From Loading Order to Loading Lanes: Rethinking the Energy Transition and Unlocking Smart Local Energy Markets for Communities of Concern

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ABSTRACT

Customers need affordable, clean, and reliable energy, but our current approach to the energy transition is hampered by the traditional notion of having to first implement energy efficiency before installing on-site solar and storage. This stepwise approach to decarbonization and energy system planning is slowing the pace of climate change goals. The economic reality is that customers will need to electrify *while* adding solar and storage. State agencies and utilities forecast hundreds of billions of dollars in grid upgrades that will require major rate increases while hindering the needed paradigmatic shifts in energy market participation. But this transition is leaving communities of concern behind and lacks a holistic plan where demand side and grid side management are truly integrated.

A recent California Energy Commission Electric Program Investment Charge grant in a low-income community in the San Gabriel Valley (eastern Los Angeles County) illustrates how residential decarbonization and grid benefits can be optimized in communities of concern. We use this project to demonstrate real-world needs and to highlight three categories of urgent reforms in policy and program implementation for a high DER future: (1) the evolution of the "loading order" approach to one of "loading lanes;" (2) multiple changes to IRP processes including a more geographically granular approach to load forecasting, the integration of DERs into resource planning, and the establishment of minimum procurement goals for VPP resources; and (3) the establishment of smart local energy markets.

Introduction

The United Nations Environment Programme's (UNEP) Buildings Breakthrough Target sets 2030 as the year to make near-zero emissions and climate-resilient buildings the new normal. Since the United States is listed as an 'endorsing country,' this goal requires the US to develop priority actions in 2024. The Intergovernmental Panel on Climate Change (IPCC) report's consensus indicates that buildings need to reduce operational emissions by more than 95% compared to current levels (UN Environment Programme 2022). Achieving these goals will require a deep examination of building sector and grid sector policies. To achieve these goals, we must challenge dogmatic approaches that may not be appropriate in today's energy landscape.

Too many households are struggling to meet basic needs and cannot afford the decarbonized energy transition as currently envisioned, further exacerbating marginalization (Rotmann 2024). Energy programs must provide financial benefits for income-qualified participants to accelerate the decarbonization of the energy sector. A recent California Energy Commission grant-funded project, spanning two phases and over six years of analysis and construction, has resulted in a compelling pathway to electrify disadvantaged communities. The findings from this project point to two areas requiring radical change: how buildings decarbonize and the role buildings play in our evolving power systems. At scale, a collection of full IDSM (integrated demand-side management) retrofitted, grid-interactive buildings creates an opportunity for policy decision-makers to reimagine two long-held concepts.

One is the loading order.[1] This stepwise process is no longer practical in today's energy landscape. Decarbonizing homes requires a *simultaneous* application of decarbonization interventions: energy efficiency, demand flexibility, and clean on-site generation and storage. A 'loading lane' analogy is better suited to the rapid approach needed in today's energy landscape. Onsite generation must be simultaneously paired with energy efficiency to meet customer *and* community energy needs. In contrast, an efficiency-first 'loading order' approach to retrofits arguably slows the pace of decarbonization (as described in this paper).

The second long-held concept for decision-makers to revisit is the binary concept of a 'supply side' and a 'demand side' in our energy system. "For much of the twentieth century, these huge and complex [power] systems, together with their regulatory models, were based on the paradigm of largely predictable and incremental change. This was a world of one-directional supply from centralised, dispatchable, fossil fuel generation to customers that were largely passive" (Patterson 2022). Bottom-up system planning and bi-directional, participatory models are needed in a 21st-century energy justice paradigm (NARUC-NASEO 2021).

This paper also considers the larger holistic ecosystem change needed for state policy, driven by the blurring of lines between the traditional 'supply' and 'demand' sides in our power system. It identifies how the demands of rapid, affordable building decarbonization require changes to the broader regulatory landscape of integrated resource planning (IRP) and makes recommendations for policy changes and the integration of a new set of energy markets.

