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Our Special 30th Year Issue!
We’ve witnessed a lot of changes in the energy efficiency industry since AESP’s founding in 1990 and we thank you for being on this journey with us. We couldn’t have done it without the support of members like you. So specially for our 30th anniversary, we look back at the innovations and people who have shaped the industry (see “30 Game Changers in the last 30 Years”), as well as look forward to the future by examining the opportunities and challenges presented to us today. We hope you enjoy this special issue.

The Promise and Challenges of DER Grid Integration
BY PATSY DUGGER AND MM VALMIKI

A Budding Industry: HVAC Savings Potential for Cannabis Growers
BY AMY GLAPINSKI, JUSTIN HOVLAND AND MIKE CHRISTIANSON

Electrification is Everywhere – Opportunities for Electrification in the Commercial Sector
BY MALLIKA JAYARAMAN AND RYAN TANNER

Not a Carbon Copy: Navigating the Age of Carbon
BY JAKE MILLETTE AND ELIZABETH TITUS

Women Trailblazers in Energy Efficiency
BY LUISA FREEMAN

IDSM-driven DR programs from Ameren Missouri and Eversource lead the way
BY JOANA ABREU, KESSIE AVSEIKOVA AND JEFF BERG

Transportation Electrification: Lessons from TVA’s Non-Road Program
BY CORTNEY MCKIBBEN AND IAN METZGER

All About Heat Pumps
BY JEFF IHNEN AND KEVIN DEMASTER

30 Game Changers in the last 30 Years
BY LUISA FREEMAN

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The Promise and Challenges of DER Grid Integration

Driven by clean energy initiatives and increasing utility infrastructure costs, there is growing interest in the promise of behind-the-meter distributed energy resources and load flexibility to compete with traditional utility investments in capacity, transmission, and distribution. These resources include combinations of energy efficiency (EE), demand response (DR), distributed generation (DG), energy storage, and flexible load management of controllable loads (EV chargers, heat pump water heaters, etc.).

This article provides an introduction to key DER integration market drivers, an overview of national and regional policies and initiatives, and shares some of the key questions and challenges that are emerging that are preventing DERs from fully actualizing their market promise.

Declining Cost of DERs and Advances in Control

Over the past 10 years, the levelized cost of energy (LCOE) for unsubsidized utility-scale solar and wind has dropped 89% and 70%, respectively. Similarly, behind-the-meter solutions such as rooftop solar are now cost-competitive with the marginal cost of existing conventional generation, and energy storage costs – particularly for Lithium Ion batteries – have declined. In some cases, even solar-storage systems have become economically attractive for short-duration wholesale and commercial.

Predictably, DER market growth has ensued, supported by state clean energy targets and utility initiatives for load growth or energy decarbonization through building and transportation electrification. The ten sunniest states added 18 GW of small scale solar in 2019. Energy storage markets grew by 45% with the highest rates of growth in small, distributed applications.
On the demand side, simultaneous advances in DER management systems (DERMS) including control technologies, software and communication standards, are enabling consumers and market aggregators to generate, store, reduce, shed and shift their energy use to optimize for cost, carbon, traditional EE and DR programs, and emerging load flexibility programs.

On the supply side, however, increasing deployment of intermittent utility scale solar and wind resources are forcing tectonic shifts in utility planning, ratemaking, operations and maintenance, and grid infrastructure investment. Grid investment has increased; as of 2020, major U.S. utilities are spending a whopping $51 billion a year to replace aging infrastructure, address traditional and electrification-related load growth, harden their grids against climate disruption, and safely accommodate increasing levels of variable generation.

### DERs as Non-Wires Alternatives (NWAs) to Emerging Grid Needs

In recent years, regions of the U.S. – particularly New York, New England, California and Hawaii – are looking to DERs and load flexibility as a promising “non-wires alternative” (NWA) part of the solution to address emerging locational and temporal grid challenges and needs. In some instances, this is driven by state-level regulatory processes; in others, utilities and other industry stakeholders are independently assessing and testing strategic, locational deployment of DERs. These initiatives require utilities to have detailed understanding of grid needs and investment drivers, and to evaluate DERs’ ability to economically replace or defer traditional capacity and T&D investments for specific projects. These utility policies are premised on ratepayer benefits including first costs, time to deployment, carbon benefits, and potential consumer or ancillary benefits. Utilities are seeking NWAs in competitive RFPs and RFOs and have begun contracting and initiating projects.

The Brattle Group estimates that by 2030 nearly 200 GW of cost-effective load flexibility potential is possible (20% of peak loads) through tariff redesign, expanded DR programs, and new load flexibility programs, with expected benefits exceeding $15 billion/year. Most of this value is from avoided generation capacity investments, with T&D deferral and ancillary services adding value in niche applications.

However, while DERs are looked upon as a promising toolkit, there are various challenges that must be addressed to fully enable their potential. Fair cost-benefit analyses of DERs is neither simple nor standardized, with a host of impacts and factors that must be counted. This is especially complicated when considering a set of diverse DERs implemented together towards a common goal. Other challenges include regulatory barriers, program design, tariffs that do not fully reward or enable benefits, perception that DER fleets are not reliable, interconnection delays, and technology gaps. Below, we provide a national and regional update on advancements in this space, and highlight some of the key questions that are emerging that will need to be addressed in order for the full market potential of DERs to be realized.

### National Highlights

#### FEDERAL POLICY

The Federal Energy Regulatory Commission Order 841 required regional transmission organizations and independent system operators to remove barriers to the participation of electric storage in wholesale markets. The California Air Resources Board and Attorneys General of California, DC, Massachusetts, Michigan, and Rhode Island filed supporting arguments in court and in public statements.

In Congress, the American Energy Opportunity Act would require the DOE to create voluntary streamlined process guidance for permitting and inspection of DERs while the Energy Storage Tax Incentive and Deployment Act of 2019 would provide storage tax credits at residential scales.

#### REGULATORY PLANNING

In 2019, NASEO-NARUC assembled a Task Force for Comprehensive Electricity Planning, focusing on aligning distribution system and resource planning processes.

#### GRID-INTERACTIVE EFFICIENT BUILDINGS (GEBS)

The DOE has been advancing load flexibility through GEB initiatives that support practices and technologies for efficient, connected, grid-responsive buildings. They recently awarded a set of emerging technologies projects and announced $74 million in GEB and technology funding. $42 million has been proposed for GEB funding in summer 2020.

In 2018, the National Association of State Energy Offices (NASEO) and the National Association of Regulatory Utility Commissioners (NARUC) also initiated an initiative to look at the role of GEBS in grid modernization efforts.

<table>
<thead>
<tr>
<th>Mega-trend</th>
<th>Challenges</th>
<th>Load Flexibility Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewables growth</td>
<td>• Low net load leads to renewables curtailment and/or inefficient operation of thermal generation</td>
<td>• Electricity consumption can be shifted to times of low net load</td>
</tr>
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<td></td>
<td>• Intermittency in supply contributes to increased need for grid balancing</td>
<td>• Fast-responding DR can provide ancillary services</td>
</tr>
<tr>
<td>Grid modernization</td>
<td>• Costly upgrades are needed to improve resiliency and accommodate growth in distributed energy resources</td>
<td>• Geographically-targeted DR can help to defer capacity upgrades</td>
</tr>
<tr>
<td>Electrification</td>
<td>• Rapid growth in electricity demand may introduce new capacity constraints</td>
<td>• Controlling new sources of load can reduce system costs while maintaining customer comfort and adding value to smart appliances and EVs</td>
</tr>
</tbody>
</table>
Regional Highlights

Regional developments are demonstrating states’ commitments to using DERs as a solution to their energy goals. Programs such as non-wire alternatives (NWAs) facilitate using DERs in lieu of generation and infrastructure investment while also achieving parallel benefits, such as carbon avoidance.

NORTHEAST

- New York is providing $280 billion in energy storage funding, while their Reforming the Energy Vision is providing an NWA framework to utilities.¹⁰
- NYSERDA announced 20 MW of battery storage with GlidePath for the Town of Ulster, replacing a planned fossil fuel plant.¹¹
- NYSERDA announced winners of the Future Grid Challenge, focused on DER data collection, controls, integration, and metering.¹²
- ConEdison’s Brooklyn-Queens Demand Management Program (BQDMP) has avoided a $1.2 billion substation upgrade through DER solutions. Customer-sited DERs contributed 33.5 MW of peak load reduction with 44.5 MW expected by 2021 and NYC’s largest battery storage system (4.8 MW) was unveiled.¹³ ConEdison has 8 MW of storage installed and 250 MW in queue.
- National Grid just finished its first 2 MW peaking battery at a substation built for future capacity.¹⁴
- In ISO New England Territory, Sunrun will provide 20 MW of solar-storage capacity distributed in 5,000 homes. NEC Energy Solutions is providing 20 MW to municipalities avoiding wired costs.¹⁵
- Maine’s Isle au Haut is establishing an islanded microgrid with transactive pricing, an experiment which may shed light on relying on market dynamics rather than pre-designed pricing structures.¹⁶
- Vermont’s Green Mountain Power recently expanded an EV management pilot to its whole territory, successfully balancing loads and lowering customer costs via rate arbitrage.¹⁷

MIDWEST

The Midwest states trail in DER integration initiatives, but it may only be a matter of time before political headwinds give way to economic and market pressures.

- Illinois recently received ten times the expected community solar project applications, totaling 1.8 GW.¹⁸
- Missouri’s Ameren announced a $7.6 billion grid modernization initiative including smart meters, rural solar-storage, storm-resilient infrastructure, and wind power.¹⁹

WEST

- The California Public Utilities Commission (CPUC) reauthorized the Self-Generation Incentive Program at $1 billion through 2024, with major equity/resiliency earmarks following a deadly 2019 wildfire season in which Public Safety Power Shutdown was used during dry, windy conditions.
- The CPUC recently updated transmission cost accounting in DER cost-benefit methodology and agreed to revisit it further, potentially leading to improved evaluation economics.²⁰
- Southern California Edison and Pacific Gas & Electric posted RFPs for their Distribution Investment Deferral Framework programs. PG&E identified 88 MW of NWA opportunities.²¹,²²
- Oakland’s Clean Energy Initiative is pursuing DER alternatives to an aging 165 MW jet fuel peaking generator. SunRun will operate a virtual power plant comprising 500 low-income residential solar-storage systems while ESVolta will provide 43.25 MW of utility-scale storage. Energy efficiency measures were initially considered, but ultimately pulled from the procurement in late contracting stages, highlighting DER program uncertainties.²³,²⁴

HAWAII

- Hawaiian Electric Company is starting their Integrated Grid Planning NWA program. The first planned project is the deferment of a substation upgrade for a new residential and commercial development.²⁵ Hawaii estimates that half of their 100% renewables goal must come from DERs.
- Shifted Energy will provide 2.5 MW of grid interactive water heater capacity through retrofit controls, leveraging a ubiquitous resource in hard-to-reach rental residences.²⁶

DER Barriers and Solutions

There has been great hope for the potential for NWAs to be a channel to bring diverse DER solutions to bear down on our grid and decarbonization challenges. Several years later, these NWA programs may appear anemic at first glance. States and utilities have experienced challenges with procurement processes, portfolio valuation, performance uncertainty, control and technology gaps, and market inertia propping up traditional programs as we have come to know them.

Indeed, the uncertainties with DER integration and NWAs are not trivial. The dynamics and nuances of a distributed set of resources require a different assessment than a single-point generator or siloed efficiency measures. NWA assets present different load and dispatchability profiles than conventional investments and require new methods of valuation (including locational and temporal value) from traditional utility economics and rate case modeling.
Most NWA programs have used competitive bidding – and while utilities can dependably price conventional capacity and T&D investments, NWA costs and benefits can be more nebulous and complicated to quantify. In some cases, resources like energy efficiency are considered already accounted for through public-good programs and have been discounted and handicapped with those rules within NWA procurements, despite having different objectives and regulatory governing rules. This has made energy efficiency less competitive relative to competing resources in that procurement. PG&E’s recent removal of energy efficiency in the Oakland Clean Energy initiative leads to new questions.

**BENEFIT AND COST ACCOUNTING**

The National Efficiency Screening Project (NESP), managed by E4TheFuture with funding from DOE, is currently updating the 2017 National Standard Practice Manual for Energy Efficiency to include DR, DG, energy storage, and electrification. The manual, expected in July 2020, will provide principles and a framework for evaluating DERs, including temporal and locational impacts, interactive effects, BTM versus FTM considerations, emissions, market revenues, and distribution impacts. It aligns primary tests with policy goals, ensures symmetry across costs and benefits, and accounts for all relevant impacts including long-term analysis with transparency and avoidance of double counting through clearly defined impacts.

**Valuing the Benefits and Costs of Grid Integrated DERs**

<table>
<thead>
<tr>
<th>Utility System Impact</th>
<th>EE</th>
<th>DR</th>
<th>DG</th>
<th>Storage</th>
<th>V2G Evs</th>
<th>Bldg. Electrification</th>
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<tbody>
<tr>
<td>Generation</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B/C</td>
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<td>Transmission</td>
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<td>B/C</td>
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<td>B/C</td>
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<td>Distribution</td>
<td>B</td>
<td>B</td>
<td>B/C</td>
<td>B/C</td>
<td>B/C</td>
<td>B/C</td>
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<td>Credit &amp; Collection Costs</td>
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<td>B</td>
<td>B</td>
<td>B</td>
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<tr>
<td>Risk</td>
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<td>B</td>
<td>B/C</td>
<td>B/C</td>
<td>B/C</td>
<td>B/C</td>
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<tr>
<td>Reliability</td>
<td>B</td>
<td>B</td>
<td>B/C</td>
<td>B/C</td>
<td>B/C</td>
<td>B/C</td>
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<tr>
<td>Resilience</td>
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<td>B</td>
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<td>Enable other DERs</td>
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<td>B</td>
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<tr>
<td>Utility Portion of DER Costs</td>
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<td>Program Administration Costs</td>
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<td>Utility Incentives</td>
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Unforeseen uncertainty such as that created by COVID-19 may pose even new challenges. NWA projects are predicated on regional load growth straining existing local capacity and T&D systems. New York’s daily demand has dropped 13% during the pandemic and behind-the-meter storage 2020 installation forecasts were cut by 31%. Although some of this is likely temporary, it remains to be seen what permanent effects materialize as locational and temporal demands shift from workplaces to homes and economies react.

Despite all these challenges, the potential opportunities and benefits of utility planning that fully and fairly integrates DERs may be greater than what we can yet quantify. The key will be in aligning policy, goals, benefit and cost accounting, and programs in support of DERs not as isolated, siloed technologies, but as an evolving toolkit which we can leverage in our progression towards cost-effective grid modernization and decarbonization.

**Emerging DER Integration Questions and Challenges**

- How can regulations and programs be simplified and streamlined to accelerate high value DER solutions?
- What is the best regulatory structure to maximize and equitably balance value for utility shareholders and ratepayers in an increasingly democratized energy industry?
- Can we add new DERs into our traditional incentive program pipelines and pursue NWAs in parallel? Or should we fully transition to a fair, benefits-driven open procurement process?
- How does ratemaking evolve to drive beneficial grid benefits and prevent disincentives?
- How can EE’s role at the top of the loading order be ensured and valued in NWA procurements?

