Here Come the Wedding Bells: the Engagement of Energy Efficiency and Electrification

A Whitepaper from WECC

431 CHARMANY DRIVE | MADISON, WI 53719
JUSTIN MARGOLIES AND GEORGE EDGER
800.969.9322 | WECCINFO@WECCUSA.ORG

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Justin Margolies and George Edgar, WECC

Executive Summary

The verdict is in. The research community has identified electrification as a key strategy to decarbonize the economy. Two fundamentally powerful trends contribute to this new opportunity. First, the electric supply mix continues to experience an increased penetration of natural gas, wind and solar, which is rapidly reducing the electric power sector's emissions rate. Second, existing and new electric powered equipment are increasingly exhibiting higher efficiency levels and lower lifetime costs than their fossil fuel powered counterparts. In this context, electrification refers to electrically powering end uses that otherwise would be directly powered by fossil fuels at the point of use. Beneficial (or strategic) electrification generally refers to electrification that lowers environmentally polluting emissions while saving consumers money and enabling grid flexibility, storage and ancillary services.

The authors explore the emerging concept of beneficial electrification, the metrics to assess its value, and pathways towards successful implementation with proper messaging, markets, policy and regulation. The paper reveals that while it may not be love at first sight, electrification and energy efficiency are mutually reinforcing partners. With the premise of careful implementation, beneficial electrification offers a practical climate solution that integrates traditional energy efficiency, increases consumer and societal net benefits, and leads us to a new era of sustainable energy production and consumption.

Introduction

Electricity has a number of traits that have led it to be the most frequently consumed form of energy in the United States (US) economy (EIA 2018). Electricity can be generated from a wide variety of sources and methods, is easy to transport and can be flexibly used. On the supply-side, new drilling techniques have opened up a domestic market of cheap, abundant natural gas. Wind and solar costs have dropped swiftly, propelling an acceleration of behind-the-meter and utility-scale electric generation. On the demand side, rapid technological advancement has resulted in market-ready and affordable electric motors and heat pumps that can provide three times higher operational efficiencies than fossil fuel combustion-powered engines and heating systems.[1] Battery capacity continues to increase while prices continue to drop, expanding the capability of electric end uses to provide storage-based ancillary services. Consumer adoption of digitally driven, connected sensors and devices makes it possible for data to be collected, processed and shared seamlessly, opening up new ways for energy consumers to contribute to grid balance as active market participants.

These developing market trends provide an opportunity to act upon a longstanding consensus in the scientific community that warming of the climate needs to be kept under two degrees Celsius to avoid severe risks to natural systems and human health and well-being (IPCC 2014).[2] To remain under two

[1] Note that fossil-fuel heating has an efficiency limit imposed by the laws of thermodynamics while electric powered renewable thermal technologies on the market such as air-source heat pumps can reach efficiencies of over 300%.

[2] It is important to note the 2°C threshold is climate scientists' prudent determination of the risk and uncertainty to avoid reasonably anticipated, albeit not certain, significant adverse impacts on the environment and economy. As part of the Paris agreement, countries committed to aim to limit a temperature rise to less than 1.5°C. While debate exists surrounding magnitude and timing, we use this goal as a baseline that justifies pursuit of emissions reductions.

degrees, it is generally accepted that a developed nation like the US needs to achieve at least 80% reductions of year 2000 carbon emissions by 2050. By the end of 2016, the US has reduced carbon emissions levels 12%, demonstrating progress, but not nearly fast enough to meet goals (EIA 2017). Scientists' warnings and recommendations are being bolstered by increased public interest in climate change. Local and state governments, as well as businesses, are committing to clean energy and sustainability at a rapid pace. To reach emissions reduction goals, the research community broadly agrees a key strategy is to substitute cleanly sourced, electrically powered equipment for fossil fuel, combustion-powered equipment in the transportation, buildings and industry sectors (NEEP 2017, Weiss et al. 2017). This simple conclusion has vast implications for the energy industry and warrants mindful, expedient implementation.

