DOCKETED

Docket Number:	18-MISC-01
Project Title:	Food Production Investment Program
TN #:	222156
Document Title:	Frank Sharp-EPRI Comments Indoor Agriculture Summary
Description:	Public Utilities Fortnightly PUF 2.0 Mid-November 2017 article republished with permission from Editor-In-Chief of Public Utilities Fortnightly
Filer:	System
Organization:	Frank Sharp/Electric Power Research Institute (EPRI)
Submitter Role:	Public
Submission Date:	1/17/2018 1:33:44 PM
Docketed Date:	1/17/2018

Comment Received From: Frank Sharp
Submitted On: 1/17/2018
Docket Number: 18-MISC-01

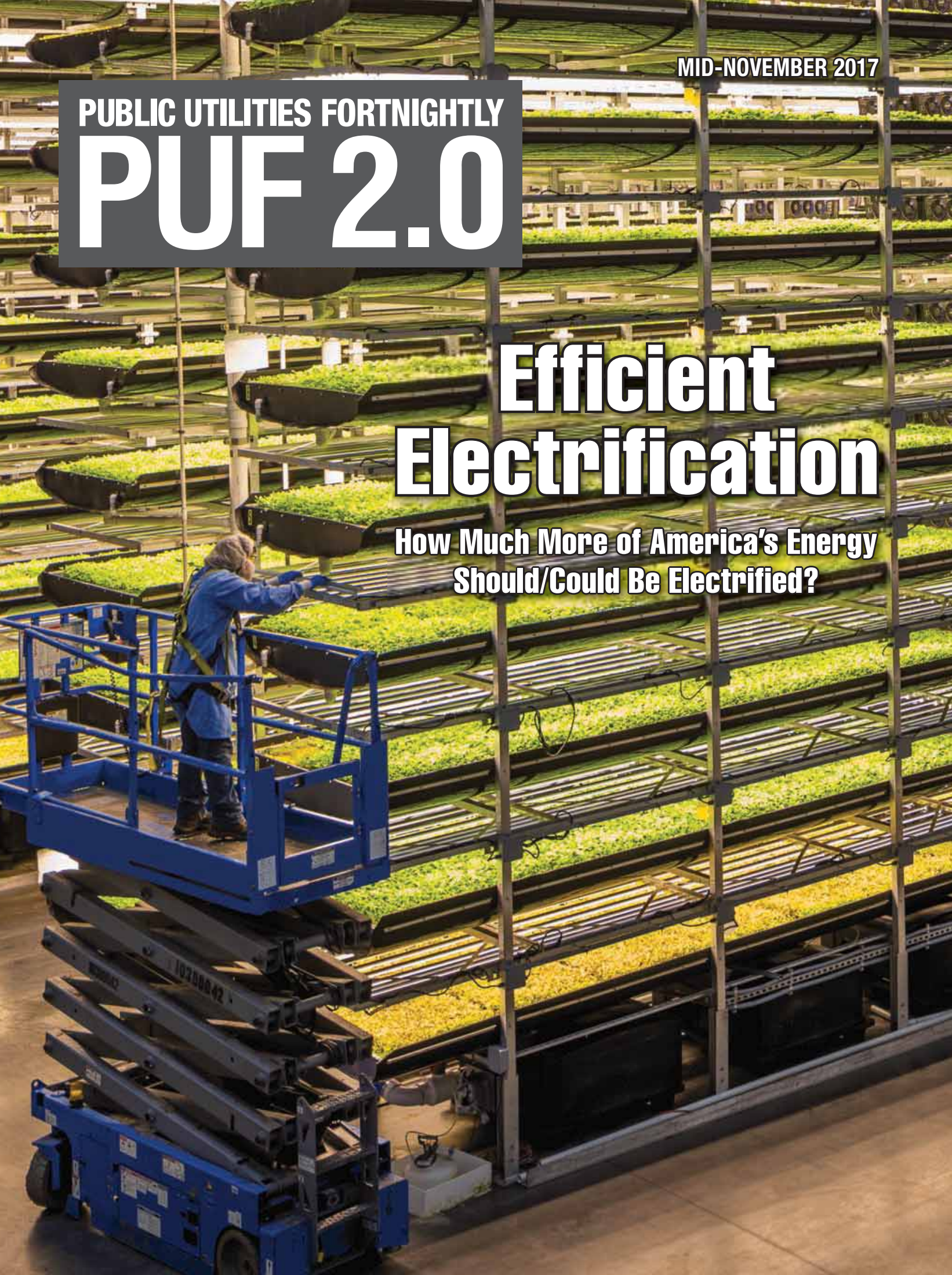
Indoor Agriculture Summary

Additional submitted attachment is included below.

MID-NOVEMBER 2017

PUBLIC UTILITIES FORTNIGHTLY

PUF 2.0



Efficient Electrification

How Much More of America's Energy Should/Could Be Electrified?

FIND THE POWER

TO CONTROL YOUR DESTINY

Witness Development | Crisis Readiness | Strategic Counsel

CCA helps utilities find and harness the power to address high-risk challenges and accomplish high-stakes objectives. Whether you need to prepare for an upcoming hearing or trial, develop the next generation of corporate witnesses, protect your reputation in an emerging crisis, or formulate an effective strategy for controversy, CCA's elite team of consultants has the expertise and industry insight to help you succeed.

Our proprietary, field-tested approach gives members of your leadership team the skills and tools they need to effectively think and communicate under pressure, putting you in control of your destiny in even the most crucial make-or-break situations.

CCA

CCA, Inc. | 17400 Dallas Parkway, Suite 200 | Dallas, TX 75287
972.713.7474 | info@cca-consulting.com

www.cca-consulting.com

In PUF, Impact the Debate

PUBLIC UTILITIES FORTNIGHTLY
PUF 2.0

Mid-November 2017 • Volume 1, No. 6

Cover photo: From the indoor farm to your grocery. An AeroFarms worker tending to salad greens. Photographer: PUF Staff.

To Further Electrify

How much of the four-fifths of America's energy should/could be electrified?

BY STEVE MITNICK

A renewed and major push to further electrify our society and economy? It wouldn't make any sense, if the production of electricity polluted the environment at twentieth century levels. It wouldn't make any sense, if the usage of electricity was as inefficient as it was in the last century.

And it wouldn't make any sense if the cleanliness in its production, and efficiency in its usage, had been purchased with electricity's essential advantages – cost, convenience, safety, flexibility and versatility – as payment. This would have been a steep price, possibly too steep a price.

But, hey, it's the twenty-first century. Electricity production and usage has undergone a metamorphosis. Pollution from its production has fallen dramatically and is still falling, at a rapid pace. The efficiency of using electricity has risen dramatically and is still rising, at a rapid pace.

Yet – and this is an astonishing fact – electricity's real cost is at its historic low. Electric bills have dropped to 1.32 percent of consumer expenditures this year. How utilities, regulators and policymakers achieved this magic is a subject for another column. But they did.

Even though electricity's environmental impact has shrunk and keeps shrinking. Even though electricity's efficiency has grown and keeps growing.

Actually, if you think about it, electricity's increasing efficiency in every dimension – production, delivery and usage – is one of the main reasons why electricity's real cost is at its historic low. Nuclear plant refueling was made much more efficient. Natural gas-fired plants were made much more efficient. Regional grids were made much more efficient. Lighting and refrigeration were made much more efficient. Hundreds of innovations large and small have managed to reduce electricity's real cost while expanding our employment and enjoyment of electricity.

Further electrifying wouldn't make sense if cleanliness in its production, and efficiency in its usage, had been purchased with electricity's essential advantages as payment.

So, the renewed and major push to further electrify. It turns out we have a long way to go.

A fifth of the energy in America is electrical. What's the other four-fifths? Generally, the burning of fossil fuels at the point of use. Right there, right where we live and work, often a few feet away from us.

We burn fossil fuels just beyond our steering wheels in our cars, to drive them. We burn fossil fuels just below our kitchens in our basements, to heat our homes. The food we eat is literally fueled, produced with farm tractors and irrigation pumps, and delivered with freight trucks (often refrigerated from the truck's diesel combustion).

How much of that four-fifths of America's energy should and could be electrified in the decades to come?

Not long ago, our electricity came from a mix of around fifty percent coal-fired generation, ten percent oil-fired, ten percent natural gas-fired, and thirty percent zero-carbon (from hydro and nuclear). Not long from now, our electricity will be a mix of around ten percent coal-fired, zero percent oil-fired, thirty percent gas-fired, and sixty percent zero-carbon. Electricity will then be far cleaner.

The zero-carbon share will double. It will rise from thirty percent to sixty percent.

The high-carbon share will be a sixth of what it had been. It will fall from fifty percent to ten percent.

The grid's electricity on average recently became cleaner than combusting

oil at the point of use. How did that happen? It's not hard to understand. The zero-carbon and low-carbon percentage shares are growing. Their growth is offsetting the shrinking high-carbon share.

So, powering your car with the grid is now cleaner than powering it by combusting a refined oil product right there under the hood. Electricity wasn't as clean before. It is now.

The grid's electricity will next become as clean as combusting natural gas at the point of use. That shall be a momentous day. Natural gas is the cleanest of the fossil fuels.

Ultimately, electricity will become about twice as clean as combusting natural gas at the point of use. Electricity will then have left all the fossil fuels – burning them yourself in your home or place of business – in the dust.

In the decades to come, burning fossil fuels right there will remain a good fit for some applications. Such as to fly aircraft. Such as to drive long-haul heavy-duty trucks. Such as to heat cold-climate buildings. And for certain industrial processes. Though these applications might someday become exceptions to the norm.

The question on the table is, how much of the four-fifths of America's energy from burning fuels at the point of use should and could be electrified? Let's see. Let's glimpse the future, in this special issue of Public Utilities Fortnightly on "efficient electrification." ❖

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

www.epri.com

ELECTRIFICATION 2018

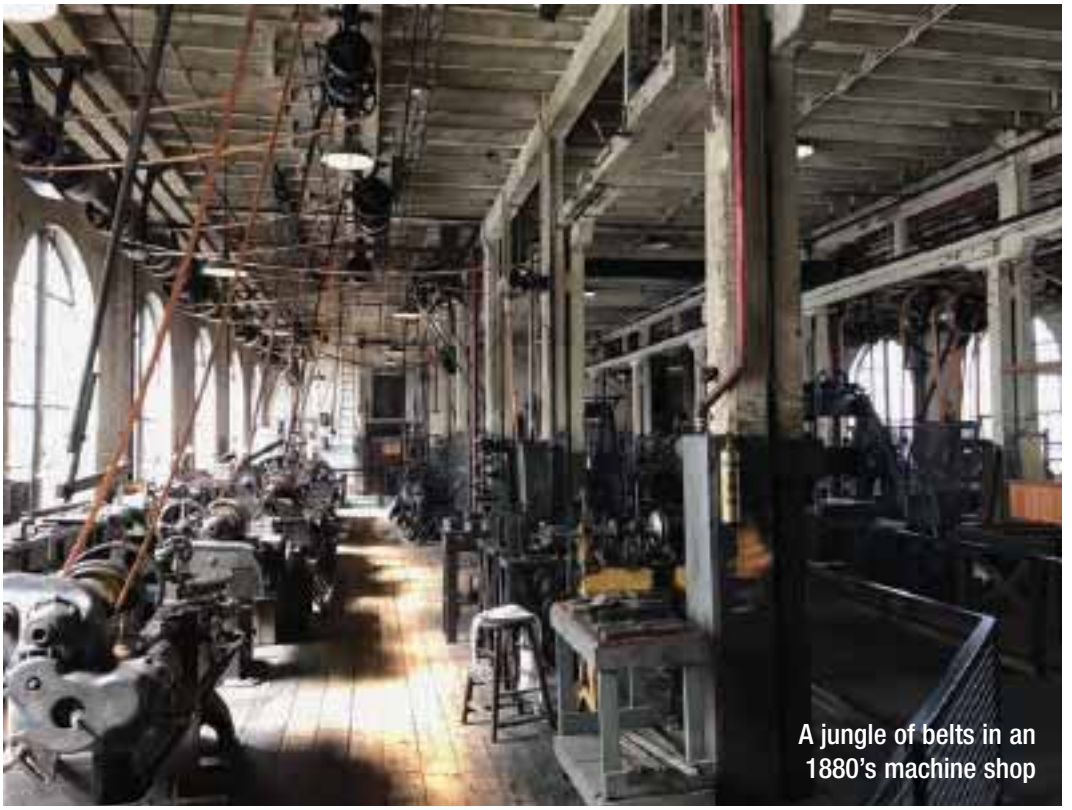
INTERNATIONAL CONFERENCE & EXPOSITION

Why Attend?

- Gain an understanding of the quantifiable customer and environmental benefits of electrification
- Learn about best practices for implementing efficient and effective electrification programs to maximize customer benefit
- Experience the latest electrification-related technologies in action
- Collaborate with industry, government, and academic leaders

For more information, contact Info@Electrification2018.com

August 20–23, 2018
Long Beach Convention Center
Long Beach, California
www.electrification2018.com



A jungle of belts in an 1880's machine shop

Electrification Perspectives

Second Great Age of Electrification is Digital and Just Gaining Momentum

BY STEVE MITNICK

Take a time machine to the 1880's. Let's see what they were seeing then.

Franklin Leonard Pope wrote his article, "The Electric Motor and Its Applications," for the March 1888 issue of Scribner's Magazine. Scribner's was one of the most popular media outlets of that time a hundred and thirty years ago.

Frank Pope's extensive text deeply analyzed the birth of the electricity industry, while the industry was still in the delivery room. The article says at one point:

"It was at once perceived that the electric lighting conductors, if introduced into every building in a town and supplying a constant electric current, at an expense ordinarily not exceeding 8 or 10 cents per horse-power per hour, could be utilized with great advantage in driving sewing machines, lathes, ventilating apparatus, and innumerable other sorts of machinery for domestic purposes, or for the lighter class of mechanical industries…"

What was Frank Pope telling us? There was enormous demand for electric lighting upon the introduction of the incandescent bulb in the 1880's, as well as in the 1890's and the early twentieth century. Everyone wanted electric lighting. Building after building was electrified.

Once connected to the grid, people realized they could use electricity for other purposes, especially with the refinement of the electric motor. Being connected crossed the threshold from lighting service to electric service and its much broader potential.

Electricity was hardly economical. That "8 to 10 cents per horse-power per hour" would be like three dollars per kilowatt-hour today, more than twenty times today's cost. That's why – as much as electricity was craved – it was initially in the reach of wealthy residences and well-capitalized businesses only.

Yet, electricity's unique qualities were clear to all. In 1888, more so than in our

day when we've become accustomed to one of history's greatest game changers. Electricity's advantages over fuel combustion at the point of use more than offset – indeed they blew away – electricity's premium cost.

The Scribner's article later explained, after listing the many applications of electricity and electric motors already in use in those first years, why those apps were so compelling:

"It would be almost impossible to catalogue the number and variety of purposes for which the electric motor is now in daily use. Some of the most usual applications are for printing presses, sewing machines, elevators, ventilating fans, and machinist's lathes…

It is a very simple matter, by means of a current derived from the same dynamo [a generator supplying incandescent electric lighting apparatus], to operate elevators, hoists, presses, pumps, trucks, tramway-cars, and many similar appliances, which are now worked at greater expense, and with far less convenience, by hand, animal, or independent steam power…

The advantages of having every individual machine driven by its own independently controlled power, and at any required speed, are so obvious that it is scarcely necessary to mention them…"

This is Frank Pope's crucial point for us. To operate a machine in the 1880's, you either used your muscles, those of other people, those of animals, or fossil fuel-fired steam power. If you used fuel-fired steam power, you wouldn't have a steam engine for each machine. That would be crazy in several regards – crazily expensive, crazily dirty, crazily space-consuming.

Instead, you had a single steam engine to power a whole shop of machines. Mechanical connections between the machines kept them all going.

Until the development of the electric motor, the transmission of motive power in industrial processes required a jungle of line shafts, belts, compressed air, and hydraulic pressure. With the electric motor, each machine could be driven by its own customized power source. This was nothing less than a revolutionary development.

Each electrical machine, appliance and device then and now functions on its own. The power – whether from a plug or a battery within – is optimized for functionality. There is no need for the user to ignite a fuel to start 'er up.

***

On the farm, until the electric motor, the handling of grain and pumping of water required human and animal work – grueling work. Most Americans lived on farms in the 1880's. With the electric motor, agricultural productivity and the quality of rural life increased dramatically.

Frank Julian Sprague had invented the first practical DC motor in 1886, just two years before the Scribner's article. Frank Sprague soon introduced the first electric trolley, elevator, and subway. These revolutionized the productivity and quality of urban life.

The Niagara Falls generating plant, completed a few years later, in 1895, was the first large central station. Some of its output was transmitted twenty miles for lighting and street cars in Buffalo.

Being connected crossed the threshold from lighting service to electric service and its much broader potential.

This next gen of the grid popularized the two-phase AC system developed by Nikola Tesla and commercialized by George Westinghouse. Tesla's AC motors were already being installed throughout the country.

***

At the industry's inception, a hundred and thirty years ago, electricity grew to take over the lighting of homes, businesses and public spaces. Once buildings were electrified, inventors thought up non-lighting uses, particularly powering motors. This mainly freed up people (and their animals) from manual work. But there was also substitution of electricity for fossil-fuel combustion in homes and workplaces.

Consider how we heat buildings. Fire heated every home in America in the early

The first Christmas lights

The first dictating machine

twentieth century. A hundred years later, fire – the burning of a fuel in the basement typically – still heats a majority of homes.

What about electricity? In the mid-twentieth century, electricity was rapidly replacing fire for home heating. Until the trend came to an end in the 1960's and 1970's.

The grid's electricity in those decades was not clean. Electric generation was a leading source of pollution. Policymakers pushed back. Electricity – as the way to heat homes – was discouraged. In favor of the burning of fossil fuels in basements.

Electric heating nonetheless grew little by little. In part, this was due to greater population growth in the south and west. Fire competes poorly there with electricity as a heating method. In part, this was due to the inherent cost and convenience advantages of electricity in housing development.

Electric service is automatically provided to every new home. Natural gas service is not. A developer must ask, do we add gas service so buyers can heat

There is no need for the user to ignite a fuel to start 'er up.

and cook with gas instead of electricity? Some developers will decide to do so. Others will decide not to.

***

In the home, electric irons and washing machines transformed the laundering of clothes. Electric vacuums transformed the cleaning of rooms. Electric refrigerators, bread toasters, tea kettles, coffee percolators, waffle irons, corn poppers and marshmallow toasters transformed the preparation of food.

To say that the lives of women particularly were transformed is a gigantic understatement. This revolution, really, set the stage for their opportunities and roles in society to expand in every direction.

And for men and women, electric fans, telephones and radios transformed comfort, communication and entertainment. We're so dependent on electrical machines, appliances and devices that – as demonstrated by the devastating damage of the recent hurricane to Puerto Rico's grid – modern life comes to a screeching halt without them.

***

It is seldom remembered that, in the 1880's, Thomas Edison invented research and development. Don't miss the enormity of this point. Thomas Edison invented R&D. The world's great laboratories – and all of us – owe the Wizard of Menlo Park for this too.