**References**

For the list of References, go to aesp.org/page/Magazine2020references

Dugger, Valmiki. 2020. (Modified from a National Efficiency Screening Project presentation)
A Budding Industry: HVAC Savings Potential for Cannabis Growers

By Amy Glapinski, Justin Hovland and Mike Christianson

As more states legalize recreational cannabis, this growing market segment has become a major focus area for utility programs. With legalization comes a rush to build facilities as growers race to establish market share. Because many have had prior experience growing at smaller scale, their plan is often to simply scale up the smaller, inefficient systems they’re accustomed to and seek the lowest cost equipment options. Unfortunately, this desire to get a jump on the competition often overlooks considerations for energy efficiency. In addition, defining baselines for cannabis is difficult given these facilities are not subject to energy code, nor do they fit nicely within a building use definition.

This article will focus on opportunities for non-lighting energy savings in the Indoor Agriculture market and how to analyze and incentivize those projects. The goal of this article is to provide utilities and program implementers guidance on how to incorporate non-lighting measures into their facility design.

This article will discuss:
1. Operating conditions, baselines, assumptions, and approaches to consider for this segment
2. “Good, better, best” savings potential for non-lighting measures
3. Recommendations for adopting these measures into a utility efficiency program

While the research to support this article was conducted by Energy 350 on behalf of a Michigan utility, the baseline assumptions, analytical approaches, and incentive structure can be extrapolated to other utility programs around the country. For purposes of this article the assumptions used are for indoor, brick-and-mortar grow facilities.

What environmental and operating conditions, baselines and approaches to consider?

Environmental needs for cannabis – this section is based on field experience working with cannabis growers, along with publicly available data, and characterizes the typical environmental needs.

- Grow facilities will design spaces for all phases of the grow lifecycle (cloning, veg, and flowering) and it is common that these facilities will also include space for non-production. Facility design is dictated by regulation which will limit the size of operation based on the area of the flowering canopy or number of plants.
- Temperature and humidity must be tightly controlled in a grow room. Plants give off water as they intake CO2, which must be removed to prevent mold growth. Simultaneously, the high-power density of grow lights adds heat to the space. Maintaining the balance of moisture removal without overcooling the space – during both “lights on” and “lights off” conditions - is a key design challenge.
- Plants require delivery of water as well as nutrients. This introduces significant moisture into the air, both through direct evaporation of excess water and through plant evapotranspiration.
- Indoor growers require a sealed, airtight environment for several important reasons: to minimize outside contamination, to avoid potential odor mitigation requirements on exhausted air, and to maintain an enriched CO2 environment. Unfortunately, this removes the consideration for outside air economization as an energy saving measure.
Baseline equipment profile – is meant to provide a realistic view of what practical, low cost and standard efficiency solutions many growers install without incentives.

- **Plant size and arrangement** – total canopy area is the primary driver for space cooling and dehumidification needs and determined by the number of plants grown and size of plant.

- **Lighting** – High pressure sodium (HPS) lighting dominates this industry still. The most commonly found in a commercial grow room is a single-ended (SE) 1,000W HPS bulb. Keep in mind that the higher the lighting power is, the rate of evapotranspiration also increases. In this article, the 1,000W SE HPS fixture (with a ballast power of 90 W) will be used as the baseline lighting design for comparing the interactivity with non-lighting measures.

- **HVAC** – the most common is the ducted split AC (DX) system. Depending on the grow room size and configuration, packaged AC systems or mini-split systems are also very common. All are widely accepted and commercially available solutions.
  - **Ducted Split AC System** – offers a simple solution for space cooling; typical cooling capacity is 5 tons for 200 square feet of canopy; equipped with constant volume supply fans.
  - **Packaged AC Systems** – available in much larger sizes, up to 150 tons, although 10-25 ton are more common; this could be a more attractive selection for larger grow rooms.

- **Dehumidifiers** – A common practice is using industrial grade portable dehumidifiers in a grow room application. These are basically heavy-duty versions of residential style units. The capacity of a dehumidifier is given as a water removal rate - typically pints per day, rated for room conditions (80°F and 60% RH). Dehumidifiers also reject heat to the space, increasing the cooling load. Baseline performance, now being required by code in some areas, is typically 4 pints/kWh.

- **Fans** – most growers use wall or ceiling mounted fans, mounted along the walls just above the canopy. Many operate 24/7.

- **Odor Control** – the most common application is using an inline fan to draw air through an activated carbon filter and then return the clean air to the room; typical sizing is 2 CFM per sq/ft of canopy.

- **CO2** – CO2 is introduced into the space by either burning natural gas or propane through open flame or by introducing gaseous CO2 directly (less common). Adding supplemental CO2 to the grow space is especially important as it increases the rate of photosynthesis (and decreases the rate of evapotranspiration).

### What is the savings potential associated with non-lighting measures? What are some good, better, best scenarios?

With environmental conditions and baselines defined, we’ve modeled and ranked the various non-lighting measures based on energy performance in Figure 1.

- **Energy consumption is displayed in kWh/yr per sq/ft of canopy area.**
- **Analysis assumes total canopy area is 30% veg and 70% flower.**
- **Blue bars assume HPS (baseline) lighting while orange bars assume LED (36% more efficient) lighting since some measures are interactive.**

Energy consumption decreases from left to right on the x-axis. These technologies are grouped into 4 bins based on energy consumption, as designated by the dashed red lines in Figure 1.

#### Baseline HVAC technology
- Baseline: Code minimum (11 EER) packaged DX
- Air and water-cooled chillers

#### Modest HVAC savings:
- High Efficiency Dehumidifiers
- High Efficiency DX
- Supply fan VFDs
- Water-side economizers

#### Moderate HVAC savings:
- Variable Refrigerant Flow (VRF) systems
- Hot Gas Reheat (HGRH) systems

#### Deep HVAC savings:
- Energy Recovery Ventilator (ERV) systems

---

**Figure 1 - Summary of HVAC Energy Use by System Type**

<table>
<thead>
<tr>
<th>HVAC Energy (kW/SF)</th>
<th>HPS Lighting</th>
<th>LED Lighting</th>
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</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>HGRH</td>
<td>ERV</td>
</tr>
<tr>
<td>Air Cooled Chiller</td>
<td>HGRH</td>
<td>ERV</td>
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<td>Water Cooled Chiller</td>
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<td>ERV</td>
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<td>HE DX</td>
<td>HGRH</td>
<td>ERV</td>
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<td>SF VFDs</td>
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<td>HGRH</td>
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Cream of the crop design

Figure 2 shows the Baseline vs. “best case” energy efficient grow room based on a combination of today’s best available technology.

In the baseline case, with HPS lighting, the total facility energy use is about 450 kWh/SF/yr. The best case is an ERV system with HGRH and LED lighting, which nets a total facility use under 400 kWh/SF/yr, almost a 50% reduction from the baseline, with the savings evenly split between lighting and HVAC.

When incorporating this information into program design, cost effectiveness must be considered. We estimated incremental cost for each technology based on 19 real-world cannabis projects representing a total of 28 energy efficiency measures. Taking into consideration the EEM energy savings (Figure 1) as well as the incremental project cost, we define cost effectiveness as the incremental cost per kWh savings achieved for each measure. This is shown graphically in Figure 3, with measures ranked by cost effectiveness from left to right.

Taking into consideration both the cost effectiveness and overall energy saving potential of individual measures is key for program administrators and growers alike in determining where to focus their efforts. Another way to look at this data is by qualitatively clustering measures into four quadrants based on savings potential and cost effectiveness, as shown in Figure 4.

How to implement these concepts in your utility Energy Waste Reduction program

Prescriptive measure recommendations – simple calculator-based tool analysis and pre-determined incentive structure; incentive levels can be modulated up or down depending on cost effectiveness requirements on measures.

The measures listed here are generally simple to implement, the resulting savings are straightforward to determine, and the probability of realizing the calculated savings is high.

- **HVAC savings from High Efficiency Lighting** – These savings should be accounted for in addition to the direct lighting savings. This can be incorporated into an existing lighting calculator tool and accounted for in a work paper or TRM. Savings can be calculated as a percentage of the total HVAC energy use if known. If HVAC savings are unknown then the HVAC savings can be assumed in terms of the application, veg room - 25% of the direct lighting savings and flower room - 33% of the direct lighting savings.

- **Insulation (roof and wall)** – baseline heating is assumed to be electric resistance and the savings level in general is around 4 kWh/SF of insulation. It can be adjusted for heat pump or gas heating as well. It is recommended a qualifying R-value of 19 or higher be required for both.

- **High Efficiency Dehumidifiers** – this is based on the water removal efficiency of 4.1 pints/kWh to 8.1 pints/kWh which results in savings between 14 and 18/PPD. Recommended a savings value of 4 kWh/PPD per pint/kWh improvement over 4.1 pints/kWh.

- **High Efficiency DX Systems** – claimed savings should be based on the efficiency level of the proposed equipment (EER). When modeled, a savings level of about 270 kWh/ton per unit increase in the EER above 11.

- **Supply Fan VFDs** – energy savings comes from straight fan energy savings combined with a dehumidifier (interactive
effects on this measure). Calculation is based on brake horsepower (BHP) and is assumed that BHP is on average 80% of the listed motor power; the average savings rate is 4,000 kWh/HP.

- **Ionization Odor Control** – modeling demonstrates typical savings at about 3 kWh/sqft or 0.37 kWh/CFM.

Custom measure recommendations – these are either more complex to analyze or more sensitive to inputs and assumptions than those in the section above and are therefore not well suited to a prescriptive approach. They are generally more complicated to implement and analyze, and if not implemented properly there is a risk that they may not deliver the calculated savings. However, they are also measures which can yield the highest overall energy savings and are considered worth pursuing whenever possible.

- **Variable Refrigerant Flow (VRF) Systems** – expected savings around 1,800 kWh/ton and cost about $0.54/kWh to implement
- **Water Side Economizers** – expected savings around 890 kWh/ton and cost about $0.59/kWh to implement
- **Hot Gas Reheat Systems** – expected savings around 2,400 kWh/ton and cost about $0.40/kWh to implement
- **Energy Recovery Ventilator (ERV) Systems** – expected savings around 4,300 kWh/ton and cost about $0.23/kWh to implement and for ERV+HGRH savings could be as high as 5,000 kWh/ton and cost about $0.29/kWh to implement

## Conclusion

It is our hope that this article helped inform readers about the immense opportunities for non-lighting energy efficiency available in the indoor agriculture sector. There are complex interactions between lighting, HVAC, dehumidification, air purification, and CO2 enrichment systems within a typical grow room that cannot be overlooked. Reducing the lighting power lowers the sensible loads as well as the latent loads since the lights drive the evapotranspiration process of the plants. Elevating the CO2 levels increases the rate of photosynthesis while further slowing evapotranspiration (making the plants more water efficient). Dehumidifiers add heat to the space as they run - while air conditioners tend to also dehumidify as they cool - and so the two systems will interact to reach an equilibrium point. All processes and interactions are dependent on the space temperature and humidity, making the analysis of energy efficiency measures in this environment challenging (but not impossible) to model.

If there is one take away, it would be that given the energy intensity of these facilities it is possible to reduce their typical energy use by 48% -- half of that coming from lighting savings and the other half from HVAC. While the considerations for incentive structure and methodology (prescriptive vs. custom) is more complex for HVAC, the savings can be substantial and should not be overlooked.

## About the authors

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Introduction

Given the strengthening economics of carbon-free electricity, electrification has become a critical step on the path to a decarbonized economy. In a time of decreasing sales, newly electrified end-uses are a potential new source of revenue for electric utilities. Utilities and consumer advocates recognize the potential for electrification to increase system optimization and decrease rates, creating a win-win opportunity for utilities, customers, and the climate.

While electrification has the potential to offer benefits, without careful load management through tools like demand response (DR) and innovative rates, electrification has the potential to increase peak demand and increase strain on the grid.

**BENEFICIAL ELECTRIFICATION** provides a framework to ensure electrification strategies meet one or more of the following criteria:

1) saves consumers money in the long run
2) enables better grid management and/or
3) reduces negative environmental impacts.

This article details opportunities for commercial electrification being pursued by utilities in the U.S., highlighting drivers and barriers to these technologies. Also outlined are potential impacts of electrification on peak load, and tools to manage these risks.

Electrifying the Commercial Sector

Electrification research and funding has largely focused on the transportation sector. Significant opportunities also exist in the commercial sector, which emits around 917 million metric tons of GHG emissions from non-electric end-uses annually, or around 13% of total U.S. GHG emissions. States and cities (including California, New York, and Washington, D.C.) rely on electrification of major loads to meet their GHG emissions targets.

Space and water heating are the largest areas of opportunity for electrification in the commercial buildings sector. However, natural gas is the dominant existing fuel type for these end-uses in many parts – particularly outside the Northeast and Northwest. Natural gas to electric conversions face more near-term barriers than conversions to electricity from other existing fuel types, including diesel, fuel oil, and propane. This is due to economic factors, including the relatively low cost of natural gas compared to electricity and regulatory concerns over fuel-switching. States with ambitious carbon goals, companies with corporate responsibility targets, and clean energy programs that target the upgrade of inefficient fuel-oil equipment will drive near-term adoption of electric space and water heating technologies.

For jurisdictions without aggressive GHG targets, utilities are starting to electrify non-natural gas end-uses through measures such as off-road vehicles and outdoor equipment. These technologies offer more immediate operational savings than space and water heating, and a variety of local air quality, health, and safety benefits.

Space Heating

Heat pump technologies are one of the most energy efficient options available to electrify space heating end-uses. The technology is generally two to four times more efficient than electric resistance and baseboard heaters, which have higher operating costs and greater potential impacts on peak demand. While widely used globally, heat pumps have seen lower penetration into the U.S. and currently only represent around 9% of commercial space heating.

One of the most popular heat pump systems in the commercial sector is variable refrigerant flow (VRF). VRF systems enabled with heat recovery can simultaneously heat and cool different zones within a commercial facility. Furthermore, VRF systems have a smaller footprint than other common commercial HVAC systems, such as boilers and chillers, making it uniquely suited for facilities with limited indoor space. These systems also require less maintenance than other commercial HVAC options, although specialized maintenance knowledge is required.

HVAC expertise can be a barrier to VRF and other heat pump systems in markets where the technology has low penetration, as specialized knowledge is required to install and maintain them. Incorrect installation of heat pump systems can prevent the realization of full energy efficiency benefits and cost savings. The HVAC community may also not be fully aware of recent improvements in the cold-weather performance of heat pump systems. Historically, at extremely low temperatures heat pumps have become less efficient and even failed to operate. In recent years, however, technological advances by manufacturers have produced systems that can operate down to -15°F. Knowledge and acceptance of these cold weather systems is still limited among HVAC contractors. Utilities may mitigate cold weather performance concerns by allowing contractors to install dual-fuel systems, where a heat pump is installed with a backup heating source, typically an existing natural gas, electric resistance, or
fuel-oil system. Backup heating systems turn on only when temperatures fall below a certain threshold (e.g., 35°F) and the heat pump system is used the rest of the time. While this approach mitigates customer and contractor concerns, it does not offer a full electrification solution.

