How next-generation smart meters can help address energy equity

Understanding inequitable access to energy

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"Energy inequality" is measured differently across academic and policy papers. It could be a certain percentage of income spent on energy, the temperature at which a household is kept, or the ability to run appliances throughout the day without the burden of considering the implications of time-of-use (TOU) prices. Energy inequality is not necessarily an issue of energy access, but rather the opportunity and quality of life energy access provides users. From the ability to refrigerate or freeze perishable foods like fruits, vegetables, and meats, reducing dietary exposure to processed foods, to access to high-speed internet for education or income generation, to household humidity or temperature control that leads to better health outcomes, energy access is an enabler of human development.

Due to the growing necessity for energy access in modern life, a lack of access can pose severe consequences for households, deepening existing inequitable distributions of wealth, education, employment opportunities, and healthful living conditions. In 2020, the Biden administration recognized the deepening divide in access to clean energy and signed Executive Order 14008, known as the Justice40 Initiative. In it, the federal government makes it a goal that 40% of the overall benefits of certain federal investments, including clean energy, flow to communities that are marginalized, underserved, and overburdened by pollution.[1]

Energy inequality is also being recognized as the inability for a consumer to benefit from emerging technologies such as solar panels,[2] electric vehicles (EVs), programmable thermostats, and battery storage systems connected to home energy management systems (HEMS). Collectively, solar, home storage batteries, EVs, and programmable thermostats fall under the category of utilities referred to as distributed energy resources (DER). Wealthier households purchase and benefit from these energy accessories, which often results in lower energy bills and less polluted local environments. However, because electric utilities are still required to maintain their infrastructure to provide highly reliable service to all their customers, utility costs may be disproportionally carried by lower-income families who cannot afford such systems.

Electric utilities and utility commissions are generally aware of this shift in the percentage of energy payments coming from lower-and-middle-income (LMI) households and often operate discount programs to offset energy costs through subsidies funded by means such as a surcharge added to higher-income ratepayers. Austin Energy, for example, charges $0.025 per kilowatt-hour (kWh) to customers who are able to pay their full bill to fund their subsidy programs. Fifty-one percent of energy assistance funding comes from other customers.[3] As for helping LMI households benefit from those emerging technologies such as solar, EVs, and batteries, utilities and local governments have programs. One example is "Solar for All," based in Washington, DC, which seeks to bring solar energy to moderate-income households in the district.[4]

One of the major hurdles to offering subsidies for cost abatement or receiving DER equipment is identifying eligible households. In 2015, the Energy Information Administration (EIA) published a survey that illustrated how energy consumption grows proportionally to income.[5] However, according to Donnie Mendoza from Austin Energy, LMI customers frequently use more energy than affluent customers because they often rent units with less efficient appliances and have multigenerational families in a single unit. It is imperative, therefore, that utilities use a variety of methods to identify eligible candidates to receive the benefits. Some of the techniques used today include reviewing data from federal or state assistance programs or contacting customers who are frequently in arrears. Still, they aren't perfect, and not all eligible customers are identified.

Potential of next-gen advanced metering infrastructure to alleviate inequality of energy access

As we reported in Deloitte's paper, "Enabling the clean energy transition,"[6] a new model of smart meters has substantially more advanced capabilities than its predecessors from just a few years ago. These next-generation meters can perform analytics in real time, observe and report energy use anomalies, and disaggregate energy consumption to identify which devices are using energy as well as when and how soon they will be able to control DER, such as solar, batteries, and EVs, without additional equipment. It is possible that these advanced capabilities can play a critical role in promoting energy equity through the identification of households that should qualify for assistance programs, by providing personalized information on how to save energy, and through their ability to improve system planning to better identify where DER is needed to maintain the grid and reduce pollution.

Edison International recently published its *Countdown to 2045* report,[7] in which it noted that by 2045 there will be an 80% increase in electricity demand in California with 90% of vehicles and 95% of buildings running entirely on electricity. To meet that demand, having access to commercial and residential DER will be critical to maintain the integrity of the grid. With that in mind, it is in the best interest of utilities, LMI customers, and higher-income customers to reduce energy inequity for the benefit of the grid as a whole. "All consumers in California must have reasonable opportunities to unlock these savings through electrification adoption; barriers including income and home ownership must be proactively addressed,"[8] states Edison's report.