Just visit his expansive R&D campus in West Orange, New Jersey, beautifully preserved by the National Park Service. Edison's scientists and engineers rolled out product after product – from industrial machinery to motive power distribution to office dictating machines to Christmas

tree lights to movies. Some of the innovations replaced fuel-burning with electrical processes. While others created whole new processes to please people and make them more productive.

***

The first great Age of Electrification continued for decades. By the late twentieth century, Edison's successors continued to roll out product after product.

Consider lighted screens. Older readers will recall that lighted screens were a rarity when they were children. Small black-and-white televisions and a sprinkling of other vacuum tube devices like oscilloscopes and radar/sonar. Today, vivid color screens – both large and small – are ubiquitous in our lives.

The first great Age of Electrification was analog. The second great Age of Electrification, that is just gaining momentum now, is digital.

***

Harvey Hubbell's invention in 1904 accelerated the adoption of appliances. His electric power plug enabled people to safely connect appliances to a light socket in a time before the wiring of buildings.

An advertisement by Hotpoint in 1919 said: "A willing servant stands at attention behind every electric light socket… Why not set this idle energy to working for you?"

The ad compared electric appliances with their competitors that combusted fuel at the point of use: "Save Food Values, Save Fuel, Save Time." And "Cook in Cool Comfort."

No one in the early twentieth century would question this motto and others like it. Because everyone wanted to live in an electricity-based world where manual labor and burning coal, oil and wood in homes and workplaces would be eliminated or drastically reduced.

***

The Census Bureau reports annually the results of its extensive American Community Survey for the prior year. Included is extraordinary detail on our population, society and economy, and on how Americans heat their homes.

As demonstrated by the devastating damage of the recent hurricane to Puerto Rico's grid, modern life comes to a screeching halt without electricity.

In 2016, 48.1 percent of all homes were heated with natural gas. 38.7 percent were heated with electricity.

Electric heat has been growing rapidly. In 2005, eleven years earlier, 50.5 percent were gas-heated and 32.5 percent were electric-heated.

At this rate of growth, electric heat will soon surpass 40 percent of all homes.

Already, 50 percent of rented homes are electric-heated. Most homes, however, are owned rather than rented. In 2016, 32.1 percent of owned homes were electric-heated.

Electric-heated homes are by far most prevalent in the South. 63.0 percent use electricity for heat. Including 74.3 percent of rented homes and 56.7 percent of owned homes.

Electric-heated homes are the least prevalent in the Northeast. 15.2 percent use electricity for heat. Under 10 percent of owned homes use electricity for heat.

In the Northeast, uniquely, oil-heated homes are common. 22.2 percent use fuel oil for heat. Over 25 percent of owned homes use oil for heat.

In 2016, the South had 16.3 million electric-heated homes that are owned and 11.9 million that are rented. 16.6 million homes in the region, owned and rented, don't use electric heat.

The West had 4.0 million owned and 5.0 million rented electric-heated homes. 17.6 million others don't use electric heat.

The Midwest had 2.6 million and 3.1 million rented electric-heated homes. 20.8 million others don't use electric heat.

The Northeast had only 1.2 million owned and 2.0 million rented electric-heated homes. 17.7 million others don't use electric heat.

Nationally, 72.7 million homes don't use electric heat. They mostly burn natural gas, fuel oil, bottled/tank/LP gas, and wood at their homes to heat them.

***

The Energy Department summarized the country's heavy dependence on fossil fuel combustion:

"Three fossil fuels – petroleum, natural gas, and coal – have provided more than 80% of total U.S. energy consumption for more than 100 years. In 2015, fossil fuels made up 81.5% of total U.S. energy consumption, the lowest fossil fuel share in the past century.

In EIA's Annual Energy Outlook 2016 Reference case projections, which reflect current laws and policies, that percentage declines to 76.6% by 2040."

Electricity powers an insignificant share of the country's transportation sector, tiny in comparison to fossil fuel combustion at the point of use. Electricity powers about ten percent of the industrial sector. About twenty-five percent of the commercial sector. And about twenty-five percent of the residential sector.

Looked at another way, fossil fuel combustion at the point of use is twenty-six trillion Btu in the transportation sector. That's a "ton" of fossil fuel. The amount is nineteen trillion Btu in the industrial sector. Four trillion Btu in the commercial sector. And five and a half trillion Btu in the residential sector.

Looked at a another way. There's a whole lot of potential for the Second Age of Electrification. ❖





Voices for Electrifying and Efficiency

The two E's. Electrifying. Efficiency. Each is compelling.

But when the two E's are paired together, they're much more so. Listen to these five senior leaders. Our interviews with them follow. You'll hear this critical message about Efficient Electrification.

Four of the five are serving on EPRI's board of directors. We interviewed Sheryl Carter, co-director of energy programs at the Natural Resources Defense Council; Pedro Pizarro, CEO, Edison International; Mark Bonsall, CEO, Salt River Project; and Bill Spence, CEO, PPL Corp. While the fifth isn't on EPRI's board, Tom Fanning, CEO, Southern Co., is a tireless eloquent advocate for the two E's.

Pedro Pizarro

CEO, EDISON INTERNATIONAL

PUF's Steve Mitnick: Tell me what excites you about EPRI's Efficient Electrification initiative.

Pedro Pizarro: For the past year or so, a working group of the EPRI board that I'm chairing has focused on efficient electrification.

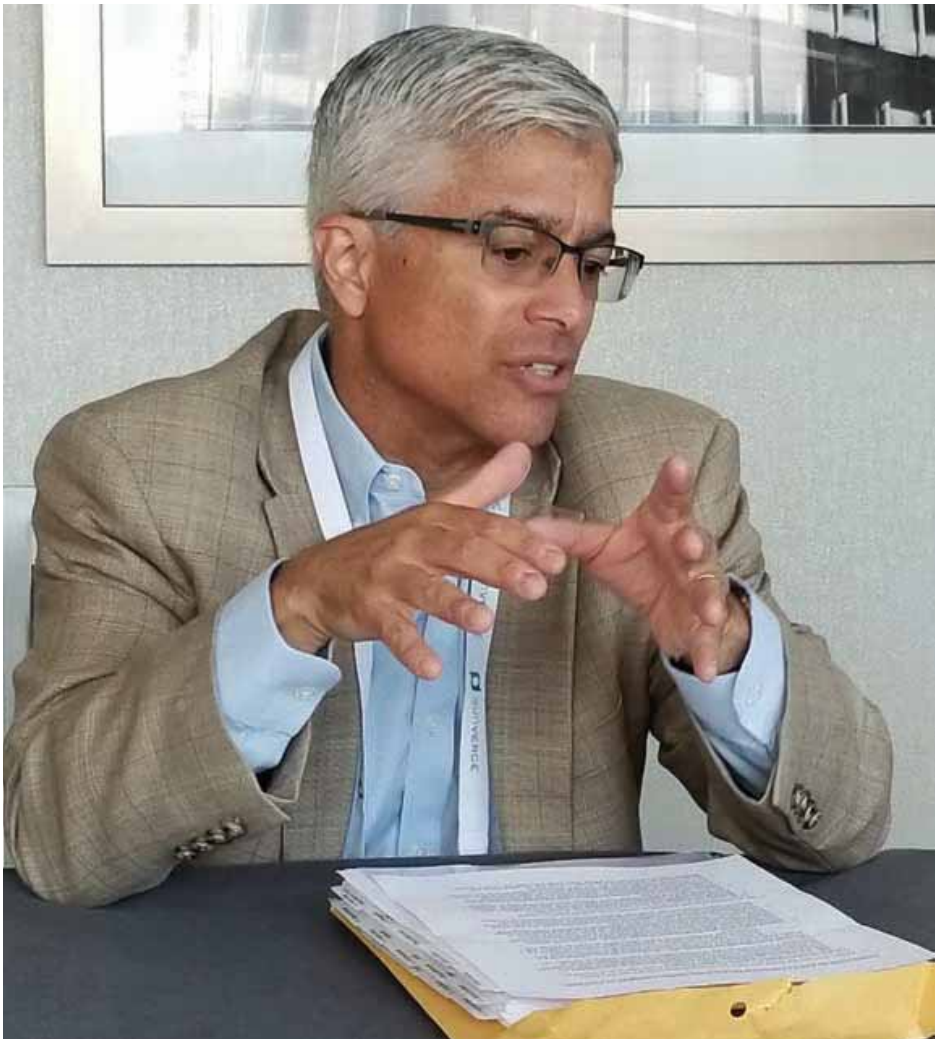
As always, the heavy lifting is done by the amazing staff there, with Arshad Mansoor and Rob Chapman leading the effort.

EPRI approached this from their usual fantastic technology-based, research-based approach.

They started by asking, how do you think about benefits versus costs, when it comes to adopting different electrification technologies? It really started with analytics.

Clearly, in California a lot is being driven by the environmental benefits of greenhouse gas reduction, but there are other issues too. EPRI is looking at this cost-benefit analysis at a national and global level. It includes a lot of important things on the benefits side: first and foremost, economics.

Can you reduce costs? Can you make manufacturing processes more efficient by using electric technologies? What about environmental costs? Are there pollutant reductions, greenhouse gas reductions? What's the value of those?



At the national level, with an endpoint of 2050, you could see adoption of electric technologies above the usual base case.

Water ends up being another big one because the water-energy nexus manifests itself in several of the technologies; they help reduce water use.

We started by developing the framework. We're going to be deep diving now, on a region-by-region basis, to give us some data points on how big this could be and how valuable it could ultimately be for customers.

Their initial work suggests that if you look at the national level, with an endpoint of 2050, you could see adoption of electric technologies above the usual base case. That could lead to reducing carbon dioxide emissions across the country thirty percent. That means increasing the electric load about thirty percent.

One of the biggest drivers for that will be electrifying transportation, particularly on the passenger vehicle side. The EPRI staff also see improvements in buildings and improvements in different industrial processes.

You could also have heat pumps, electric water heaters, or electric technologies for indoor agriculture, which have outstanding water reduction benefits as well.

From our vantage point, we see that efficient electrification is going to play a tremendous role. California is continuing to march towards a forty percent

greenhouse gas reduction by 2030.

We believe that this is not just about California. Technology is creating some real economic opportunities for customers around the country and around the globe.

PUF's Steve Mitnick: With those benefits, what's holding us back? Do still more technologies have to be developed? Is it public policy?

Pedro Pizarro: I think it's a collection of things. First, some of these technologies are mature, and some are still climbing up the maturity curve. I don't think they made any big leaps of faith in their analysis, but they include reasonable improvement in the technology cycle in several areas.

On the policy side, and this is important, the analyses do not assume adoption of new policies. They're not assuming a return of the clean power plan nationally. They're not assuming mandates on electric vehicles.

One other factor is, what's the customer understanding of that potential benefit? I think there's a natural education process as folks get their arms around these technologies.

Two other areas of work can answer your question of what's getting in the way, or how do you help catalyze electrification.

EPRI is looking at the pipeline of some early stage technologies to determine what's expected in terms of their maturation rate and their adoption rate.

They're also looking at how EPRI plays a role in really stimulating research and development collaboration on a global basis.

The idea is how do you start interconnecting potential customers, the technology developers, and the roles utilities and regulators are going to play.

PUF's Steve Mitnick: What does this say about the future role of the utility? Does it change what we do, what Edison looks like ten, fifteen or twenty years from now?

Pedro Pizarro: Yes. I'm going to try to provide both an Edison perspective and a broader national perspective. At a national level, and even a global level, as customers increasingly adopt efficient electrification technologies it reinforces the need for a very robust and modernized grid. A lot of the infrastructure built after World War II continues to age.

When it comes to efficient electrification, one of the earliest examples will be the role of the utility in deploying vehicle charging infrastructure.

We must deploy capital in a smart, efficient way to maintain those grids, to strengthen them, and to modernize them.

From an Edison perspective, if you looked at our current rate case request it's about both continued reinvestment in our grid and a pretty significant investment in modernizing the grid.

It's accelerating the upgrading of older circuits so that they can come up to modern higher voltage standards. I think that's point one.

Point two, utilities will have to help educate customers, help accelerate and enable the deployment of the technologies.

I think there are states where regulators, especially in the vertically integrated states, will call on utilities to play a much deeper role. There will be states like ours where the regulators want to see a different kind of balance between the natural role of the utility and the important role of third parties competing in open markets.

California likes to see more third parties competing, whereas in vertically integrated jurisdictions, you see utilities deploy more of that within their own grids.

When it comes to efficient electrification, one of the earliest examples will be the role of the utility in deploying vehicle charging infrastructure. Edison has some very progressive proposals for helping stimulate the charging market.

We're piloting one now for helping support chargers for passenger vehicles. We have just filed a similar proposal for charging heavy duty vehicles.

We're going to be doing the work and rate-basing the upgrades on the customer side of the meter, up to and including the plug that goes in to the charger. We're treating the charger as an appliance that connects to the grid and is owned by the customer.

We had good support from the charging companies because we had that balanced approach. Some of our peers have proposals in which they own the charger itself. I expect there will be a number of states where utilities may be doing that as well.

Look at passenger vehicles. We think that if you really build in all life-cycle costs, including the much-reduced maintenance costs you get with an all-electric vehicle, you get close to parity with gasoline engines.

I'm not sure if consumers understand that. That's a role the utility can play, as a trusted advisor in the deployment of these technologies.

From an Edison perspective, we also see an opportunity to help large commercial and industrial customers that are likely to be early adopters of new technologies. We're using Edison Energy as a platform to provide advice to large customers as they make these choices. I think there's an opportunity for us to serve there as well. ❖

Tom Fanning

CEO, SOUTHERN COMPANY

PUF's Steve Mitnick: Tell me what gets you excited about EPRI's Efficient Electrification initiative.

Tom Fanning: I think the potential demise of the electric utility industry has been way overstated. In fact, I view the electrification initiative as a strategic blueprint for the way forward for electricity use in America.

It has so many advantages: economic, environmental, and operational. It's going to be good for customers, good for the economy, and good for the utility industry.

PUF's Steve Mitnick: Will it make a substantial difference in American society and the economy?

Tom Fanning: I certainly think it offers the opportunity to do that. We've already demonstrated enormous advantages in electrification in the Southeast. For example, when you fly through Hartsfield-Jackson International Airport in Atlanta, you will notice that all the ground equipment at the new 40-gate international air travel complex is electric.

I view the electrification initiative as a strategic blueprint for the way forward for electricity use in America.

When you look at the Georgia Ports Authority in Savannah, we've lowered their operating costs and eliminated using more than 4.5 million gallons of diesel per year by converting ship-to-shore cranes and refrigerated cargo racks to electric equipment.

When you look at the Port of Mobile, Alabama, where we electrified a six-month dredging project, EPRI estimates we avoided more than twenty-eight tons of emissions per day. There are enormous economic benefits, environmental benefits, and huge productivity benefits. It's a better operation using electricity.

If you think about the next layer of things to come, when you think of driverless vehicles, and a sharing economy, more and more of the future is going to be driven by electric transportation.

PUF's Steve Mitnick: What's holding us back? Is it technology? People doing things the old way?

Tom Fanning: Yes, to some extent, it's cultural norms. Those are hard to overcome. Being a Tesla owner myself, when I go fill up my other car with gasoline, I feel kind of dirty, to be honest with you.

I really do like the qualitative attributes of electric transportation. Further, what we're seeing is a generation of people of a certain age and younger who are used to the idea.

They are much more likely to be early adopters of driverless vehicles and a transportation mindset that is centered much more on third parties such as Uber, Lyft, and others. My sense is, these are

ideas whose time has come.

The other thing that's going to drive the adoption of this technology is operational improvement in energy storage technology. That will get better and better. As it does, the adoption rates will get higher and higher.

PUF's Steve Mitnick: Does this, in turn, change the role of the utility in society?

Tom Fanning: It certainly has the potential to do so. More efficient use of energy is a driver for the economy. It presents a global, competitive environment for the U.S., and it offers significant advantages in terms of price, efficiency, and environmental impact. We think it will accelerate our move to these kinds of technology, and it will help everyone.

PUF's Steve Mitnick: How are you working to accelerate this?

Tom Fanning: Southern is the only utility in the U.S. today that has robust, proprietary research and development. Our approach has always been that we will attempt to positively influence an uncertain future. We could be just a taker of whatever the future provides us, on the other hand.

But I think it's much better for our customers, and much better for our shareholders, for us to have a direct influence and have that uncertain future unfold the way we want it to. So, we want to play offense relentlessly as this marketplace emerges.

PUF's Steve Mitnick: What's the timeline? Are we going to notice some big changes in which a percentage of the economy is electrified in ten years? In twenty years?

EPRI projects electricity could see its total load grow probably thirty percent between 2015 and 2050.

Tom Fanning: Yes. The best guess of that is to look at what Ford and some of the other big auto manufacturers are saying. I would expect to see enormous production increases, and as a result, tremendous market penetration by 2022.

If you want to see a precursor to that, look no further than China. China will drive a lot of the production and demand going forward. In many cases, the barriers here in the U.S. are not only cultural norms but also adoption of standardized technology.

China may lead the way. My sense is that we'll catch up quickly.

PUF's Steve Mitnick: What should the rest of us be doing?

Tom Fanning: Let's just think about it. EPRI projects that electricity could see its total load grow probably thirty percent between 2015 and 2050, and at the same time, non-electric carbon dioxide emissions could fall by forty percent.

U.S. policymakers should enact consistent policy that will enable, not inhibit, a good kind of market development. My sense is that the U.S. moves to a low-to-no carbon dioxide generation portfolio by 2050, and electrification will be a strong contributor to that.

When you think about the positive trade-offs, both in the economy and in the environment, created by a transition from fossil-based fuels such as oil and gasoline to electricity, we should see enormous national benefits emerge. My sense is we will see regulations that are supportive.

You will see infrastructure developed. We should see states adopt constructive policies that enable electric utilities to participate in the development of, for example, charging infrastructure.

PUF's Steve Mitnick: What you're saying is, as electricity becomes cleaner it becomes something that we'll want to use across society as much as possible. To substitute for fuel combustion at the point of use.

Tom Fanning: You've got it. That's it.

PUF's Steve Mitnick: How do you inspire your workers to support this enthusiastically?

Tom Fanning: I've often used an expression that any idiot will jump off a burning platform. The real point of leadership is to mobilize the team to move before we have to.

That is centered on the principle of playing offense relentlessly. We need to influence positive future outcomes, for our customers, for the environment, for our nation, for our employees. These things are a series of win-win propositions that we can help drive and influence. ❖

What if Electricity Was Cheap and Clean?

Throughout the last four decades, utility regulation and policy was a field of constant strife. Critics charged that electric service was too costly. And that it would become even more costly in the future. They charged that electric service was dirty, polluting the environment as almost no other industry.

From the strife came extraordinary legal and regulatory measures to restrain electric service. Practitioners in the field participated in one negotiation after another to mitigate electricity harms while preserving its reliable provision as society's dependence on it grew regardless of the restraints.

One might have wondered during all those years: what if electric service ever becomes cheap and clean? What then? Would the consensus resume for the natural progression of electrifying society?

Sheryl Carter

CO-DIRECTOR OF ENERGY PROGRAMS, NATURAL RESOURCES DEFENSE COUNCIL

PUF's Steve Mitnick: What does a board member do?