Real-World Experience

To illustrate the barriers and solutions to rapidly scaling comprehensive retrofits in the residential sector, the authors provide a summary of an equity-focused grant project in California. While this project does not solve the policy barriers, it provides a proof of concept that a new approach to income-qualified retrofits results in affordable energy bills by pairing the electrification of homes with on-site distributed energy resources and the stacking of multiple incentive programs.

Project Basics

The California Energy Commission awarded an Advanced Energy Community project in 2016 to a team primed by the University of California Los Angeles with The Energy Coalition as a sub-consultant. This planning grant identified a low-income disadvantaged population in the San Gabriel Valley (eastern Los Angeles County) for a multi-sector zero net electricity strategy. The Energy Coalition now serves as the prime contractor for the five-year, $9M implementation award (2020-2025), known as the Bassett Avocado Heights Advanced Energy Community (BAAEC). The project encompasses 4.7 square miles and 28,000 residents within census tracts scoring in the top 10% of disadvantaged communities in California.[2] Residents are 84% Hispanic with a median income of $60,000.

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[1] California has established energy efficiency as its highest priority energy resource for procurement of new resources. Under Assembly Bill 1890 (1996) and Assembly Bill 995 (2000), California has established a "loading order" that calls for first pursuing all cost-effective efficiency resources, then using cost-effective renewable resources. Only then may conventional energy sources be used to meet new load.

[2] In 2013, California's Environmental Protection Agency released CalEnviroScreen to identify California communities with the highest pollution burdens and vulnerabilities.

Among many other objectives, this project seeks to (a) demonstrate the feasibility of creating net zero energy homes for low-income households in disadvantaged communities at zero cost to households; (b) identify the best practices in technology selection and installation sequencing during retrofits; (c) determine the best available strategy for stacking multiple incentive and subsidy programs for low-income households; (d) analyze how household-level and community-level demand flexibility strategies maximize energy, economic, and climate benefits for customers and the grid; and (e) create policy recommendations for scaling the project beyond grant-funded activities.

The project includes an Advanced Homes program where 34 income-qualified homeowners receive no-cost, no-debt service retrofits that include weatherization, solar photovoltaics (PV), and two Tesla Powerwall batteries. Up to 20 of the 34 households will receive a 240V heat pump water heater and a home energy monitoring node. Up to 10 households will receive induction ranges. Where necessary, the project team has installed no-cost electrical panel upgrades and provided re-roofing services to accommodate the solar PV. The average income for participant households is $47,885. Before the listed equipment is installed, the average combined electricity and fossil gas home energy bill for participants is $2,520 annually, which represents 5.3% of the household's annual income. Furthermore, previous studies in this community have shown that households in this community that already have air conditioning equipment use it infrequently. For those households, the indoor air temperatures regularly exceed 85ºF during summer days and advocacy is needed to support the *increased* use of efficient cooling equipment in these homes to ensure a higher standard of safety and habitability (Fournier et al. 2022).

BAAEC Project Analysis

One of the most challenging aspects of the project was the sequencing of equipment installation. In addition to the logistical and physical challenges of sequencing, the consideration of impacts on the customers' energy bills was critical to ensure clear economic benefits and financial protection for low-income customers. Customers' first impressions of the value of decarbonization were also an important consideration. In this community, separate electric and fossil gas providers serve households. A no-cost solar array will instantly lower monthly electricity bills, whereas electrification of home appliances will increase electricity bills while lowering fossil gas bills. Therefore, the team decided to lead with the solar PV installation, forecasting that the bill impacts of renewable energy would outweigh the increases from electrification. The section below details these forecasts. If the retrofits started with electrification, the first impression to the homeowner would have been that the electricity bill increased. An important context to this work is the history of predatory solar installation practices that have been common in these communities in past years, and which eroded trust in clean energy programs. Gaining trust is the single most important theme in engaging hard-to-reach communities (Rotmann 2024).

Our team's models projected a 59% reduction in annual electricity costs on average, or a savings of $1,487 over a baseline of $2,520, from combining solar PV with appliance electrification. This was a far greater reduction than savings from the other project components alone.

