 5 See <http://www.roadbotics.com>
- 6 See <https://www.youtube.com/watch?v=aFZfd5GxL4>

Grid Challenges and Opportunities:

Pittsburgh's Leadership Role in the Energy Transition

By Gregory Reed, Ph.D., Katrina Kelly, Ph.D.; Brandon Grainger, Ph.D.; Michael Rooney

Transition, modernization, instability, turmoil....no matter the tone or connotation that is used to describe the energy industry, one thing is certain: it is currently undergoing a series of changes that are perhaps more complex than the issues facing any other sector in the global political economy. From the fall of oil prices in 2015, to increasing headlines related to cyber and physical security, to the still struggling coal industry, and the push for the integration of renewable technologies, few industries are struggling with the technological, economic, business, and regulatory challenges that are facing the energy industry.

Much of the conversation in the energy industry centers on the discussion of energy resources. Coal industry concerns seem to dominate discussions in nearby West Virginia, while gas and the shale boom have certainly claimed the leadership positions in western Pennsylvania discussions. However, these discussions stem from a macroeconomic viewpoint and often avoid discussing the most complicated of energy challenges: the balance of maintaining our current electric grid's operating stability and its overall reliability, in the midst of these new resource paradigms.

The U.S. electric power grid is at the center-point of the energy crossroads, yet it is not focused upon, nor discussed often enough, for its importance in supporting the transition to a more sustainable future. The electric grid can be seen as the middle of a spiders' web where all of the regulatory and technological challenges come together in an intricate maze of energy complexity. This rapidly evolving environment is made up of massive arrays of electric power technologies, both in its systems operations, as well as its assets and designs. At the same time, much of the electrical infrastructure itself is comprised of aging, legacy-based systems. Coupled with the current demand

to integrate the growth of distributed and renewable energy resources, and dealing with the rapid shutdown of many older fossil-fired plants, planning and decision-making in the electric industry now requires an intricate understanding of growth and stability in both its operations and economics.

When structured correctly, decisions made in the electric power industry can provide

ators, and academic partners work together here in our city shows how Pittsburgh can act as a leader in the innovation that is needed to address the challenges of the 21st century.

A HISTORY OF LEADERSHIP

Pittsburgh is well-known for being a steel city, yet its history with the electric industry is just as rich. Few people are aware that

over one hundred years ago, Pittsburgh was the heart of a rivalry as intense as Steve Jobs and Bill Gates: the battle between George Westinghouse and Thomas Edison over alternating and direct current electricity.

In 1866, George Westinghouse founded Westinghouse Electric as a response to Thomas Edison's grid designs which laid out a vision for US infrastructure that was based on DC currents. Even though Edison had hired Nikola Tesla to help handle the problems in reliability of the long-distance delivery of power supplies using DC, he was unable to

compete with the stability and security that was clearly laid out within Westinghouse's AC-based system. Tesla, at odds with Edison's approach, eventually became Westinghouse's partner. Although local initially, the firm and its AC concept helped to develop the entire electric grid infrastructure across the United States as we essentially still know it to this day. The company also produced the power equipment required including turbines, generators, motors, and switch gear, with more advanced technologies that followed throughout much of the 20th century. And while its initial marriage with the electric industry was founded on the relationship with Westinghouse, energy research and operations soon after became a critical component of the Pittsburgh economy.

Over the past four decades, our region, once known as the Rust Belt, successfully



The Pitt Electric Power Systems Lab in Benedum Hall, Swanson School of Engineering
Pictured left-to-right: front — Dr. Brandon Grainger, Dr. Gregory Reed; back — graduate student researchers Ansel Barchowsky, Patrick Lewis

a plethora of new options for economic development. In western Pennsylvania, in particular, we often neglect the historical importance that our region and our cities have played in developing the technologies that are used for keeping our lights on. We instead focus on our own resource challenges so much that we miss critical opportunities for improving the income that is so badly needed for those who have been displaced by technology change. However, Pittsburgh is well-versed in handling change, and in making difficult decisions. We know what it means to care for your workforce and to find a balance between the old and new; indeed, we have thrived on it.