The opportunity for electrification is large. As of 2016, approximately 40% of energy in the entire US was consumed by the electric power sector (EIA 2018). Transportation end uses represent the largest electrification opportunity. Currently 30% of energy consumed in the US is taken up by the transportation sector, of which 92% is provided directly from petroleum. Space and water heating end uses represent the next largest electrification opportunity. In the residential sector, 62% of homes have space heating equipment directly powered by fossil fuels and 55% of homes use fossil-fueled water heaters (EIA 2015). An assessment of the Northeast reported that 86% of direct fossil fuel consumption in the region is attributed to the transportation sector and heating and water end uses in commercial and residential buildings (NEEP 2017).

Electrification is increasingly recognized by policymakers, regulators, electric utilities and energy efficiency practitioners as an essential contributor to a low-carbon future but it also brings to the forefront some critical questions. What makes electrification beneficial and not detrimental? What exactly are all the benefits of electrification and how do we measure them? How does electrification fit with the current concept of energy efficiency? And most consequentially, how do we develop and execute a strategy to realize the full promise of beneficial electrification?

Beneficial electrification represents a seismic shift of focus from end-use energy savings to end-use carbon savings. However, pursuit of efficiency in carbon is not mutually exclusive of efficiency in energy use. In fact, energy efficiency is a driving input in the defining environmental metric of beneficial electrification. This paper continues the emerging dialogue surrounding implementation of beneficial electrification from a perspective of the public good.

Defining the Benefits of Beneficial Electrification

Electrification refers to powering end-uses with electricity that would otherwise be directly powered by fossil fuels at the point of use. Dennis (2015) coined the term "environmentally beneficial electrification" to refer to the potential of electrification to reduce greenhouse gas emissions and air pollution. While a primary focus on environmental benefits gave rise to the term, an assessment of economic benefits shapes the viability and strategy of beneficial electrification initiatives. We begin the discussion on benefits by summarizing three conditions of beneficial electrification introduced by the Regulatory Assistance Project (RAP) and commonly referenced in the emerging body of grey literature produced by industry stakeholders.

- Reduce environmental impact
- Save money for consumers in the long run
- Enable better grid management

Reduce environmental impact

Lower greenhouse gas and air pollutant emissions make up the primary environmental benefits associated with beneficial electrification. Most simply, environmentally beneficial electrification means that the emissions per unit of useful energy of an electrically powered device are lower than the emissions per unit of useful energy of a fossil fuel powered device. Dennis, Colburn, and Lazar (2016) refer to this metric as "emissions efficiency". Quantifying the reduction in environmental impact is no easy task, and we will go into further discussion about how to determine the emissions efficiency of a beneficial electrification action in an evidence-based, transparent manner.

Save money for consumers in the long run

From a consumer purchasing perspective, the goal is to minimize full cost of ownership when choosing between a fossil fuel powered and electric powered device that provide equal levels of service.[3] The methodology here is really no different from a simple customer lifecycle cost analysis. Capital costs and ongoing operational costs must be accounted for in the calculation. Just as in traditional energy efficiency, the assessment will typically involve weighing higher initial upfront costs for electric equipment with lower operational costs compared to fossil fuel powered equipment. This analysis is pretty much identical to the traditional participant test in energy efficiency, except equipment with different fuels are inputted into the equation rather than a "baseline" and "efficient" equipment with the same fuel. Importantly, while a given customer's total electric bill will likely be higher due to higher consumption of kilowatt-hours, overall customer expenditures on energy will be lower when beneficial electrification is implemented. Assessment of lifetime operational costs has some degree of uncertainty that is dependent on future fuel prices, rate designs and consumer behavior.

Enable better grid management

The source of better grid management from beneficial electrification boils down to demand management and storage capacity of electric end uses. Electric devices provide behind the meter capability to dynamically adjust demand in response to supply conditions at a given point in space and time on the grid. End uses that can flexibly consume energy add value to the grid as a load management tool. Examples of load management strategies include demand response (DR) dispatch and load shifting in response to real time price signals. Some electric end uses exhibit higher potential of adjusting the time of energy consumption than others. For example, a consumer may exhibit more time elasticity of demand on his dishwasher than his electric induction stovetop.