Another reason the choice of sequencing solar PV first was so important was because of the logistical challenges involved in coordinating across multiple trades and ratepayer program requirements. Full electrification and decarbonization require multiple trades and multiple firms, especially when leveraging subsidy programs for income-qualified households. Furthermore, not every participating household was immediately interested in, or had the time to support, full home electrification, whereas other households had plans for an electric vehicle. It was essential to leave these participants with the means to afford future electrification upgrades by starting out with solar and storage.

The analysis informing this project includes the following information on households that have installed solar, storage, a heat pump water heater, and in some cases an induction range. The analysis elements include the following, with results summarized in Table 1:

- Historic baseline data calculated from 12 months of actual energy bills obtained through UtilityAPI for the time period prior to the installation of solar PV. These data were obtained at 15-minute intervals and were aggregated to calculate a complete year baseline.
- Forecasts of combined energy bills, calculated as follows: a building performance contractor conducted an on-site home energy assessment and blower door test at each participant's home and created a corresponding building energy model using SnuggPro software. Inputs included a comprehensive set of home attributes and operating characteristics, as well as the historic 12-month electricity and fossil gas consumption. The model was calibrated to solve for any default or unknown parameters that were not collected on-site. The output of the simulation included forecasts of the electric, fossil gas, and GHG impacts of the electrification measures (heat pump water heater, and induction range where applicable) and solar PV installed at the household. The impacts from the batteries were not modeled due to the limitations of the software.
- It should be noted that the current analysis was conducted using software modeled on a flat tariff for electricity and fossil gas. This analysis did not include a simulation of the battery system. As of the drafting of this paper, EnergyPlus-based models are currently being developed to reflect time-of-use and net energy metering impacts. The team anticipates that this new analysis will show increased bill savings as a result of modeling time-of-use rates and the battery providing retail price arbitrage services.

The project's average rooftop solar PV system is approximately 4 kW in capacity and will generate roughly 6,252 kWh per year. This will vary depending on the roof size and orientation. The average annual historic consumption of project participants' electricity usage was 8,662 kWh/year. Solar PV production is able to generate 72% of the participants' average net volumetric annual electricity use,[3] which will significantly reduce household electricity bills. Absolutely no energy efficiency technology yields such a clear and direct bill reduction as rooftop PV. No single energy end use in the majority of homes, even if completely eliminated, represents even 50% or more of total electricity consumption.

[3] These metrics were derived from obtaining actual historic electricity consumption, and comparing against the solar forecasts from the solar permit and ratepayer program documentation.

Table 1: Summary of household historic energy consumption, forecasted impacts of appliance electrification with PV, and energy burden impacts

Self-reported income	Historic baseline electricity (annual kWh)	Historic combined energy bills (annual)	Forecasted combined energy bills w/o solar PV, w/ partial electrification (annual)	Forecasted combined energy bills with solar and partial electrification (annual)	Energy burden % total baseline energy bill as % of income	Energy burden % total forecasted energy bill as % of income	Total forecasted energy bill savings % (annual)
$33,722	6,457	$2,143	$1,990	$287	6.4%	0.6%	88.2%
$69,374	6,101	$1,758	$1,515	$321	2.5%	0.5%	81.7%
$16,812	6,506	$2,274	$2,070	$519	13.5%	3.1%	77.2%
$32,336	8,501	$1,521	$1,399	$446	4.7%	1.4%	70.7%
$75,559	2,889	$981	$862	$279	1.3%	0.4%	71.6%
$52,248	19,776	$6,659	$6,583	4,464	12.7%	8.5%	33.0%
$29,119	6,050	$1,525	$1,337	$256	5.2%	0.9%	83.2%
$80,000	12,612	$2,913	$2,868	$1,608	3.6%	2.0%	44.8%
$46,998	8,339	$2,973	$2,861	$1,015	6.3%	2.2%	65.9%
$50,000	4,889	$1,514	$1,381	$411	3.0%	0.8%	72.9%
$76,437	13,215	$3,464	$3,352	$1752	4.4%	2.2%	49.8%
Averages							
$51,146	8,667	$2,520	$2,383	$1,033	5.78%	2.05%	67.18%