Sheryl Carter: EPRI's board has six external, or nonutility, members. Since EPRI is a public interest organization and a nonprofit, they have included external board members to provide diverse perspectives.

PUF's Steve Mitnick: Can you say a little about what your involvement is? What you are looking to accomplish?

Sheryl Carter: Like EPRI, NRDC has been looking at how we transform the entire energy system, not just the electric sector. We recently laid out a pathway to how we could do that.

It's called "America's Clean Energy Frontier, The Pathways to a Safer Climate Future," and electrification figures prominently in that. The U.S. can meet its 2050 goals for greenhouse gas reductions primarily through energy efficiency, renewables, electric vehicles and decarbonized buildings with existing technologies.

Clean and efficient electrification is playing a very big role. NRDC came up with numbers separately, but they are very similar to EPRI's. We see ourselves needing to go from the twenty percent of the U.S. economy that is electrified today to about forty-five percent in 2050.

We see ourselves needing to go from the twenty percent of the U.S. economy that is electrified today to about forty-five percent.

Whether that number is precisely forty-five percent or something in between, it is clear we will need a significant increase. This means we need to modernize the grid. The electric industry will be very important in that transformation.

PUF's Steve Mitnick: Is it possible to move from twenty percent to forty-five percent?

Sheryl Carter: It is very achievable, but it is going to require a lot of work and a lot of support from policymakers going forward. We are looking at the regional, state and local levels for that support.

PUF's Steve Mitnick: It sounds like other leaders, regulators, and maybe the public need to be involved. What is their role?

Sheryl Carter: Making a transformation of this magnitude is going to require a lot of infrastructure change.

We could do it with technologies that are mostly commercialized today, but their performance and costs need continued improvement. But we don't see any real barriers on the technology side.

The industry is changing quite a bit now anyway, but for it to go in this direction, we need policies that are supportive. For example, when we look at electrifying buildings, the first thing we are looking at is leveling the playing field.

Right now, electric technologies are

at a little bit of a disadvantage in building codes, which tend to favor natural gas. When they were put into place ten to twenty years ago, the electric technologies weren't as efficient, and electricity wasn't as clean.

We need fuel-neutral comparisons of technologies, when it comes to energy efficiency programs and building codes and standards.

In terms of electric vehicles, charging infrastructure is one of the biggest road blocks right now. That is something that electric utilities can facilitate and help invest in, to accelerate the market for electric vehicles.

PUF's Steve Mitnick: Are you saying there are some policies, zoning and building standards that are biased against electrification?

Sheryl Carter: In some cases, yes. I don't think a lot of policy makers and a lot of people out there are aware of how much these technologies have changed.

The end uses for electricity overall have become much more efficient. Technologies such as electric heat pumps and electric vehicles are commercially available and becoming much more affordable.

The other thing is, the grid is getting cleaner and is on a trajectory to becoming even more so.

PUF's Steve Mitnick: What can EPRI do, and what can NRDC do to push this along and maybe even accelerate it?

Sheryl Carter: We are working to make sure that what the policymakers support is the cleanest, most efficient and cost-effective alternative. That is essential for us.

We are also working with utilities. Technologies that emit fewer pollutants, including greenhouse gases, and that are much more efficient, mean the customers are going to use less energy and pay less.

Working with utilities, EPRI can continue doing what they do best, which is research, development, and demonstration of these technologies. There are certain technologies that need even more work, like heat pumps for space heating.

Electric passenger vehicles are the big focus. But even though the total emissions are less, trucks and buses have a lot of potential as well.

PUF's Steve Mitnick: All this wouldn't be possible, if we hadn't made major strides in energy efficiency in recent years. Isn't that a big part of the equation?

Sheryl Carter: It's huge. When I first started working in the energy sector, more than twenty-five years ago, we in the environmental community weren't too keen on electrification. That was because it was much less efficient and dirtier than natural gas end uses, for example. That is what has changed over the last couple of decades.

PUF's Steve Mitnick: What are the big impact areas of electrification that you really pay attention to?

Sheryl Carter: In the building sector, I would say heat pumps are the biggest piece. About ninety percent of the thermal uses in buildings can be replaced with heat pumps.

That's a big one for buildings, both residential and commercial buildings. On the transportation side, electric vehicles, passenger vehicles are the big focus. But I really think, even though the total emissions are less, the freight area and trucks and buses have a lot of potential as well.

One reason we should really be looking at that goes beyond just reducing greenhouse gas emissions. They can make a big difference in disadvantaged communities by reducing diesel fuel use and the local air emissions that cause serious health problems.

PUF's Steve Mitnick: People like me may think, "Okay, electric cars, that's doable." But those long-haul trucks, they are so big, you could never have them running off batteries.

Sheryl Carter: Long-haul trucking is much harder to tackle. We are probably looking at some other kind of renewable fuel: sustainable biomass or synthetic fuels made from renewables. But ports offer a good example of where heavy-duty transport can be electrified – a confined area, with short distances.

Europe is looking at putting infrastructure along frequently traveled highways that freight companies can use to run electrified trucks. That is probably a little further out and still limited.

PUF's Steve Mitnick: Let's look out into the future. How about 2030? Are we going to have some discernible progress by 2030?

Sheryl Carter: Because the technologies are here today, certainly for passenger vehicles and for the heat pumps in buildings, we are going to see a lot of progress. The one challenging thing, other than the policy, is infrastructure. Charging infrastructure for electric vehicles is a key challenge.

But also, making sure we don't build too much new natural gas infrastructure, for example, where we might create stranded investments. Planning is going to be important. What kind of a transformation do we want to see and how are we going to manage it? Those are the big questions. ❖

Bill Spence

CEO, PPL

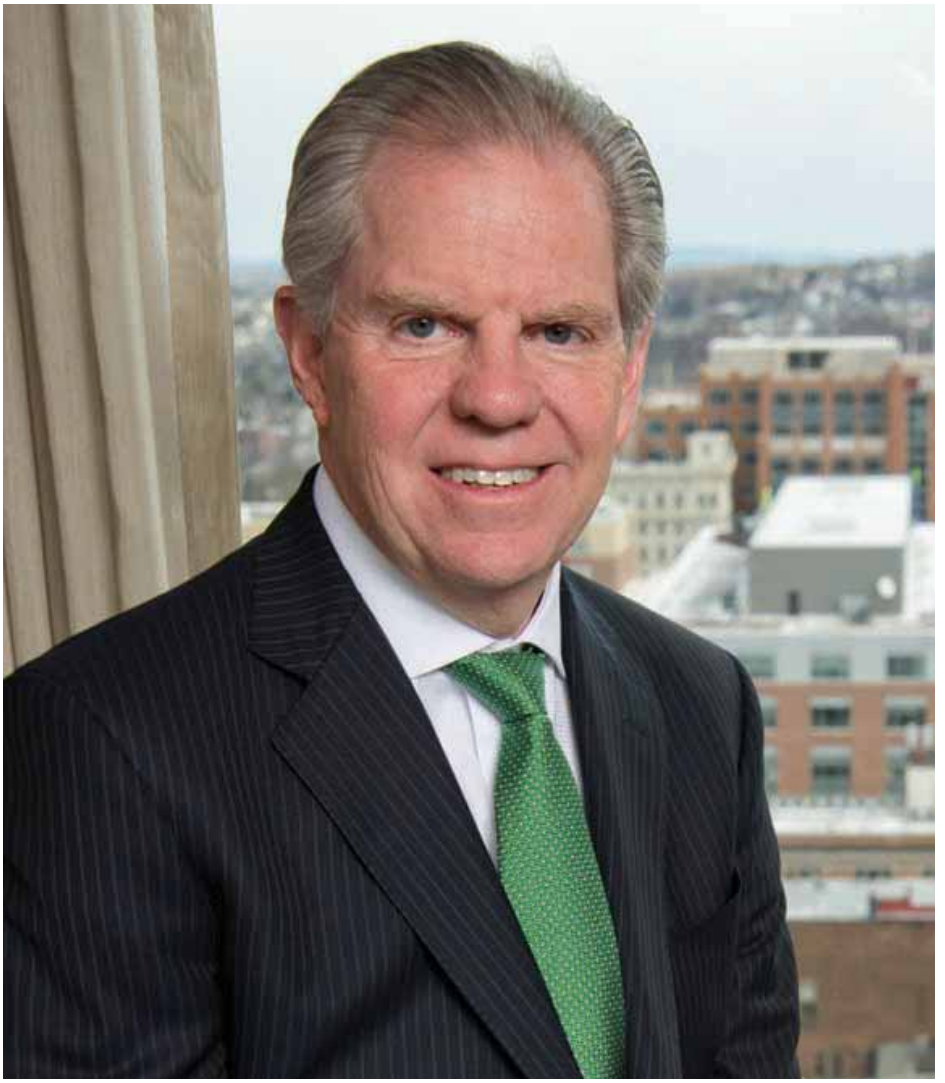
PUF's Steve Mitnick: I want to get your take on EPRI's Efficient Electrification initiative. How are you involved in this initiative and with EPRI?

Bill Spence: PPL has been involved in several of EPRI's research projects, including projects focused on electrification, end-use efficiency and evaluating the potential for electrification in PPL's service territories. I have also been serving on the EPRI Board for several years and I'm a member of its task force on efficient electrification.

Overall, we believe the opportunities for efficient electrification are significant and growing. I think what's really driving this are advances in technology. That's enabling many of these opportunities to become cost efficient and very effective.

PUF's Steve Mitnick: Will it be a real game changer?

Bill Spence: It could be a real game changer. The key to how rapidly change comes is how quickly the technology continues to evolve and how well customers adapt to and adopt these new technologies.



Overall, electric vehicles hold the most promise in terms of future electric sales in both the U.K. and the U.S.

I'll give you three examples. PPL is currently focused on three specific areas that we believe hold promise for our customers. The first is commercial food service equipment. These are relatively small items but could be of significant benefit for our customers. These include things like electric fryers, griddles and combination ovens.

The second area is commercial and industrial electric forklifts. The Lehigh Valley region of Pennsylvania, where we have our headquarters, is a significant logistics and transportation hub because of its proximity to major population centers like New York and Philadelphia. Whether it's FedEx, Amazon or others that operate these large warehouses, they can use electric forklifts to great advantage.

The third area is commercial next-generation rooftop heat pumps that could also benefit warehouses, and others such as restaurants and standalone retail businesses.

PUF's Steve Mitnick: Why are those electric technologies and others so good for customers? What are some of their promising advantages?

Bill Spence: Electrification offers potential economic and environmental benefits. This includes the potential for greater energy efficiency, reduced costs to customers, lower emissions from customer activities, and job creation as new products and technology are developed and deployed.

The benefits can extend to other less

obvious areas, as well. These include saving water. For example, applying efficient electrification to agriculture, farmers could see water use drop by sixty to eighty percent.

PUF's Steve Mitnick: As these things progress and get accepted and have an impact, do you see an effect on the role of the utility?

Bill Spence: I do believe the role of the utility will change over time. If these electrification technologies are adopted, that could take many forms. As we focus on advancing a cleaner energy future, utilities can play an important role in advancing these technologies and communicating the benefits to customers.

PUF's Steve Mitnick: What's the time frame?

Bill Spence: Many of the opportunities are happening now and are growing rapidly. I believe the industry will be communicating a lot of the benefits and the technologies in a much more meaningful way than we have in the past.

In other words, we are going to promote these technologies and these business opportunities in a very direct way to customers. For example, you may be aware that EPRI is going to be hosting an electrification conference in California next year. While EPRI is not in the business of promoting any particular fuel or technology, they will be sharing the research aspects of electrification.

Utilities are hoping to bring thousands of customers together to show them what's new and exciting as it relates to efficient electrification.

Utilities are hoping to bring thousands of customers together to show them what's new and exciting as it relates to efficient electrification.

I think this is probably going to be just the start of our industry's efforts to get the word out on how these technologies are evolving and how they can benefit consumers.

PUF's Steve Mitnick: Where is this ultimately going?

Bill Spence: I think you're going to see a very meaningful component of our electricity sales being driven by this electrification initiative, especially beyond 2025.

I'll say it's an initiative, but it's really a trend. That trend is going to accelerate as adoption rates climb. You're also going to see a lot more investment by industry, as well as private equity, in some of these technologies. I expect to see the cost come down significantly as we get to scale.

I see this trend happening as it has with battery, wind and solar technologies. Those technologies began fairly modestly, but are now mainstream components of the electric grid.

PUF's Steve Mitnick: What about your companies in the United Kingdom?

Bill Spence: Our four electric distribution companies in the U.K. are currently piloting a project called Electric Nation. It's the largest electric vehicle charging pilot in the U.K. We're testing various charging methods to better understand customer behavior and vehicle use, and the impacts to the distribution network of charging a diverse range of electric vehicles at home. Overall, electric vehicles hold the most promise in terms of future electric sales in both the U.K. and the U.S. ❖

Electricity Beats Fire

We rarely notice the burning fires about us, in our homes, vehicles, workplaces and other buildings. Twentieth century technology successfully isolated, from us, the combustion that heats our spaces, cooks our food, propels our cars and trucks, and animates our industrial processes.

But burning fossil fuels, hidden or not, has inherent disadvantages nonetheless. Combustion emits. It is relatively slow to turn on and turn off. It is not that controllable and difficult to direct. And it generally heats a volume of air to do its work for us.

Heating a volume of air gets the job done but generally indirectly. The heated volume of air helps us cook, bend metal, and push a mechanism with its pressure. Sometimes combustion heats a volume of water to do its job.

Twenty-first century technology is electric, electronic and digital. In contrast to combustion, twenty-first century electricity is remarkably controllable. Its energy is precisely applied to the job with little loss to the surrounding environment.

In the future, there will be far fewer burning fires about us in our buildings and vehicles. It's inevitable, because electricity beats fire in many dimensions. That future is fast approaching.

Mark Bonsall

CEO, SALT RIVER PROJECT, AND HANK COURTRIGHT, EXECUTIVE ENGINEER

PUF's Steve Mitnick: Mark, what's your take on EPRI's initiative, this Efficient Electrification initiative? And how do you fit in with EPRI?

Mark Bonsall: SRP was a founding member of EPRI at their formation in 1973 and has been a full member of EPRI since its beginning. We've had a significant involvement with EPRI's R&D program over the decades. I currently serve on the board of EPRI and have been on the board for several years.

The Efficient Electrification initiative is a continuation of work that EPRI has been doing for several years as the whole industry works to decarbonize the economy.

Economy wide, if your objective is decarbonizing by X percent by Y year, then you can change X and Y in a number of different ways. One option is by electrifying customer applications that result in a net decrease of carbon emissions.

EPRI's mission is to focus on factual analysis. It poses the questions about where electrification could occur, identifies possible directions and options and analyzes the impact of those options. Given that factual background, utilities can then work with their customers to identify potential applications and jointly work on the best path forward for that customer or group of customers. That is what the Efficient Electrification initiative is about.

A good example is the number of major airports looking to change out the airport 'tugs' that move the baggage and push planes, from diesel driven to electric driven.

Hank Courtright: A key question in the debate on carbon reductions is how can we reduce carbon in the overall economy? We can do it through electricity. This is especially true as the electric generation portfolio becomes decarbonized, as we utilize existing nuclear power along with more wind, more solar, and a migration from coal generation to gas generation. As the generation portfolio gets cleaner, it enables carbon reduction in other parts of the economy.

PUF's Steve Mitnick: This initiative in electrification, can it make a big difference? Are we going to see, say over the next ten years, a big change or a very gradual change?

Mark Bonsall: It may be spread over that time frame. However, things are happening now throughout the economy. One of the most evident places right now is the transportation sector. You're seeing many of the major auto companies, here in the U.S. and in Europe and Asia, moving towards electric vehicles as a way to decarbonize the auto fleet. That will take time, actually decades, as that phases in.

Today, many utilities are working with major customers to reduce their carbon footprint by looking at industrial and commercial processes. In some cases, those processes could be done through electrification versus a natural gas use or even some type of oil use.

A good example is the number of major airports looking at how to modify or change out the airport "tugs" that move the baggage and push planes, from being diesel driven to being electric driven. That also helps with the local air quality issues where those airports are located.

It will be a gradual transition. I don't think you're going to see a huge bulk of it in any particular timeframe, but just a gradual trend towards more electric use and less fossil use.

PUF's Steve Mitnick: There's going to be a big conference next summer in Long Beach. What's EPRI's role and what is the utilities' role going to be?

Hank Courtright: There are a couple key roles for EPRI. Probably the most important role is to provide thought leadership coupled with factual analysis. It is important to work with the electricity industry, regulators and legislators across the country to develop a better understanding about the value and impacts of moving from fossil fuel-driven applications to electric applications.

Another key role EPRI will have is providing information to individual utilities so those utilities can better work with their customers on electric applications. EPRI also serves as an information clearinghouse, as utilities share information with each other based on successful customer applications.

It's a joint effort between EPRI and the electric industry to share data, share expertise, and work with each other to enable Efficient Electrification to be applied this across the country.

Mark Bonsall: This will take some time and a concerted effort. To me, the profound importance of the work is the analysis that goes into it.

For example, it is critical to understand how the use of electricity for transportation purposes has a larger benefit in reducing carbon from gasoline use than the corresponding increase in carbon from the electric generation needed to power those cars and other vehicles.

I don't think the focus on emissions and carbon management is going to go away, as many utilities (SRP was the first) have established sustainability objectives.

That's the premise. One of the challenges that poses is, how do you measure all of this?

Our production of electricity may go up, but the aggregate amount of emissions goes down. How do you measure and account for all of that? Those are the type of questions being addressed by EPRI's analysis.

EPRI is holding lots of industry and stakeholder meetings in the process of answering those questions. And the Electrification Conference in 2018 will be an important event to discuss the analysis developed and the pathways for future electrification. Is that fair to say, Hank?

Hank Courtright: I think that's accurate, Mark. EPRI is providing that analysis not only at a national level, but we'll be helping to do similar analysis at a state level, and an individual utility level, too. As we build the databases around the country, we'll have a better indication of how to measure and document the emission reductions.

PUF's Steve Mitnick: What are the main barriers as you see them?

Hank Courtright: The primary barrier is lack of information. As more people get to understand some of the benefits of going to electric vehicles or electrifying certain business processes, it tends to sell itself.

Mark Bonsall: The concept of generating more electricity, nonetheless, seems to run counter to a belief that it would lead to lower overall emissions. That point needs to get across.

That's one of the barriers. Although, I don't think that's huge because it's so obvious in relation to the electrification of transportation.

PUF's Steve Mitnick: Are you going to Long Beach for this mega-conference on electrification next August?

Mark Bonsall: SRP is a platinum sponsor of the conference. We think it's a very important way to get the conversation going, develop a broader consensus and get more people working on the basic ideas. Yes, we absolutely will be there.

We are a sponsor of the work. I think it's very exciting work. To be quite honest with you, it is terribly important work. I don't think the focus on emissions management or carbon is going to go away, as many utilities (SRP was the first) have established long-term corporate sustainability objectives. This is a long-term issue, and it requires some long-term thinking and application of sweat equity. I think it's a good way to get it started.