In addition to load management, some technologies offer storage potential. Electrically powered water heater tanks can serve as a storage vessel for hot water and electric vehicle batteries can serve as storage for electricity that can be charged or discharged depending on grid and consumer needs (Hledik, Chang, and Lueken 2016). Electric vehicles are perhaps the greatest risk and opportunity related to grid management. If all customers charge vehicles in early evening, peak demand could spike, along with prices and emissions associated with backup generators. However, if vehicles are simply controlled to charge at low cost and low emission time periods, and discharge at high cost and high emission time periods, they can be valuable, reliable, capacity assets for the grid (Lazar 2018).

Better grid management yields utility cost savings which can be shared via incentives or time of use rates with customers who provide valuable flexible load or storage capacity. In the long-term, system cost savings can be passed through to benefit the entire rate base, including non-participants of demand side management programs enabled by beneficial electrification.

Appropriate application of beneficial electrification initiatives should lead to faster deployment of new low cost, low emission generators. Growth in electricity use may contribute to lower retail rates by enabling electric utilities to spread large fixed costs over more sales. Flexible end uses provide a strategy to better integrate the increased proportion of variably producing renewables such as wind and solar and minimize curtailment. Curtailment of wind in the Mid-continent system operator (MISO) was over 4% in 2016. Lazar

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[3] In reality, electric and non-electric devices often contain differences in levels of service that may or may not be reflected in the price.

(2018) illustrates how flexible equipment such as electric vehicles can help convert that curtailed energy into useful energy that can be provided at low costs to consumers and help pay for the distribution system.

Other Factors to Consider

The Regulatory Assistance Project (RAP) introduces a simple conditional test that states electrification is beneficial if it meets one of the above three conditions without adversely affecting the other two (RAP 2017). This checklist definition serves as a helpful rule of thumb but important interpretative questions remain. What do we exactly mean by "adversely affecting"? Does each of the three conditions receive equal or different weights when making a policy decision? How should other benefits and costs associated with electrification be accounted? Ultimately, we recognize climate change is the primary driver of beneficial electrification and that there are temperature threshold dynamics at play and uncertainty in the severity of damages. What is the value of marginally reduced emissions and which tipping points have we crossed if we don't reach full carbon reduction targets to limit warming to less than one and a half to two degrees Celsius?
A few additional individual consumer benefits that can be achieved from electrifying end uses include convenience, safety, health and comfort. The car owner no longer needs to refuel at gas stations, and the home owner no longer needs to monitor tank levels and coordinate fuel deliveries for heating or outdoor power equipment. Removing combustible fuels from an environment can improve safety and health by lowering risk of carbon monoxide poisoning and fires and improving ambient air quality.[4] Finally, electric technologies are typically quieter, since no internal combustion process is needed to convert fuel to usable energy.
Nonpecuniary costs can also be associated with electrification of an end use. One example is that electric vehicles may be less convenient for owners that are renters without easy access to charging stations and take many long trips where there is a lack of fast charging infrastructure. Other examples are that some consumers may prefer gas flame cooking equipment over electric cooking equipment and quieter cars on the road could contribute to increased risks of accidents.
From a political perspective, beneficial electrification can help promote local economic development and energy independence. Many states do not have the luxury of being endowed with a reserve of fossil fuel resources and will experience benefits of capacity capital investments in people's homes such as electric vehicle batteries and water heaters in addition to the prospect of more in-state development of renewable supply.