In Decision 21-11-002, the CPUC directed all investor-owned utilities (IOUs) to study bill impacts from electrification of gas water heaters using heat pumps. The Southern California Edison study[4] found that across available tariffs and climate zones, water heater electrification would only result in a 1%–4% average bill increase. Based on the BAAEC participant homes, we have modeled that in the absence of solar, but with electrifying only a heat pump water heater, customer consumption increased within this range. Gas bills would go down by 38%–68% from water heating electrification and weatherization measures. But in this scenario without solar PV, overall energy bills would only be reduced by $137 annually on average. The forecasted overall energy bill savings with solar PV and electrification, however, yields an average of over $1,033 in annual savings—a substantially greater financial benefit to participants. The energy industry cannot expect households to rapidly adopt electrification measures if they provide the same function with a higher energy bill, even if they are installed at no cost.

Expanding this logic beyond the BAAEC project, this paper points to recent findings from the TECH Clean California Heat Pump program. A recent evaluation of this program found that the presence of existing solar PV is an extremely important determinant of choosing electrification appliances in the home. In the study, half of HPWH customers' monthly energy

[4] SCE AL 4713E-A

bills went down (152 of 300; 51%), although most of those perceiving a decrease had rooftop solar (72% of the 152). While 24% said their monthly energy bills stayed about the same when considering gas and electric bills combined, 19% were unsure (Opinion Dynamics 2023). This finding further reinforces this paper's premise that pairing solar with electrification can reduce energy bills, while electrification in the absence of solar PV results in energy bills being the same or higher, depending on the specific appliance and baseline conditions at the home. Furthermore, customers are likely to be more resistant to appliance electrification in the absence of solar and storage. The immediate positive financial impacts of solar PV, combined with the fact that appliance electrification is a strong determinant for future electrification, makes the case for leading decarbonization efforts by pairing renewables with electrification.

California has created an energy efficiency-focused movement, and rightfully so, with its $1 billion annual investment of ratepayer funding. At the same time, the state has invested $166 million annually in the self-generation incentive program for the years 2020 to 2024, which includes resources for distributed energy resources. A logical assumption is that the volume of energy efficiency work occurring would be larger for EE than DERs at those levels of investment. The separation of these funding programs leads to only EE or only DERs being offered to households when participating in ratepayer programs. However, if every income-qualified customer received a full suite of EE and DERs while participating in programs, the stage could be set for a rapid scaling of equitable decarbonization. Otherwise, some customers would pursue EE, some customers will eventually receive electrification measures without compelling financial benefits, and some would receive only DERs with compelling economic benefits, but not fully decarbonize by keeping fossil gas appliances. The solution is to combine all efforts to decarbonize *and* improve energy bill affordability.

This raises two policy issues: rethinking the concept of a loading order where EE is promoted *before* DERs; and second, rethinking how state agencies approach energy system planning in a future of a high penetration of DERs that contribute significantly to the energy supply.

A strict loading order based on an inflexible "in series" approach is no longer appropriate, especially for low-income communities, and will only become more inappropriate over time. The thinking needs to change to an "in parallel" approach to building decarbonization. We refer to this concept as "loading lanes."

Furthermore, as households are rapidly decarbonized with the help of solar and storage, a significant amount of energy self-consumption will occur, and local demand profile volatility will increase. At times, households will self-consume all the energy they generate. At other times, such as winter mornings and evenings, increased electricity imports will be critically needed, but on mid-summer days, electricity exports will occur. The tidal nature of variable renewable energy and the local grid topologies require a more granular approach to load forecasting, integrated resource planning, and distribution system planning. In this scenario, the lines between our traditional concepts of 'supply side' and 'demand side' are eroding and require a rethinking.