Hank Courtright: We expect attendance at the conference to include several of our customers who want to learn more about electrification, representatives of the environmental community to help build a broader understanding of the positive benefits of electrification and representatives of the supplier community who provide the products, vehicles and services to the marketplace. It should be an exciting event. ❖

Join us in Charm City!

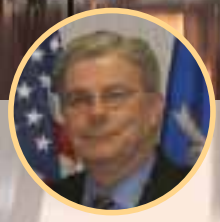
Baltimore is the host city for the 129th Annual Meeting and Education Conference!

Infrastructure, Innovation, and Investment
Driving the Future of Regulation

November 12–15, 2017 • Hilton Baltimore

We know that energy and utility matters affect everyone, every day.

NARUC convenes engaged stakeholders, informed experts, and dedicated state regulators for robust, timely discussions of energy policy, telecommunications, and other utility topics.



John Betkoski III will be formally installed as the NARUC President.

#NARUCAnnual17

Register at naruc.org/annual-meeting/2017-annual-meeting/.

NARUC's Task Force on Innovation Presents

The 2017 Innovation Awards

Who are the best and brightest innovators?

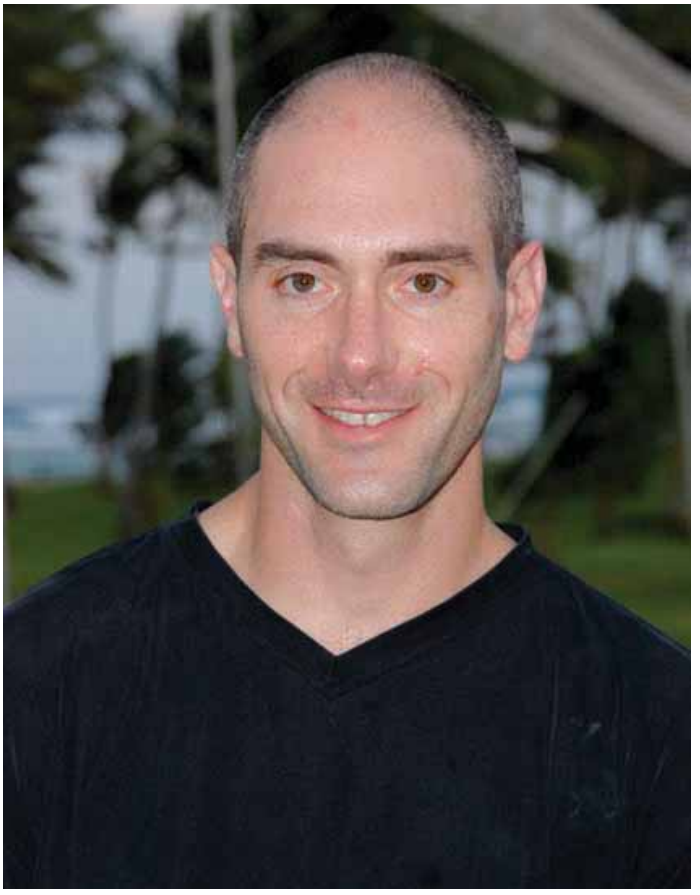
Join us to recognize the winners at the Installation Luncheon on November 14, 2017.

Electrification in Action

Efficient electrifying is much more than an initiative with growing support and momentum. Look around you. It's happening. Public Utilities Fortnightly looked around and here on the following pages is what we saw.

When we stepped into the AeroFarms facility in Newark, New Jersey, it was like stepping onto the Starship Enterprise. Truly amazing. A super-high-tech farm, growing massive amounts of beautiful greens, all indoors in a strictly-controlled environment. Busily working were AeroFarms scientists and engineers testing and learning how to grow your salad so it's tastier, healthier, cheaper and better for the environment.

When we stepped into Georgia Power's Customer Resource Center, it was like joining the cast of the classic television series The Jetsons. The home of the future and the workplace of the future especially were right there for us to see, touch and try out. Only, all this electric-powered equipment is on the market today, and it typically has huge advantages over the equipment commonly in use that is fossil fuel-powered.



David Rosenberg

CEO, AEROFARMS

PUF's Steve Mitnick: Why is indoor vertical farming a big game changer for society and the electric industry?

David Rosenberg: It helps illustrate some of the innovation that needs to come together to solve big problems. How are we going to feed our planet with its growing population? By the U.N.'s estimate, we need fifty percent more food by 2050.

Seventy percent of our fresh water goes to agriculture. Seventy percent of our fresh water contamination comes from agriculture. Additionally, the world lost thirty percent of its arable land, that is, farm land, in the last forty years.

We need new ways to feed our planet and indoor vertical farming allows us to, essentially, do more with less. Also, the cost structure of indoor vertical farming is going the right way.

The biggest part of the cost is the lights. The LEDs are becoming more efficient. The capital cost and the energy costs are being reduced.

PUF's Steve Mitnick: Can indoor vertical farming have a big impact as far as its costs, and its acceptance by consumers?

David Rosenberg: It can have a big impact, and it really needs to. We need lots of ways to solve problems, but this is going to be one of them. There is less and less land. Less and less water. More and more pollution. More and more contaminants in our soil. More and more people. Those are big problems out there.

PUF's Steve Mitnick: I am astonished at the scale and technical sophistication of AeroFarms. How do you see your company pioneering this revolution?

David Rosenberg: We have been doing this since 2004. It is not easy, and the scale is a big part. That signals how we've evolved past where a lot of the competition is. There's a big difference between growing small systems and growing big systems. There's scaling biological processes. New problems emerge, and we're just further down that path of solving a lot of these complex problems.

PUF's Steve Mitnick: What do you do there? What are you growing, and how are you growing it?

David Rosenberg: We're predominately focused on leafy green vegetables. We're growing kale, arugula, watercress, mustard greens, Asian greens, and lettuces. We're growing them in a warehouse, as opposed to a greenhouse or the field. There's zero sun, zero soil. Instead of soil, we have a patented cloth growth media. Instead of sun we have a series of LED lights.

We are figuring out what the plant wants when it grows in its optimal setting outside, and working to mimic those conditions inside. Figuring out, not only what are the right seeds for these conditions, but also what's the right amount of light, intensity, frequency, nutrients, temperature, humidity, and carbon dioxide. All of these are different aspects that stress the plants, and help drive optimal plant production.

PUF's Steve Mitnick: Does an AeroFarms salad taste pretty good?

David Rosenberg: I used to think that we were a supply chain play and that's our competitive advantage. As it turns out, we can also compete on taste and textures. We've gotten good at understanding how to grow these plants, giving them what they want, and therefore, positively impacting their taste, texture,

and nutritional value. It's a better experience for the customer.

PUF's Steve Mitnick: Your power bill and managing the power, isn't that a big part of your cost structure and operation?

David Rosenberg: It is. The biggest part of our cost structure is energy. We've got to be smart about energy. Being smart means two things; one is design. Whether designing the right light, right luminaire, right climate controls, or the right pump. Next is operations.

That's the one that is meaningful for your readers. It means great relations with the energy providers and this is tied into the design. There are better places to put these farms, where there's more capacity from an energy standpoint. Also, there are better ways to integrate the grid with the energy producers.

PUF's Steve Mitnick: You use very large amounts of energy, which means where you locate, which utility, and, also whether you're near a substation that can handle you or not. That's really important.

David Rosenberg: Absolutely.

PUF's Steve Mitnick: You're producing for supermarkets in pretty big numbers. What's holding you back from going even faster and growing more?

David Rosenberg: Two things. While we're the leader, there's still more to prove out. We just built our 9th indoor vertical farm that is largest in the world. We're still integrating elements of automation. That reduces the labor components of our cost structure.

Now coming out of Q4 2017 and Q1 of 2018, we will have more pieces of the puzzle to inform future debt financing to build more farms. Financing strategies are also part of the pioneering work at AeroFarms.

It's expensive and we need capital suppliers that are willing to take on more risks than they might with tried and true systems. They need to appreciate the environmental and societal benefits and have a willingness to do a hard deal, as things get proven out in both the project finances and debt in that group.

It's the data science that really pulls it together. Engineering needs horticulture, and the bridge is the data science and these programmers.

Proving it out further and the right capital partners are really two things tied in together. We have a pipeline of projects. It's putting the capital together in different pieces, and it's still coming together in pieces, not as elegantly as if we had X number of years of proving out the business model.

PUF's Steve Mitnick: You were telling me about how sophisticated some of your staff is, using some pretty advanced technologies, automation, and machine learning. Talk about that a little bit.

David Rosenberg: What I'm most proud of is our people. We have a hundred and twenty people, of which about half have a technical background. Here, for example, we have mechanical engineers, structural engineers, lightning engineers, electrical engineers, PLC engineers, and system engineers.

On the plant and science side, we have plant scientists, plant biologists, plant physiologists, plant pathologists, microbiologists, and nutritionists. It's the data science that really pulls it together. Engineering needs horticulture, and the bridge is the data science and these programmers.

PUF's Steve Mitnick: What can my industry do if they want to promote this?

David Rosenberg: A few things come to mind. One, we are aware of all the complexity around changing an industry, and changing the world. We're going to get there faster, working in partnerships with different industries. The energy is, absolutely, one way.

There's room for collaboration in terms of how we can better draw down energy from the grid, how we can better set up our own energy sources, and whatever that right combination is. There are ways to optimally pro-locate, and explore if there are opportunities in being more energy efficient in some of the features of a farm. Whether that's our environmental controls, or specific lights, pumps, things of that nature.

There's a tremendous amount of research and development. For example, we could lower our energy just by understanding what optimizes photosynthesis. What spectrum, what intensity, what frequencies, could have significant impact. There's a lot of innovation collaboration potential.

Then beyond that, it's easier when we go in to build a facility if the infrastructure of an existing city is up to date. There are too many antiquated infrastructure grid systems in cities. We looked at projects where one of the challenges in cities is upgrading a transformer.

Not only is there a capital expense when you upgrade a transformer, but also in a lot of poorer cities the infrastructure just isn't there. It's not only upgrading it, but it's knowing when the work is going to be completed. Even if we pay for it, or help pay for it, understanding when the work is going to be completed is critical. It's hard to go into a project with those unknowns.

Then, sometimes, it's hard to navigate each of the providers to get answers. What's the capacity of a transformer, or what part of the grid it is, and when it would be upgraded, and what an assessment is and who's

going to pay for it. Sometimes, what sounds like a simple question is hard to get simple answers to.

The other piece, are there incentives in place that encourage innovative companies that have a positive environmental footprint? Incentives work. Incentives help get projects moving faster and they help policy makers encourage the kind of projects they want.

PUF's Steve Mitnick: Your senior team includes some people with real energy experience. What professional background did you come from, and why you are doing this? Why did you create and grow AeroFarms?

David Rosenberg: For me it was water. Before AeroFarms, I built a nanotechnology company that was involved in water proofing and corrosion control. I learned how much water gets wasted in agriculture and how much water pollution comes from agriculture.

It's easier to build a facility if the infrastructure of an existing city is up to date. There are too many antiquated infrastructure grid systems in cities.

Inspired by that, I wanted to build a company that had a positive impact on water. From there, I realized I wanted to focus on agriculture. Then, I liked the plan of local food production.

I focused on leafy greens because of high rates of spoilage. Fifty percent of all food that comes from a farm in this category doesn't get eaten. They also have high rates of contamination. Eleven percent of food contamination is in leafy greens. They get infected with listeria, salmonella, and e-coli.

It's some of the most nutritional food we have in the world. For a confluence of reasons, we decided to focus here. We're also trying to make the business plan as good for shareholders, as well as have a positive and social impact.

Here we're helping alleviate a food desert, we have a model that helps educate kids, and we get them to eat more leafy greens. Most importantly, we're inspiring people with our innovation. ❖

We are thankful that many customers have seen the benefits of electrification. More than fifty percent have all-electric heating, cooling, and water heating.

Kenny Coleman

SENIOR VICE PRESIDENT, MARKETING, GEORGIA POWER

PUF's Steve Mitnick: Tell me what the CRC is.

Kenny Coleman: This is our Georgia Power Customer Resource Center. We opened this place in 2014 to use as a demonstration showcase for electric end-use technologies. We're able to demonstrate everything here, from end-uses like cooking, heating, and water heating, to many of the electro technologies that are available to customers in those fields.

Through our manufacturing applications process, we are demonstrating things like infrared heating and paint coating applications. We've had seventy-five hundred customers come through our doors in just three years, and have been excited to have this as a place for our customers to come.

PUF's Steve Mitnick: What's so good about these electro technologies?

Kenny Coleman: We think electrification provides a lot of benefits to customers. One of the things that we at Georgia Power have been very specific about, is we want to do what's right for the customer. If you do what's right for the customer, things will turn out right for the company.

What we found with some customers is they come in and they're able to demonstrate their products with our equipment. They're able to find out in real terms, does this work for my product? Can I take it back to my application at my home or office?

In many cases, it saved them some significant dollars. Schools came in, and they were redoing their kitchens and cafeterias. They were looking at natural gas alternatives, and electric end-use alternatives, and could come in and visit the CRC to compare different electric equipment. As a result, those school cafeteria kitchens are now all-electric.

PUF's Steve Mitnick: The companies bring in their products, like food or equipment, and try it out?

Kenny Coleman: We had a customer come in who bakes pizzas for a living, and we let them come in and use our cooking equipment to cook their product. They baked sixty or seventy pizzas, and now the pizza ovens in their facility are all-electric. They will tout energy savings, less heat in the kitchens, consistent quality and a better environment for their cooks to work in.

PUF's Steve Mitnick: This Customer Resource Center is unusual. I don't know how many other utilities have one. Is this a good way to get the message across?

Kenny Coleman: Oh, no question. In addition to customers coming in to see the benefits of electrification, we also use it as a training facility for many of our reps. We've got sales reps who are out working with builders, developers, and industrial customers, trying to help make sure we are in a place where we can create value for their operations.

Hopefully they expand in Georgia, add more employees, and use more energy. We use this as a place where they can come in, get early indications about both the benefits and challenges of certain technologies, and then take that knowledge back to customers.

PUF's Steve Mitnick: How does this work?

Kenny Coleman: We've got partnerships with many of the vendors across Georgia. If the customer is interested, we can connect them to a vendor partner who manufactures, and in some cases, installs and maintains the equipment.

Or, they can choose their own vendor. For us, it's not really a vendor selection process. It's more of an awareness. Hopefully we encourage some zealots to go out there and champion electrification.

PUF's Steve Mitnick: Is Georgia electrifying faster than other states? What's the reaction out there?

Kenny Coleman: We are thankful that many customers have seen the benefits of electrification. We've got electric end-uses in the residential customer space. More than fifty percent of those customers have all-electric heating, cooling, and even water heating in some cases.

We've embarked on this effort. It's been a couple of decades of work. We have high saturation rates of electric end-uses, particularly in our residential space, and we continue to work and grow in the commercial and industrial space.

PUF's Steve Mitnick: Why is electrifying further a good thing? Why the push to electrify more?

Kenny Coleman: We believe that every kilowatt-hour now being produced is cleaner than in the past – we're focused on that aspect, as well as making sure that the energy we produce is reliable and affordable as well. Our customers are watching the continued transition of our fleet toward more natural gas and renewables in the generation fleet, while also expecting low energy costs and high reliability. More electric end uses mean more demand for electricity, which equals further opportunity to diversify our fuel mix with more low and no-emission sources.

Whether it's the end-uses we were talking about here, or electrifying transportation. We have continued to work with many of our vendor partners across Georgia. Georgia has over twenty-six thousand electric vehicles, now registered in Georgia.

As recently as 2015, we were the second fastest growing state, next to California. We think that electrifying transportation not only saves customers money, but the operation and maintenance costs in owning electric vehicles now has a value proposition: it costs less to maintain them than cars with internal combustion engines. Customers get benefits from the value proposition, and there are environmental benefits as well.

Georgia has over twenty-six thousand electric vehicles. At one time, we were the second fastest-growing state, next to California.

PUF's Steve Mitnick: What is your role in the company?

Kenny Coleman: I'm thankful to be the senior vice president of marketing. I get a chance to work with the great folks here at the CRC who work with customers every day on electric end-use. We've got a team of people working with our customers across the state to do just that. Our team also runs our energy efficiency program, which is also one of the most successful in the country.

This year we have launched ten new programs across our residential and commercial classes of customers. We work with those folks, and our electric transportation teams. We also work with our renewables team, which operates the largest voluntary renewables portfolio of any utility in the country. By year-end 2021, we'll have nearly three thousand megawatts of renewable generation online, procured both through purchase power agreements and self-built.

I get a chance to work with our renewable team. I also work with our pricing and planning team who does our long-range energy planning, our rates, design and administration, and our forecasting, among other things.

PUF's Steve Mitnick: Take me through what marketing means at Georgia Power.

Kenny Coleman: You'll hear our Southern Company CEO, Tom Fanning, and our CEO in Georgia, Paul Bowers, talk about our customer-centric business

(Cont. on page 56)

At EPRI Labs

Conversations with EPRI Scientists in Charlotte and Knoxville

What is Efficient Electrification? I mean, what is the term supposed to signify, and what actions is it intended to spur? To answer these questions, I asked the pioneers of electrifying efficiently, what's up? I had eleven of EPRI's top scientists explain for me – in plain English – about Efficient Electrification's advantages, achievements and aspirations.

It sure opened my eyes. The two E's promise to transform our economy and society. And the technologies are progressing at such a pace that we'll see the beneficial impacts as soon as the next few years.

Ron Domitrovic told me about the next-gen heat pump and its potential to heat most of the nation's homes and workplaces in the near future. Frank Sharp told me about indoor agriculture and the benefits for, well, the planet. Baskar Vairamohan told me about electrifying industrial process heating and its huge upside.

See what I what saw, talking with Ron, Frank, Baskar and the others. Excerpts of my conversations with these eleven pioneers follow on the next pages.

EPRI Chief Executive On Efficient Electrification

Combines CEO and DIY Roles

Electric Power Research Institute (EPRI) CEO Mike Howard is guiding the institute's broad initiative examining the potential gains in efficiency, economics, environmental impacts and customer value that can be realized through what EPRI has named "Efficient Electrification." In this interview with PUF Editor-in-Chief Steve Mitnick, Howard's hands-on experience with residential energy technologies sheds light on how they are assessed and adopted – why an Integrated Energy Network identifies efficient electrification as a significant outcome in the pathway to the future.

PUF's Steve Mitnick: Set the stage for us. What is Efficient Electrification?

Mike Howard: First, momentum is building to achieve unprecedented efficiency in every aspect of energy production, delivery and use. And as we move toward an integrated energy network we see all forms of energy are becoming more interdependent. Customers are increasingly more concerned with convenience, choice, and comfort rather than the form of energy. And we must bring a more concerted R&D effort to the various technologies and opportunities we see.

We can get to peak efficiency only if we're fundamentally agnostic about the energy source, and the technology. In a variety of scenarios EPRI sees opportunities to replace higher emitting and less efficient end-use energy sources with electricity – as it becomes cleaner and is combined with more efficient technologies. That is what is meant by "efficient electrification".

PUF's Steve Mitnick: So, seeing a growing role for electricity, EPRI has initiated an "Efficient Electrification initiative."

Mike Howard: Technology is driving us in that direction. Our Efficient Electrification initiative already encompasses industrial energy use, residential uses,

transportation and agriculture. But remember, the first word in the initiative is "efficient." Regardless of the energy source, its production, delivery and use must become more efficient – meaning using less of it to do the same work as before.