To understand how next-generation smart meters can help identify customers who should be eligible for discounts or have access to subsidized DER, Deloitte has identified five categories that are very likely to help locate why and where energy inequality exists:

1. Household economic status
2. Comfort and health
3. Demographic information
4. Structural conditions
5. Regressive tariffs

These indicators and their associated metrics offer a reliable conception of who is at risk of energy insecurity, the impacts on the well-being of those at risk, and how next-generation smart metering can play a role in addressing these situations.

Household economic status: Income and indebtedness

Income and financial position alone may be a strong indicator of energy poverty. The relationship between income and energy consumption is usually discussed as either high consumption due to energy inefficiencies or an inability to afford baseline utility payments, resulting in accrued debt due to utility arrears. While there is variation in opinion on incorporating utility arrears as a measure of energy poverty, in a research article by Ray Galvin, he argues that utility arrears, if checked against a poverty index, could be a useful indicator for energy poverty if correlated between arrears and inadequately warm homes at a national level.[9] Moreover, unaffordable utility bills can lead to insurmountable levels of debt, preventing families and individuals from moving to more energy-efficient housing or causing utility shutoffs.[10] According to the Department of Energy's (DOE) Low-Income Energy Affordability Data (LEAD) Tool, the national average energy burden for low-income households is 8.6%, three times higher than for non-low-income households, estimated at 3%.[11] The inability to change residences plays a particularly crucial role in long-term energy poverty when considered alongside the increased inadequacy of energy efficiencies in private rentals.

One of the most impactful new capabilities of next-generation smart metering is the ability of the meter to disaggregate energy consumption behind the meter. Disaggregation breaks down the use of electricity at a certain location and identifies individual devices consuming energy. Because a dishwasher has a different energy signal than an air conditioner, software algorithms on next-gen meters will be able to recognize the different appliances at a residence. Through artificial intelligence and machine learning (AI/ML), the meter can compare a customer's appliance usage against models with millions of data points from other appliances and identify inefficient appliances—an indicator of a customer who may be experiencing financial hardship. According to Donnie Mendoza, LMI households are often multigenerational and thus have more people living in a residence. While this may or may not show up in state or federal assistance program data, it will be evident from energy patterns such as running inefficient washing machines or dishwashers more than usual for a similar-size dwelling, indicating a larger number of people living in a household potentially eligible for energy assistance or appliance efficiency rebates.

An example of the steps being taken to increase clean energy usage is the Illinois Solar for All program, which focuses on residential and community solar projects[12] and aims to provide residents with greater access to renewable energy through the use of incentives that make it more affordable. Those incentives are available for residential properties, properties that house nonprofits and public facilities, and community solar projects. The residential solar program provides income-eligible households access to solar installations with no upfront cost, made possible by providing incentives to approved vendors that perform the solar installation. The incentives that the approved vendors receive come from selling renewable energy credits (RECs) represent the environmental value of electricity created by the solar panels. Households must meet eligibility requirements, defined as income that does not exceed 80% of the area's medium income.

The key to recognizing customer income factors is making identification of the problem as easy as possible and the resolution as specific as possible. Next-generation smart meters can do that.

Comfort and health

The next factor we considered as a measure of energy inequality is how energy is used for comfort and health. For developed countries, often those in the Northern Hemisphere, literature emphasizes maintaining a certain level of internal heating as a primary metric. The United Kingdom invested in alleviating fuel poverty partially as a response to excess winter mortality.[13] Cold household temperatures were found to increase risks of stress on the cardiovascular system and worsen respiratory conditions, leading to 35,200 excess winter deaths per year in Europe.[14] This metric is problematic, however, when applied to more temperate locations, as it may not encompass energy insecurity in hotter or mild climates. While it is possible that air conditioning usage may reflect the same consumption behaviors, the use of fans, windows placed strategically for cross ventilation, and the overall materials used in the built environment may also lead to lower consumption of air conditioning. Due to record summer temperatures, such as Arizona saw in 2023, and global climate change,[15] continued monitoring of both heating and cooling needs for safe living environments is necessary for policymakers.