It is also important to recognize that while beneficial electrification signals an overall winning value proposition for electricity providers, consumers, and society, there are losers in a transition to a more electric economy. More electrification means more sales for electric utilities and less sales for fossil fuel companies such as natural gas utilities, oil and gas companies, gas station operators, and delivered fuel providers. Also, consumers that are later to adopt electric measures may be subject to extra high fossil fuel prices due to these businesses' need to spread fixed costs over a shrinking customer base. There are limited opportunities to switch certain types of equipment that have long lifetimes and so consumers who purchase fossil fuel powered equipment in the next couple years will likely bear higher costs than those who switch sooner, reflecting the frequently referenced "lost opportunity" concept common in energy efficiency.
The tension between efficiency and equity is front and center in beneficial electrification. Electrifying end uses will be more difficult for low income consumers who have less money to pay upfront costs and may not qualify for market-based credit. From a policy perspective, a strong case could be made for inclusion of an equity condition to be met by beneficial electrification initiatives to ensure access to benefits for all.

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[4] While representing a much smaller share of emissions reduction potential, lawnmowers, snowblowers and other outdoor power equipment are end use electrification opportunities that yield air quality and noise pollution benefits.

How Beneficial Electrification Fits with Energy Efficiency

Actions justified by beneficial electrification do not necessarily neatly fit within the framework of traditional energy efficiency. It is possible more site input energy may be required to power an electric end use, compared to the non-electric alternative, but still be beneficial. A good example is electric resistance heating. On a source net Btu basis, the energy consumption of an electric resistance heater is higher than a fossil fuel powered furnace. However, depending on time of use, rate design and the electricity generation source, the electric resistance heater could lower emissions, save consumers money, and enable better grid management (Mahone, Mahone, and Hart 2016). Beneficial electrification also goes at odds with policies and program designs where traditional fuel switching is prohibited. This begs the question just how does beneficial electrification align with energy efficiency?

To answer this question, we have to unpack the meaning behind energy efficiency in the current industry context. In energy efficiency programs in the US, efficiency has focused predominantly on operational efficiency. Operational efficiency can further be subdivided as functional efficiency and scheduling efficiency. Functional efficiency refers to the technical energy efficiency of equipment or the building shell and is focused on quantity of site energy saved. Scheduling efficiency refers to a more system-based perspective that focuses on timing of site energy saved coinciding with peak power demand. While possible with other fuels such as natural gas, scheduling efficiency opportunities are more prevalent and extensive today in the electricity sector due to the low variable production costs of wind and solar generators as well as system capacity constraints. Demand response programs and critical peak pricing are examples of electric utility initiatives that aim to drive scheduling efficiency. Demand response presents consumers with potential financial benefits if they are willing to demand energy flexibly over time. Critical peak pricing presents consumers with potential financial costs if they are not willing to demand energy flexibly over time. Either way, the goal with scheduling efficiency is grid balance.

Perhaps the best way to think about how beneficial electrification fits with energy efficiency is that it helps forge a transitional pathway to a new generation of energy efficiency; one that is more integrated and designed to better reflect the positive and negative externalities of input energy consumed by end uses. Beneficial electrification takes into account the full lifecycle of the *fuel* being consumed by a product. It is just one step further to add to the mix the entire lifecycle of energy needed to produce, maintain and dispose or recycle a product.[5]

Beneficial Electrification Metrics

Source Energy

Source energy is important to consider in the context of beneficial electrification since different generators of electricity have different emissions, costs and grid impacts. Source energy will always be equal to or larger than site energy since it captures the efficiency losses of the generation, transmission and distribution process. Each gallon of gas stored in a vehicle's tank, or handful of kilowatt-hours stored in a vehicle's battery, has a production and transportation history that a source-site ratio captures.

While transmission and distribution losses contribute to the source-site energy ratio for electricity, the heat rate of the power plant is the primary driver of the metric. From a physics viewpoint, the heat rate simply reflects the power plant's efficiency of converting input energy into output electricity. Input energy for fossil fuel plants is the fuel's contained chemical energy prior to combustion. Input energy for renewable resources

[5] An example of a model that accounts for the entire lifecycle of a product is the concept of the "circular economy" put forth by the Ellen MacArthur Foundation. In this model, a product is often leased and paid for "by use" rather than outright purchased by a customer. This encourages more durable manufacturing and refurbishing.

such as geothermal, solar, hydroelectric, and wind, is simply the naturally occurring earth heat, sunlight, water current, and wind force.