From Loading Order to Loading Lanes

Background on the Loading Order

In 1996, as a policy leader, California enacted Assembly Bill 1890 establishing energy efficiency as a resource along with an energy "loading order" that calls for "first pursuing all cost-effective efficiency resources, then using cost-effective renewable resources. Only then may conventional energy sources be used to meet new loads. As authorized under California Public Utility Code § 454.55-56, the [California Public Utilities Commission] CPUC has established aggressive targets and associated funding for energy efficiency programs."[5] This initial concept of loading order established laws and subsequent regulations for energy efficiency as a procurement resource, and gave rise to dedicated funds totaling $1B a year for energy efficiency investment that generally excluded DERs. Prioritizing energy efficiency created a robust industry that has made significant progress on climate change.

Over the last decade, though, a growing attention on DERs has occurred throughout industry organizations, nonprofits, and trade associations born out of EE advocacy. However, this evolution has been uneven. Valuable trade associations such as CalCERTS and CHEERS focus on HVAC systems, duct leakage, and refrigerants, but recently have included renewables for the DOE Energy Ready Homes initiative. The organization Efficiency First advocates for EE as the first step in retrofits, although it includes 'clean energy' in its vision. ACEEE, founded in 1980, has rightfully advocated for EE and now includes a range of topics and sectors. Industry organizations such as the Efficiency Valuation Organization and the Association of Energy Engineers still provide protocols and training on the measurement and verification of EE retrofits, but have not reached a consensus on how to measure simultaneous impacts of EE and DERs. Critically, Public Utilities Commissions have relatively siloed regulatory proceedings and associated funding portfolios that distinguish between EE, DR, and DERs.

The transition to full recognition of DERs across all programs and industry sectors needs to be formally championed and accelerated. In today's energy landscape, a continued focus on "efficiency first" impedes the deployment of full decarbonization in households. This is especially true in disadvantaged and low-income communities, where social subsidy programs have historically focused on energy efficiency investments to the exclusion of DERs.

A complementary approach that combines renewables with energy efficiency is necessary to curb climate change, but today's energy industry is its own worst enemy. Strictly advocating for efficiency first before considering renewables is misaligned with today's economics and customer preferences, as observed in the BAAEC Advanced Homes project. We have limited time to avoid irreversible climate change, so every interaction with a homeowner *must* include every opportunity to slash carbon emissions through holistic approaches.

Defining a New Term: Loading Lanes

This paper proposes a new paradigm of "loading lanes" which can be defined as the simultaneous pursuit of all cost-rational and efficient integrated decentralized energy resources required to achieve economy-wide decarbonization and optimize capital expenditures related to power systems infrastructure. Simultaneous is the operative word, which unlocks the ability to achieve a depth of retrofit required to surpass the limitations of energy efficiency. As the International Energy Agency notes, "As part of the energy transition, distributed generation has been increasing in many parts of the world. This is most notably reflected in rising rooftop solar PV installations and growing amounts of self-consumption from behind-the-meter solar PV"

[5] This information was obtained from the ACEEE EE as a resource database.

(IEA 2024). The IEA Technology Collaboration Programmes (TCP) expects a fourfold increase in rooftop residential solar PV deployment, primarily driven by the need for local embedded electricity production (IEA 2022). However, the local context of heat pump deployments in California is described as "nascent and growing" for space heating, "small" for water heating, and a "niche market" for clothes dryers (Opinion Dynamics 2022). With heat pump deployment and electrification currently requiring acceleration, and with solar PV deployments rapidly rising, policymakers must seize the opportunity to combine both efforts in a structured policy by taking a "loading lanes" approach. This concept reflects the evolution of monikers in the energy community. First, the megawatt scale systems were displaced by 'negawatts.' In this new era, the concept of 'make-a-watt' reflects the trend towards customer self-sufficiency and the grid service potential needed to manage the future of our power system.