Next-generation smart meters with disaggregation capabilities can identify households at risk for setting their thermostats either too high during cold weather or too low during heat spells. The new meters are Wi-Fi–enabled and connect to utility-approved weather data sources that allow the meters to identify households that are intentionally not heating or cooling their residences based on outside temperatures in their neighborhoods. Next-gen meters will be able to connect directly to Wi-Fi–enabled smart thermostats, record temperature settings, and compare them against others in the same neighborhood. But even if a residence doesn't have a smart thermostat, the meter will be able, through disaggregation, to detect when HVAC equipment is running, inferring if a household is sufficiently maintaining a comfortable and healthy temperature. Through observations and comparisons of other similar dwellings, the next-gen smart meter can pinpoint customers that are candidates for either payment assistance or energy-efficient HVAC equipment or can suggest weatherization options specific to that customer. Next-gen smart meters can also distinguish customers who are using fans or space heaters instead of HVAC and tell them, for example, if they should be using HVAC instead of a fan when the temperature is too high to avoid dehydration.[16] They can even detect when a customer runs their clothes washer and forgets to move the clothes to the dryer after the wash cycle ends, presenting them with a reminder that potentially saves the customer from having to rerun the washer cycle.

Demographics

Demographic characteristics such as age, disability, and chronic illness may be useful metrics to identify populations vulnerable to energy poverty. A UK study found that of households living in energy-impoverished conditions, 34% of those households included someone with a disability or long-term illness, 20% a child age 5 or younger, and 10% an adult age 75 or older.[17] In addition to the health risks of poorly heated or cooled households for older populations, energy poverty has been linked to worsened outcomes for those with mental illness, disability, pregnancy, and chronic illness.[18] While outcomes for these populations may be generally negatively affected by their low-income status, the added challenge of energy poverty increases the severity of symptoms or leads to dangerous health outcomes, such as increased risk of hypothermia in populations with restrictions on physical activity.[19]

Similarly, single-parent households may fare worse than dual-parent households. The German Statistical Office found single parents in 2016 to be 6.9% more likely to experience fuel poverty than all other households and 33% more likely to be considered at risk of poverty compared to two-adult households with children.[20] In addition to carrying an increased financial burden due to the relationship between fuel poverty and single heads of households, a 2019 study published in *Energy Research & Social Science* on gendered partitioning of household labor showed that, if household labor falls to single women, they are more likely to be required to manage load-shifting their household workload patterns to adjust for time-of-day rate structures that may lead to lost economic opportunity.[21]

With next-generation smart metering, single female parents who have shifted their workloads to off-peak times to save money, potentially affecting their ability to generate greater income, can be identified through energy consumption patterns that are indicative of a single-parent household. For example, appliances that could be detected through disaggregation that are more frequently associated with women include hair dryers, curling irons, electric nail files, electric facial cleaners, and electric blankets. Children in the household, defined by the US government as those under age 12,[22] could be identified by energy consumption associated with baby monitors, electric baby swings, gaming consoles, electric pencil sharpeners, and multiple televisions operating simultaneously. For example, a typical TOU plan might have the lowest rates from 8 a.m. to 4 p.m., with higher rates from 4 p.m. to 9 p.m. A single female parent may take a lower-paying job to run appliances during the day. If they could be offered either payment assistance based on their income or a tariff plan tailored for single mothers with lower rates in the evening, they might be able to work at a higher-income profession.

Structural considerations

Structural issues in buildings can lead to leaks, dampness, and drafts that are often associated with decreases in thermal comfort, leading to either higher costs in energy consumption or unhealthy household temperatures.[23] Measuring internal household temperatures is invasive and often infeasible for researchers or for wide-scale application of social programs. Similarly, measuring structural issues that may cause thermal losses is often not possible for large-scale identification of energy-impoverished households. The American Council for an Energy-Efficient Economy found that increasing the energy efficiency of low-income households to that of median-income households would "eliminate 35% of excess energy burden" experienced by low-income households on average.[24]

The Home Energy Rating System (HERS) or the Energy Rating Index[25] provides a possible energy-specific model; however, HERS has only been applied to 2.8 million US homes as of July 2020.[26] Like Leadership in Energy and Environmental Design (LEED) certifications, HERS is a privately administered rating system. The US federal government currently emphasizes certifications like Energy Star,[27] which tracks only homes that meet a high level of energy efficiency, as opposed to those households struggling with inefficient structures, and local regulations for energy efficiency are primarily placed on new buildings, as opposed to existing infrastructure. Being able to remotely assess the energy efficiency of existing residencies, apartments, mobile homes, and public housing projects could provide a key metric in understanding those at highest risk of energy poverty and the interventions most likely to be successful for those households.