PUF's Steve Mitnick: I was interested to learn that you've taken a hands-on approach to some residential technologies that EPRI has researched and helped develop. You installed new heat pump technology that is prominent among the technologies your initiative has focused on. Tell us about that.

Mike Howard: I've always been a hands-on tinkerer. I grew up on a farm. If the horse broke the fence down, it was my job to go fix the fence. So, when my wife and I bought a house in the North Carolina mountains we dug into making it energy efficient.

EPRI sees opportunities to replace higher emitting, less efficient end-use energy sources as electricity becomes cleaner and combined with more efficient technologies.

We started with the basics; putting R70 insulation in the attic; sealing around canister lights, and sealing and insulating around doors and windows. Once the house was sealed, the next step was making our heating and cooling more efficient.

Advanced heat pumps have significant benefits over traditional heat pumps and gas furnaces, and are perfect for mountain conditions. With older heat pump technology, the colder mountain climate could be a challenge. Ron Domitrovic and his team in our Knoxville lab had tested the latest Carrier unit, called Greenspeed. It's an ultra-efficient heat pump system. I contacted the Carrier distributor in Asheville, and they told me this was so new, they had just gone to school to learn about it.

PUF's Steve Mitnick: As a consumer, what do you think of its performance?

Mike Howard: We've used it for almost a year now. The unit not only keeps the temperature steady, we can adjust the humidity for more comfort. I used to have to empty the basement dehumidifier every three days or so. Now I may empty it every couple of weeks.

You can't even hear it running. The comfort and convenience of the system is

Mike Howard's Energy Efficient Home

- R70 Insulation in attic and around door frames
- Sealing around light canisters, doors, windows
- HVAC: Next-generation, variable-speed heat pump (Carrier's Greenspeed system)
- Watch for static pressure in duct work when using advanced systems
- Equipment monitors indoor/outdoor temperature as an EPRI test facility
- Estimated energy savings at this location of $3,000 for the first year

significantly better than older models, and it automatically adjusts the fan speed to what's needed.

PUF's Steve Mitnick: So – bottom line – how do you see this technology as a consumer, a researcher and executive?

Mike Howard: It's much more efficient. In fact, heat pumps are 300% to 400% efficient because electricity is only used to circulate the refrigerant between copper coils to extract heat or cold from one place and move it to another. Thus I have both a heater and air conditioner in the same unit. One of our research teams uses it as one of their test facilities. They're monitoring outside and inside temperature, humidity, air speed and electric efficiency. The total energy savings was more than $3,000 for the first year.

As heat pump efficiency increases, they can extract heat from much colder air. That opens a much broader swath of the U.S. for heat pumps. Today, a heat pump with a natural gas furnace for emergency heat (replacing less efficient supplemental resistance heating) is often used in climates that face extreme cold.

So my experience – and EPRI's research – show how this and other electric technologies can improve efficiency, savings and comfort. We're continuing to quantify these benefits. Just as important, we're launching research to look more broadly at the implications for consumer markets, utility loads, environmental benefits and overall efficiency gains for the economy.

As heat pump efficiency increases, they can extract heat from much colder air, opening a much broader swath of the U.S. for heat pumps.

PUF's Steve Mitnick: What does that say about going all-electric?

Mike Howard: There are more contractors to help you do it. But to get to where you need to go from an efficiency and emissions reduction perspective, you have to tackle both space heating and cooling, plus water heating.

PUF's Steve Mitnick: What's the future for electric water heating?

Mike Howard: Heat pump water heating, which combines two familiar pieces of hardware – a heat pump and a tank of water – this is an efficient and cost effective option to consider for some residential applications.

PUF's Steve Mitnick: EPRI has focused research on heat pump water heating, and you have put it to work in your own house. Safe to say you made an informed choice. Why the switch?

Mike Howard: I installed the heat pump water heater to replace a propane water heater in our basement. This accomplished multiple things. It's more efficient and delivers 50 percent savings on the water heating share of the energy bill. The heat pump water heater takes heat out of the air and puts it into the water. Because the exhaust is drier, cooler air, this helped reduce the need for dehumidification in our basement.

PUF's Steve Mitnick: Is it practical? Ready for consumers now?

Mike Howard: Yes. And it's not that difficult to install. I ordered a GE GeoSpring from a local "big box" store, had it drop shipped to our basement and cut out the old water heater. Just a few copper tubing solderings, add a 240-volt connection, and away you go.

PUF's Steve Mitnick: You really are a do-it-yourself guy. And how has it gone?

Mike Howard: The costs have come down significantly, and I found other savings. In my case the North Carolina code had been updated, which could have required me to relocate the vent.

I didn't want to have to punch another hole through the wall, but with the heat pump I could use the existing pipe. And, the heat pump just vents cold air so I don't have to worry about carbon monoxide.

PUF's Steve Mitnick: It's generally agreed that natural gas still has a great future, but these technologies indicate that we may see a changing role.

Mike Howard: Natural gas and electricity combine very well. They can serve multiple purposes with versatile technologies and applications – from generation to end-use. Customers can chose different technologies based on their needs and the particular installation options or requirements. In EPRI's Efficient Electrification initiative we are researching applications that can drive greater energy efficiency overall.

PUF's Steve Mitnick: I looks like you're taking the "whole house approach" to efficiency, so it's about more than just "gas versus electric"?

Mike Howard: In one sense I started at the top – with the roof, the attic, the doors,

heating and cooling, and then the water heating, and just kind of worked my way down from there. I changed all the lighting to LED. Next, I wanted to control the lighting.

I went with Lutron to control the lighting. I just changed out the light switch itself with the new hardware. They make it easy to do. Now, I can control the lighting from my smart phone.

I can also control the HVAC system and I can even control my water heater. When we're not there, I lower the temperature of the water heater and lower the temperature of the heating or cooling on the heat pump, the HVAC system, and turn off the lights.

PUF's Steve Mitnick: This new level of control is a key to electrification's efficiency gains, isn't it.

Mike Howard: I'm also monitoring the amount of energy I'm using that is coming into my panel. When we're not in the house my goal is to get energy use down into watts, not kilowatts. In the winter we don't want our pipes to freeze, when we're away, and with precision and remote control we can do it more efficiently.

PUF's Steve Mitnick: Do you think you've overlooked anything?

Mike Howard: I'm a researcher who likes the do-it-yourself approach. There was a koi pond on the property. Nothing had been done for 10 years so I had to clean it up. It had a motor that pumped the water up the hill, about a 12-foot rise, then it flows back down and over a little waterfall.

It's a nice feature of the property, but I realized that was one of the bigger energy drains because the pump did not use an adjustable speed motor – it was either on or off. EPRI had just tested a variable speed pump, so I checked it out and installed it. I cut the koi pond's cost of energy in half. And yes, I can control the variable speed motor remotely from my phone, I can increase or decrease the flow or turn it off altogether.

PUF's Steve Mitnick: Is your house the house of the future?

Mike Howard: These technologies are available now. This is why it's important to draw much more attention to electrification across the board. I'm an engineer who likes to do a lot of the work myself. What I've done with this house just makes it clear that technologies are coming on the market that you can install in your own house, to make it much more efficient, improve your comfort and convenience, without spending a lot of money.

I want my example to make it easier for people to see the lower risk, the potential payback and the benefits for today's efficient technologies. And understand that this increasingly applies to industry, business, transportation and agriculture.

So it's not really about the house of the future, it's about customer value and comfort. Maybe we can call that the wave of the future. ❖

Allen Dennis

Electric Power Research Institute Senior Program Manager Allen Dennis talks about the payback of efficient electrification through customer productivity.

PUF's Steve Mitnick: How are you involved with efficient electrification at EPRI?

Allen Dennis: I manage EPRI's R&D program, Electrification for Customer Productivity. Our program evaluates the potential of residential, commercial, and industrial technologies to make end use customers more productive in their business or to provide more comfort and value at home. Residential technologies, such as next-generation heat pumps, and commercial and industrial technologies, such as electric forklifts, infrared and induction heating, are proliferating and expanding. Utilities need to know how these loads have the potential to benefit customers and society.

We work with thirty-six utilities, developing customized case studies for them and examining electrification technologies that show the most potential for their markets.

PUF's Steve Mitnick: What are the most interesting ways that we can electrify things we do with fossil fuel now?

Allen Dennis: There's a very good payback on airport transportation and forklifts. Another aspect of transportation is electric transport refrigeration units, also called eTRUs. Those are trailers that keep food frozen or refrigerated.

We're trying to bridge the electrification value chain by quantifying the potential benefits of electrified technologies for residential, commercial, and industrial customers, in specific markets.

Right now, those run on diesel. The two manufacturers of that equipment also make electric equipment that you can plug in. When the long-haul trailers or short-haul trucks are parked or docked, it's no longer necessary to keep the diesel engine running to refrigerate the food. The grid can do it more economically and cleanly.

PUF's Steve Mitnick: Are the technologies getting better and more cost-effective?

Allen Dennis: Yes. Our area primarily focuses on proven technologies that are commercially available in the market today. The vendors we work with are trying to sell these products every day. We also focus on future electrification technologies that may be in the pipeline.

PUF's Steve Mitnick: What is necessary to provide electrification a better footing in these new applications?

Allen Dennis: I think it takes all of us. Policymakers ask, "How do we set the right framework to get customers to put in these technologies?" Utilities ask, "How do we understand what the system impacts are?"

The environmental folks ask, "What are the benefits from these technologies with respect to emissions reductions?"

It's not any one player. EPRI and other organizations are working to bring all these folks together.

PUF's Steve Mitnick: Where do you focus your thinking and your work day-to-day?

Allen Dennis: We're trying to bridge the electrification value chain by quantifying the potential benefits of electrified technologies for residential, commercial, and industrial customers, in specific markets. Bringing data into sharp focus can help utilities and their customers realize the full potential of efficient electrification. ❖

Ron Domitrovic

Electric Power Research Institute Program Manager Ron Domitrovic explains why the next-generation heat pump can make electric heating and cooling much more efficient.

PUF's Steve Mitnick: Tell me what you do here at EPRI.

Ron Domitrovic: I manage the end-use energy efficiency and demand response group. My technical area includes heating and air conditioning.

PUF's Steve Mitnick: The American Community Survey for 2016 shows that electricity is now heating 38 percent of American homes. Are you saying that we've got some technologies coming down the road that will encourage electric heating?

Ron Domitrovic: Yes. Traditionally, heating has been fossil fuel, gas or bulk fuel, or in some cases, electric resistance.

In pockets in the South, heat pumps were used. Traditionally, heat pumps functioned somewhat like air conditioners turned in reverse. They couldn't necessarily serve the entire load and they weren't appropriate for colder latitudes.

Ten or so years ago, variable speed

and variable capacity air conditioning heat pumps were introduced. They enabled heat pumps to deliver a lot more heating capacity than they used to.

These heat pumps can be used in Ohio or in Pennsylvania or the Pacific Northwest, because they have the heating capacity to provide what used to be served by some other source.

PUF's Steve Mitnick: The breakthrough was variable speed?

Ron Domitrovic: Yes, the foundational breakthrough is the variable speed compressor.

PUF's Steve Mitnick: Is the modern heat pump as comfortable or efficient as these other forms of heating?

Ron Domitrovic: There are so many engineering choices that must be made when you design a system but in general, yes. A heat pump can be made much more efficient than other heating sources. It can be made to provide equal comfort.

Can you tweak a gas furnace to be a little different and a little more comfortable too? Certainly; but the heat pumps now are very competitive, whereas 10 to 15 years ago, they weren't.

PUF's Steve Mitnick: What's the potential – and the potential impact?

Ron Domitrovic: It depends a lot on policy. It depends on cost, capital cost of equipment, and contractors' familiarity with installation.

In 20 years, the technology could allow for the entirety of the U.S., with the exception of Alaska, to be heated with electricity.

PUF's Steve Mitnick: What kind of policies could stimulate this progress, or delay it?

Ron Domitrovic: If there were policies limiting greenhouse gases or affecting which technologies can be deployed relative to greenhouse gases, that would certainly affect it one way or another.

PUF's Steve Mitnick: What's your role in all this?

Ron Domitrovic: Over the past couple of years, I've managed the Next Generation Heat Pump project.

During this time, EPRI developed the Next Generation Heat Pump Specification to define what makes a unit "next generation." The specification defines the heating and cooling capacity and includes the requirement that the unit be able to perform demand response; something the manufacturers needed guidance for.

We helped the manufacturers understand demand response and how their air conditioners, their heat pumps, can be resources for that through a utility program. ❖

Mark Duvall

EPRI Director of Energy Utilization Mark Duvall explains how his group takes new end use technologies from the laboratory to demonstration as part of EPRI's efficient electrification R&D.

PUF's Steve Mitnick: How is your R&D group tackling efficient electrification?

Mark Duvall: Our R&D programs are focused on identifying promising electric technologies, those that provide customer and societal benefits, and then moving these technologies along a path of development toward commercial readiness. This includes working with manufacturers to develop promising new electric technologies, performing laboratory testing, and when ready, migrating them into pilot demonstration projects. The results of this work then guide the first commercial applications.

Plug-in electric vehicles are one example of this process. Several years before the Chevrolet Volt hit the market in late 2010, EPRI initiated long term battery testing that helped prove the durability of lithium-ion battery systems. We worked closely with a few automotive manufacturers on the development and real-world testing of PEV prototypes. When General Motors announced the development of the Volt in 2008, EPRI and a large utility collaborative worked closely with them on deployment issues. Everything from infrastructure standards to smart charging to customer education.

PUF's Steve Mitnick: Take an area that will have a big impact on society, and let's talk about what EPRI's been doing there.

Mark Duvall: I'll start with advanced energy communities: that is, zero net energy homes and buildings.

An advanced energy community is any building or collection of buildings that

have a highly efficient building envelope. That can mean smart appliances, home energy storage, thermal energy storage, distributed generation, rooftop solar, or electric vehicles in the garage.

PUF's Steve Mitnick: What's so great about using more electricity? Also, is this something that's very futuristic?

Mark Duvall: What is interesting is that our analysis has shown that an all-electric home is not more expensive to build and the monthly utility bills are also about the same. If the homeowner also switches to electric vehicles, then their monthly costs would be even lower.

In California, we're evaluating zero net energy communities in action: one in Fresno and one in Fontana. We worked with the home builders, equipment manufacturers and software companies to install and monitor how these communities are performing, and to ascertain total benefits for consumers. What we have learned is how closely connected efficiency and electrification are for ZNE homes. A very efficient building envelope reduces peak heating and cooling loads, lowering the cost of the rooftop solar system.

PUF's Steve Mitnick: I suppose this is what's required if we're ever going to establish residences as a grid asset.

What we have learned is how closely connected efficiency and electrification are for ZNE homes.

Mark Duvall: That's part of the R&D – how can these residential structures and customers both rely on and complement grid operations?

If a home is all electric, the peak demand is potentially higher, but you also have more to work with to provide flexibility. Connected appliances, smart inverters, electric vehicles, residential storage. An effective customer-centric system can make decisions on where load can be reduced with impacting the residents, ideally without them even noticing it. Now scale that up to an entire community with dozens of homes and hundreds of residents. Can it become a dependable and effective grid resource?

PUF's Steve Mitnick: Do you expect electric vehicles to become a major part of the equation?

Yes. We think someone will buy an electric car if it's cheaper and better than the car they have now. Our electric transportation R&D is examining many aspects of consumer adoption and the market. Prices continue to come down and manufacturers are introducing more options.

Long term, the market looks strong and will continue to grow. The main signal to look for, in that regard, is automaker investment. It's predominantly in electric powertrain technologies.

Another signal is that globally, countries and manufacturers are placing long-term bets on electric vehicles. Meeting long-term targets for greenhouse gas emissions like those in the Paris Agreement will require the participating countries to almost completely de-carbonize both light-duty and heavy-duty transportation fleets. ❖

Bill Gould

Electric Power Research Institute Director of Research and Development Bill Gould talks about the modeling and analysis efforts of EPRI's Efficient Electrification initiative.

PUF's Steve Mitnick: How do you figure into this efficient electrification initiative?

Bill Gould: My team is largely responsible for economy, energy and environmental modeling and analytics, at both national and state levels.

PUF's Steve Mitnick: The United States could appreciably increase the share of electricity as final energy, currently around twenty percent over the next few decades. You're modeling the effects on the environment, on energy costs, and on water costs?

Bill Gould: Yes, all the above. We don't prescribe a specific scenario. Our analyses are informed by a range of scenarios and associated assumptions, and our models apply the most economically efficient technologies based on those assumptions. Those can include fuel costs, potential policy implications or overlays, the development and implementation and market acceptance of end-use technologies, and the development and implementation of supply-side technologies. All those factors figure into the overall analysis.

PUF's Steve Mitnick: How do you quantify and model all this?

Bill Gould: Our continually updated and improved U.S. Regional Economy, Greenhouse Gas and Energy (US-REGEN) model is revolutionary in many ways, because it looks at economy-wide energy implications.

Not just in the electric sector, but in one consistent and comprehensive framework that economically models outcomes.

Regardless of the specific policy or technology analyses being considered, the use of our REGEN model has provided far-reaching insights to help inform our member and stakeholder communities in many ways.

PUFs Steve Mitnick: Who will use the model and how will they use it?

Bill Gould: Most recently we've used it to inform our members, and their stakeholders. Those include policymakers who want to know the implications of the Clean Power Plan, for example. We've also used it in a range of other scenarios, including increasing deployment and use of renewable technologies.

One particular strength is the model's ability to provide detail at the state level.

PUF's Steve Mitnick: Assuming certain carbon reduction goals are in place, can you determine, for example, that we must electrify to a certain extent?

If you embed electrified end-uses that replace fossil end-uses into the economy, the value of those grows over time.

Bill Gould: It comes to the same end, but not necessarily by solving for a particular carbon goal. The model can do that, but if you back up a step and model, quantify, and aggregate the vast potential benefits of electrification for society and for customers, our analysis suggests it is an economically efficient strategy for emissions reductions.

If you embed electrified end-uses that replace fossil end-uses into the economy, the value of those grows over time as you continue to decarbonize the electricity sector.

For example, every petroleum-based vehicle that comes into the economy is an emitter for its entire life, and its emissions probably increase over time. On the other hand, an electric vehicle brings more value over time.

Given the trajectory we're seeing for cleaner power production, an electric vehicle's overall emissions will decline over time. And our results demonstrate that the benefits go beyond GHG reduction, to include air quality benefits as well as cost-effective results for customers and society as a whole. This is all taken into account in the model capabilities.

We will see our modeling capabilities and methodology in action in our forthcoming National Assessment for Efficient Electrification, which will be released in the first quarter of 2018. ❖

There's 250 million small and medium-size computer server rooms in the U.S. That's a lot of data centers, twelve times as many as the number of fast food restaurants in America. While not nearly the size of enterprise, corporate and multi-tenant data centers and the high-performance and hyper-scale cloud computing facilities, the small and medium centers use as much energy collectively.

Arshad Mansoor

EPRI Senior Vice President Dr. Arshad Mansoor talks about the potential of efficient electrification.

PUF's Steve Mitnick: What is efficient electrification and why is it needed?