In practice, a loading lanes approach requires the simultaneous installation of EE and DERs in ratepayer and publicly funded programs. PUC rulemakings would first require an analysis of balancing a continued level of EE investment with a complementary braiding of DER funding. PUCs and state energy offices (SEOs) would need to collaborate in identifying what existing statute governs limitations on funding applicability or climate goal attainment. These agencies need to inventory existing programs and future program investment plans and systematically ensure that both EE and DERs are simultaneously prescribed as a directive. For existing programs, state agencies would issue guidance to program administrators to file IDSM plans, starting with DAC and income-qualified customers, with a goal of converting 100% of customer-oriented funds into prosumer system planning programs.[6] Any unspent previously authorized funds would augment the DER capital required to support DACs. All EE, DR, DER, and even transportation electrification program administrators would benefit from building staff capacity to recognize IDSM opportunities and find pathways to deliver comprehensive decarbonization services to program participants. All new implementation activities would include activities such as energy assessments that perform both EE and DER analysis, incentives support, and calculations that would accommodate the interactive effects of EE and DERs. Installed equipment would contain grid-interoperable hardware, software, and networking capabilities. This overall approach would position EE to save the grid billions of dollars of costly upgrades (Specian and Bell-Pasht 2023), but it must be paired with inverter-based DERs to fully leverage the power of customer action and grid services.[7]

It is important to acknowledge a customer-centric approach to this transition. Rapid residential building decarbonization requires making the case to residents. Otherwise, advocacy efforts must only rely upon codes and standards or appliance regulations to affect naturally occurring turnover of equipment and buildings. That pace is too slow to meet the world's needs and fails to acknowledge the cumulative year-over-year effects of carbon emissions. Rapid decarbonization also requires upstream planning coordination to integrate a "high IDSM" future into an affordable energy system, as discussed in the following section.

Changing Thinking About DERs

[6] These programs decarbonize homes while accommodating electric load and generation in the electrical system planning process .

[7] Distribution grid services require local resources to provide a range of services from bi-directional power flows including voltage optimization, which EE alone cannot deliver.

DERs are becoming a large part of the 'supply' of energy but are not being treated as such. This manifests itself in demand forecasting and the state's energy planning process, neither of which is reflective of the grid architecture of the future. This leads to the undervaluing of local assets that would diminish the need for utility-scale assets, resulting in continued over-investment in grid upgrades that may or may not accommodate these DERs, and therefore to higher energy bills.

In 2023, the CPUC authorized[8] $8 billion in ratepayer funding for energy efficiency and notably included the recommendation to create integrated demand side management (IDSM) pilots for ongoing load shifting that reduces peak consumption. Although IDSM activities were not generally prohibited previously, this regulatory decision points to the need for more holistic interventions that address 'grid' issues.

Even with the promise of IDSM programs in California, an equally important challenge faces the energy efficiency community: affordability and power system costs. Not all energy efficiency practitioners understand the complexity of electrical power systems. Not all power systems practitioners understand the complexity of energy efficiency. In other words, "plausible decarbonization pathways that consider both buildings and their interactions with the power grid remain poorly understood" (Langevin et al. 2023). The policy exercise of integrated resource planning exposes this disconnect. Energy efficiency and local distributed energy resources require a bottom-up analysis that is often inconsistent with the system-wide planning of utility-scale generation assets.

Given the above policy background, this paper questions (1) how a massive scaling of household-level decarbonization fits within our system planning process and (2) how the process and policy affect the ability to massively scale such retrofits.

Background on State Energy Planning Processes

A brief understanding of the Integrated Resource Plan (IRP) process is critical to understanding the need to rethink the role of DERs in supply-side planning. This process combines the efforts of multiple state agencies and market actors to define the electric procurement needs for the state over a multi-year planning horizon. This occurs in three overlapping steps: (1) a GHG intensity target is set for the electrical grid (California Air Resources Board (CARB)); (2) an electricity demand forecast is created for grid needs (California Energy Commission (CEC) and Load Serving Entities (LSEs)); (3) an IRP is created to specify what power sources meet the grid needs while meeting the GHG targets (CPUC).

In California, CARB conducts a scoping plan[9] for achieving carbon neutrality, which includes a GHG target for the state's economic sectors, one being the electricity sector. The metric for this sector is a CO2e (carbon dioxide equivalent) intensity per megawatt of power for the electrical grid. At the same time, the CEC collects energy demand forecasts[10] from LSEs as

[8] CPUC. D.23-06-055

[9] The 2022 Scoping Plan for Achieving Carbon Neutrality (2022 Scoping Plan) lays out a path to achieve targets for carbon neutrality and reduce anthropogenic greenhouse gas emissions by 85 percent below 1990 levels no later than 2045, as directed by Assembly Bill 1279.