**Water Heating**

Heat pump technologies are also a prime candidate to electrify water heating due to their high energy efficiency and cost-competitiveness. Heat pump water heaters (HPWH) are often designed as hybrid systems, incorporating a heat pump and backup resistance element to heat water. Facility types with high hot water demands, including lodging, healthcare, schools, and restaurants, may be good candidates for adoption of this technology.

HPWHs face similar barriers as heat pumps used for space heating applications. For example, lack of contractor acceptance can create supply-chain barriers, as contractors may not have HPWH systems available for emergency replacement scenarios. HPWHs require a large room to provide a sufficient volume of air, so cold weather performance can create challenges in smaller facilities. In temperate climates, HPWHs space concerns can be addressed by installing units on rooftops or in garages. However, in colder climates, HPWHs need to be installed indoors (e.g. in a maintenance room, basement, or storage area). HPWHs cool the space they are in; a unit installed indoors will increase the heating load in the winter and decrease cooling load during the summer.

**Off-Road Vehicles**

While on-road EVs often take the spotlight as technologies disrupting the electric utility industry, off-road vehicles and services have been steadily moving to electricity as battery and charging technologies have matured and grown cheaper.

**Forklifts, Airport Ground Equipment, and Drayage**

With advances in battery and charging technology, most forklift configurations now come in an electric option with life cycle costs that are competitive with or cheaper than the internal-combustion (IC) equivalent. Electric forklifts never produce onsite emissions, do not idle or consume energy when not in use, and require less maintenance than IC units.

Ground-support equipment serving airports and aircraft, including the vehicles that tote luggage around the tarmac, push the jets away from the terminal, or provide conditioned air to parked aircraft, can all be electrified. These provide many of the same benefits as electric forklifts and are a quieter alternative to IC versions, which is especially beneficial in airports where ambient noise is a health concern and communication is critical.

Drayage vehicles, which move containers of goods a short distance in shipping ports or logistics terminals, and the cranes that move shipping containers between ships, land, railcars, or trailers can also be electrified. Reducing GHG emissions is a driver in these environments, where air pollution is often high due to the concentration of vehicles running constantly.

Barriers to electric forklift or other off-road vehicles often mirror those of on-road vehicles, including perceptions that electric versions cannot perform the same duty-cycle as an IC model or that they are not as powerful, and they have higher upfront costs. Charging time can be a barrier for equipment using conventional chargers, but advances in rapid charging mitigate this challenge.

**Trucking Refrigeration and Truck Stop Infrastructure**

Outside of moving the vehicle, long haul shipping and local delivery fleets can electrify two additional end-uses: cooling the cab and refrigerating the cargo in the trailer. Electric truck refrigeration units enable a trailer’s cooling by plugging in and using grid electricity instead of an idling engine.

Electrified truck stops provide heating, cooling, electricity, and Wi-Fi to truck cabs, offsetting the driver’s need to idle their diesel engines. In hot climates, this technology is also used to pre-cool truck cabins before or between delivery runs; reducing the engine’s idle time thus extending the life of the engine and reducing maintenance costs.
Cost is among the main barriers to adoption of these technologies. The trucking industry’s boom-and-bust cycles make it challenging to prioritize proactive installation of electric equipment, despite cost savings over the long run. Decision makers may also be skeptical of the long-term benefits and savings from electrification as many fleets underestimate idling time and cost. Additionally, buy-in from drivers is essential to ensure cost savings are realized, as drivers may not use the technology if not educated on its benefits and proper use.

Lawn Appliances

Electrification of lawn appliances has several benefits, including reduction of noise and local air pollution, decreased maintenance and fuel costs, and cost-competitiveness of current models compared to their IC equivalents. OEM Off-Highway Research and Markets projects a 5% compound annual growth rate in U.S. electric lawn mower sales from 2018-2024, driven by increased interest in sustainable and energy efficient solutions. The primary barrier in the commercial sector is the need to charge batteries between job sites. Current batteries are too small to last the entire day, and while it is possible to swap out batteries for smaller handheld devices, larger devices such as riding lawn mowers need to be charged for up to 10 hours with a conventional charger or 2 hours with rapid charge.

Promoting Load Management

Utilities facing infrastructure constraints and load management challenges are looking to electrification as part of a solution. Electrifying otherwise fossil-fueled processes increases the net electrical load, a boon for electric utilities looking to increase revenues. Reducing natural gas loads can benefit capacity-constrained gas utilities but faces regulatory barriers absent capacity constraints. At a macro level, utilities with a low system load factor looking to fill off-peak lows in demand can look to electrification in concert with well-designed rates, DR programs, and customer education to nudge commercial and industrial consumers toward off-peak load growth.

Demand Response

Space and water heating technologies can often be ramped down or turned off during peak hours, or pre-loaded before a DR event. This allows buildings or hot water tanks to ride their thermal inertia through system and distribution peak periods. In capacity-constrained networks, utilities may work with electrified smart appliances to implement DR programs in the commercial sector that mirror those in residential settings.

Just as fleets of EVs or networks of EV chargers can be aggregated into a pooled resource and bid into energy markets, utilities can use fleets of commercial forklifts or other equipment. The chargers and batteries of off-road EVs will be another distributed energy resource available for the local grid to meet intermittent needs for capacity. A key consideration is the relative intelligence of the chargers in question. Conventional chargers may be available for reducing demand, while smart chargers can enable remote control and bidirectional charging or discharging of connected batteries to support grid ancillary services.

Rate Design

For electrified technologies with relatively high load factors, time-of-use rates show the consumer that there are more and less attractive times of day to charge equipment. Demand-based rates aim to provide utilities with some way to capture the costs of system availability for customers with lower load. A demand-based rate should nudge a customer to distribute energy-intensive operations throughout the day, rather than stacking them all in the same 1-2 hours. Critical peak pricing puts a premium on demand during a specific time of day, on certain days of the year. In regions with high cooling loads, critical peaks typically fall on summer weekday afternoons or evenings.

Conclusion

Utilities and consumers alike face new choices as many technologies change their power source from fossil fuel to electricity. Electrification technologies are entering the commercial sector through space and water heating systems and in applications such as forklifts and electrified truck refrigeration units. Electric options reduce onsite GHG emissions, can be cheaper than the corresponding IC option, and offer utilities opportunities for load growth.

Electrification brings risks such as increasing peak demand or straining areas of the grid that are not ready for heavier loads. Just as some residential feeders are not ready for EV charging, utilities can mitigate risk to their grids by considering how to manage load through rate design and DR, and through incentivizing beneficial electrification.

About the authors

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For the list of References, go to aesp.org/page/Magazine2020references
**Introduction**

Electrification and decarbonization are coming, and utilities, regulators, and the energy efficiency industry must adapt to this reality. Think of the future of utility energy efficiency programs like an iceberg. Carbon reduction sits visible above the waterline – it will become an explicit target and major performance metric for utilities. What we don’t know is how utilities and states will carry out electrification and decarbonization and what programs, incentives, and metrics will be used to drive it forward. These complex issues remain below water and out of sight. A valuable contribution evaluators can make is to help stakeholders better assess the impact current energy efficiency programs have on carbon emissions now, so that we are better prepared for the age of quantifying carbon.

Implementers and evaluators have established methods to measure energy savings, and it is time to adapt these processes to measure carbon impacts. Through an iterative approach that continuously refines savings attributed to certain equipment, the evaluation industry has become adept at fine-tuning the energy savings from light bulbs, air conditioners, and a variety of other equipment upgrades provided through energy efficiency programs. The assumptions about how the efficient equipment operates and what baseline equipment has been displaced are stated in technical reference manuals and DSM program documents. At the end of a program year or cycle, these savings assumptions are often revisited and updated. The end result is that we broadly understand energy savings resulting from DSM programs. Program administrators, utilities, and regulators can plan and rely on energy efficiency activities to generate the expected results. As utility and state goals evolve beyond specific kWh or therm targets, the iterative estimation approach that has allowed mass-market DSM programs to flourish must be modified. It is not sufficient to simply assume that installing high efficiency equipment is enough to reduce carbon emissions.

**All kWh are not created equal**

Accurately quantifying carbon savings can be a significant problem for evaluators of energy efficiency programs because they are highly variable depending on when and where the energy savings occurs. The good news – power generators and independent system operators (ISOs) provide the information needed to assess the carbon emission intensity of electric generation. For example, a recent study on consumption-based carbon intensity found that the average carbon emission intensity of electricity consumed in the United States in 2016 was approximately 1 lb/kWh. However, this carbon intensity varied from as low as 0.2 lb/kWh in the Pacific Northwest, to 0.5 lb/kWh in NY ISO, to as high as 2 lbs/kWh in parts of the Great Plains. This variability means that the effect of energy efficiency programs on carbon emissions is highly dependent on the location where the programs are active. The relative carbon intensity and total energy consumption for balancing authorities in the mainland U.S. are shown in Figure 1.

This geographical carbon intensity variance is further complicated by the fact that the carbon intensity in each region varies over time. The hourly carbon emissions for the MISO Central and MISO North regions are shown in Figure 2. The overall emissions factor for the North region is highly variable relative to the Central region because of the intermittent contribution of wind generation into the grid.

**Heat Pump Water Heater Example**

Consider the heat pump water heater (HPWH). As heat pump technology improves, HPWHs represent a significant opportunity for energy efficiency programs to continue...
to deliver savings and value to energy users. The overall energy savings from HPWHs are well documented for conversions of electric resistance heating to HPWHs. They present an attractive measure for mass-market utility energy efficiency programs.

In Minnesota, the installation of a HPWH in a commercial space is estimated to save 440 kWh per year assuming that the new HPWH is installed instead of a code-compliant electric resistance water heater. The average emission factor in the MISO North region is approximately 0.92 lb/kWh. It is tempting to assume that reducing energy consumption in MISO North will reduce carbon emissions by approximately 400 lbs (440 kWh x 0.92 lb/kWh). This value is reasonable if we restrict ourselves to looking at the electric-only impacts of moving from one electric heating technology to a more efficient one.

Considering merely electric-only impacts presents a challenge as utility programs shift toward electrification and have to assess the impact of fuel switching on carbon emissions. The carbon impacts of energy efficient equipment vary widely when fuel switching occurs. Estimating electric energy impacts while neglecting reduced fossil fuel use does not provide enough information to determine what the installation of a HPWH is actually having on carbon emissions or grid loads.

To illustrate this point, consider a worst-case emissions scenario where a relatively efficient gas water heater in an internal space is replaced with a HPWH. A simple e-Quest model was constructed to determine the actual carbon emissions impacts from the installation of a HPWH in a commercial space in Minnesota. The negative heating load on the space was included in the analysis. The energy savings from the installation of a HPWH were modeled using the actual weather in Minneapolis in 2016. The hourly results of this model and hourly emissions factor of electricity generated in MISO North in 2016 were used to determine the impact on carbon emissions from the installation of this measure. The savings were then scaled to reflect the same annual hot water use and efficiencies used in the deemed savings.

The results may surprise you: Installing the HPWH instead of a gas water heater actually increases emissions by approximately 263 lbs and may increase the load on the grid by 0.34 kW during maximum draw periods. This information is not typically captured in TRMs or reported by energy efficiency programs.

The Take-away

The take-away is simple. Our industry must begin to consider fuel switching and holistic building energy consumption to provide the information needed to integrate carbon goals into existing utility-funded energy efficiency programs. We can’t adapt our current programs to meet future carbon goals without taking inventory of all emissions back to the source.

Throughout the Northeast as well as other regions, state and utility energy plans are beginning to respond to broadened policy goals that establish longer term carbon reduction targets, such as the “80 x 50” goal (reduce carbon emissions 80% by 2050) in Massachusetts. These policies are counting on strategies to decarbonize buildings. How can TRMs evolve and how can evaluation more broadly evolve to meet the needs of the evolving policy environment? When we start to think about the implications for energy program planning and evaluation, the TRM issue is just the tip of the iceberg, it invites us to take a deeper look and devote thought to where energy program evaluation needs to be headed.

Furthermore, strategic electrification and integration of energy efficiency with distributed energy resources and non-wires alternatives are impacting the electric grid. States could benefit from modernized approaches to savings calculations of energy efficiency programs that enable them to link more accurately with carbon impacts. Some suggestions include:

1. Adoption of standardized simulation-based calculation methods supporting an expanding range of state-of-the-art energy efficiency technologies that support electrification and grid modernization. These methods will produce credentialed impacts that are specific to location and time.

2. Updates of data management techniques. To ensure successful grid modernization and program delivery, data processing, data storage and data access must be updated to manage an overall increase in data volume, as well as an increase in third-party data requests. California developed data sharing protocols in 2011. New Hampshire and New York are currently developing frameworks to enable online storage and safe data sharing with third parties.
3. Implementation of reporting that help states track and respond effectively to information about short-term progress toward our long-term carbon goals. This likely involves expanding the metrics that are used. For example, add carbon emissions metrics, including a $/metric ton avoided carbon as recommended in California, and include a fuel-neutral metric such as BTUs saved for efficiency program impacts. NYSERDA’s data dashboard that reports New York’s energy efficiency program performance is an example of more comprehensive and transparent program reporting. In addition, a shift in focus from annual to lifetime impact assessment and tracking may be appropriate.

Moreover, to be successful in tracking energy efficiency programs environmental and energy impacts and ensuring that the impacts are aligned with policy goals. EM&V for EE should not take place in a vacuum or within a silo. Some things that are needed:

- **Integration or embedding of evaluation with implementation** to enable rapid feedback for program optimization. This would be enabled by the advanced M&V tools noted above, particularly when combined with smart technologies to deliver data.

- **Building-level as well as technology-specific accounting.** Carbon-reduction policies, such as building performance standards that set energy consumption or emissions targets, are one example. Building energy labeling is another.

- **Revisiting baselines, attribution, and benefit-cost assessment within an integrated DER framework.** It will be important to take DERs into account to capture and understand load shapes in the context of shifting system peaks. An update to the National Standard Practice Manual is under development to provide guidance on cost-effectiveness testing for DERs. Homes with rooftop solar versus homes with grid-supplied power differ in impacts. ISO-NE is currently examining its PV forecast and the implications of behind-the-meter PV on its system peaks.

**Conclusion**

**Back to the iceberg.** By taking a look at how TRMs could capture carbon savings, we start to see that this invites thinking about what else is possible and needed for a more nuanced and complete understanding of program impacts on relevant policies. Hopefully, it helps us avoid crashing into an iceberg, and rather navigates us in the direction of a more holistic framework of methods founded on metrics, coordination and transparency across disciplines and nimbleness.
Implementing EE in the Community

Doris Iklé

You may think that all great small businesses start in the garage, but Doris Iklé started hers at the kitchen table. Iklé created Conservation Management Corp. (now CMC Energy Services) in 1977 to not just study but to implement energy efficiency. She was a pioneer, serving as one of the very few women in the energy sector to launch an energy efficiency services business in the early days, still women-owned today. She was also an inventor having developed several patented energy efficiency-related tools including the Fuelomizer (a do-it-yourself energy audit slide rule for use in the field) and the Home Tune-uP – a sophisticated software and auditor management tool for residential energy audits.