Arshad Mansoor: Efficient electrification is the use of more efficient electric systems to reduce emissions, improve productivity, reduce water consumption, enhance grid flexibility and improve worker health and safety.

Compare 1990 to today: the air quality emissions related to every kilowatt hour of electricity is eighty-five percent down. Less NO_X, SO_X, mercury.

If I look at carbon emissions, I find that from 2000 to 2017, we are almost twenty percent lower in the U.S., primarily due to the market dynamics of gas, wind, and solar.

Then I look at electricity productivity. How much work we can get from each unit of electricity used. From 2000 to 2017, electricity productivity has increased more than fifty percent.

But electricity, the energy form that has shown that level of improvement in reducing emissions, enhancing productivity, is still only twenty percent of our overall energy mix. We have the opportunity to provide customers and society the choice to increase that number to forty, even fifty percent.

PUF's Steve Mitnick: It's not just technology; public policies are also important.

Arshad Mansoor: Yes. A good example is energy efficiency. Energy efficiency has meant tremendous benefits for

You can't be building data centers and powering up renewables if you've got a diesel forklift truck inside your warehouse.

customers. The industry has led that push.

But energy efficiency in most states is not fuel neutral. That's where policy comes in. It means if I'm in New York or California, I can only do energy efficiency projects or technologies in the electricity sector, or only in the gas sector, or only in the petroleum sector. There is a policy gap: we must make energy efficiency fuel-neutral. Energy efficiency means how efficiently you use all forms of energy. It's not how efficiently you use electricity.

PUF's Steve Mitnick: What's great about a future in which forty percent of the work in America is done by electricity?

Arshad Mansoor: Less emissions. Enhanced productivity. Less waste use. Improved worker health and safety. Less energy use. Enhanced affordability and grid flexibility. That and more is what could be great if customers and society choose to increase the adoption of efficient electric systems based on a clear understanding of benefit and cost. That is what our research is doing. Provide solid science and data to understand the benefit and cost of today's efficient electric technologies and tomorrow's.

Reducing emissions is the goal for many companies like Apple, Amazon, Google etc. You can't be building data centers and powering up with renewables if you've got a diesel forklift truck inside your warehouse. Those are the clear choices customers will need to make to achieve their goals – whether it is productivity or emissions, energy or water use, or any combination thereof. It's great to have a clear choice.

PUF's Steve Mitnick: The biggest conference since the 1893 World's Fair, is the EPRI Long Beach conference next August on efficient electrification. What's great about that conference?

Arshad Mansoor: The 1893 World's Fair in Chicago was the dawn of electricity with electric lighting. Electrification 2018 will be the next step, where we bring in all the stakeholders – customers, technology providers, policy makers and regulators and energy companies – so that they can make a clear choice on accelerated adoption of efficient electric technologies that could lead to a future where half of the energy use in the country and the world is cleaner electricity. ❖

Because electric machines, appliances and devices have become much more energy-efficient, and because they promise to become even more so, a consensus has emerged to further electrify the economy. Still another achievement for energy efficiency. Perhaps as important as efficiency's achievement in keeping electric bills in check to the extent that electricity's never taken up a smaller percent of consumer expenditures. Electrification is a great initiative. But Efficient Electrification – the two E's – is a greater one.

Tom Reddoch

EPRI Senior Technical Executive Dr. Tom Reddoch talks about the efficiency of electrifying at the point of end use.

PUF's Steve Mitnick: Describe our progress in energy efficiency over the past 10 years.

Tom Reddoch: We've made enormous strides on multiple fronts. First, there's been innovation in diverse technologies.

Second, we see electric technologies being widely adopted. Today, when we look at how flat the growth of electric loads is, energy efficiency is probably the single largest underpinning effort.

We've wrung out many inefficiencies in the system. Some say, "Wow, with this lack of load growth, what will electric utilities do?" This suggests, going forward, that electricity is a great energy choice.

My answer to that is, "Actually, as we've made the use of electricity more efficient, it becomes an increasingly valuable asset."

PUF's Steve Mitnick: What if someone says, "We're probably about as efficient as we're going to be?"

Tom Reddoch: I don't buy that. When we set out to make lighting more efficient, we made the move to compact florescent lighting, or CFLs, which use about a quarter of the electricity that incandescents burn. And then along came LEDs. LEDs use about 15-20% of the amount of electricity of an incandescent bulb, for the same light. Moreover, LEDs have longer life, more color options, and they avoid the mercury that is associated with CFLs.

PUF's Steve Mitnick: Yet, in making lighting so much cheaper, and refrigeration so much cheaper, we see more uses for refrigeration and lighting.

Tom Reddoch: Without a doubt. Today, for all fixed lighting, whether we're talking about in a building or in a home, we wire infrastructure with twelve-gauge wire. When we had incandescent lighting, the wires had to support large current levels. Going forward, we will put in lighter gauge wire that may not even require an electrician to install.

PUF's Steve Mitnick: Sometimes if you say electrification, people say, "Oh, yeah, a Tesla, or a Prius." But you're working more broadly.

Tom Reddoch: We look at taking any end-use and powering it with electricity. Our lead technology for residential heating is the heat pump, for space and water. A lot of water is heated by burning natural gas or propane at the point of use. But we are looking to electrify more of that with heat pumps. A heat pump is much more efficient.

If I burn natural gas at the point of use, that is going to be about eighty-five percent efficient. But if I replace my gas furnace with a heat pump, that heat pump might be two hundred and fifty percent efficient.

For example, I take that natural gas from the water heater and use it to fuel a combined cycle power plant, with an efficiency of sixty percent. If I use that electricity to power a two-hundred and fifty percent efficient heat pump (COP=2.5), 250 times 0.60 is a net efficiency of one hundred fifty percent. That is still considerably more efficient than the eighty-five percent efficiency provided by the gas-burning water heater.

A lot of water is heated by natural gas or propane at the point of use. We are looking to electrify more of that with heat pumps.

From the customer perspective, the costs of operation for the electric heat pump and the gas water heaters, respectively, are about the same for typical fuel costs. However, the heat pump uses less energy and has a smaller impact on the environment.

It's what EPRI is pointing to with the Integrated Energy Network, which is to use all our energy resources in the most efficient way with the least impact on the environment. Integrated approaches can result in greater total efficiency. ❖

Tom Reddoch & Tom Geist

Electric Power Research Institute Senior Technical Executive Tom Reddoch and Principal Technical Leader Tom Geist discuss alternatives to using power at the U.S. standard of 60 Hz, and what it could mean for efficiency and electrification strategies.

PUF's Steve Mitnick: We're talking about powering devices with electricity, but not with the standard AC frequency of 60 Hz that comes from the plug. Why would we do that? What would Nikola Tesla and Thomas Edison say?

Tom Reddoch: The reason we look at these other options is that we want to get the best and most efficient delivery solution, which may not be at 60 Hz. It could be at 400 Hz, as is used in motor drive applications.

Tom Geist: The use of 60 Hz is

historical and not universal. In Europe, the standard is 50 Hz. While 60 Hz is traditionally used for producing and shipping electricity, it is not the best form of electricity for powering end-uses. In fact, most loads require DC and a significant amount of energy is lost converting AC power into DC power. Our research is focused on identifying the form of electricity, AC, DC, or other, that's best for various applications.

Tom Reddoch: Here's some examples of what we're focusing on. First, we're looking at more efficient ways of coupling energy into a process. For some situations, the best choice is DC. Tesla would likely not be excited about DC solutions, but Thomas Edison would be thrilled!

PUF's Steve Mitnick: How do you determine whether to use 1400 Hz, or 140 Hz: do you have to test?

Tom Reddoch: There's no universal answer, but testing and analysis is part of it. We need to examine each application, keeping in mind such things as efficiency, controllability, safety, and reliability to determine the best choice.

Often, the electricity format is determined by the physical parameters of the workpiece or process. We're also looking at new, emerging technologies with interesting potential, such as pulsed power for distribution of electricity in residential and commercial applications.

Tom Geist: Pulsed power is a confluence of digital control and powered electronics to enable the safe delivery of power at a high voltage (380 VDC) in applications ranging from 100W up to tens of kW. Here's how it works. The circuitry is arranged to supply a pulse of power at 380 volts DC for a millisecond (0.001 second). Then the circuitry turns off the power for a shorter period, say 10 microseconds

TOM REDDOCH

TOM GEIST

EPRI seeks to uncover the best and most efficient means for electricity delivery to end-use loads, and often the answer is not 60 Hz.

(.00001 seconds), during which time the circuity tests the impedance of the wires and end-use equipment.

The circuitry checks the safety of the circuit by determining if something changed. "Is there an open circuit? Is there a short circuit? Is something different than what we expected?" If nothing inappropriate has happened, the circuitry delivers another pulse, but if something has happened, the circuitry doesn't deliver another pulse and the wires and end load remain disconnected from the power source.

Tom Reddoch: The latter situation signals a safety problem. A change in impedance indicates that perhaps the wires are crossed, or worse, a person has come into contact with the distribution wires.

Tom Geist: What's interesting about 380 volts and 1 millisecond is that it's a significant amount of energy, but not so significant that an injurious amount of energy is delivered. In other words, if someone touches the wires, despite the high voltage, they will not receive a substantial shock. More like a tickle.

The benefit is increased safety and improved efficiency. And, because it's a form of DC, it enables more efficient integration of renewables and energy storage. Some estimates are up to 14 percent savings in energy.

PUF's Steve Mitnick: So where could customers use pulsed DC? What's next?

Tom Geist: Pulsed Power is ideal for appliances such as refrigerators, dishwashers and light emitting diode (LED) lighting in the home and in commercial buildings. EPRI has been involved with this technology for several years and, like any new technology, we are working to inform decision makers on all aspects of the technology. From safety standards to the potential for energy efficiency and demand response. More work is needed, but results are encouraging. ❖

In the late 20th century, electricity's mascot Reddy Kilowatt fell out of favor. The '70s, '80s and '90s was a time when policymakers pushed back against the industry's inclination to expand. Now that electricity is considerably cleaner, support has returned for resuming the economy's electrification. Perhaps we should call upon our old friend Reddy to help lead the charge.

Morgan Scott

Electric Power Research Institute Senior Technical Leader Morgan Scott discusses the tie between sustainability and efficient electrification.

PUF's Steve Mitnick: What's your research area here at EPRI?

Morgan Scott: My research addresses sustainability, which refers to the concept of the triple bottom line: economic, environmental and social responsibility. We strive to develop the tools and resources that electric power companies need to build and enhance their sustainability programs, as well as strategically embed a sustainability mindset into their long-range planning and operational activities.

Efficient electrification ties nicely into sustainability, because the potential societal and customer benefits can map directly into an organization's sustainability efforts.

PUF's Steve Mitnick: What does your research involve?

Morgan Scott: It's unlike some of the other research that happens at EPRI. It's not looking at application of technologies or environmental modeling, but is instead aimed to conduct focused technical research to support individual company sustainability commitments, planning, and disclosure.

Our work aims to help companies better understand what "sustainability" actually means for this industry and how it affects stakeholders and customers. We currently have five specific streams of research in this area, with a new research program launching in January of next year.

One, we identify the electric power industry's priority sustainability issues – of which twenty were identified in research published earlier this fall. Second, we have built a maturity model to help companies

assess how mature they are on particular priority issues and where they may want to enhance maturity moving forward.

The third stream focuses on metrics. In 2014, we tallied close to four hundred fifty individual metrics that companies are asked to disclose or report voluntarily each year. Our research since has focused on refining that list to the metrics appropriate for benchmarking performance for this industry.

The fourth stream of research is actually doing the benchmarking. We've developed an online platform where companies can submit their data and benchmark performance with their peers using the refined metrics.

Last but not least, we are examining how companies engage stakeholders and disclose their sustainability initiatives and performance. The goal is to help utilities understand current sustainability reporting trends, which may inform their decisions about future reporting and how to most efficiently and effectively allocate their sustainability-focused resources.

PUF's Steve Mitnick: Quite a few companies are working with you in these

In its various aspects, sustainability can be both a driving force in efficient electrification, and a direct result.

five areas. Why do you think there's so much interest?

Morgan Scott: Yes, we have 45 electric power companies collaborating on this work with us. Part of that is because there's keen interest among their stakeholders.

For example, customers who are setting their own sustainability goals, especially around emissions reductions or renewable generation, can have direct impacts on the electricity sector. When Google says it wants to be a hundred percent renewable, that can have a direct impact on their electric power providers.

We see a growing number of questions being asked from investors and the broader investment communities around ESG (environment, social, governance) performance and strategy.

Research has also identified a correlation between employee engagement and a visible commitment to sustainability. In an industry with a maturing workforce, sustainability may be helpful in both recruitment and retention of employees.

But the companies are also engaged because they see how sustainability can contribute to their overall business value, either through the development of new revenue streams, cost savings or avoidance, or managing risk.

PUF's Steve Mitnick: Where does the efficient electrification initiative tie in?

Morgan Scott: If you begin to consider the benefits of efficient electrification,

(Cont. on page 56)

Frank Sharp

Electric Power Research Institute Senior Technical Leader Frank Sharp discusses research to examine opportunities and benefits of indoor agriculture.

PUF's Steve Mitnick: Can we really do some farming inside buildings, using electricity?

Frank Sharp: We can and here's why.

First, we'll probably need to. Currently, there are about seven billion people on Earth. By 2050 it'll be around 9.5 to 9.6 billion, by U.N. estimates.

Next, we're running out of farmable space to meet demand. About 80 percent of arable farmland in the world is already in use. We're also seeing more people become urban. Throughout the world, people are moving to cities and away from rural areas, which requires food to be transported. On average, a head of lettuce may travel several thousand miles from farm to table.

Finally, we have an opportunity to reduce water use and emissions, while growing produce closer to home. It takes six gallons of water to grow a head of lettuce outdoors, and a gallon, or less, indoors. Furthermore, growing crops indoors, closer to consumers, reduces the need to transport them long distances, reducing vehicle emissions associated with that transport. This logistics improvement also expands shelf life and provides fresher vegetables to consumers.

PUF's Steve Mitnick: How does indoor agriculture work?

Frank Sharp: I'm a lighting researcher here at EPRI. A few years ago, I began to look at agricultural lighting, the primary load source for indoor growing. We didn't know a lot about it and wanted to understand it. We wanted to understand agriculture lighting fixture performance

(light output, energy, and so forth), the potential energy profile of the lighting load, the unique spectral nature of agricultural lighting, lighting manufacturers working in this space, and what lighting research was occurring.

Our research gave us some insight into this emerging industry, and we determined that agricultural lighting was, and is, different from commercial, or residential, or industrial lighting in many ways.

We started looking at the three primary forms of indoor agriculture: the converted warehouse or the custom building, the converted shipping container or pod, or an augmented greenhouse where we add heating and lighting to keep that greenhouse operating year-round.

What we found is that this industry still had a lot of unanswered questions, but had a lot of utility impact. Indoor food production has a large potential energy profile, but it may lend itself to demand response opportunities in some situations. It is an expanding, energy-intensive industry where efficiency takes a back seat to crop yield (though efficient farm operations are critical for business success). This focus on yield, combined with high energy use, could directly impact many utilities' goals for efficient electrification.

You can grow herbs, lettuce. Literally, the restaurant could grow the food they're serving you, in the back of the building.

Indoor agriculture greatly reduces the amount of water usage to grow crops, so it may provide opportunities and benefits in water-restricted or water-sensitive areas. It is also an industry whose key technologies such as LED lighting, tunable spectrum LED's, and systems driving heating, cooling, pumping, insulation, glazing, building control systems, refrigeration are all in a state of change or evolution.

This combination of factors and forces made this an industry that is ripe for research about the industry, its loads, impacts, and technologies. We've launched a project to begin addressing these issues and are now preparing to launch several other indoor food production projects.

PUF's Steve Mitnick: Is indoor agriculture best for smaller crops and/or more specialized foods?

Frank Sharp: The simple answer is yes. Could you grow long shelf life row crops indoors, yes, but long shelf life or tall crops don't lend themselves to indoor production. What you want to grow are high-value or short shelf life crops that you can stack.

In pods and warehouses, you grow your plants vertically, either by vertical beds or stacking multiple, horizontal beds. You can also stack multiple pods vertically. For example, in a pod, you can grow a wall of lettuce, and it's a foot or two feet wide, in rows. Electric lighting

(Cont. on page 57)

Baskar Vairamohan

Electric Power Research Institute Senior Technical Leader Baskar Vairamohan explains how industrial customers can employ efficient electrification to improve efficiency and productivity.

PUF's Steve Mitnick: What do you do here?

Baskar Vairamohan: I am a senior technical leader and help run our program called Electrification for Customer Productivity. We identify opportunities for end-use commercial and industrial customers.

Currently they may be using various technologies, mostly fossil fuel-based. We identify an equivalent electric technology that can increase their productivity, worker safety, product quality, and reduce emissions.

PUF's Steve Mitnick: How do you prioritize applications and technologies?

Baskar Vairamohan: We see process heating technologies as relatively low-hanging fruit. Process heating is one of the major energy-consuming areas within industrial processes. Many different industries use process heating: automotive, bottle manufacturing, and aerospace to name a few.

From Pepsi or Coke cans to water bottles, every product that we come across uses heating. That heating could be done more effectively with electricity than with fossil fuel.

PUF's Steve Mitnick: You're saying that it's more efficient?

Baskar Vairamohan: In many cases,

yes. When it comes to process heating, electric infrared technology can be used where natural gas is used today.

Here's an example. Currently, if you want to cure and dry paint on a product, it goes through an oven, heated by natural gas burners. The heat cures the paint. It's inefficient because the medium of heat transfer is air.

When you use infrared technology, it uses electromagnetic waveforms to heat the surface of the object directly, not the air around the object. A good example of infrared is our sun. Sunlight is a natural source of infrared. Another common infrared source is the toaster oven. The coils become red-hot. But it's not the coils that heat the bread.

It's the infrared emissions that heat the bread.

PUF's Steve Mitnick: What other technologies are you working with?

Baskar Vairamohan: Ultraviolet curing is another technology that does not use thermal energy. One of the beer can manufacturers was using a traditional oven. When they switched to an ultraviolet oven it increased productivity by forty-three percent, going from fourteen hundred cans-per-minute to two thousand cans-per-minute.

One of the beer can manufacturers switched to an ultraviolet oven and increased productivity by forty-three percent.

PUF's Steve Mitnick: Where else does electrification provide benefits?

Baskar Vairamohan: Airports. Next time you are on an airplane at the gate look out the window.

You'll see baggage tractors and airplane pushers. Usually those machines have diesel or gasoline engines. The workers leave them idling so they can be moved when necessary. They don't want to turn them off and on.

With electric versions, the moment you get off the machine, it shuts off automatically. Likewise, it can turn on instantly when needed. That's another example where we can add more sophisticated electric technologies.

PUF's Steve Mitnick: Why don't the airports switch?