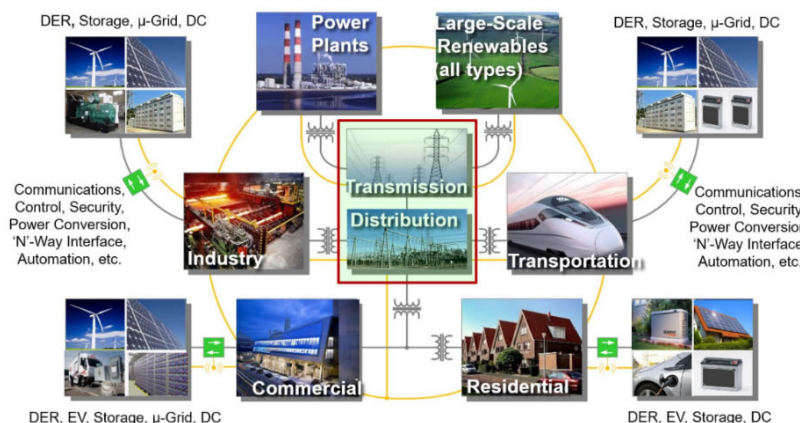
By focusing on new electric grid solutions, Pittsburgh can play a leadership role in handling the dual challenge of sustainability and economic stability. Reviewing how industry members, government officials, utility oper-

transitioned from a highly industrial economy to a highly diverse economy based on technology, energy, education, health care, and medical research. Today, almost 20% of Pittsburgh's economy depends on the energy sector, of which clean energy solutions are the leader. These not only include research in wind and solar, but other clean energy sources and leading technological grid solutions in the form of high-voltage alternate and direct current systems (HVAC/HVDC) that can be used to make our homes, schools and offices more economically and environmentally efficient. However, continued efficiency, innovation and growth require equivalent modernization of our legacy grid. The transition of the Mid-Atlantic economy has and continues to evolve against the backdrop of a legacy grid infrastructure. To be sure, our local and regional utilities have done a tremendous job of maintaining high reliability and are advancing in a new era of investment and modernization. After several decades of arguably a stagnating environment, it is once again a very exciting time to be in the power industry, and Pittsburgh can again be at the forefront.

CONTINUING THE POWER INNOVATION LEGACY

The electric utilities and supporting industry organizations who have been the stewards of our current grid infrastructure, which was designed and built to support a machine-age economy, now have the opportunity to become part of an integrated technological future. One example is in the area of microgrids, which are playing an increasingly popular role in discussions relating to the reliability of the electrical grid, and are now a central focus point of Pitt's Electric Power Systems research lab. Focusing on applying interconnected loads and distributed energy resources within clearly defined boundaries to act as a single controllable entity, microgrid developments may help to redevelop an industry that has been challenged by integrating innovative solutions, due in some part to economic and regulatory constraints. Most recently, microgrid developments have

The 21st Century Grid – RD&D is Imperative



The 21st Century Grid – Evolving Infrastructure and Technologies

been primarily based upon new technology deployment such as power electronics, energy storage, or forms of renewable integration. These have mainly been applied to military bases and associated applications to-date. However, microgrids can play a much larger role in the resiliency of the electric grid. These applications are focused upon grid islanding and synchronization, black start capability, generation/load balance control, battery energy storage and frequency regulation, and load control with demand response, which means that they can connect and disconnect from the built grid to enable it to operate in both grid connected and islanded mode.

Enter the Pittsburgh District Energy Initiative, which can be thought of the plan to untangle the mess that is the center of the energy web. The joint initiative, established through close collaboration with the Mayor's Office at the City of Pittsburgh and the University of Pittsburgh's Center for Energy in the Swanson School of Engineering, has helped to create and develop innovative ideas including Pitt's 'Grid of Microgrids' concept. This project is intended to help better prepare the city against the low-probability-but-high-consequence threats of sustained power outages caused by natural or manmade disasters. The plan includes the identification and creation of microgrid districts throughout parts of the city, along with various energy resource plans, with a goal of creating one of the most advanced and sustainable energy ecosystems in North America.

IMPROVING DC INFRASTRUCTURE RESEARCH

Integral to this vision is the role of DC infrastructure for electric power delivery. The Center for Energy acts as a technical partner to the city itself. The Center helped the city to develop the concepts and value proposition of the district energy plan, but also contributes significantly to its potential success through technology research, development, deployment, and demonstration.

The support of industry partners engaged in the District Energy Initiatives sets a leading example nationwide. This importantly includes Duquesne Light, People's Gas, as well as the U.S. Department of Energy. Other organizations, including energy suppliers (such as NRG), technology vendors (such as Eaton), and key end-users (such as PITT OHIO Express) are being strategically engaged in the process, through Pitt's leadership role.

The Center recently completed a novel project with the trucking company PITT OHIO. Pitt and PITT OHIO, working in collaboration with a team of 8 local industry organizations, installed a renewable DC nanogrid at PITT OHIO's Harmar facility. The buildout included solar and wind energy, as well as battery storage integrated into a direct current (DC) infrastructure within the facility. This first-of-its-kind implementation is not only groundbreaking, but will serve as a national demonstration for future distributed and DC project developments.