President and CEO of CMC Energy Services until 2010, she received the Lifetime Achievement Award from the Alliance to Save Energy in 2010. Iklé built the company from a single employee to an organization with over 250 professionals administering energy efficiency programs in 7 states today.

Her daughter Mimi Iklé-Khalsa, Chairwoman of CMC’s board, said “Mom was a pioneer in the energy efficiency field who had an insatiable curiosity and a desire to make the world better, CMC President & CEO Tina Bennett added, “She inspired a generation of women like myself to join the energy efficiency field. She truly was ahead of her time and demonstrated to everyone the ability to empower communities through energy efficiency and clean energy.” Iklé passed away in 2012.

References

For the list of References, go to aesp.org/page/Magazine2020references

The energy industry has traditionally been a male dominated field, and some would say that it still is. According to the 2019 U.S. Energy and Employment report, women account for only one-fourth of energy efficiency workers. Even so, the energy efficiency industry today would be a totally different place if not for major contributions by women who entered the field in its early days and paved the way for today’s leaders and entrepreneurs, while originating some of the foundations on which the industry stands on today.

For example, do you know who...

- Developed the first software for estimating energy savings from utility bills, still in use today?
- Launched one of the first woman-owned energy services companies?
- “Wrote the book” on statistical sample design for determining energy savings?
- Invented and patented the first slide rule energy savings calculator?
- Developed the field of process evaluation as an essential part of understanding EE program effectiveness?

We recognize several female trailblazers you need to know about – leaders we can all hope to emulate in addressing the challenges of our industry.
The energy industry has traditionally been a male-dominated field, and some would say that it still is. According to the 2019 U.S. Energy and Employment report, women account for only one-fourth of energy efficiency workers. Even so, the energy efficiency industry today would be a totally different place if not for major contributions by women who entered originating some of the foundations on which the industry stands on today.

We recognize several female trailblazers you need to know about—leaders we can all hope to emulate in addressing the challenges of our industry.

**Creator of the PRISM software**

**Meg Fels**

Margaret “Meg” Fels was a pioneering research staff member and one of the first female faculty members in the Civil Engineering school at Princeton’s former Center for Energy and Environmental Studies.

Fels is best known in our industry for creating a software package called the Princeton Scorekeeping Method, or PRISM, which helps assess the effectiveness of energy conservation projects in a building. While the model importantly accounts for externalities such as changes in weather between time periods, her major contribution was in producing and disseminating an inexpensive package with transparent analysis that was used by agencies all over the world to understand their programs and their customers. As such, Fels’s PRISM model basically laid the groundwork for billing analysis methods used today.

She was IEPEC’s 1993 Lifetime Achievement Award recipient. She passed away in 2011, and is remembered fondly by colleagues such as Robert Jahn, former dean of Princeton’s School of Engineering and Applied Science for her low-key demeanor in spite of her many accomplishments. “She just went and did her thing and did it well – in a very solid scholarly fashion.”

**A Pioneer in Behavioral Science**

**Jane S. Peters**

Jane Peters is probably best known for elevating the field of process evaluation into the energy efficiency landscape such that regulators and program managers alike understand not just how much energy has been impacted by technologies and programs, but why. She chaired the first look into EM&V standards in the early 1990s and was a member of AESP’s evaluation training team for many years. Peters founded Research into Action in 1996 to do social marketing research and program evaluation, now a part of Opinion Dynamics.

As an IEPEC Lifetime Achievement Award winner in 2013, Peters was recognized for her qualitative research work, including process and market evaluation, focus group moderation, and quantitative assessment of behavioral and indirect impacts. Though her work has spanned the U.S., one of her most significant contributions is helping develop the 2006 Evaluation Protocols for the California Public Utilities Commission. She was its lead author on the chapter on Market Effects Evaluation, and more recently coauthored the California EM&V Framework Refresh Needs Assessment.

On how she got involved in energy efficiency, she said “In the early 1980s, I realized that energy was a root cause to many social and environmental problems, so I focused my psychology training on how to make energy programs work for people.” Now as a Senior VP at Opinion Dynamics, she is still doing that – unpacking how and why people interact with energy, technology and services.

**Standardizing EM&V**

**Miriam “Mimi” Goldberg**

Perhaps best known for her seminal work in applying statistical methods to the evaluation of the impacts of energy efficiency programs, Mimi Goldberg has conducted methodological assessments for impact evaluation including net-to-gross methods, demand response baseline specifications, and load profiling for market settlement. Her doctoral dissertation under Meg Fels provided the technical foundation for PRISM and established many principles for “billing analysis” that continue to be important today. As Executive Strategy Advisor of DNV GL Energy’s North America division, Goldberg has served on many national and international committees, however an important capstone is her contributions to the Uniform Methods Project (UMP) as an author, reviewer, and member of the Technical Advisory Group. The UMP is a set of widely used “how-to” guidelines on conducting and interpreting EM&V.

Goldberg’s interest in energy efficiency traces back to high school activities that included the first Earth Day celebration. After college she visited with several faculty in the Center for energy and Environmental Studies at Princeton. “By the end of that day, I knew these were the people I wanted to be working with. Meg Fels became my mentor, friend, and continuing collaborator for many years.” Mimi was the recipient of the Lifetime Achievement Award from IEPEC in 2009.

**Then and Now**

There are many other female pioneers who have helped build and expand the energy efficiency field that exists today. More importantly, many new women entrants to the field are making important contributions. Mimi Goldberg offers this advice to those starting in the field today: “Do work you care about, that tickles your brain, and that keeps you surrounded by people you want to be with. Expect change, expect failures, celebrate successes, and keep learning. You’re going to be in charge not long from now, so get ready and enjoy the ride.”

**About the author**

Luisa Freeman has more than 30 years of experience in energy efficiency, renewable energy technology and distributed generation program planning and evaluation. She has served on the boards of the Smart Energy Consumer Collaborative and local chapters of AESP.
Utilities are embracing a more holistic perspective that combines energy efficiency with demand response and other distributed resources in a concept called Integrated Demand Side Management (IDSM). The proliferation of connected devices helped mobilize the emerging vision of the future which includes a transformed relationship between households and the grid. Demand response is an important element in enabling demand flexibility, and new program designs are at the forefront of these industry advances. Here we put the spotlight on two industry leading examples. Eversource’s Residential ConnectedSolutions Program demonstrates how utilities can successfully design a program that integrates multiple, complex distributed resources (DERs) while Ameren Missouri shares valuable insights and best practices gleaned from the evaluation of its Peak Time Savings program. Their experiences can greatly help inform your own integrated program design.
Eversource Energy – Residential ConnectedSolutions

Program demonstrates innovation in program design

Eversource is harnessing the potential of IDSM by implementing a DER flexibility and demand management program. Its ConnectedSolutions program applies the Bring Your Own Device (BYOD) model across three device categories: smart thermostats, EV charging, and residential energy storage. Its approach is vendor agnostic, allowing the utility to leverage DERs that its customers own (Figure 1).

Benefits of the BYOD design

ConnectedSolutions uses a single grid-edge DER management system (DERMS) platform to manage grid services from the utility’s multi-DER portfolio. The program is designed to achieve several operational objectives including distribution system peak load reduction, ISO-NE system coincident peak demand reduction, customer savings, and ultimately, reducing costs to customers.

The rapid growth of connected devices such as smart thermostats has made DER management a powerful tool for multiple groups across utilities, including demand-side management and grid operations. The Massachusetts Department of Public Utilities’ guidance allowing behind-the-meter solar generation to export excess electricity to the grid also helped drive the inclusion of batteries in the program to help incorporate solar generation efficiently.

The presence of residential solar generation in Eversource’s service area created the opportunity to charge batteries with clean solar energy and discharge them at peak times to benefit the grid. The growing adoption of EVs will add significant load while also providing a flexible grid resource. Together, these factors led Eversource to implement a multi-DER program aimed at providing immediate demand response results and gaining insights for the future on how different types of devices can affect and serve grid needs.

Management of the multi-DER portfolio

Eversource is one of the first utilities in the country to manage a multi-DER portfolio. A key element of this strategy is managing multiple assets with multiple dispatch strategies using its DERMS platform. This allows Eversource to combine the capabilities of different device types for benefits greater than the sum of the parts. For example, customers can use their batteries to absorb residential solar generation and if requested by Eversource, they can then dispatch the batteries at peak times, minimizing stress on the grid, while managed EV charging can smooth load during a second evening peak.

Program Implementation

EnergyHub, which has significant experience managing Wi-Fi thermostat DR, evolved to include other residential asset types: EV charging stations and batteries. Thermostat brands integrated into the program include: Nest, ecobee, Honeywell, Alarm.com, Lux, Emerson, Building36, Vivint, and Radio Thermostat. EVSEs include: Chargepoint and EnelX. Battery vendor partners include Sonnen, Tesla, and Generac. These device categories allow Eversource to operationalize BYO-thermostat Demand Response, EV managed-charging, and BYO-energy storage.

Furthermore, the integration of activities enabled by Eversource’s DERMS platform provided by Enbala, allows for a holistic perspective on the real-time capacity in different parts of the territory, which could be called to help meet the system peak, or to meet local constraints.

Eversource can orchestrate (model, schedule, and control) behind-the-meter assets to operate in such a way that the utility sees a desired load shape at a specific location on the grid. This serves as a capital and cost-effective non-wires alternative to distribution infrastructure upgrades.
A potential use for this capability is renewables matching – also referred to as solar sponging - where Eversource can identify behind-the-meter batteries and instruct them to “soak up” excess generation or export/curtail load during periods of high/low generation. This minimizes stress on the grid. Specific to EVs, managed charging shapes load by intelligently staggering the charging of EVSE cohorts while ensuring the timely charge of each vehicle.

The EnergyHub uses granular charging data and customer usage profiles to derive EV-specific asset models. With these models, charging activity is forecasted and the optimal portfolio of EV-specific charging schedules is identified to create the utility’s desired load shape.

The connected thermostat program exceeded enrollment goals for the program’s second year before the end of their first demand response season. Eversource’s incentive compensates participants at enrollment and again at the close of the demand response season, balancing initial enrollment and participation throughout the season. Eversource relied on best practices around dispatch parameters to ensure customer satisfaction and comfort during events, which resulted in a low opt-out rate. The program successfully dispatched thermostats on multiple occasions to relieve peak load -- satisfying the directive from their regulator, and achieving relatively high load shed per device.

Batteries serve a different grid need from thermostats, and also come with a new set of customer preferences and behavior. Batteries participating in the program could be paired with residential solar generation, which unlocks the full potential for grid services for this DER. Eversource’s research showed that batteries are significantly more effective when dispatched frequently and flexibly. The higher cost of batteries and its flexible value to the grid prompted a higher incentive – for those purchasing a new battery and existing battery owners.

As noted earlier, batteries can deliver solar sponging. There are multiple ways to implement solar sponging, and the program so far has allowed Eversource to experiment and analyze how the technology performs in practice. This will be an important capability for Eversource to achieve daily grid flexibility, especially with increasing adoption of residential solar panels.

Meanwhile Electric Vehicle charging reflects a paradigm shift with significant implications on grid health. Eversource worked directly with EV charging device providers and EnergyHub to design the program to manage charging so as to alleviate risk of a second peak demand during evenings due to charging. It will typically slow down charging, not stop it completely (although there is a stipulation to halt charging during a grid emergency).

Putting it all Together

Eversource’s ConnectedSolutions residential program has allowed the utility to manage customer DERs to provide valuable grid services. The program responds to immediate grid challenges and provides value in the present, while also preparing Eversource to manage future shifts such as increased renewable generation and EV adoption. In the residential sector, the program enrolls customer-owned connected thermostats, batteries, and electric vehicle charging devices as assets to be managed by Eversource. The program fits a relevant and timely need – tying together customer demand for connected devices, with the ability of those devices to provide value for grid health and financial savings.

Ameren Missouri – Insights from its Peak Time Savings program

Ameren’s Peak-Time Savings program (PTS) was intentionally designed and implemented as a single integrated demand-side management program, with integration occurring not only at the resource level, but across all program facets, including technology, customer, and administration.

At its core, the PTS program falls under the category of common IDSM programs, yet the intentional approach to multi-level integration presents an interesting case study with important lessons learned and insights for Program Administrators from the design, implementation, and evaluation and measurement perspectives. More specifically, it addresses: is the sum greater than its parts? What are the challenges, and what can utilities do to ensure they are prioritizing and optimizing key benefits from integrated programs?
The PTS program leverages smart thermostats as a control mechanism; it integrates demand response and thermostat optimization strategies to deliver stacked benefits, which include load shaving during peak conditions as well as continuous energy savings associated with cooling runtime reductions in the summer season. This program was designed specifically to achieve system reliability load-shaving benefits to support long-term integrated resource planning (IRP).

The PTS program integrated various sources of customers; it drew customers from a broader market channel through Its Bring Your Own Thermostat (BYOT) program design as well as from existing Online Marketplace energy efficiency programs. Customer enrollment through the latter channel was designed to be seamless operationally, with incentives and enrollment at point of purchase occurring simultaneously. Enrollment in both the BYOT and existing program channel was integrated on Ameren Missouri’s website. From the customer perspective, smart thermostat optimization and demand response elements were part of a singular programmatic offering.

The PTS program design, which included multiple manufacturers, was sensitive to individual manufacturer device control strategies. For some device manufacturers, the program layered implementer-driven control platforms on top of existing thermostat manufacturer platforms to dispatch DR events and optimize device setpoints. For others, it worked with device manufacturers to pursue their preferred control and deployment processes. The graphic below provides a visual summary of the complex nature of device-specific design in which DR and optimization interventions were integrated. It also illustrates the complexity that unique program design elements presented from both the implementation as well as evaluation perspectives.

Carefully planning for resource prioritization and the evaluation approach (including baseline development) in light of those particular complexities is important. For example, running optimization without setting aside an “untreated” or control group runs the risk of contaminating the baseline. For example, if non-event day runtime is lower than under normal conditions because of optimization, DR impacts would be underestimated. Depending on the algorithms, both DR as well as optimization strategies vary in the specifics of their deployment, including aggressiveness of setpoint adjustments and ability for participants to opt-out mid-event. Those variations result in differences in impacts but also impact customer experiences, including comfort. Finally, as device manufacturers make their device optimization upgrades broadly available, the effects of these additional optimization opportunities and interventions on program implementation and evaluation need to be assessed.