Currently in the US, the "fossil fuel equivalency" site-source ratio for electricity is the most common approach used in practice in numerous Department of Energy (DOE) approved products, reports and programs. Many have pointed out the technical inaccuracy and practical shortcomings of a fossil fuel equivalency based source-site energy ratio (Dennis 2015, Mahone, Mahone, and Hart 2016). The fossil fuel equivalency method assigns renewable energy generation the same level of inefficiency in energy conversion as average fossil fuel generators. This did not have meaningful consequences when renewables made up a small fraction of electricity generation but increasingly puts electricity at an unfair disadvantage when making efficiency-based recommendations of fossil fuel versus electric powered equipment.

In October of 2016, the DOE published a report addressing the outdated accounting methodology for non-combustible renewables (Donohoo-Vallett 2016). The recommendation of the report was to apply the "captured energy" method, which signals zero efficiency loss from wind, hydro or solar generation. Table 1 displays four distinct possible heat rates and their impact on the source-site energy ratio of a hypothetical 20% efficient solar generator.

Table 1. Different methods of calculating source-site energy ratios for a hypothetical 20% efficient solar generator

Source Energy Method	Heat Rate (Btu/kWh)	Source-Site energy ratio
Physics	17,060	5
Fossil Fuel Equivalency	9,232	2.7
Captured Energy	3,412	1
Fossil Fuel*	0	N/A

*This method better represents "source emissions", rather than "source energy"

While the exercise of determining an energy source-site ratio is helpful conceptually, the metric is not adequate as a stand-alone proxy for economic or environmental value. Notably the "fossil fuel" source-site ratio is proposed by some as one possible alternative metric that better reflects a source-site emissions ratio rather than a source-site energy ratio (Dennis 2015). This metric applies a heat rate of zero to non-carbon-emitting renewables since these resources have no impact on emissions. While we commend the fossil fuel source-site ratio for measuring what matters, we take a slightly different approach and simply embed the "captured energy" source-site ratio within an equation on emissions efficiency outlined below. Either way, in the sphere of beneficial electrification, when thinking about efficiency of energy generation, the metrics that matter are emissions, flexibility and cost.

Emissions Efficiency

Dennis, Colburn, and Lazar 2016 coined a new metric called emissions efficiency (or 'emiciency') to account for the interaction between end use energy efficiency and fuel source emissions.[6] We describe the logic of this metric in equation form in figure 1 below. We assume the useful site energy demand is equivalent for the fuel sources in question; or in other words, the consumer will drive the same number of miles in their vehicle, take the same number of hot showers, or cut their lawn the same number of times. This leaves two primary drivers of end use emissions efficiency: 1) energy efficiency of the end use and 2) emissions efficiency of the fuel.

$$End\ Use\ Emissions\ Efficiency = End\ Use\ Energy\ Efficiency \times Fuel\ Emissions\ Efficiency$$

[6] Emissions efficiency is closely related to the concept of emissions intensity, but rather than focusing on magnitude, it focuses more on the relativity of emissions impact for comparison purposes between end uses.

$$\left(\frac{CO_2\,Emissions}{Site\ Useful\ Energy} = \frac{Site\ Input\ Energy}{Site\ Useful\ Energy} \times \frac{CO_2\,Emissions}{Site\ Input\ Energy}\right), where$$

$$\left(\frac{CO_2\,Emissions}{Site\ Input\ Energy\,*} = \frac{Source\ Input\ Energy}{Source\ Useful\ Energy} \times \frac{CO_2\,Emissions}{Source\ Input\ Energy}\right)$$

Figure 1. End Use Emissions Efficiency Equation
*Note site input energy is approximately equivalent to source useful energy[7]