Now, Pitt and Duquesne Light Company (DLC) are collaborating along with other industry partners to design and build a fully operational microgrid at DLC's own Woods Run Facility which will be operational by the end of 2018. The microgrid will integrate both renewables and other clean energy solutions, will include advanced delivery methodologies, and will have the ability to operate in full 'island' mode independent from the grid. The Woods Run project will also serve as a living laboratory for Pitt graduate students, working in the electric power and energy fields, and yet another national example of Pittsburgh's innovation leadership.

THE ENERGY GRID INSTITUTE: EXPANDING THE SUPPORT OF INNOVATION

Expanding its leadership in energy-related research and the evolution of U.S. power and energy infrastructure, Pitt recently announced the establishment of a new institute to address these 21st century challenges of the electric utility industry. The Energy Grid Research and Infrastructure Development (GRID) Institute will leverage Pitt's public and private partnerships and the resources of new laboratory space at the Energy Innovation Center in downtown Pittsburgh to create a comprehensive international solution center for the electric utility industry.

The GRID Institute's inaugural partners include Duquesne Light, Eaton, the Electric Power Research Institute (EPRI), Dominion Virginia Power, FirstEnergy, Emerson, PITT OHIO Express, Sargent Electric Company, Siemens, and Universal Electric Corp. Nonprofits including the Henry L. Hillman Foundation and the Richard King Mellon Foundation are also supporting the work of GRID. The Institute's leadership team is also exploring additional public-private partnerships in the Pittsburgh region, throughout the U.S., and internationally.

GRID's operations will be based in new

offices, research labs, and incubator spaces currently under construction by Pitt at the EIC. The nearly 20,000 square feet of facilities will include an expansive high-voltage/high-capacity Electric Power Technologies Laboratory, the Next Generation Energy Conversion and Storage Technologies Laboratory, a High-Temperature Corrosion Testing Laboratory, and Energy Incubator Laboratories.

In collaboration with these labs and their respective capabilities, the GRID Institute will address the utility sector's critical issues, including: microgrids and resilient energy systems, renewable and clean-energy integration, energy storage systems, power electronics and conversion technologies, electric vehicle concepts, direct current (DC) infrastructure and standards, hybrid AC/DC systems, and integrated energy networks. More importantly, the GRID institute will serve as an extension of Pitt's on-campus activities, where the GRID institute can help to address the skills deficient in the electric-ity industry.

INVESTING IN INNOVATION

Working to deploy better and more efficient power solutions here in Pittsburgh through strong partnerships can help both the economy as well as the environment.

In 2008/2009, when the economy was crashing in the rest of the country, and jobs were being lost, Pittsburgh was only one of three cities in the US where growth was still being maintained. Having a more diversified economy today, including one that embraces a strong leadership position in electric power can help Pittsburgh grow in the way we know best – economically, environmentally, and socially strong. Electric grid innovation is a significant part of our regional heritage, and it is now our responsibility to once again take advantage of the opportunity to lead the next grid evolution.

About the Authors...

Gregory Reed, Ph.D. is a Professor at the University of Pittsburgh's Swanson School of Engineering and the Director of Pitt's Center for Energy, the Electric Power Systems Lab, and the Energy GRID Institute; Katrina Kelly, PhD is a Research Assistant and Manager of Strategy and Business Development in the Center for Energy; Brandon Grainger, Ph.D. is a Research Assistant Professor in the Swanson School of Engineering and affiliate in the Electric Power Systems Lab; and Michael Rooney is Manager of District Energy Programs in the Center for Energy.

What's Next?

Laura Meixell is Chief Data Officer for the City of Pittsburgh Department of Innovation and Performance

What is the technology that will be impacting your industry most dramatically in the next five years?

I think that the open-sources tools for creating web-applications are going to dramatically change the landscape for creating public sector software tools, for especially business intelligence and mapping. In the past, very specialized skillsets were required to develop reports and applications that facilitate views into data. With the expansion of platforms like GitHub and packages like R Studio, bootstrap, and leaflet developers with limited experience can patch together available tools with relevant data and create modern, flexible tools quickly and easily.

How is Pittsburgh poised to take advantage of the new technology?