Opinion Dynamics conducted a comprehensive evaluation of the program in 2019. The evaluation activities included estimating demand and energy savings, and a survey of program participants. Here are the key evaluation highlights:

- The PTS program exceeded its participation goals. The program enrolled 63% more participants than the planned number of participants.
- During DR events, the program achieved 74% in cooling load reduction and 112 kW per-device impacts, on average. Energy optimization resulted in 9% reduction in average baseline energy usage. Program impacts varied considerably across both DR and optimization components. More specifically, cooling load reductions varied from 72% to 84% depending on the manufacturer. Load reductions were largely driven by setpoint adjustments and event opt-out procedures during the events. Optimization impacts ranged from 3% to 15% and were largely a function of the aggressiveness of the deployed algorithms.
- Despite multiple eligibility checks and verification steps, virtually all participants found the process of enrollment and registering their device either very or somewhat easy. Participants also reported high satisfaction ratings across most program components – from program enrollment to satisfaction with their devices, demonstrating that integrated programs can lead to ease of participation and positive customer experiences.
- While only 2% of participants opted out of the program as of the end of the 2019 summer season, the opt-out rate for devices with more aggressive event management and optimization strategies was seven-fold higher. Participants with more aggressive optimization strategies were significantly more likely to notice temperature changes.
- Concerns with comfort and utility control of devices emerged as some of the core barriers preventing greater program uptake.

As IDSM efforts mature further, find their way into more utility portfolios, and increase in their complexity of stacked resources and benefits, the planning and administration of such programs will become more complex and require more flexibility. The evaluation community will need to innovate and diversify its evaluation toolkit. However, the core questions that utilities will face when planning for such programs will remain similar to the questions that Ameren Missouri tackled in its PTS program:

- How do we select the interventions to ensure maximum grid benefit and flexibility?
- How do we bridge administrative and implementation silos to establish a program that effectively leverages existing program infrastructure?
- How do we balance aggressiveness of interventions with customer satisfaction and experience?
- How do we integrate research design elements to ensure rigorous measurement of impacts without sacrificing additional savings opportunities?

References
For the list of References, go to aesp.org/page/Magazine2020references
As states begin implementing clean energy policies, the vision of a new energy future is becoming reality.

Customers will have the flexibility to buy power from the grid or generate it themselves. These “prosumers” will charge their electric vehicles at night using grid supplied wind energy, power their home during the day with onsite solar photovoltaics, store any excess generation in a battery and control it all through their mobile phone and home Wi-Fi network. As intriguing and encouraging as this future looks, it is a future that may not be distributed equitably. A segment of your customers will not have the ability to make the transformation to be a prosumer. Some customers in low income or disadvantaged communities do not own their homes nor are they able to install the latest technology. Programs targeting low income communities are usually the most challenging due to the multiple, interrelated factors that these customers face. Additionally, these customers pay to fund these programs through their energy bills, yet do not have an easy access. How can they participate in the new energy future? Additionally, how does the traditional utility business model adapt without further penalizing the customer who does not have this choice? What are steps that we as energy service professionals take to mitigate this inequitable energy experience?

What Prevents an Equitable Distribution?

The barriers that keep customers from purchasing energy efficient products are often the same ones that are barriers to equity. The barrier of initial cost is exacerbated by limited disposable income along with difficulty in securing loans. Low rates of home ownership coupled with age and physical condition of the structures they live in can also prevent customers from installing new efficient technologies. As has been demonstrated recently with the COVID-19 pandemic and the education system; a significant percentage of customers may have smart phones but lack access to broadband internet for children to do schoolwork. In these underserved areas, there may also be a lack of trust in local governments and utilities.

How large a segment of your customer base falls into this category? While social scientists have many different indexes for calculating inequality, such as Gini, Theil, and Hoover; looking at a customer’s...
percentage of annual income spent on energy may be more appropriate for this discussion. Using the Department of Energy’s LEAD (Low-income Energy Affordability Data) Tool, almost a third (31%) of the 122 million households in the United States fall under the 200% of Federal Poverty Level guideline. How does this relate to equity?

This bar graph illustrates a rather high-level view of how energy burden can impact customers’ lives. For the customer segment 0-100% of Federal Poverty Level, 16% of their household income is spent on energy; significantly higher than that of the ≥400% segment. Persons living with a high energy burden are faced with making tradeoffs to match expenditures to income. Most will sacrifice health and comfort; neither of which are good alternatives. Since they have limited discretionary income, they are not able to invest in technologies such as solar photovoltaics or high efficiency air conditioning that may ease the energy burden. Unfortunately, low income does not translate to low energy bills. As the data shows, the average energy bill for the ≤100% of FPL is $1,500 per year compared to $2,100 per year of the ≥400% group; a difference of about $50 per month. As a group, they are very sensitive to energy bill increases.

**Equity and the Utility Business Model**

Utilities, justifiably so, are concerned about the impact to their business model from the new “prosumer.” Traditionally, utility rates are set by taking historical test year costs allocated to each customer class, dividing them by expected annual sales. As prosumers elect to purchase their energy from other sources, their buying behavior has the potential to raise rates for other consumers. Cost causation is the driving philosophy behind the design of energy rates. In other words, the customer class that received the benefit and caused the cost is allocated that share of the utilities cost through rates.

Utilities are exploring potential options to account for this change in customer behavior by shifting from volumetric rates to fixed charges. Such a movement as this could unintentionally have an adverse impact to low- and moderate-income households, not to mention reducing the incentives for installing energy efficiency measures. Customers can reduce their consumption but still have an equal or larger energy bill as their fixed charges have increased. As utility cost of service regulation is being revisited, how do we thread the needle where the financial interests of the utility are met, but without placing additional energy burdens on low-income consumers? Special low-income rates could be created, but utilities have traditionally not wanted to perform the customer income verification. As an option, utilities could coordinate such a rate with agencies that provide bill payment assistance. However, this approach only treats a symptom and does not solve the issue of access to clean energy technologies.

As this issue is being debated at utility commissions across the nation, advocates state that the new clean energy future will help all customers, not just the prosumers. Cleaner air and water, they suggest, will benefit everyone. However, will this end up being another tradeoff the low-income customer need consider? Higher energy bills for a cleaner environment? In calculating the impacts of externalities, the devil is in the details. As Richard Lazarus wrote about environmental equity in 1993, “Pareto optimality in the sense of making everyone better off and no one worse off is beyond the reach of virtually all law and policy.” Policy makers and all stakeholders in the ratemaking process will need to cooperate in creating rate options that foster the clean energy movement, but do not harm those customers whose transition may take longer.

**A New Obligation to Serve?**

Today, regulated utilities operate under an obligation to serve all customers. As new entities, such as solar photovoltaic and battery companies, enter the energy market; will they meet the same obligation to serve every customer that contacts them? Probably not. For the most part, these new energy providers operate outside the state regulatory jurisdiction. Since they operate in a competitive market, they seek to maximize their profits by soliciting the most attractive customers. To an extent, this behavior may be modified by utilities creating demand side management programs where these new providers participate but must deliver services on a nondiscriminatory manner. Another option would be to allow utilities, with approval from their regulator, to provide the services themselves. Frequently utilities are discouraged by their regulators from engaging in competitive energy services. In certain scenarios, the utility could provide these energy services directly to customers in targeted under-resourced areas and recover the costs through rates. Given the cost causation conundrum, however, the costs of this program would be allocated back to the residential class and would result in higher bills once again.
Utilities are exploring potential options to account for this change in customer behavior by shifting from volumetric rates to fixed charges. Such a movement as this could unintentionally have an adverse impact to low- and moderate-income households, not to mention reducing the incentives for installing energy efficiency measures.

The Telecom and Health Care Experience

Does the experience from other industries offer any insights into providing equitable outcomes? Yes and no. In the field of telecommunications, there are provisions in Federal law for providers to offer universal service to underserved areas such as inner city and rural areas. Yet, broadband service is not evenly distributed. In a recent Brookings institution report, 18 million homes in the United States do not have access to high speed wired or wireless service. In response to Internet service providers’ slow response to expanding broadband service, communities are pursuing local control through public ownership, cooperative models, and other nonprofit approaches.

From the healthcare perspective, states such as Virginia, Arkansas and South Dakota have created pathway or pipeline programs that recruit students from backgrounds that are historically underrepresented in health care professions. The primary goal of these programs is to promote greater diversity in the healthcare workforce. It is expected that participating students might be likely to return to practice in their communities. This accomplishes two objectives. First, it increases the number of providers in underserved areas, who have existing relationships in those communities. Second, by having members of the community return, trust barriers will be overcome. States have also provided scholarship and loan repayment programs to increase healthcare provider recruitment and retention. These programs typically provide students in health professionals with financial assistance in exchange for committing to practice in a medically underserved area for a specified period.

Solutions for the 31%

Policy and regulatory decisions are typically not resolved quickly. The traditional approach to low income community programs has been to offer payment assistance and the direct installation of efficiency measures. Equity considerations should be part of the design of demand-side programs. We see from the telecom and health care industries that there are strategies that can also be implemented to increase access to clean energy. Let us keep in mind that equity has other dimensions, such as access to economic opportunity. These underserved communities more than likely have workforce and other economic development needs as well. Utilities themselves can accelerate the solutions. Recently, Public Service Electric and Gas announced a partnership with the NAACP to implement New Jersey’s clean energy policies into disadvantaged communities. This partnership will offer universal access to energy efficiency technologies coupled with workforce development.

Examples of Projects

Community solar, either through the utility or project developers, is another alternative approach to expanding access to clean energy for targeted neighborhoods or communities. CPS Energy offers a community solar program where the utility installs and maintains solar photovoltaic systems throughout its territory and sends credits to subscribing customers on their energy bill. Another model is the District of Columbia’s Department of Energy and Environment’s “Solar for All Program.” The program offers grants to solar photovoltaic developers to install systems in single and multifamily homes and offer access to other customers through a subscription service community solar. Recently, the California Energy Commission approved a grant to build and demonstrate the Basset-Avocado Advanced Energy Community (BAAEC) in Los Angeles County. The BAAEC proposes to supply renewable energy and energy services within a disadvantaged community. The BAAEC will include a community solar and storage system to offset the annual electricity load of low-income participants, a microgrid, 50 single family homes equipped with solar photovoltaic and battery storage to be integrated with a blockchain community network and electric vehicle charging stations with mobility options.

Perhaps we can look back to the examples such as the Rural Electrification Act of 1936 with a focus on ensuring that all customers have access to clean energy alternatives. During the late 1940s, crews worked across the rural countryside installing the needed infrastructure to provide a basic level of electric energy to farms and ranches. Not only did this provide energy to remote areas, it was also an economic development activity as well. Today, block grants could be created to provide the financial incentives to governments and developers give clean energy access to underserved communities. Working with other industries facing similar equitable delivery of service issues, energy, telecommunication, and health care providers could partner to find solutions that address all the interconnected issues facing the underserved markets.

As the article opened, a future scenario was painted where customers could purchase solar and control their usage through their Wi-Fi network. Perhaps a parallel scenario might be one where residents of an inner-city apartment complex check their energy usage on their smart phone and notice they have received credits from their community solar subscription. They then dim their Wi-Fi connected LED lights that were installed as part of an energy and healthcare collaborative, and then log into an online training session on building science provided through their broadband cooperative. All this is possible as we create solutions where no customers are left behind in the clean energy future.

References

For the list of References, go to aesp.org/page/Magazine2020References

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Postscript – June 15, 2020

This article was submitted to AESP for review in May, 2020. The protests that happened in May and June are an indication of a lack of trust in the institutions that serve these neglected or under-represented neighborhoods. While offering easier access to clean energy options will not solve all the complex issues these communities are facing, it is at least a starting point to rebuild both infrastructure and relationships.
TRANSPORTATION ELECTRIFICATION: LESSONS FROM TVA’S NON-ROAD EV (NREV) PROGRAM

By Cortney McKibben and Ian Metzger, with contribution from Jennifer Rosenthal, Steve Bell and Angela Gordon

Introduction

Transportation electrification...today, it has the demand-side management (DSM) industry so confused that many suspect we are operating in Abbott and Costello’s famous “Who’s on First?” comedy routine! Is it because EVs were around 100 years ago, disappeared, and are now back again? Or, is it because EVs are being included in DSM programs that were developed to reduce energy consumption, not increase it? How come we are using EVs to beneficially increase electric load, just so that we can curtail it during peak events some time in the future? Can we really use the state-of-the-art EV battery technology for vehicle-to-grid energy storage? Can EVs really be a single technology that fits the definition of “integrated demand-side management” (DSM) all by itself? These questions are only the tip of the iceberg that is driving the increasingly loud call for decarbonization goals and measures. It’s no wonder we feel like we are working within a comedy routine written as an endless loop. Luckily, there are a lot of smart people in this industry working to untie this knot.

Regardless of how the questions above get answered, and the program label the DSM industry ultimately applies to EVs, this technology provides value to the utility, the customers, and the community, which is the win-win-win opportunity we seek within our program designs. In this article, we follow the TVA EnergyRight for Business & Industry Program, and its implementer TRC on a journey of innovation – as the value proposition from a Non-Road EV Program provides the confidence and courage to transition completely from energy efficiency to beneficial electrification.

Timeline

TVA provides electricity to 9 million people through 154 Local Power Companies and 59 directly served industrial and institutional customers, in a service area covering seven states. In 2009, TVA launched the Commercial Efficiency Advice and Incentives Program, ultimately branded as the TVA EnergyRight for Business & Industry Program. TRC (formerly Lockheed Martin Energy) implements its nonresidential portfolio, which include: development of incentives for smart energy technologies for C&I, and technical advice, tools and research to help customers better manage their energy usage. To achieve TVA’s emissions-mitigation objectives within the Tennessee Valley region, TVA and TRC launched the Non-Road Electric Vehicle (NREV) Program in 2015. The NREV Program offered valuable non-energy benefits while increasing market momentum during the initial two-year pilot. The program also led to an expansion of Smart Electric Technologies Offering through adoption of electrification measures. By 2018, TVA and TRC fully transitioned the TVA EnergyRight for Business & Industry Program to beneficial electrification (BE) only. Today, this program is a market leader in electrification and innovation with many other utilities learning from this exercise in nontraditional DSM program delivery, enabling many to journey down a similar path.

Benefits of Electrification

Technological advancements and more competitive prices have encouraged the implementation of renewable energy resources. These market conditions, as well as energy- and emissions-reducing policies and mandates, have resulted in cleaner energy supplies. The Electric Power Research Institute (EPRI) conducted a U.S. National Electrification Assessment in which they found that cleaner generation, grid modernization, and continued rapid adoption of electric end-use technologies was needed to realize the full benefits of efficient electrification. EPRI also found that efficient electrification’s benefits can include: lower cost, lower energy use, reduced emissions, reduced water use, improved health and safety, gains in productivity, more precise process control to improve product quality, and increased grid efficiency and flexibility.

TVA’s generation fleet has been a market leader in greenhouse gas (GHG) reductions through investments in cleaner and less expensive technologies. TVA reduced their generating fleet GHG emissions by 58% from 2005 to 2020.
Non-Road EV (NREV) Program

To capitalize on the lower-generation emissions, TVA and TRC launched an EV incentive program in 2015 targeting non-road vehicles that have lower emissions standards than other vehicle types or fuel sources. NREV leveraged the existing incentive program structure to provide public benefits, encourage clean load growth, and replace aging, less efficient equipment for TVA customers. Specific non-road vehicles were targeted for this program, including electric forklifts, airport ground support equipment (GSE), heavy-duty truck stop electrification (HD-TSE), and electric truck refrigeration units (eTRU). The objective of this program was to reduce local emissions and achieve 5% aggregate market development of EV technologies in place of internal combustion (IC) technologies.