Baskar Vairamohan: They are switching. We have done assessments of several major airports, accounting for benefits, not just to the airports and airline carriers, but also the customers, the nearby community, and to society. ❖

It sure seems like cars will increasingly be electric cars in the near future. But what about trucks? Smaller trucks that travel short distances are easily electrified. Such as local delivery trucks. Battery technology can apparently meet the need. But larger trucks that travel long distances? That's a tall order for battery technology. At least until fast-charging stations become ubiquitous along the nation's highways from sea to shining sea. However, many of those trucks are refrigerated. They're keeping your food fresh while on the road. A truck's refrigerator usually runs on the truck's energy – diesel-powered. Couldn't the refrigerator run on an electric battery? Yes, it turns out, with environmental and other benefits.

Ladies and gentlemen, start your innovation engines.

In an energy landscape ruled by uncertainty, innovation is imperative to get—and stay—ahead. Get our utility-tested strategies for powering up your innovation agenda at:

go.innogyconsult.com/innovation

innogy consulting

A Day at EPRI's Charlotte Labs

Public Utilities Fortnightly visited EPRI's Charlotte labs on September 25. Very cool. We met scientists working on leading edge technologies for electrifying industrial processes particularly and other sectors of the economy as well. Watch these videos at fortnightly.com/epri-charlotte.

Non-Destructive Test

One of the things we're doing here is nondestructive testing. Nondestructive testing is when you try to evaluate the integrity of the different component without actually cutting it open or digging into the component. This is a method that's used in pretty much all of the power plants, and also in other industries.

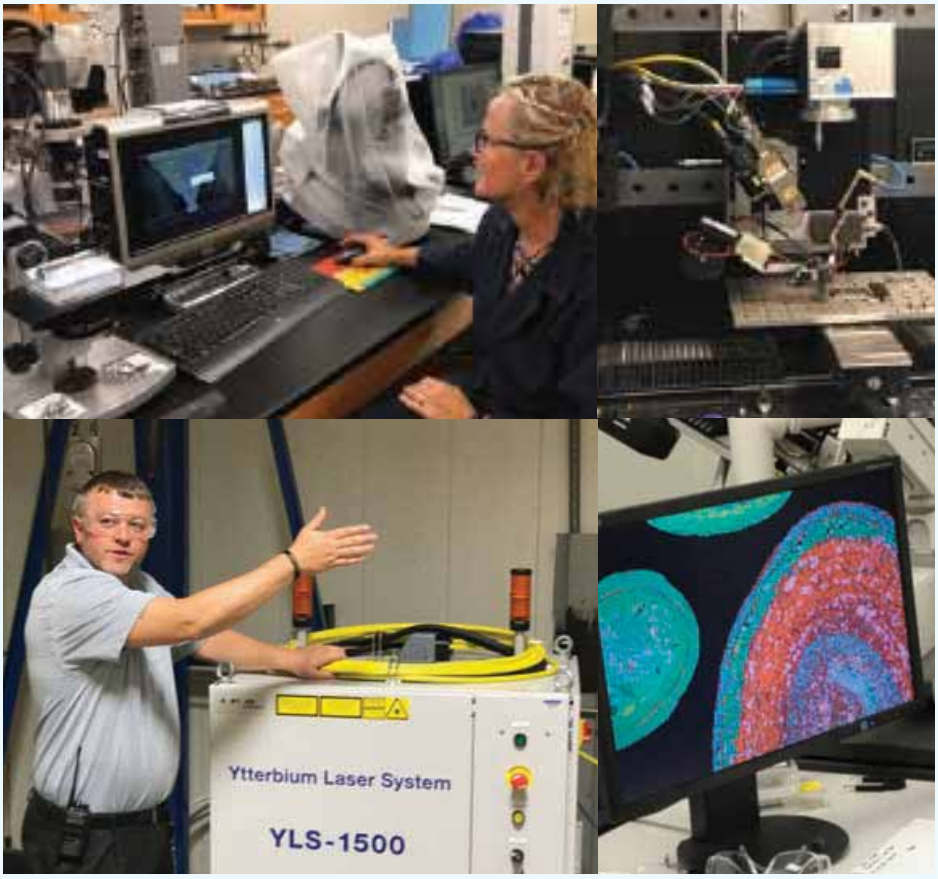
One of the methods that we use the most is called ultrasonics. You're probably familiar with ultrasonics. Ultrasonics is used for a lot of different things. It's used to clean jewelry, it's used in sonograms to create images, and we use the same technology to also look at the integrity in components in power plants.

Robot Welder

It's basically like a semi-robotic, remote controlled welding application. We use it because it is super repeatable and we can track all of our data. We have a commanded set of perimeters and we also get that feedback of actual perimeters, as well as times and positions and all kinds of stuff, so we can use that real data to help in our models and calculations of heat input, stresses and all that stuff.

Cool Shop

This helps us with the fatigue aspect so we can keep jamming out long days and get good consistent welds. We also have a wave, so there's the spin the part, weld on a part, that kind of thing. We don't have it set up now, but we also a vision system with a touch screen interface so we can record video as well as graphical and numerical



data all at the same time coming off this machine.

Then we can compile those in a presentation to say, "Hey, this is what the weld looks like." If we go through inspection and come across something, we can track that back to the data, graphical and numerical, and the video and try to figure out what might be going on.

Finding Defects

This is basically an oscilloscope, and you also need a transfixer like this one here. Inside this case is a piece of electric crystal and since this piece is electric, when you apply a voltage to it, it vibrates. In ultrasonics what we do is this instrument applies a voltage to the crystal, it vibrates and sends a sound wave throughout the component that we're testing, and that helps us to determine whether we have any defects in that component.

Generally, how we do that is by looking at this display here, which is called an A-scan because it shows the amplitude of the sound wave as it travels through the component. If you look at this screen here, as I put this sensor on this component, you see that I get a signal here. I get a signal from the back wall of this particular component. What you would do in your ultrasonic test is look at this A-scan, moving the sensor around and trying to determine if you have any anomalies or any integrity issues throughout that component.

Duo Lasers

Once the heat input from the main laser ... as it passes by, you want this other laser to continue to warm that area so that it doesn't just ... it cools down, but controlled. You don't want that quick cooling. Right? You want to be able to control the cooling, and that's what the secondary laser does.

Super Microscope

Right now, he's got it at 100,000 X magnification, and he is really close up. He's trying to find ... he's looking at coatings that are along here in oxide layers. It can also, along with EDACS, it will shoot the beam on an area, and it will tell you what your microstructure is.

Microstructure 1

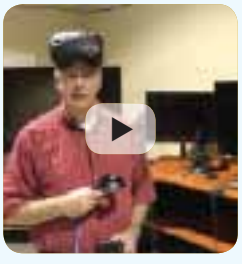
Here's a weld that I polished and etched, it brings out the microstructure here, which he wants to see ... It brings out the weld beads, plus the microstructure where you can't really see it in this picture because I haven't captured it yet, but that's what I do in here. I polish samples to a mirror image so you can see yourself, and then I etch 'em so you can see microstructure, weld beads, whatever the person wants to see, and I take pictures of 'em.

Microstructure 2

One of them has lack of fusion in it, and this should be one of them. Let me see if I can show you that. And this machine is awesome, because it stitches everything for you. All you have to do is focus and guide the little square. And there is some lack of fusion in this one here. ❖

A Day at EPRI's Knoxville Labs

Public Utilities Fortnightly visited EPRI's Knoxville labs on September 26. As cool as the Charlotte labs. We met scientists doing applied research with the most advanced virtual reality, robotics, and lighting. Plus we saw world-class work on indoor farming and on combating cyber-attacks. Watch these videos at fortnightly.com/epri-knoxville.



Virtual reality collaboration

It's a virtual reality collaborative environment. And in that environment, we have a substation.

The idea is that two or more people can meet in this virtual substation from anywhere in the world, and look over features, white-board solutions for problems, rearrange things, perform tasks such as changing settings. And maybe doing some training exercises like walking through procedures.

Trying virtual reality

EPRI scientist: Can you see?
PUF Editor: Whoa.
EPRI scientist: Can you see the substation?
PUF Editor: Yeah.
EPRI scientist: All right. Can you see the red ball?
PUF Editor: Not yet.
EPRI scientist: Try looking to your…
PUF Editor: Oh, yeah.
EPRI scientist: Okay.
PUF Editor: There it is.
EPRI scientist: Can you reach it without moving?
PUF editor: Oh, well, no, I can't.
EPRI scientist: You can actually physically walk toward it, or you can teleport.
PUF editor: It's kind of ... oh, yeah.
EPRI scientist: The teleport is the middle of the disc, so if you point when you press the middle of the disc…
PUF editor: Yeah.
EPRI scientist: And point it at the ground near the red ball. You'll jump to that location. You'll see it change to a blue disc, and you'll just jump there. So, let go. Did you jump?
PUF editor: Oh, I should jump?
EPRI scientist: No, no, no.
PUF editor: No?
EPRI scientist: The disc points you where you want to go.
PUF editor: Oh, okay.
EPRI scientist: So, press the middle of it. Do you see? There's a beam of light.
PUF editor: Yeah, it's like a beam.
EPRI scientist: And then, it turns blue.
PUF editor: I'm inside.
EPRI scientist: You're inside it?
PUF editor: Oh, there it is.
EPRI scientist: The red ball?
PUF editor: Should I pick it up?
EPRI scientist: Can you touch it?
PUF editor: Yeah.
EPRI scientist: As soon as you feel the vibration, squeeze either one of the triggers.
PUF editor: I got it.
EPRI scientist: Now, move it.
PUF editor: What should I do with it?
EPRI scientist: Anything you want.
PUF editor: Okay.
EPRI scientist: I don't think you can actually throw it, can you? Did it throw?
PUF editor: Yeah. Yeah. I pushed it over there. How's that?

Combatting cyber-attacks

What we have here is an overview of some of the cyber-attacks that are occurring in quasi-real-time throughout the world at any moment. This is a public-facing website that actually shows various cyber-attacks going on.

What should be noted is this only shows attacks that are using the Norse equipment. This is a small subset of the actual attacks. This is just an overview, or a small subset, of what we see at any time.

What EPRI's group does is, they work with these kinds of technologies to help utilities better defend themselves against cyber-attack, and resolve cyber-security issues before they impact generation, transmission and end-use.

Power supply units

This is a 230-test bench for the PSUs, in which we test them and we get the information to get the efficiency level of bronze to titanium. This is for the 230 units.

All kinds of lighting

An integrating sphere, which allows us to have a high-accuracy, high-resolution measurement of any light source we place in the sphere from less than one lumen (which is one candle power) to about a hundred and seventy thousand candlepower. About anything we can fit in here, we can measure.

AC or DC, we have utility grade power, and power control systems allow us to interject harmonics. Again, high-quality power, but we can also interject harmonics and other things to see how the light's going to respond. We can dim the light, measuring its changes in efficacy, which is lumens per watt and efficiency, which is consumption.

We want to understand both of those, where the utility can better understand how lighting can work in its various programs, be it electrification, energy efficiency, demand response, or energy customer satisfaction.

A product we have in here at the moment is a color-changeable product that does spectrums of light. You can see as I make changes, the light itself changes colors.

This product is also capable of doing about sixteen million colors. It can do things in green and reds, blues and oranges. We see more and more of these kinds of lights coming in to the market.

And what we want to understand is as we change the color temperature or the color output itself, how does the light change in operation? And how does it change in terms of consumption and efficacy?

Agricultural lighting

What we're looking at here is agricultural lighting. What's interesting to note is, plants don't necessarily need the full spectrum of visible light. They only use certain spectrum. This fixture, and fixtures like it, are designed to deliver only the nanometers of light that are the plants desire.

Go ahead and flip the other switch.

We can create different conditions. More red. More blue. Less blue. Less red. Where we can create the different

days or seasons. This is what allows indoor lighting, agricultural lighting, to offer high-yield and a lot quicker crop times.

Simulating outdoor and indoor conditions

We have our thermal chambers. We're able to create indoor and outdoor conditions for HVAC systems and other systems we want to test. We can create an outdoor condition from a few degrees minus to roughly a hundred and ten F.

Same way inside. We can create any indoor conditions you want in terms of temperature and humidity. And understand the impacts of the operation.

This allows us to test things like variable-speed refrigeration systems to see how their energy uses varies at different load levels. It compares a variable-speed compressor with how different is it when it's at full capacity versus twenty to thirty percent.

Data center efficiency

What everybody does in our Data Center Research Lab is look at various ways we can help utilities, and their end users who own data centers, improve the efficiency and operation of small to medium-size data centers.

Looking at novel cooling and operational things like power supplies. We've looked at DC in data centers. We've looked at immersion cooling, where you take the server and actually immerse it in a liquid.

There's a lot of different opportunities around improving the operation and efficiency of small to medium-size data centers in the U.S. ❖

Electrifying the Workplace

Public Utilities Fortnightly sat down with Baskar Vairamohan at EPRI's Charlotte Labs and talked about the potential for further electrifying the industrial and commercial sector. Watch these videos at fortnightly.com/epri-charlotte.

Process Heating

In the industrial technologies, process heating is a major energy user. Currently, the conventional methods heat the air, and the hot air heats the part. With electric technology, such as infrared heating, the heat is directly applied to the part by increasing the thermal efficient going to the part.

Also, if the plant has a conventional oven, the process can be improved and the productivity of the plant can be improved by adding an electric booster oven in place of the traditional convection oven.

Airports

When we are looking at electrification technologies, industrial, commercial, and even large commercial facilities like airports can benefit from the electrification technologies. When you look through the windows of an airplane you see baggage pushers or baggage tractors, plane pushers and other technologies that could be easily electrified with the current existing commercially available technologies that can not only help the customers but reduce emissions and help the community as a whole in reducing noise pollution and emissions. ❖

Electrifying the Home

Public Utilities Fortnightly sat down with Tom Reddoch at EPRI's Charlotte Labs and talked about the potential for further electrifying the residential sector. Watch these videos at fortnightly.com/epri-charlotte.

Shaping AC & DC

Part of our research is focused on the issue of, what is the best format, or how should we shape the voltage and current so that electricity can be a best use to electrify in use loads. In some cases, this could be alternating current, something other than sixty hertz. It could be a pulsed format like in pulsed DC. In lighting, we might go to a somewhat different format.

If we could look at something like a Category 5 distribution for power ethernet, that also allows us to look at other in use loads like computers and thermostats. Outside of that, we could even look at things like DC street lighting where we bring a DC as a service, do a single step down from the medium distribution DC to some kind of in use load, twenty-four-volt, twelve-volt DC, kind of to be determined, and we power our street lights off of DC directly.

Energy Future

As we begin to look at the practice of what we would call the integrated energy network, we're looking at a situation where we're trying to use all of our resources in a most efficient way. In particular, this results in us using electricity in appropriate applications as well as natural gas and other fuels in order to meet our collected energy need.

As a part of that effort, as we focus on efficiency for meeting our energy needs, our efforts to include renewables and that entire equation is best achieved by getting it in an electric form. In order to balance out the full equation, what we should also do is look at water because water makes up part of our total natural resource base and our objective is good energy efficient solutions that minimize the amount of water to carry out the transaction.

Lighting

That reduction has come about by displacing the incandescent bulb with CFLs. This resulted in a significant reduction in overall energy use, about seventy-five percent for a given app. Just as we thought maybe we had been quite successful with our lighting energy efficiency efforts, LEDs began to appear.

With that advancement, we're potentially able to remove as much as ninety percent of the amount of lighting, energy used in lighting. Along with this, with these much lighter lighting loads, the amount of infrastructure that's built into buildings to service or fix lighting can also be reduced.

We don't need twelve-gauge wire. We can accomplish that with a much lighter gauge wire, and in many cases, this does not even require an electrician to install this.

EV Charging

Let me just share a little with you about the charging of electric vehicles. We're interested in achieving fast charging.

One of the ways that we're doing this is actually using DC at the site of where the vehicle, or perhaps an off-road

(Cont. on page 57)

A Day at Georgia Power's Customer Resource Center

Public Utilities Fortnightly visited Georgia Power's Atlanta Customer Resource Center on October 10. It's an amazing place where industrial and commercial customers can see their future and test out the best equipment on the market for their businesses. Watch these videos at fortnightly.com/crc.

Electric Griddle

They will have different temperatures per tray. Mine's a three-tray unit I have back here. So, I could cook at 500, 300, and 100.

In the restaurant industry, they kind of design their whole menu around any temperature and the different times. We have that piece of equipment.

How do we promote the electric griddle? Well, when we serpentine an element on here, we cover more surface space than a gas one does. We're going to have less temperature differential on this plate.

Now, if you're Waffle House, that doesn't work, right? Waffle House, you ever seen them? They like to cook and like to hold. We wouldn't go show them an electric griddle.

For somebody spitting burgers out every day, and doing eighty percent of their business in two hours, we want to show them the more productive piece of equipment.

Fryers

Fifty dollars a vat, right, the year's savings. That's what we talk about when we talk about fryers.

They're more productive on the electric side. Every piece of equipment you see here comes in gas. There's a gas alternative. Every piece of electrical equipment is more efficient than its counterpart in gas, probably on average about twenty to twenty-five percent.

Maintenance

We talk about equipment, we don't talk about measuring the plug, load, and then measuring the pipe. We talk about the system impact of that equipment.

So, maintenance is a big part of this. There's a lot of moving parts on gas. You've got to have the burner. You've got to have the air flow. You've got to have the gas pressure and all that. Electric is much simpler, much more longevity, less maintenance. So those are the things we talk about if somebody came in to our place to talk about the electric advantage.

Snow Melt

We want to address things at what I call the snow melt, up top, and let it come down. Our next venture, which is very important to the other utilities out there is to prop up what we call the Electric Foodservice Council, where electric utilities come together with manufacturers of this equipment to address the change. If any utility guys are listening out there, let's go together. Let's approach these customers together. Much more effective.

Induction

Have a flame, a conducted flame, or an electric range element that's conducting heat. We're actually, through induction, heating the pan itself, internally, which heats the product. Therefore, the only reason the surface gets hot is because the pan got hot, the exact opposite of conduction.

Tractor Trailer

A tractor trailer refrigeration unit. You see them, they mount on the front of the trailer. Next time you're out on the freeway, see these big trucks.

You might notice these things on the front of the trailer. Its purpose is to refrigerate or freeze and maintain temperature in the trailer. That truck is shipping frozen goods, refrigerated goods, those kinds of things.

It's powered by a diesel engine. What sets this one apart is the diesel engine actually turns a generator, and the refrigeration part of the system is electric. But it's powered by this generator when that truck's going down the road.

What that means, when this thing is parked (a lot of times these trucks are parked for hours), the truck pulls into a distribution center. They may load that truck during the night. The driver with the tractor shows up 6:00 a.m. and hooks up, pulls that trailer out, and he heads off across country.

Well, if this thing is sitting for two, three, four, five hours, that engine is going to have to run. You got a diesel engine sitting there idling, running, that's emitting emissions, it's using diesel fuel, it's putting runtime hours on the engine. It's just a like a car, you got to maintain it, and it's noisy, so if there are residential areas nearby, it could be a factor. You may have half a dozen of these trucks sitting out there running.

Hybrid Unit

The unit is called a hybrid unit because the diesel engine doesn't power the refrigeration equipment directly. It powers that generator.

So, you shut the diesel engine off and connect this to, say, shore power, you can call it. And it will operate that electrically.

So, it's much cheaper to run this on electricity than diesel fuel. It's very quiet. There's no emissions. There's less run time. Wear and tear on that diesel engine. It just makes perfect sense to do that.