Pittsburgh is well poised to take advantage of this shift for two reasons: 1) Our universities provide us with a steady stream of young folks with modern skillsets who are plugged into the world of online resources and 2) the Western PA Regional Data Center (WPRDC) provides a great starting place for locals looking to build applications with relevant local data. With the knowledge of how to employ open sources tools and access to the rich resources of the WPRDC, local non-profits, governments, universities, and really anyone can build their own tools of high quality with limited resources.



invitation for student contributors

The *Pittsburgh Engineer* is the official magazine of the Engineers' Society of Western Pennsylvania, and is published in print quarterly. The *Pittsburgh Engineer* is seeking content for our magazine from engineering students in the Greater Pittsburgh area. Articles should be 500–1500 words, and pertinent to the theme of the issue. Articles should provide a technical overview of a topic of interest to the readership, without requiring the audience to be trained in the discipline of the author(s). Examples of the publication may be found at <https://eswp.com/about/publications/>

The themes for 2017 are:

Issue	Theme	Deadline for submittal
Spring	Engineering in Agriculture	March 17, 2017 (St. Patrick's Day)
Summer	Bridges	May 29 , 2017 (Memorial Day)
Fall	Hunting & Fishing	September 4 , 2017 (Labor Day)
Winter	Automotive	November 23 , 2017 (Thanksgiving)



Articles will be reviewed by the ESWP Publications Committee for content, originality, and relevance to the engineering profession. Chosen articles will reach a readership of more than 4,000 engineers, architects and construction managers. Photographs and illustrations are welcome, as long as the author has permission to publish them. Multiple authors may be listed for one article; all must be students. The winner will be awarded a \$100 gift card, first and second runner up will receive \$50 gift cards. Articles and stand-alone high resolution images should be submitted in MS Word via email to *Pittsburgh Engineer* editor Dave Teorsky by e-mail at d.teorsky@eswp.com

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What's Next?

Aurora Sharrard, PhD, LEED AP BD+C, Green Building Alliance; Executive Director & Vice President of Innovation

What is the technology that will be impacting your industry most dramatically in the next five years?

Because buildings have interconnected systems, no single technology can effect great positive change in the building industry by itself. However, when applied across systems, a combination of several technologies and occupant behavior change have great potential to create more efficient, healthy, and sustainable buildings and communities.

Specifically, the future of real-time building performance information will continue to change dramatically in the coming years as more low cost energy, water, and air quality meters, sensors, and controls come onto the market. Harnessing the vast amount of data and information coming out of these systems is the true opportunity that awaits property owners as they work to save money, create healthy indoor places, and reduce their environmental burdens. It could also be a key hurdle, as building engineers must also come up to speed on how to fully utilize this sophisticated information & technology combination.

How is Pittsburgh poised to take advantage of the new technology?

Pittsburgh has long been on the green building forefront and smarter building performance is no exception. It's true that we have a lot of older of existing buildings with automation systems that can't necessarily easily integrate with these newer technologies. However, they don't have to, as many newer approaches work directly adjacent to existing systems, instead of supplanting them. There already quite property owners, researchers, and startups attempting to take advantage of these new opportunities locally. A few that jump to mind include Hibersense, kWanterra, BOSS Controls, Speck, Lean FM Technologies, and several yet-to-be-named university spinoffs. Additionally, several Pittsburgh companies are also layering in consumption and performance information with on-site considerations that attempt to maximize the renewable energy generation and storage benefits. Those include Aquion Energy, Energy Independent Solutions (EIS), EverPower, Scalo Solar, Windstax, and others.



What's Next?



Ngani Ndimbie is a Women in Transportation Fellow for Heinz College, Carnegie Mellon University

What is the technology that will be impacting your industry most dramatically in the next five years?

Adaptive traffic control systems could have a large impact on transportation (and in my particular interest, affordable transportation,) in the coming years. Currently adaptive traffic control systems can monitor car volume with video feeds and ensure that motorized vehicle traffic moves efficiently. Within the next five years it is expected that these traffic control signals will also be able to and manage the volume and flow of people biking and walking, and additionally offer prioritization to public transportation vehicles.

Bet you thought I'd say autonomous vehicle technology. Well, OK that too. Shared autonomous vehicles are poised to have a tremendous impact on the way people get around in the coming (5-25) years. If we aim to drastically improving the disparity in access to goods, services, and employment and are willing make some smart policy decisions in the coming years to discourage the use of personal vehicles, we have the opportunity to correct the access and land use mistakes of the past and reconnect communities. Furthermore, it is my hope that these new technologies will bring the heyday of an older tool: the jackhammer. Parking lots converted to parks and housing, anyone?

How is Pittsburgh poised to take advantage of the new technology?

We're lucky to have Rapid Flow Technologies here in Pittsburgh deploying and improving their SURTRAC system. Pittsburgh's unique street city form and lack of street grid makes it so that there is often only one street connecting two places which, then, requires all modes of transportation to share the limited road space. With our newly minted complete streets policy, Pittsburgh is the perfect place to take advantage of traffic control system responsive to all modes of travel to make moving about the city more efficient.