End use energy efficiency needs to be evaluated based on Btu or joules to allow for comparison across fuel types. Fuel emissions efficiency is easy to quantify for fossil fuels but hard to quantify for electricity. Kilowatt-hours are a secondary unit of energy and not all kilowatt-hours are created equally in terms of their emissions profile. While fossil fuel powered equipment emits the same amount of greenhouse gases and air pollutants regardless of location and time, electric powered equipment emissions are time variant and location specific.[8]

With regards to time, there are generally three possible perspectives. First, an average emissions factor serves as a rough account of the overall fuel mix creating electricity on the grid at a given point in time and space. Second, a marginal emissions factor accounts for the short-term generator on the margin to serve additional load at a given point in time and space. Lastly, an incremental emissions factor accounts for the responsiveness of the supply-side of electricity to increases in demand. Incremental emissions efficiency addresses that the fuel mix of new generation built to meet demand growth is likely to be a higher percentage of zero or low carbon supply than present in the current market.

The choice of timing horizon in determining the emissions efficiency metric mirrors a debate on source-site ratios whether to take an average or incremental perspective. The incremental site-source ratio more accurately accounts for the fact that fuel switching happens on the margin and as time goes on, the incremental fuel added to the grid will more often be high efficiency combined cycle gas turbines and wind and solar.[9] While we decided to not use the source-site energy ratio as a stand-alone measure in the realm of beneficial electrification, the basic "average" versus "incremental" debate remains.

Another critical timing question is to what extent new natural gas plants are at risk of becoming stranded assets. While natural gas powered electricity helps move towards beneficial electrification, new natural gas plants lock in emissions and costs for years to come and recent research shows clean energy portfolios are currently cost-competitive with proposed natural gas-fired power plants in case studies across the US (Dyson, Engel, Farbes 2018).

The choice of how to delineate a geographical boundary for end use assignment of emissions depends to some extent on whether a demand-side or electric service provider perspective is taken. Regional transmission organizations (RTOs) reflect locational based wholesale electricity prices for much of the US which signals the fuel mix being dispatched at a particular location on the grid. This perspective will yield the most accurate results of the actual emission efficiency of an end use. However, there is also a line of thinking that if an entity such as an electric utility or municipality is actively promoting beneficial

[7] In reality, there will be some minimal energy losses from transportation of energy from the source to the site.

[8] Natural gas companies are likely to contend the assumption of a flat emissions profile for delivered gas and would make the case that gas emissions intensity is going down. Natural gas producers may develop a means to achieve "renewable" natural gas that could compete in meeting beneficial electrification criteria.

[9] NRDC proposes using this methodology but they call it a marginal site-source ratio. We describe it as incremental to distinguish between fuel sources on the margin in the real-time electricity markets and to consistently align with the distinction between the average, marginal and incremental emissions factors (NRDC 2015).

electrification, they should own or purchase a supply mix whose characteristics they can account for and justify end use electrification (MCEA 2017).[10]

Emissions efficiency is likely to be a contentious metric due to uncertainty inherent in predicting electric consumer behavior and forecasting market trends such as power plant retirements and replacements, fuel prices, and future policies regarding carbon, renewables, distributed energy resources and efficiency. All of these factors contribute to the future fuel mix and emissions efficiency of electricity consumption. In addition, a variety of perspectives could be taken on a utility's accountability to decarbonize its own generation assets. Ultimately, the methodology of assigning emissions impact to a given beneficial electrification initiative will need to be clearly articulated and there will be a role for utility regulators or other public officials to approve the approach and ensure it is within the public interest.

Demand Flexibility

Flexibility of new electric load is a key parameter that determines emission and consumer and grid cost impacts. Flexibility depends on characteristics of the technology in question, customer preferences and behavior, and the incentives or penalties for energy use during time periods deemed by grid operators. We do not address the question of how to value a specific project's demand flexibility in this paper but recognize that valuation will be geographically dependent on the transmission and distribution network, and that proper market design will be essential to ensure proper price signals are communicated to customers.