So, the reason we have this here in our facility is we want to educate our customers who are in that kind of business, about this capability. Most of the smaller truck refrigeration units are already equipped to do this. The large units like this, it's typically an option, an extra cost option, to get the hybrid capability.

A lot of folks may have it. They don't even know they have it.

SafeConnect

When the trailer is parked, this thing is sitting there, and they can plug it in. This is called the SafeConnect.

Which if you think about, you've got a 480-volt three-phase power connector out in a parking lot. It might be raining. It might be a puddle of water. That driver

may show up in the morning and he hasn't had his cup of coffee yet. He's not thinking. He may forget to unplug this thing, and pull that trailer away.

So, this thing is designed to take care of those kinds of situations safely. It's called a SafeConnect. It's got a device here that when if you pull on this, it releases the connector. It also detects the loss of continuity. It shuts itself off instantly.

Heat Pumps

What you see in here is a state of the art heat pump or HVAC equipment. This display, it's to illustrate all of the little details that need to be taken care of, if you're building a house or a small commercial building, to improve the energy efficiency of that building.

All of these units are operational. We turn them on, you can hear them run.

This is a dual fuel system. We don't have a gas connection to it, but it's designed to run on gas or electric. It's a high-efficiency heat pump, as well as a gas furnace. This unit and that one and this one over here, these are all what we call "variable refrigerant flow," VRF systems. I don't know if you're familiar with VRF.

What a variable refrigerant flow system can do is replace multiple zone systems with one system. The way it works is it can send the refrigerant, either hot gas or compressed.

Each coil in each area can either be an evaporator or a condenser. You can either heat or cool each zone with one system. It's all automatically controlled.

Water Heaters

Plenty of different types of electric water heaters. There's a couple of them here that aren't connected up, as you can see. But the rest of them are all operational.

This is a heat pump water heater. Then down here we have an electric resistance water heater. Then a couple more heat pump water heaters down there. This little gray box on the wall is a tankless electric water heater.

And they all have applications, advantages and disadvantages. That's why we have all of these here. So that we can discuss with our customers.

The best application for this is in an environment where there's a lot of heat and humidity. Think about what kind of environment would have a lot of heat and humidity. A kitchen maybe.

Think about a school system. You go visit your kids at the elementary school. If you could go back in the kitchen, you'd see all this cooking equipment. There'd be a lot of activity. They wash a lot of dishes. It's hot back there. It's humid. They need a lot of hot water.

This thing's perfect for that application. Because it's going to take heat from surroundings, and put it in that tank of water.

Infrared Ovens

The reason we have it is because most of our customers have these. What we're trying to help them decide is whether or not adding an infrared oven to their convection oven would make sense.

If you peek inside there, you'll see some infrared heaters that are actually inside the oven. That would be a type of way to apply infrared heating in an industrial process.

If they don't have room to add a separate oven outside their convection oven, maybe the heaters can go inside. They work just fine in there.

The concept there is, if you've got an

oven that will provide curing on a product in twenty minutes at a certain temperature, what if that customer wants to cut that time in half? They want to double their productivity. Well, they're going to have to boost that system somehow. Either make their oven twice as long, or boost it maybe with an infrared add on.

How Infrared Works

Convection is faster. Infrared is much faster.

Now, induction is not heat transferred. It's not one of the three forms of heat transfer. It's the transfer of energy using an electromagnetic field.

That field is created with a coil. When he showed you that demonstration, the coil was underneath that cooktop. You couldn't see it. It's a flat coil. But it was in there.

If you think about, a long time ago in school, did you ever do an experiment where you made an electromagnet? Take an insulated wire and wrap it around a nail. Then you connect it to a battery, and you've got a magnet, and it has a North pole and a South pole.

Then, if you take those leads on that

battery and switch them, then you create another magnet, electromagnet. But now your North pole and your South pole have switched.

If you could take those leads on that battery and switch them back and forth really, really fast, what do you think might happen to that nail? It'd heat up.

Why does it get hot? The reason it gets hot is when that nail is in that magnetic field, and there's a North pole and a South pole, the polarity of that field wants to push the electrons in the metal in a direction. If you reverse your North pole and your South pole, then those electrons are pushed back another way.

If you do that fast enough, then you're causing electrons to move back and forth in the metal, in the nail, and that's an electric current.

Slot Furnaces

We are using a gas fired furnace called a slot furnace to heat these up. A slot furnace is just an insulated box with a great big gas burner on it. Operates at about twenty-five hundred degrees, but it has an open slot.

These bars – kind of like blacksmith technology honestly – these bars are inserted in that slot and they stay in there long enough to get red hot. They actually had a system, a rail system, where they'd load these bars in and they'd kind of roll down.

They would take them off the bottom, when they're hot, and put it in their forging press and form the end of the bar. Well, that heating process took about twenty minutes in the slot furnace.

But the big problem they had with that process, it was very inefficient. It was about ten percent efficient by our best estimate.

When they were heating metal bars, and the other negative to that process, was that furnace was pretty much left on all the time. Because these high temperature furnaces have a refractory lining. They don't like to be thermally-cycled.

It destroys the lining, causes it to crack. And then it's expensive to rebuild the furnace. So, they leave the furnace on all the time.

When they're not heating bars, what's the efficiency of that process? Zero. It's just wasting energy.

Not only that, but if you think about a process inside a plant that is ten percent efficient, well, it's ninety percent of the energy that it's consuming, is going where? Either out the exhaust, or out into the plant.

It was a very hot area to be working in. It was unpleasant. Nobody wanted that job.

They wanted a better way to do it. And they asked us to offer suggestions. We said, well, you really need to look at induction.

Water Cooling AC

Remember, I said, you got to switch those leads really fast. This operates at about eight kilohertz. So, the current flowing through this coil reverses at about eight kilohertz.

I've also got a timer set. Because if I didn't turn the thing off at the right time, we would melt the bar. I want to demonstrate this for you.

You can see we're in an air-conditioned building. The unit's not even on. There's nothing has to be pre-heated. Don't have to keep it on all the time.

It is water-cooled. I'm gonna start my water cooling system, and then my controls boot up in just a few seconds and it's ready to go.

Now I'm not heating the part yet. I have to energize the coil. When I do that, you'll hear it because we can hear eight kilohertz.

This is a thermometer. It's a digital infrared thermometer. It's looking at the [metal] bar.

Right now, it says the surface of that bar is seventy-seven degrees. If you keep an eye on that, you can see how quickly we can heat that bar. It can barely keep up.

That's the surface of the bar. Now the core of the bar is not that hot. It takes a little bit of time.

Ideally, we would heat this thing to about fifteen hundred degrees, and hold it for a few seconds to get it thoroughly heated. Then we would take the bar and go into our forging machine.

But I've just got it ... When we get close to fifteen hundred, it times out. We use 27.6% of fifty kilowatts. And we operate it for twenty-eight seconds.

If you do the math, you can see how many kilowatt-hours we used. Not very much.

Electric Pizza Ovens

Can heat the stone up to whatever temperature you want. Let's say six hundred degrees. And your air temperature up here can be eight hundred degrees. Why would you want to do that? Or why would you even want this thing?

If you think about, if you go to a high-end Italian restaurant, and you're going to pay a lot of money for a pizza, that restaurant probably has a chef that is a career chef. He knows what he's doing. He knows how to cook pizza.

And if you go to one of those places where they have the brick oven type

(Cont. on page 57)

Huge Indoor Farm in Downtown Newark

A smart warehouse full of growing plants. Lettuce, kale and other leafy greens.

If you saw the movie The Martian you'll get the idea right away. But on a much bigger scale. And not on Mars, but in Newark, New Jersey.

AeroFarms is an agriculture company that uses vertical farming to produce 130 to 390 times the output of a conventional farm. It's all done indoors under LED lights. The lights shine at a specific intensity and spectrum that's tailored to each plant.

The plants are stacked on racks thirty feet high, in containers using cloth instead of soil and a light mist instead of water. Sensors in the trays collect 30,000 data points to track how the plants grow. If the kale isn't sprouting at a certain light spectrum or oxygen level, the farmers can tweak the settings for the next batch.

Every year, AeroFarms will produce up to 30 harvests and yield two million pounds of greens.


3
2


6
5
4
3
6
5
4

Electrification in Action

(Cont. from p. 29)

model. For us, that puts the customer in the center of all we do and the decisions that we make, relentlessly focusing on keeping prices low, keeping reliability high and doing the things that increase customer satisfaction. That helps us, hopefully, have constructive regulation in our jurisdictions. Then we can invest further in our business through those things.

We view marketing as figuring out how we can improve the lives of our customers through our efforts, products, services, and energy efficiency programs. We wake up every day trying to figure out, 'how do we make life better for Georgians?' In some cases, it's the industries in Georgia that will help create better jobs and a better way of life for our customers.

That's the way we view marketing. We continue to ask our customers, what do they want to see from Georgia Power? We continue, in some cases, to be surprised by their belief that we should offer additional products and services beyond electric end-use.

Those are things like home automation, security lighting for our communities, or advanced lighting technologies. We're doing those things for our customers. We'll continue to listen to them and figure out how we can add more value.

PUF's Steve Mitnick: Efficient, as well as electrification. Both E's?

Kenny Coleman: Yes, absolutely. We've talked with other utilities about it. For some people marketing is load-building. But we view it as helping our customer. If you're able to find opportunities to sell or get additional off-peak kilowatt hours, that don't add to your peak, that's great.

They help us spread more kilowatt hours over our fixed costs. It's really beneficial for all customers. You take, for example, a heat pump: what you're doing now is adding winter load. You're not really adding a summer load.

Add some winter load. That gives more kilowatt hours to spread. The specific customer benefits because their overall cost profile goes down. Customers as a whole in Georgia benefit because now we're spreading more kilowatt hours over the same fixed cost. ❖

Morgan Scott

(Cont. from p. 40)

you can see how they align with the sustainability triple-bottom-line concept of economic, environmental, and social responsibility.

In its various aspects, sustainability can be a both a driving force in efficient electrification, and a direct result. When you choose to electrify an end use, the potential benefits include improved air and water quality, enhanced customer relationships, enhanced power system operations. These are themselves priority sustainability issues.

I really see them going hand in hand: efficient electrification could be a sustainable strategy for an electric power company. Those are the things we're researching to understand more precisely. ❖

PUBLIC UTILITIES FORTNIGHTLY
"In the Public Interest"

EXECUTIVE EDITOR
Bruce W. Radford
radford@fortnightly.com

EDITOR-IN-CHIEF
Steve Mitnick
mitnick@fortnightly.com

EDITOR-AT-LARGE
Pat McMurray
mcmurray@fortnightly.com

EDITOR
Angela Hawkinson
hawkinson@fortnightly.com

LEGAL EDITOR
Phillip S. Cross
pcross@fortnightly.com

PUBLISHER
Joseph D. Paparello
paparello@fortnightly.com

ART DIRECTOR
Michael Eacott
eacott@fortnightly.com

MARKETING & CUSTOMER RELATIONS
Alexandra Revel
arevel@fortnightly.com

CIRCULATION
Teela Wormley
twormley@fortnightly.com

EXECUTIVE MANAGEMENT
Bruce Radford, President; Phillip S. Cross, Vice President; Lewis Turner, Treasurer; James Norris, Secretary

Frank Sharp

(Cont. from p. 41)

is directly in front of each wall or row of lettuce. Think of a shipping container, and you walk down the row so your fields are on both sides of your shoulder. Another way to do this, in a pod or warehouse, is to build horizontal beds with lighting directly above each bed and then stack the beds vertically.

You can grow herbs, lettuce. Literally, the restaurant could grow the food they're serving you in the salad, in the back of the building.

PUF's Steve Mitnick: Do we think by 2040 or so, that cities will use buildings for indoor farming? What's the potential?

Frank Sharp: The potential is good because of indoor farming's potential versatility. Maybe you could convert a space. A business moves out. Let's put a farm in it.

You could operate them for profit, like a farm or a community service, where a local group running the farm is feeding the local community. There are many opportunities around water usage, sustainability, food availability, and substantial, potential benefits associated with indoor agriculture. ❖

Electrifying the Home

(Cont. from p. 49)

vehicle, might be charged in a much faster way. Today that current thinking is that the utility delivers AC through the meter, and at the customer location a device is used to change the AC into DC to operate the charger.

Going forward there are discussions about perhaps utilities should consider establishing a DC service. In that scenario, the DC could be shifted to the utility side of the meter, and the utility deliver the electric service as DC.

More on EV Charging

For fast charging, we are having increasing conversations that the level of power that might be used is of the order of two hundred to three hundred kilowatts DC. As we continue to advance this DC charging concept it is entirely possible that we could have as much as a megawatt of power being supplied at DC. This could be a master station to charge several vehicles. ❖

A Day at Georgia Power

(Cont. from p. 53)

pizza ovens, that brick oven is probably a gas-fired oven. It's got a stone at the bottom. It's got a dome, and the air up there is heated, and it's all heated with this gas flame.

That chef knows, he puts his pizza in with this big spatula, like those things, and he puts it on that stone, and he knows exactly how long to leave it on that stone to get the crust just right. And then he picks it up and he holds it in that dome where that super-heated air is, to sear all the toppings. And he has the skill to do that. He'll make a perfect pizza, and they're great.

But what if you're running a Pizza Hut and you're hiring high school kids. These high school kids work for you for about a year, maybe if you're lucky. You're retraining these guys all the time. They're not going to have the skills that this career chef had. But you've got to make a lot of pizzas, and you want good quality.

Well, this kind of oven can do that, operated by someone with almost no skills. Because all you got to do is know what set points, and know how long to leave the pizza in there. That's really all they need to know. ❖

Grow Greens

If you're from Brooklyn, you probably didn't grow leafy greens on a farm. But you probably eat a lot of leafy greens.

Your arugula, romaine etc. may be grown in California. It takes a quantity of water and petroleum products to grow and ship it to a Brooklyn market. Note California is sometimes short on water.

It takes awhile to get the greens to Brooklyn and then onto your table. So they're grown to endure the long trip and time.

Along the way, there's plentiful waste. Some of the greens hold up and are still appetizing. But as much as half are rejected and trashed.

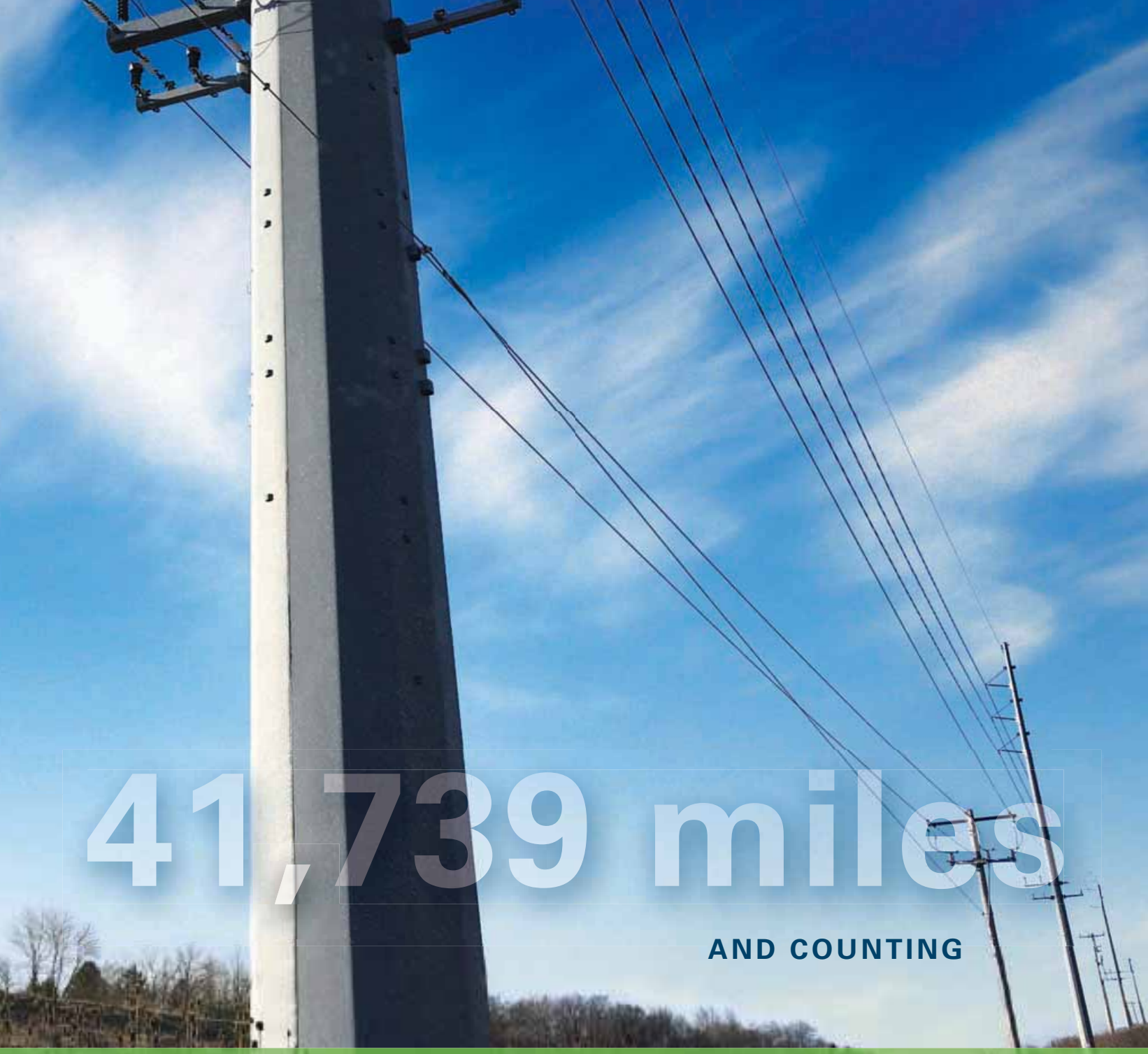
What if greens were grown in Brooklyn? Under LED lights in that abandoned warehouse? With little water, waste and petroleum? And with little time between when grown and when eaten?

Electrified farms within buildings in Brooklyn. In Baltimore. In Atlanta. In Chicago. In, well, anywhere people are. Might be the future.

Farming Inside and Without Soil

Visiting the huge AeroFarms indoor ag facility in downtown Newark NJ is like watching Matt Damon grow potatoes in The Martian. Unlike on Mars, the farming in Newark is done without soil. A cloth medium is used instead. Add plenty of LED lighting and voila, beautiful greens for your salad.


WHAT IF
you could achieve sustainable
results in an ever-changing market?
Our expertise in customer engagement,
grid modernization, advanced automation
and cost reduction can increase revenue
and improve performance.
At Navigant, we help
turn *what if* into *what is*.
Consulting | Outsourcing | Advisory
Visit Navigant.com/energy
NAVIGANT
PROFIT FROM EXPERIENCE



Our experience building transmission systems is miles ahead of the pack. As a leader in transmission development, Duke American Transmission Co. offers you a level of expertise in planning virtually unmatched in the industry. That means we won't just help you build a system better equipped for your needs today, but one better prepared to handle the demands of tomorrow as well. It's part of what makes DATC one very powerful partner.

DATC
DUKE American Transmission Co.®

A POWERFUL PARTNER

datcllc.com