Using disaggregated energy data, coupled with weather and demographic data run through an embedded AI learning model that includes not only other local similar dwellings but millions of others as more utilities adopt these meters, next-generation smart meters are able to identify potential signs of structural concerns for customers. For example, a next-generation smart meter could detect that a residence runs its HVAC to heat the home during a time when there is a low outside temperature, turns it on again to reheat the home sooner than expected, and does this repeatedly. This would be an indication that the home is cooling faster than expected as compared to other dwellings, indicating poor insulation or drafts. A next-generation meter could detect this and alert the customer that they have a high likelihood of needing to address insulation or weatherization issues. A customer using a utility app connected to their next-gen meter could receive specific recommendations. If the meter detects the problem abating, it could ask the customer's utility app to confirm what weatherization steps they took to help further train the model.

Utilities also often have weatherization inspection and remediation services that could be provided to LMI customers at little or no charge after being identified through their next-gen meter. The federal Inflation Reduction Act will provide funding for whole-house energy efficiency. For households with low or moderate income (LMI), it will also fund point-of-sale rebates for panel upgrades and qualified high-efficiency electric appliances, such as heat pumps for space heating and cooling. These programs are operated at a state and local level. Information on California's Inflation Reduction Act programs, for example, can be found here.[28]

Regressive tariffs

The final energy poverty metrics considered here are regressive electricity tariff structures and the type of energy payment plan the household utilizes. Existing electricity tariff structures were established to recoup expensive fuel costs. Consumers are charged both a fixed cost to cover capital expenses and maintenance of the power generation and transmission systems, and a fee per kilowatt consumed to cover the cost of fuel input. However, as renewable energy projects come online, the cost requirements are reversed. Renewable energy generation has high capital costs with low operational costs, as fuel inputs are minimal. To account for the changed cost structure, a majority of states are considering raising fixed fees for electricity consumption, with 14 states proposing fixed fee increases above 100%.[29] With the revised structures, households will be charged a higher fixed fee and charged less per kilowatt consumed, resulting in higher-consumption consumers paying less per kilowatt-hour and lower-consumption consumers paying more per kilowatt-hour, creating an inequality among consumers.[30] Likewise, Paolo Mastropietro points out that when there is a support charge created by a utility to cover more solar energy, the effect is, in fact, a regressive tariff on the LMI individual, who is paying a substantially higher portion of income toward their energy bill.[31]

Mastropietro suggests alternative solutions to address a surcharge that's become a regressive tariff, such as having the surcharge be included in other fees like gasoline taxes, income taxes, or emission auction schemes.[32] However, these have their own pitfalls. Customers who don't see their energy bills go up may be less incentivized to conserve or purchase solar, and those who purchase solar may feel cheated. A novel approach using next-generation smart metering would involve a relatively new capability that involves tagging the energy that is put onto the grid or into an electric vehicle (which could later discharge the energy back to the grid via a bi-directional vehicle-to-grid charger) using a distributed electronic ledger, aka blockchain. Energy could then be traced to its source of origin, such as a customer's solar or home battery system. These units of energy could then be sold as carbon offset credits or RECs,[33] generating revenue for utilities to offset the reduced revenue from solar-generating customers while eliminating the need for a special tax on lower-income and eco-friendly customers.

Next-generation smart metering is poised to solve some very complex socioeconomic issues while encouraging the development and growth of renewable energy and electrification. For cities looking to deliver affordable energy to their most vulnerable customers without driving away eco-friendly customers, encouraging electric utilities to invest in next-generation AMI should be part of the discussion.

Connect with us

Let's continue this conversation. Reach out to us.

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