The Counterfactual Conundrum

Beneficial electrification is likely to take on a variety of forms and scopes that will call for unique approaches to metrics and impact assessment. Regardless of the specific approach, casting beneficial electrification into a decision framework will be helpful when assessing impact. For example, emissions savings should be benchmarked by extrapolating a baseline counterfactual trend of emissions per unit of useful energy that would occur absent any beneficial electrification market intervention. A particular project, program or policy could be judged environmentally on whether it causes an emissions change above or below a baseline trend of electrification and other market forces impacting emissions. It is important to remember that beneficial electrification will face competing decarbonization strategies. Embedding sensitivity analyses into the decision framework which address the counterfactual conundrum will enable a better comparison of environmental, economic and equity impacts between beneficial electrification and the most reasonable alternative scenarios.

Cost Effectiveness Tests

Benefits and costs come down to values; and there is a need for public policy makers, regulators and electric providers and implementers to address some difficult questions in the face of uncertainties such as the pace of climate change, severity of damages, counterfactual business-as-usual scenarios and alternative decarbonization strategies.

It is possible, that beneficial electrification could apply cost effectiveness tests similar to those used in traditional energy efficiency programs but simply shift focus from achieving site energy savings to achieving source emissions savings at the lowest cost. On the benefits side, consumer financial savings, system benefits and reduced carbon emissions could be inputs into beneficial electrification versions of the participant cost test, utility cost test, and total resource cost test.[11] However, further investigation is needed

[10] In comments regarding Great River Energy's Integrated Resource Plan, certain stakeholders claimed that the utility would need to own cleaner generation assets to claim beneficial electrification whereas Great River Energy was basing a claim of beneficial electrification on the MISO fuel mix.

[11] Under some circumstances, utilities could experience avoided compliance costs to meet environmental regulation and both consumers and utilities could experience avoided emissions costs if a price is put on carbon.

to determine whether it is appropriate and desirable to just import elements of energy efficiency tests, policies and procedures (including EM&V) into the realm of beneficial electrification. Previous papers have explained why some such tests applied to beneficial electrification may produce an inappropriate result (Dennis 2015, Dennis, Colburn Lazar 2016). At its core, beneficial electrification represents a paradigm shift to a more integrated form of energy efficiency and there is likely value in considering the full array of approaches to impact assessment.

Beneficial Electrification Implementation

Beneficial electrification merits a holistic, results-focused, adaptable and transparent implementation approach. Policies, regulation, and market design have typically focused on the supply side and demand side of energy separately. Beneficial electrification links source emissions savings, from an increased supply of carbon free resources, and site emissions savings, from operational efficiency improvements. Some tangible reforms in policy, regulations, market design and overall messaging will pave the way for beneficial electrification initiatives to achieve meaningful impact on emissions targets and maximize net social benefits in the process.

First, electric utilities need to be empowered to promote source emissions savings. In this model, energy savings should be tracked by net Btu rather than by net kWh since beneficial electrification increases electric usage. In general, any beneficial electrification program, policy or action should be judged against the most reasonable counterfactual scenario applying a decision framework. Transparency should be priority in forecasting baseline counterfactual market trends that exhibit a certain degree of uncertainty. Institutional legacies prohibiting promotion of fuel switching will pose a regulatory hurdle but will need to be addressed for beneficial electrification market interventions to reach scale and capture this limited window of opportunity to accelerate baseline electrification trends in the market. Undoubtedly there will be disagreement. Stakeholders may find the equation we outlined coupled with the decision framework helpful in conceptualizing emissions impacts.