EV Savings Methodology

Estimating local emissions from IC engines in non-road equipment can be complex and depend on many factors. Some programs have oversimplified the calculation to basic factors that erroneously estimate emissions reduction and fail to consider different equipment types and operating conditions. The U.S. EPA developed a simulation model, NONROAD, for estimating broad populations of non-road vehicles for regional reporting and emissions accounting. This model evaluates the emissions from several different processes associated with IC equipment emissions. The technical approach developed by the U.S. EPA for broad population studies was adapted for the NREV Program and applied to custom and prescriptive EV projects to quantify the emissions reduction and economic benefits of transportation electrification measures. A paper published by this team at the International Transportation Electrification Conference in 2018 describes the methodology in greater detail. Table 1 below describes different emission events and the applicability to various fuel types and equipment types.

Participant documentation requirements were developed to be straightforward, easy to obtain, and verifiable. The EPA NONROAD model methodology was calculated during the application process which included an integrated emissions factor calculator in the online form. Local weather variables such as ambient temperature, daily high temperature, daily low temperature, and Reid vapor pressure were also used in the calculation, because emissions are weather-dependent. EPA emissions standards have changed over time with the implementation of four tiers of emissions reduction standards between 1996 and 2012 for non-road IC engines. Therefore, model year was an important input. The output of the calculator was measure-specific emission factors that can be used to estimate annual savings, shown in Figure 1.

Table 1. Types of Emissions from IC Equipment

<table>
<thead>
<tr>
<th>EMISSION TYPE</th>
<th>DESCRIPTION</th>
<th>APPLICABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diurnal</td>
<td>These emissions are due to temperature changes throughout the day.</td>
<td>Applicable only to gasoline/E85.</td>
</tr>
<tr>
<td>Permeation</td>
<td>These emissions are due to fuel that works its way through the material used in the fuel system.</td>
<td>Not applicable to large equipment.</td>
</tr>
<tr>
<td>Hot Soak</td>
<td>These emissions are due to residual heat from the equipment just after the engine is shut off.</td>
<td>Applicable only to gasoline/E85.</td>
</tr>
<tr>
<td>Running Loss</td>
<td>These emissions are similar to diurnal except the heating is caused by engine operation.</td>
<td>Applicable only to gasoline/E85.</td>
</tr>
<tr>
<td>Displacement</td>
<td>These emissions are the vapors displaced from the fuel tank when the tank is refueled.</td>
<td>Applicable only to gasoline/E85.</td>
</tr>
<tr>
<td>Spillage</td>
<td>This refers to fuel spilled during refueling events.</td>
<td>Applicable only to gasoline/E85.</td>
</tr>
<tr>
<td>Crankcase</td>
<td>These are vapors released from the crankcase of an engine.</td>
<td>Not applicable to large equipment.</td>
</tr>
<tr>
<td>Exhaust</td>
<td>These are the vapors released through the exhaust from the combustion chamber in the engine.</td>
<td>Applicable to all IC equipment.</td>
</tr>
</tbody>
</table>

![Figure 1. Application-to-Savings Process](image)

**EV Incentive Design**

EV incentives were designed to cost-effectively increased adoption of forklifts, airport GSE, HD-TSE, and eTRU. Calculation of measure specific emissions factors allow for a robust and accurate incentive rates to be paid per ton of emissions reduction (or beneficial load growth) for each of the different technology types in order to accelerate adoption of EV transportation assets. Incentives were developed and offered for both EV vehicles and EV infrastructure.

**Insights and Results from the Field**

Program staff found that stakeholder engagement, and communicating the benefits of EV adoption, was a top priority for lasting impact. In addition, several EV technology specific lessons learned were identified throughout implementation.

- **Forklifts**: Number of shifts and leasing contracts can affect the useful life of equipment and life-cycle savings.
- **Airport GSE**: Be aware there are many potential participants at airports: airport authorities, airlines, cargo carriers, corporate procurement offices, and other airport businesses that operate GSE.
- **TSE**: Infrastructure-based measure with emissions saved per parking space at the truck stop rather than when the vehicle is mobile.
- **eTRU**: Similar infrastructure-based measure where time at dock is a key parameter. You will need to separate refrigeration cycle power source from main engine.

Between March 2015 and September 2017, the TVA program paid $3.6 million in incentives to facilitate conversion of 651 fossil-fueled units of equipment to electric powered alternatives, and the installation of 24 electrification stations at truck stops throughout the TVA service territory. As a result of these conversions, net emissions of GHG were reduced 209,337 tons over the lifetime of the new equipment. The average incentive cost of emissions reduced was $17 per ton of GHG. The beneficial electrification resulted in a net load growth of 9,445,276 kWh annually for local power companies, with estimated revenue increase of $755,000 annually. The revenue increase is estimated to surpass the cost of the incentives in less than five years while providing cost-effective and measurable economic and environmental benefits to TVA customers.
Transition to Beneficial Electrification

The TVA NREV program was very successful at reducing emissions, enhancing environmental benefits, supporting capital investment in local businesses, and improving commercial and industrial customer operations. The success of this EV program led to an expansion of electrification measures through a Smart Electric Technologies Offering. That expansion continued through 2018, when TVA and TRC fully transitioned the TVA EnergyRight for Business & Industry Program to beneficial electrification (BE) only.

The market has been conditioned to make energy efficient upgrades and get an incentive, and consumers don’t think of their utility as a place to go for electrification technologies. In addition, beneficial electrification creates a need to provide customers with the right energy solutions without incentives in some instances. The value proposition of traditional energy efficiency programs was simple: save energy to save money. Beneficial electrification requires consumers to understand longer-term alternative benefits, which involves discussions that aren’t necessarily limited to cost savings. Communicating the right message is even more important because there are no external agencies (e.g. ENERGY STAR) promoting beneficial electrification in the marketplace. Electrification presents the opportunity to expand the value proposition to target customer pain-points such as operating costs, health and safety, planning uncertainties, load controllability, and environmental goals. Therefore, it is extremely important for program outreach staff to be equipped with the knowledge and resources to identify and communicate the right value proposition for TVA customers. Training, targeted marketing, data analysis, and other tools to convey the quantifiable benefits to customers is paramount to adoption. For example, in the current forklift electrification program, the program identified the following benefits as key consumer interests:

- Cash incentives to reduce capital investment
- Reduces incremental payback
- Reduced operating costs
- Lower maintenance costs
- Non-Monetary benefits:
  - Reduced emissions
  - Quieter operation
  - Cleaner workplace

Following this approach, the program has achieved 198 GWh of new load as of early 2020, with a strong electrification pipeline of nearly 280 GWh of new load. By partnering with a process-driven implementer, TVA was able to quickly and seamlessly round second base.

Final Thoughts

EV technology provides utilities with a strong value proposition, a remedy for aging infrastructure, beneficial load growth, and a new and valuable use case for public benefit funds. In addition, EVs provide customers with valuable fuel and maintenance savings, improved indoor air quality, quieter operation, and greater process precision, while contributing to a cleaner environment and sustainability goals. Through efforts such as effective program design and the recruitment and training of program partners, utilities can make meaningful contributions to emissions reduction and economic development through beneficial electrification programs, including transportation electrification efforts.

TVA’s leadership in Transportation Electrification and Beneficial Electrification continue to be monitored by the DSM community as programs evaluate options to promote economic development, address changing infrastructure constraints, and emerging, high-efficiency technology deployment.

References

For the list of References, go to aesp.org/page/Magazine2020references

About the authors

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Nearly all heat pumps and refrigeration cycles use a refrigerant that boils at low temperature and pressure, and condenses at high pressure and temperature. The production of high pressures and temperatures requires energy input. Figure 1 shows boiling and condensing pressures at typical cooling (indoor) and outdoor temperatures.

The primary energy requirement for a vapor-compression cycle is the compression stage, which is driven by natural gas or electricity, as we shall see. The primary input for the absorption cycle is heat.

For reference, ammonia is the most common industrial refrigerant, particularly in food processing and freezing. It is also used in the absorption cycle with water. Refrigerants 410a and 134a are common for residential and commercial space cooling. Carbon dioxide is gaining ground as a “low side” (low temperature) refrigerant, and as a working fluid in emerging heat pump technologies. As a refrigerant, water is strictly for absorption when paired with lithium bromide.
ELECTRIC HEAT PUMPS

Electric heat pumps are significantly more common than absorption heat pumps, primarily because of two factors: they are less expensive to manufacture, and they are reversible. This reversibility means they can provide heat in winter and cooling in the summer with the same system. We will explore four classes of electric heat pumps.

- Single zone central residential
- Zoned
- Variable refrigerant flow
- Water-source

All electric heat pumps work on a reversible refrigeration cycle. A simple vapor-compression refrigeration cycle is shown in Figure 2, for air conditioning. The difference between the Figure 2 system and a heat pump is the heat pump has extra plumbing and a reversing valve to reverse the flow of refrigerant. The difference, including the reversing valve, is shown in Figure 2. The valve switches the direction of heat flow from inside-out (summer cooling) to outside-in (winter heating). Figure 3 shows the system in heating mode. The ingenious valve design simply slides the “U-turn” shown to reverse flow direction. With reversibility, the outdoor coil serves as the condenser in the summer and evaporator in the winter and vice versa for the indoor coil.

Figure 2 – Simple Refrigeration Circuit

Figure 3 – Heat Pump Circuit with Reversing Valve
Single Zone Central Residential

Perhaps the most common heat pump system is the single zone unit. Like the decades-old central air conditioning systems, these outdoor units supply heating and cooling to an air handler that distributes heating and cooling via ductwork to an entire home or group of rooms in a commercial building.

Installations of this type of system are most appropriate to retrofit or replace air handlers where ductwork is already in place. Air source systems, as shown above, or ground source heat pumps, discussed below, are viable options.

Zoned Systems

Zoned heat pump systems, also known as “ductless” or “mini-split” systems are newer and preferred technology compared to the single zone system described above. In general, the industry uses a wide variety of terms, but this section describes zoned systems for residential applications. They can also include an air handler that serves multiple rooms, such as one floor in a home, as shown in Figure 4.1

Variable Refrigerant Flow

Variable refrigerant flow (VRF) systems are larger versions of zoned residential systems, and many are designed for heat recovery, allowing heat to be moved within a building. Many commercial buildings, especially those with large footprints, have internal spaces, such as conference rooms, cubicle areas, or large retail floor areas that need cooling all year because they have no heat loss. They only have heat gain from people, electronics, and lights. In northern climates, the heating season spans more than six months. During this time, heat from internal spaces can be moved with the VRF system to external spaces where heating loads exist. Similarly, solar exposure throughout the day and seasons impact building loads. The VRF option can save a lot of energy as only one vapor compression cycle is needed to simultaneously cool inboard spaces and heat outboard spaces. It also reduces the capacity required for the outdoor compressor unit.

Water Source Heat Pumps

To this point, all types of heat pumps discussed are used to exchange heat between indoor air and outdoor air; or in the case of VRF, from one indoor space to another indoor space. Water source heat pumps are used to condition spaces with a circulating water loop, which acts as a heat source and heat sink.

With water source heat pumps, the combinations of heat sources, types of heat pumps, and systems expand exponentially. Water heat sources and sinks include:

- Closed-circuit loops heated by boilers and cooled by cooling tower heat exchangers outdoors.
- Closed-circuit ground-source heat exchangers.
- Open-circuit groundwater source heat sinks.3

Most water source heat pumps are single-zone water-to-air type. Each heat pump has its own compressor, airside, and water-side heat exchanger. As described above, the refrigerant boils at low pressure and temperature to cool air or condenses high-pressure refrigerant to heat air. Heat is rejected to or extracted from the water loop, respectively.

Other water source heat pumps exchange heat between two water loops to make chilled water for cooling or hot water for heating. Chilled water and hot water are circulated to heat exchangers in buildings to exchange heat with air to condition occupied spaces.

GAS FIRED HEAT PUMPS

We're almost home! We will describe three types of gas-fired heat pumps: engine driven, absorption, and thermal compression.

Engine Driven Heat Pumps

The engine-driven heat pump uses an internal combustion engine with natural gas as a fuel, like many standby generators, rather than an electric motor to drive the refrigeration cycle as described above. Engine-driven heat pumps have potential advantages over electric heat pumps in that they can be fitted with heat recovery off the engine for supplemental heat in very cold weather.

Absorption Heat Pumps

Absorption heat pumps require two sources of energy: heat, in this case, from burning natural gas, and electricity to drive a low-power pump to move the refrigerant. Absorption cycles use solute (water) and a solvent (ammonia) to move heat. Commercial systems use lithium bromide as the solute and water as the solvent to produce chilled water. The absorption cycle is shown in Figure 5.4 In this diagram, the heat supply at the bottom is from outdoor air. That heat, plus the heat of natural gas combustion is included in the heat discharge for space heating.

The absorption cycle works as follows: Water has a strong affinity to absorb ammonia, creating a low-pressure, low-temperature fluid state that boils at low temperatures to absorb heat. The ammonia refrigerant enables the cycle to absorb heat in the evaporator at cold outdoor air conditions for space heating. Heat...
from outdoors is leveraged with the heat from natural gas to drive the cycle resulting in efficiencies, also known as coefficients of performance, of greater than 100%. A typical seasonal efficiency, or annual fuel utilization efficiency, is 140% for these systems.

However, unlike vapor compression cycles, absorption systems are not reversible, and can only move heat in one direction. The water/ammonia system is used for heating for smaller applications, and the lithium/water system is used for cooling in commercial and industrial applications.

**Thermal Compression Heat Pumps**

Thermal compression heat pumps are an emerging technology using external combustion to drive a piston in a cylinder filled with helium or carbon dioxide to exchange heat by compressing the gas to heat, and expanding the gas to cool. The heat from compression is used for space and water heating. The heat absorbed by the cooling expansion of the working fluid is used to produce chilled water for space cooling. Unlike every other heat pump described in this article, there is no phase change from gas to liquid and back with this technology.

**Summary and Closing**

Options for heat pump and system design are as unlimited as the building designs to which they can be applied. This article covers only common electric and less-common gas-fired heat pumps. A summary of usual applications and best fits are provided in Figure 6. A plus sign indicates a good fit or superiority. A plus/minus sign indicates case-specific applications, and minus signs indicate a typical mismatch of technology to application.

**References**

For image credits and the list of References, go to aesp.org/page/Magazine2020references

Contributor Ryan Kerr is the Emerging Technologies Manager at Gas Technology Institute.
In 1990, when AESP was founded as the Association of Demand-side Management Professionals, there were no ENERGY STAR appliances, homes were still mostly lit by the warm glow of incandescent bulbs and iPhones were literally unheard of. Talking about controlling your home thermostat or security system from a phone thousands of miles away either meant you were a sci-fi writer or maybe a little crazy. The world today has changed dramatically from the one we knew in 1990. But what has not changed are the hearts and minds of people who work in this field. Driven by a desire to make the planet more sustainable for future generations, we are also realists in recognizing that consuming energy is an unavoidable piece of modern living. AESP members work each day to squeeze the most practical use out of every kilowatt hour, or therm, of energy being used. That’s energy efficiency.