Deborah A. Lange Wins Prestigious Metcalf Award From ESWP:

Powering the Future With Engineers

Deborah A. Lange has been selected to receive the 2017 William Metcalf Award from the Engineers' Society of Western Pennsylvania (ESWP) for her work in environmental policy, STEM education, brownfields development and critical job training for rust belt communities, among many other innovative initiatives and research over the past two decades.

Lange, the first female to receive the award in 53 years, will officially be recognized at the ESWP's 133rd Annual Engineering Awards Banquet on Wednesday, February 15, 2017 at the Westin Convention Center Hotel in Pittsburgh.

"I am both honored and humbled to be a recipient of this important award and I embrace it as a message to continue to help to create a diverse interest in the engineering profession starting with the support of innovative partnerships for K-12 students throughout Allegheny County" said Lange, director of strategic initiatives for the Steinbrenner Institute for Environmental Education and Research (SEER) at Carnegie Mellon University. She is also involved with STEM outreach for CMU's top-ranked College of Engineering and assists with alumni relations at CMU's Department of Civil and Environmental Engineering.

"Deb's contributions to this industry and her profession are outstanding and her achievement of the Metcalf Award truly recognizes a lifetime of meaningful accomplishments. Her contributions and leadership have had a significant and positive impact on the reuse of brownfields, engaging and encouraging youth in STEM activities, and to the success of the Engineers' Society of Western Pennsylvania," said H. Daniel Cessna, P.E., PennDOT District 11-0 Executive and current ESWP president.

Lange's tenacity when it comes to cleaning up the region's old industrial brownfields has been an economic beacon for places like Ambridge where one site now houses a hotel and grocery store.

"Allegheny County is fortunate to have such an environmental leader. She's been great for our Green Team and a pioneer in the engineering field where women are still breaking into many areas of that competitive profession," said Rich Fitzgerald, chief executive of Allegheny County.

And because of Lange's dedication to quality high school education, particularly for urban students she helped Propel implement a novel STEM outreach program, according to Carol Wooten, a coordinator and consultant for Pittsburgh's Schools That Can, and a faculty fellow at the University of Pittsburgh's Center for Urban Education. "She worked with Kristen Golomb, science program director, to plan and execute a program that gave students in grades 9-11 an opportunity to meet and speak with engineers."

Wooten said the program was unique because it gave engineers the opportunity to visit classrooms and give demonstrations. "Most programs are self-selective but this program provided a STEM experience to all students" said Wooten.

The ability to humanize the engineering profession has been Lange's greatest asset and challenge. And her own career is evident of the pioneering path she has taken from her early days at U.S. Steel to helping solve brownfield issues in the Czech Republic.

"I tell students the work is hard, but you can use engineering as a successful platform for any profession from medicine to law, and even the financial sector," she said.

To that end, Lange was instrumental in spearheading the 2008 Sebak project titled, "Invented, Engineered and Pioneered in Pittsburgh," – the first foray of the ESWP to make Pittsburgh –centric engineering stories (George Ferris, John Roebling, George and Westinghouse) available and interesting to view for the public. Lange served as ESWP president from 2010-2011.

As an alumna of Carnegie Mellon, Lange has carried the school's mantra of community service and research excellence to a higher level.



"The faculty, staff, students and alumni of CMU's Civil and Environmental Engineering Department are very proud of the accomplishments of our alumna Deb Lange, and congratulate her on being recognized with the ESWP Metcalf Award," said David Dzombak, Hamerschlag University Professor and Department Head. "Over the past two decades, she has made significant research contributions in and helped to define the field of brownfield re-development. In her role as Executive Director of the Western Pennsylvania Brownfields Center, she effectively integrated research and practice and in doing so helped advance brownfields redevelopment regionally and nationally. Also for more than a decade, Deb has been a leader in bringing engineering into K-12 STEM education through creative partnerships that have leveraged effectively her role at the Carnegie Mellon Steinbrenner Institute for Environmental Education and Research, and her leadership roles at ESWP. Because of Deb's multi-faceted achievements in engineering research, practice and education, she now joins the prestigious group of previous Metcalf winners. The Carnegie Mellon CEE community is thrilled," said Dzombak.

In addition to being a registered engineer, Lange is on the board of directors of the Allegheny County Conservation District. She received a bachelor's degree in civil engineering from the Pennsylvania State University in 1979. She earned a master's degree in 1982 and a Ph.D. in 2001 in civil and environmental engineering from Carnegie Mellon.

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