Social equity also needs to be front of mind in the design of beneficial electrification programs since highly efficient electric devices exhibit steep upfront price premiums and will be difficult for lower income customers to adopt without access to rebates and financing. Beneficial electrification is also at risk of suboptimal outcomes if a program's focus remains simply on the adoption of electric widgets and does not provide opportunities for a customer to leverage the end use as a grid management asset. The most beneficial electric end uses will express flexibility; either aligning timing of consumption with variably produced supply, or storing and dispatching energy according to grid needs. Customers should receive price signals that reflect emissions and cost to be able to act when and where their willingness to accept flexibility in energy consumption outweighs the cost to the grid operator. Customers who own generation or storage assets should be given opportunities to opt into the market as "prosumers" who can provide capacity or ancillary services. Flexibility valuation can be addressed through proper utility rate design and is bolstered by price reform in organized wholesale markets.

Increased reliance on electricity could be seen to pose increased risk to costly power outages caused by cyber-attacks and natural disasters. Addressing grid resiliency upfront in beneficial electrification initiatives will be important to ensure communities are able to be adaptive, and either anticipate and prevent disruptions, or quickly recover from disruptions to the power system. Pairing beneficial electrification actions with on-site renewable generation, utility-scale and behind the meter storage, microgrid construction will mitigate risks of increased reliance on electricity as the primary energy source.

Policies and regulation play an important role in maximizing the benefits of beneficial electrification by providing the foundation for strong program and market design. However, even if emissions is not a strong policy goal, less beneficial, but still beneficial electrification, can be executed by a diverse set of stakeholders. Outreach and marketing does not necessarily need to be contained within a traditional utility regulated program. Local government or community based organizations could lead the charge to accelerate adoption of beneficial electric equipment. The core market intervention of beneficial electrification is to convince customers to electrify equipment when it is beneficial for them, the grid and the environment. To change market behavior, the wide variety of barriers to electrification must be addressed (NEEP 2017). The budding concept of beneficial electrification will benefit from early and robust stakeholder discussions. In the end, beneficial electrification should ideally be implemented in a holistic way, coordinated with electric utility energy efficiency, and bundled with other mutually reinforcing demand side management strategies that produce value.

Conclusion

To achieve carbon emissions reduction targets, significant changes are needed in the way we produce and consume energy and urgent action is needed to ensure the appropriate emissions minimization decision. Beneficial electrification presents an immediate opportunity for market interveners to accelerate the adoption of low emission, flexible electric end uses. Transportation and heating industries exhibit the largest electrification potential. Electric vehicles and heat pump technology for space and water heating are poised for immediate deep market penetration. Electrification opportunities will be most immediately achievable when substituting away from gasoline and delivered fuels like propane and oil due to immediate, significant operational cost advantages that contribute to shorter payback times for investment in electric equipment. The US is overdue for infrastructure improvements. For every instance a beneficial electrification opportunity is not seized, we lock in more emissions, set up households for stranded assets that cost more money in the long run, and curb growth in the rapidly evolving clean energy economy. On top of environmental value, beneficial electrification brings economic development, energy security and resiliency to local communities. Beneficial electrification presents an opportunity today to inspire the reshaping of our energy system to be more renewable, less carbon intensive, and more time, location, and data driven.
Beneficial electrification at its core is a practical solution to climate change, which if properly applied, can maximize the value realized by consumers, the grid and the environment. Beneficial electrification presents consumers with highly efficient, flexible, value-laden electric technologies and presents electric utilities and communities an actionable pathway to deep decarbonization and energy optimization. To ensure equity and to be effective, it will be important for policy and programs to proactively address impacts on those who may be adversely affected by beneficial electrification. In the end, the framework of beneficial electrification will help transition us into the next era of energy efficiency, while building an improved energy system to promote future economic well-being. Equipment replacements do not happen overnight. Every beneficial electrification opportunity we miss today will translate into a more difficult barrier in the quest for emissions cuts and economic gains. There is no fossil fuel to waste or time to wait. Let us begin.

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About WECC

Founded in 1980, WECC is a mission-driven nonprofit designing and delivering real energy solutions for our clients' benefit. WECC champions and delivers innovative energy initiatives that produce enduring economic and environmental benefits for all. WECC's team of experts are passionate about delivering measurable results. For more information about WECC, call 800.969.9322 or visit weccusa.org.

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