In conjunction with AESP’s 30th anniversary in 2020, let’s look back at the last 30 years of our energy efficiency industry and recognize the innovations and people behind the ideas, products, policies, processes etc., which have improved and shaped the energy efficiency industry we know today. We can’t wait to see what you’ll come up with in the next 30 years.

By Luisa Freeman
## Evolutionary & Technology Changes

<table>
<thead>
<tr>
<th>Lighting Innovations</th>
<th>Electric Vehicles</th>
<th>Federal Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rebates</td>
<td>Smart Thermostats</td>
<td>Building Codes and Rating Systems</td>
</tr>
<tr>
<td>Solar and Renewables</td>
<td>Internet of Things</td>
<td>ENERGY STAR, Codes and Standards</td>
</tr>
<tr>
<td>AMI and Smart Meters</td>
<td>Digital Marketing</td>
<td>States as Driving Forces</td>
</tr>
<tr>
<td>Big Data and Data Analytics</td>
<td>Integrated Demand-Side Management</td>
<td>Decarbonization and Greenhouse Gas Reduction</td>
</tr>
<tr>
<td>Weatherization Assistance Programs</td>
<td>Behavioral Programs</td>
<td>State Utility Regulatory Policy: Ratemaking and Decoupling</td>
</tr>
<tr>
<td>Integrated Resource Planning</td>
<td>TOU Rates</td>
<td>IPMVP, EM&amp;V and the Uniform Methods Project</td>
</tr>
</tbody>
</table>

## Rebates: Show Me the Money!

Early energy efficiency programs from the 1970s and ’80s focused on providing information to consumers and businesses about the value of taking energy saving actions. These programs featured energy savings tips and on-site energy audits and had an important impact on driving action. That changed in the 1990s, when it was recognized that information alone did not address the incrementally higher cost of many energy efficiency products over standard models that served as the major barrier to adoption. In the 1990s regulators started supporting the concept of offering incentives (or rebates) for the purchase of energy efficient appliances and equipment. The color of money became decidedly green and ushered in a long run of utility rebate programs aimed at making the efficient choice cost-competitive with standard options. Such programs were easier to evaluate as records could be maintained on equipment purchased and the determination of savings could be easily estimated on a per unit basis. Major gains were made during this period where incentives served as the main method of intervening in the appliance and equipment marketplace. The era of generous rebates, however, is coming to an end as appliance and equipment standards have transformed the market and made inefficient equipment obsolete; and as considerations turn toward net savings, including the role of electrification.

## Lighting Innovations: LEDs Light the Way

Even though electricity powers thousands more uses today, some folks still refer to their electric bill as their ‘light bill,’ because since Edison’s dual invention of the electric bulb and the electric utility, lighting is the most ubiquitous ‘service’ that electricity provides. Incandescent lighting remained relatively unchanged until the introduction in the early 1980s of the Compact Fluorescent Lightbulb or CFL, a game-changing technology that dropped lighting energy use significantly. With the help of utility programs, homes and businesses converted to CFLs in droves. After the introduction of the electronic ballast in the early 1990s, Light Emitting Diode products or LEDs then came on strong, swiftly overtaking the lighting market with efficiency increases of 78% over an incandescent and 18% over a CFL. Bonus: LEDs generate far less heat than incandescent or CFLs, which means lower air conditioning requirements and thus even more energy savings. The Energy Independence and Security Act of 2007 phased out most inefficient light bulbs – signaling the end of an era for the common household incandescent bulb.

## Solar and Renewables

A game changer that was slow in gaining traction, but that has since taken off in recent years is renewable energy technology—electricity-generating systems that rely on wind, solar and other renewable fuel sources. Prior to the 2000s, utilities had begun incorporating solar and renewable energy resources – both utility-scale and customer-sited – into their generation plans in varying degrees based on such factors as technical viability and comparative costs to traditional energy resources. Climate change and the need to reduce fossil fuels have recently combined with lower technology costs to dramatically increase the renewables proportion of both supply and demand-side plans. Energy planners, regulators and policy makers alike view solar and renewable energy systems as critical to grid modernization and the achievement of a lower cost, sustainable energy future. Most promising has been the commercial development of storage technology which combined with solar can help extend the availability of electricity to times when the sun isn’t shining. Innovators such as Tesla are building storage products today for the business and consumer markets, which will likely be yet another game changer as this technology becomes more widely available.
**AMI and Smart Meters**

Electric meters had not materially changed for 50 years until Advanced Metering Infrastructure or AMI came along. Also called “smart meters,” this technology got a huge boost from the ARRA stimulus funding which allowed many utilities to conduct mass conversions from older manual-read meters to AMI. AMI is an essential foundation for grid modernization and for unlocking the potential for Demand Response (DR) and enabling the increased penetration of Distributed Energy Resources (DERs) such as rooftop solar and storage. It allows for netmetering, turning consumers into “prosumers” and achieving policy and grid modernization objectives. But perhaps most importantly, AMI provides for increased granularity into the energy usage patterns of facilities and households – opening up a world of new energy services and products to help people manage their usage and bills. This technology enabled utilities to up their game from legacy water heater and air conditioning control programs to full-on demand response programs, which gives them the chance to modulate critical demand on the system in exchange for customer incentives. In this way, smart meters and AMI help utilities better manage circuit loads and support integrated system planning, including the development of non-wires alternatives (NWAs). Tomorrow’s grid will undoubtedly include more renewables, storage and information flows between users and suppliers of our increasingly sustainable energy system.

**Smart Thermostats**

Thermostat technology has been the lynchpin to energy consumption in buildings for decades, starting with the simplest dial units, to radio-controlled units, to units with timers or demand limiters, to today’s WiFi-enabled smart thermostats. This latest class of thermostats can not only be remotely controlled, but more importantly can learn and react to the behaviors and preferences of the people in your household or office. For the utility sector, smart thermostats present an important resource for capturing demand response resources, whereby people are incentivized either passively (through rate signals or rewards) or actively (through contracted agreements to curtail usage or via remote control). Smart thermostats are one of the first applications of Artificial Intelligence, where programs continually react to human interactions, then eventually settle on settings that deliver the best service based on previous behaviors. For utilities, the increased penetration of smart thermostats give them another important tool in their resource toolbox for optimizing the performance of the grid and delivering reliable, reasonably priced electricity.

**Big Data, Data Analytics**

AMI and Smart Meters may be transforming the grid, but they are also the primary game changing source of data on energy usage. As utilities and energy service providers daily gather mega-millions of data points – down to 5-minute intervals per meter – there has been an explosive need for ways to manage, clean and analyze the data. Added to the usage data from AMI is the equally transformative data source from the digitization of all manner of lifestyle and business activities – from social media clicks, to online purchasing behavior, to GPS location feeds. The energy sector is not the only one grappling with how to turn all these data into insights. Energy efficiency programs are using data analytics tools to identify underserved markets, link opportunities for savings against the location of distribution assets, and surgically target customers with a high propensity to adopt products all based on reams of data combined with everything from advanced statistical analysis methods to Artificial Intelligence (AI).

**Weatherization Assistance Programs**

Houses waste energy through air leakage due to poor caulking, outdated single pane windows, inadequate insulation in the roof, walls and crawl spaces, and all the hundreds of penetrations in walls from outlets and fixtures. Plugging these leaks has been the mission of weatherization programs, starting with the federal Weatherization Assistance Program (WAP) of 1976. Created under the Energy Conservation Policy Act, the early programs provided local grants to help low-income households weatherize their homes and included limited subsidies for paying energy bills. Techniques have evolved regarding the best ways to weatherize buildings including sophisticated tools such as blower-door technology or thermal scans that show where leaks are occurring and insulation is inadequate, all the way down to caulking products and foam gaskets that plug leaks in exterior wall outlets. Weatherization strategies continue to be paramount in areas where both heating and cooling demand is high, with more recent programs focused on home energy kits of self-install measures and direct install programs for multifamily buildings. Weatherization strategies have expanded significantly over the years as utilities, state and local social services agencies and other federal departments such as Housing and Urban Development and Health and Human Services have embraced the concept that energy efficient healthier homes make for healthier and more productive households. Even so, WAP continues to be a cornerstone of efforts to improve the building stock of lower income neighborhoods and families everywhere.

**Integrated Resource Planning (IRP) and Renewables Integration**

Integrated Resource Planning (IRP) is the modeling process of comparing both supply and demand options for meeting electricity demand. PURPA established the concept of avoided costs – or how to establish a price for electricity that does not have to be generated. This mechanism allowed utilities to compare investments in supply options – such as new generating units that produce megawatts (MW) – against investments in programs that reduce the demand for electricity (which spawned the term “Nega-watts”). Since the 1980s and the advent of least-cost planning, IRP has become the preferred method required by regulators for utilities to present their long terms plans for meeting forecasted loads, replacing the capacity expansion plans of yesteryear. The engineering and economic planning models of today enable consideration of widely expanded adoption of both utility scale and customer-sited distributed generation, from massive solar farms to solar rooftop systems.
Electric Vehicles (EVs)

While the Corporate Average Fuel Economy Act of 1975 (CAFE standards) first recognized the need to increase fuel efficiency in cars, the big game changer in transportation efficiency has been the emergence of electric cars. Natural gas vehicles made important inroads into the transportation sector in the 1990s with most of the traction in buses and fleet vehicles. Highly disruptive to the transportation sector today however, EVs are on the periphery of the energy efficiency space in their implications for both programs and buildings. The efficiency gains in energy consumption over gasoline-powered vehicles, combine with the lower maintenance costs of EVs to offer benefits to users, while reducing carbon emissions as a benefit to society.

Electric motors are inherently more efficient than internal combustion engines, with estimates of 95 percent vs. 35 percent. Furthermore, electric fuel cost is cheaper because all fuel sources to make it are typically cheaper than petroleum, and combined with the motor efficiency advantage, EVs are an overall win-win. This technology impacts energy efficiency policies and programs in two ways: 1) utilities in certain markets have started incentivizing electric cars, fleet vehicles and even electric buses and 2) EV charging units are being incentivized and incorporated into new buildings and homes. However, there’s another benefit in this game changer: the contribution that EVs can make to optimizing load shapes by integrating their charging and storage capabilities with buildings that is probably the biggest opportunity for EE – accommodating other electric loads around EV charging or vice versa. Utilities across the U.S. are still developing their strategies for this game changing technology. Whether they are proactively promoting it or making plans to react to increased production, demand and lower prices, EVs are undoubtedly going to be a bigger part of the future of transportation.

Internet of Things

For many consumers, the convenience, if not the complete seduction, of new digital technologies is trumping concerns over the erosion of privacy in our lives. Sales of voice-activated assistants, smart phones and interactive doorbells attest to that. We live in an era where our thermostats can interact with our voice-activated assistant and our convection oven to produce chocolate chip cookies by the time we arrive home. These same tools, however present a myriad of opportunities to consider the energy use and carbon emissions implications of our actions. Sensors are everywhere, giving us remote information on the performance of our homes, appliances, cars and communities. This information can be used to track our impact on issues important to us, such as our personal carbon footprint, and give us rewards and suggestions for doing more. The IOT is indeed a game changer for the energy community, with opportunities for more inventions and implications for how we run appliances more efficiently for years to come.

Digital Marketing & Engagement

Digital technology has radically changed how we market and engage with energy efficiency programs and services. Smart phones have put the power of choice in our hands. Today we can literally control the energy use in our homes from the palm of our hand via wireless technology. More than that, we can compare our usage to our neighbors, check the status of our carbon footprint, or apply for an energy efficiency program all from our smart phone, laptop or tablet. Programs are going wholesale on-line through energy Marketplaces, trade ally portals and on-line dashboards that enable detailed tracking of applications, results and the impacts of marketing and outreach strategies. EE program marketing too has evolved from 1990 to present – from non-digital printed mailers or bill stuffers, to free ubiquitous email blast marketing, to all that today’s Internet, WiFi/mobile technology, Big Data and social media have unleashed, including geotargeting, push-notification and gamification apps. Consumers speak loud and clear about their expectations for utility programs to offer an Amazon-like or Google-type experience, and energy services providers – and their regulators - are heavily challenged to keep up with these digital trends.

Behavioral Programs/Social Norms

Most of the focus around energy efficiency lies in technology (from LEDs to high efficiency heat pumps to smart thermostats) and how people interact with them (e.g. turning off lights or reducing water heater temperatures). With the advent of wireless and digital technologies, more recent focus has been around human behaviors in response to feedback, even in real time. Behavioral programs are specifically about the use of data for influencing behavior; from data about your energy use or that of your neighbors or other cohorts that are important to you (the realm of social norms), to data sent to your cellphone from your thermostat, refrigerator or doorbell. This latest wave of energy services harnesses vast quantities of digital information and translates it into insights through data analytics and artificial intelligence, to help us all make wiser energy related decisions through changing our behavior.

Integrated Demand-Side Management

In an industry full of acronyms -- EE, DR, DER. DSM -- Integrated Demand Side Management (IDSM) refers to combinations of these strategies for increasing the efficient use and production of energy on the customer side of the meter. With the recent decrease in prices of distributed energy resources (DER) such as rooftop solar panels, plus the increased viability of smaller customer-sited energy storage units, program portfolios are expanding their offerings from traditional energy efficiency (EE) and demand response (DR) strategies to the promotion of on-site generation and storage. Even so, getting the combinations right is not so straightforward. For example, electric vehicles are being valued for their contribution to building off-peak loads, and while that’s good for electric utilities, it can have a negative impact on the growth of solar. Carefully planned DSM is necessary for shaping and shifting loads in the most beneficial manner for both utilities and their customers. These integrated strategies are made possible partially because of another innovation: net-metering, where households and building managers can optimize their energy related usage patterns as both consumers and producers of electricity i.e. “prosumers”.
The energy used by appliances and equipment has been modified through two mechanisms – mandatory and voluntary codes and standards that set maximum levels of energy use per unit or product. As early as 1975 some states implemented appliance efficiency standards in response to the energy crisis at the time. Then the DOE was given the authority to set mandatory standards for household appliances starting in 1978, but it wasn’t until 1987 and the enactment of the National Appliance Energy Conservation Act (NAECA) that efficiency standards became mandatory for certain products at the national level. The big push came, though, with the federal ENERGY STAR program, a voluntary certification and labeling program which popularized the brand and notion of minimum levels of energy efficiency for appliances and equipment. Such codes and standards have effectively transformed the lighting, appliances and HVAC markets in the US, negating the need for incentives in some cases. Even so, they continue to play a critical role in pushing manufacturers to design ever more energy efficient products.
States as Driving Forces

Did you know that the first energy efficient appliance standards were established at the state level? California started the trend in 1974, quickly followed by New York, Florida, and Massachusetts. In fact, states from two coasts have led the way in state level policies and programs ever since. The California Energy Commission (CEC) and its regulatory partner, the California Public Utilities Commission (CPUC), have promoted aggressive energy efficiency policies impacting the state’s IOUs: PG&E, Southern California Edison, Southern California Gas, and San Diego Gas and Electric. Not to be outdone, the progressive public power utilities of Los Angeles Department of Water and Power (LADWP) and Sacramento Municipal Utility District (SMUD) have consistently kept pace if not blasted past the private utilities in promoting energy efficiency and renewable energy in tandem with California State legislators and regulators.

California led the way in measuring “negawatts” through its Standard Practice guidelines and concept of avoided cost. Rapid promotion of electric vehicles and net zero buildings are the latest in a string of EE’s greatest hits to come out of this progressive state. The other coastal powerhouse that has competed with California for top spot on the energy efficiency leaderboard can be found in New York and the New England states, particularly Massachusetts. The New York State Energy Research and Development Authority (NYSERDA) has been a statewide and regional think tank investigating emerging technologies and programmatic solutions to increasing the efficiency of buildings and equipment, while the NY Public Service Commission has led the way in leveraging the state’s private utilities in carrying out those programs. Massachusetts has taken the approach of coordinating the efforts of its utilities and other Program Administrators - such that policies and programs have consistency across the state and take advantage of collaborative research. The latest iteration of policies adopted in the region is the New York Reforming the Energy Vision (REV) proceedings, a policy that recognizes the importance of market enablement, planning improvement and support for increased penetration of Distributed Energy Resources (DER).

Decarbonization, Greenhouse Gas Reduction

Former Vice President Al Gore’s 2006 documentary “An Inconvenient Truth” catapulted the challenge of climate change to the popular forefront. Perhaps even more impactful than looking at the TV is to simply look out the window at the myriad of extreme weather events that have occurred in the past decade – Hurricanes Katrina, Sandy and Maria to the recent wildfires in California and Australia. Cities, states and countries have been experiencing unprecedented impacts due to part to human activity increasing the global climate change. The global depletion of carbon-capturing and -eliminating mechanisms such as rainforests. Strategies for mitigating the effects of climate change include renewable energy systems and energy efficiency programs aimed at reducing fossil fuel demand, electrification programs aimed at replacing natural gas use, market mechanisms such as a carbon trading credits that put a value on carbon-reducing strategies, and a federal tax on carbon-emitting technologies. In the transportation sector, EV manufacturers promise to radically alter the impacts of GHGs if widespread adoption takes hold (a big “if” when gasoline prices continue to fluctuate so radically and the charging infrastructure continues to move at a snail’s pace). As car and truck manufacturers make significant shifts in their production of EVs, this technology has the potential to have a game-changing impact on significantly reducing carbon emissions. Finally, some utility programs are pivoting their skills and tools for reducing energy use toward the challenge of increasing the resiliency of the building stock. Both strategies – adaptation and mitigation – will be needed to face the looming challenge of climate change.

State Utility Regulatory Policy: Ratemaking and Decoupling

NECPA and PURPA heralded the first time that gas and electric utilities were tapped as a vehicle for carrying out federal energy conservation policy, with the lever being on the state regulation of utility rates. In many states ever since, utilities have filed energy efficiency program plans as part of rate cases and have been allowed to recoup program costs – to varying degrees and based on evaluated results – through the ratemaking mechanism. The concept of such regulatory practice has been that all ratepayers (customers) benefit from utility promotion of energy efficiency as one of the resources in their portfolio of demand and supply options. But as utilities pointed out the unintended consequence of lost revenues, regulators took two approaches: 1) allowing utilities to recoup a portion of lost revenue, and 2) having utilities essentially “decouple” the business of providing energy efficiency programs from the business of selling energy (natural gas or electricity). Decoupling essentially eliminated the disincentive for utilities to promote programs that reduced sales.

IPMVP, EM&V and the Uniform Methods Project

Ever since energy efficiency policies and programs were first launched, the industry and regulators alike have had to address the question of how to measure energy savings. Thus was born the field of evaluation, measurement and verification (EM&V). While methods for assessing the costs and benefits of energy efficiency measures emerged from places such as California (Standard Practice Manual), and billing analysis tools were designed including Princeton’s Scorekeeping Method (PRISM), a virtual quilt of evaluation methods developed with regulators across the U.S. The International Performance Measurement and Verification Protocol, started in the 1990s, was the industry’s attempt to harmonize the latest and best EM&V methods that utilities and other energy service providers could agree on for assessing project level impacts. The DOE took matters in its own hands with the Uniform Methods Project in 2013, where a set of protocols for determining savings from energy efficiency measures and programs was developed by a team of industry scientists. All these tools continue to provide the backbone to how we value investments in energy efficiency today, with modifications continually being applied to recognize impacts beyond energy such as those associated with greenhouse gas emissions and other non-energy impacts (NEIs).
Amory Lovins & the Rocky Mountain Institute

Amory Lovins is credited as the one who in 1989 coined the term “Negawatt,” a negative megawatt or a megawatt of power that does not have to be produced because of increasing efficiency or reducing consumption. As Chairman Emeritus and Chief Scientist of the Rocky Mountain Institute, a think tank for efficiency which he founded in 1982 with his then-wife Hunter, the Lovins promoted a “soft path” supporting efficiency and renewable energy over fossil fuels and nuclear. He is a physicist and industry game changer because he radically challenged the incremental efficiency gains being made up to the 1990s and continues to challenge policymakers today to be more aggressive in our energy saving goals, particularly with the threat of climate change. Throughout his career, Lovins has taken the scientific approach to showing us that significant long-lasting change in the efficiency of appliances and equipment is possible. For example, Lovins put his scientific mind behind his claims -- inventing high efficiency demonstration products such as the hypercar and the ultra-efficient refrigerator.

Regional Energy Efficiency Organizations (REEOs)

Following the founding of the Association of Demand-side Management Professionals (former name of AESP) in 1990, groups started forming at the regional level in recognition that one size does not fit all when it comes to energy policy and programs. Regional Energy Efficiency Organizations or REEOs acknowledge the regional nature of energy markets (e.g., energy sources, end uses of energy and regulation) as being important to moving the efficiency ball forward. For example, homes in the Northeast are heated with oil so weatherization was an important early focus of efficiency programs there, whereas southern regions are concerned with air conditioning loads, making demand response programs important. These entities carry out work funded through various sources such as utility consortia, federal agencies and various advocacy groups, to support policy development, program design and implementation. Most importantly, they serve as important regional knowledge transfer and networking platforms for energy efficiency professionals closer to home.

National Laboratories: LBNL, NREL et al

Many of our most lauded inventions around energy efficiency were conceived in the lab, mostly, the national laboratories. These include the buildings and appliance research done at Lawrence Berkeley National Laboratory (LBNL), the policy and EM&V research of Oak Ridge National Laboratory (ORNL), and the technology developments out of National Renewable Energy Laboratory (NREL). Art Rosenfeld launched the Energy Efficient Buildings Program at University of California - Berkeley which eventually evolved into the Center for Building Science at LBNL. The Center focuses on how to make everyday appliances energy efficient and how to reduce energy consumption and costs in buildings. Funded through the U.S. Department of Energy, each of the national labs has served as important incubators for basic research.

Clark Gellings & EPRI

Clark Gellings was the first industry leader to get the Electric Power Research Institute (EPRI) to formally embrace energy efficiency and demand side management as legitimate topics worthy of its attention. He was a game changer in that energy efficiency immediately moved from being a fringe topic directly to the forefront of issues warranting serious industry consideration. What had formerly been an exclusive club of supply and transmission scientists at EPRI, Gellings shifted the organization to address concerns of its members around the policy and regulatory shifts and opportunities around managing customer demand. In the 1980s Gellings enthusiastically led a diverse group of utility member representatives in the consideration of such topics as cost-benefit analyses, alteration of utility planning models to incorporate energy efficiency resources, to IRP and grid modernization. Based in part on his leadership, EPRI maintains research programs on customer-side of the meter issues including distributed and customer-sited generation, valuation of electrification measures, and efficient and emerging technologies on behalf of its members.

Jim Rogers, former Duke Energy CEO

Jim Rogers was one of the industry’s most visionary utility company CEOs and was one of the first leaders in the energy industry to speak about climate change and the changes needed to address it. He embraced sustainability and efficiency as important objectives. He not only talked the talk, but he led Duke Energy and its companies to lower greenhouse gas emissions and expand renewable energy investments. Jim was a model for many future generations of utility and energy services industry leaders to emulate.
Arthur Rosenfeld

Long considered the ‘Father of Energy Efficiency,’ Arthur Rosenfeld was a physicist and visionary that helped launch an entire industry from his cluttered desk at the University of California at Berkeley. Rosenfeld was a tireless proponent of energy conservation, challenging traditional practices around energy consuming appliances, lighting and buildings as well as the roles of stakeholders such as utilities, the federal government and regulators i.e. the entire universe of entities, technologies and behaviors that, until he came along, promoted wasteful energy using practices. He singlehandedly pushed our collective conscience toward finding ways to do more with less energy, and more importantly to consider the environmental and financial consequences of inaction.

Bill LeBlanc

Bill LeBlanc is an energy services industry veteran, currently the Chief Instigation Agent at E Source. He is an innovator in the utility-customer space, bringing concepts such as design thinking, behavior change, DSM bidding, and customer segmentation to the forefront of utility offerings. LeBlanc was a key founder and president of AESP in 1990, when he saw a need for a professional home for DSM practitioners. His specialty throughout his career has been customer engagement. He created Powerwalking man-on-the-street videos in 2006, which through reality and humor, helps utilities understand what regular people know and think about energy issues from their perspectives, and how far off we often are at understanding their wants and needs. His engaging presentations bring home the fact that energy service providers need to continually take the pulse of regular people – not nameless "ratepayers" - in order to design better human-centered products and services.

Ahmad Faruqui

One of the primary levers of influence for how people use energy is through price – the cost per kWh or therm that’s tied to each unit of electricity or gas that we use. Faruqui knows all about rates and has built a career around experimenting with ways to redesign utility rates to address policy and business objectives. He is an economist and senior member of the Brattle Group, where he continues to consider customer rate design, load management, the valuation of distributed energy resources and demand forecasting. More recently he is working on the issue of electrification, or the promotion of electric technologies for new and replacement uses over fossil fuel alternatives, and how to value the benefits therefrom. Faruqui was part of California’s experiment with dynamic pricing in the early 2000s and continues to research the economic levers for securing our sustainable energy future.

Ralph Cavanagh & NRDC

Cavanagh is an attorney and ‘professional agitator’ for energy efficiency and was instrumental in founding the Natural Resources Defense Council. NRDC has been a fierce defender of environmental causes, educating regulators and policymakers and intervening in utility rate cases to promote utility investment in reducing energy consumption over building more power plants to meet ever increasing demands for energy. Cavanagh and his colleagues at NRDC provided the legal points of leverage for regulators to directly drive utility planning toward energy efficiency programs and policies. Such concepts as Least Cost Planning and Integrated Resource Planning were heavily influenced by his work and have become a legacy to his tireless promotion of energy efficiency.

About the author

Luisa M. Freeman has more than 30 years of experience in energy efficiency, renewable energy technology and distributed generation program planning and evaluation for government and private industry clients. She has served on the boards of the Smart Energy Consumer Collaborative and local chapters of AESP. She holds degrees in Economics and Economic Geography and was most recently a Senior Principal Consultant at DNV GL.

HOW THE LIST WAS COMPILED

In the fall of 2019, AESP polled its members, asking you to nominate a list of the most important developments, technologies and entities that have shaped the energy efficiency industry in the past 30 years. All these submissions were compiled, ranked, then further reviewed by a selected panel of industry veterans and longtime AESP members – to arrive at the final list of 30. The game changers are presented in random order. AESP is grateful to member Luisa Freeman who volunteered her time to research and write the descriptions for each of the 30 game changers you see here.
Course 1: Energy Basics - DSM

Approximately 1-2 hours ONLINE. Earn 0.2 CEU

Energy. We use it every day, but why is it important? Who uses it? How is it generated and transmitted to end users? This course will enable DSM program managers to answer these foundational questions.

Upon completion you will be able to:
• Define and describe the different types of energy resources
• Understand how these resources are generated, transported, measured, and consumed
• Understand how the energy industry functions.

Course 2: Utility Fundamentals - DSM

Approximately 1-2 hours ONLINE. Earn 0.2 CEU

You may work in the demand-side management industry, but do you know how this industry, or even utilities for that matter, came about? This course helps DSM program managers understand basic industry fundamentals, including its origins and the complex relationship between regulation and operations.

Upon completion, you will be able to:
• Recall how legislation and regulation have shaped the industry.
• Identify how federal, state, provincial, and local regulation provided North American utilities a framework to standardize their operations
• Identify the regulatory policy tools for increasing adoption of energy efficiency, demand response, and distributed energy resources
• Recognize the impact of regulation on utility operations, as well as the various levels of regulatory oversight.
• Recognize current policy and regulatory trends that are impacting the future of the utility industry.

Course 3: Utility Business Models - DSM

Approximately 1-2 hours ONLINE. Earn 0.2 CEU

Much has changed to the traditional utility business model over the past decade. This course is designed to enable DSM program managers to understand how utilities traditionally operate (make money) and how their traditional operations are being disrupted through the advent of new policies and technologies.

Upon completion you will be able to:
• Define and describe the traditional utility business model.
• Identify how a utility generates revenue.
• Identify the major changes occurring to traditional generation and transmission that are impacting the utility business model.
• Describe utility customers adoption of new technology is changing the utility business model.
• Explain how improved access to new technology and real-time information is impacting utilities relationship with their customers.

Course 4: Contract Management - DSM

Approximately 1-2 hours ONLINE. Earn 0.2 CEU

Contract management matters, especially so for a demand-side management program manager who uses contract vehicles to manage and execute all their work. This course instructs attendees on the best practices in contract, budget, change, and risk management necessary for successful project and program management.

Upon completion, you will be able to:
• Describe why contracts and contract management matters, and the steps to ensuring contracting success.
• Identify pre-contracting needs and how to prepare for going out to contract.
• Describe the steps and components of the solicitation process.
• Outline how to initiate, setup, and manage a contract successfully post-award.
• Identify best practices in managing vendor and financial risk, and how to enact change management.
• Identify how to initiate and manage change within a contractual relationship.
• Define and describe the project-close out process.

Everything You Wanted to Know About Cost Effectiveness - EM&V

Approximately 2.5 hours ONLINE. Earn 0.2 CEUs

Cost Benefit Tests have the power to make or break a program. If TRC, SCT, UCT, PCT, RIM, and RVT just look like alphabet soup to you – then this is for you. Suitable for implementers, marketers and business developers, or evaluators who want to get back to basics. This course explains the different tests, the inputs, and how to run the tests. Understand how various inputs affect cost effectiveness. Be prepared to do some math and have a few “aha” moments.

After taking this class you will be able to:
• Run simple cost effectiveness analysis for most DSM programs (energy efficiency, demand response, distributed energy resources).
• Interpret results when an offering or program passes some, but not all the tests.
• Understand what revenue requirements mean and how the tests impact it.

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