[10] The California Energy Commission assesses and forecasts the state's energy systems and trends. Decision-makers and the public use the information to develop policies that balance the need for adequate resources with economic, public health, safety, and environmental goals.

part of the Integrated Energy Policy Report (IEPR).[11] The demand forecast contains LSE estimates of energy efficiency, behind-the-meter solar photovoltaics, and battery electric storage systems. The CPUC then performs a series of optimization analyses to adopt a plan for all LSEs to procure enough clean energy to meet the grid GHG intensity target. This is the IRP, which also includes estimates for energy efficiency, demand response, and customer battery systems as a resource, but behind-the-meter customer solar PV is not considered a candidate resource.[12] Figure 1 illustrates the IRP process which starts with a load forecast and ends with action plans to procure electrical generation meeting defined climate, reliability, economic, and affordability goals.

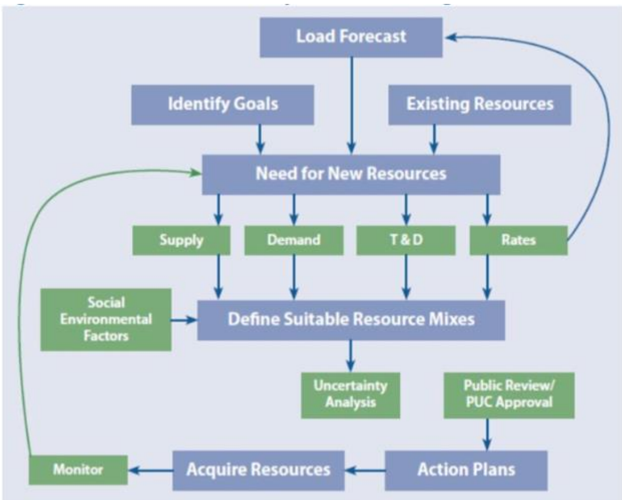

Figure 1: Process flow for electricity resource planning.
Source: Synapse and RAP 2013.

The loading lanes approach requires a structured integration of residential PV into this process. With the lines blurred between customer resources as a generation asset, and also as a factor in the demand forecast, state agencies will need to take a more granular approach to this process. The results of IRP optimization are currently at odds with energy efficiency goal-setting processes. Regulatory bodies must determine if legislative goals take primacy over the IRP process, or if regulatory cost-effectiveness rules constrain the role of EE. Instead, a minimum goal for facilitating the decarbonization of DACs should guide the process to systematically ensure the most vulnerable to climate change are safeguarded.

Demand Forecasting and the IEPR

To improve the IRP process, the first step of load forecasting must become more granular. It must reflect the localized distribution system capacity impacts that a high DER future enabled by loading lanes will create.

[11] The IEPR provides a cohesive approach to identifying and solving the state's pressing energy needs and issues. The report, which is crafted in collaboration with a range of stakeholders, develops and implements energy plans and policies.
[12] This is per the CPUC IRP Inputs & Assumptions as of October 2023

Figure 2 shows the percent of unadjusted baseline consumption load forecast coming from behind-the-meter solar PV, additional achievable energy efficiency (AAEE), and additional achievable fuel substitution (AAFS) (i.e. electrification), along with the combined impact of the latter two on the baseline load. The values in the table represent the highest and lowest percentage impacts on the baseline for each of the three selected planning years (2024, 2030, and 2040) in Southern California Edison (SCE) territory.

Baseline Consumption Planning Year	BTM Solar PV min and max impact (BTM PV as a % of baseline consumption)	AAEE min and max impact (%) aka savings	AAFS min and max impact (%) aka increase load	Combined AAEE + AAFS min and max impact (%) net effect
2024	0.00 44.06	-0.54 -1.45	0.02 0.24	-0.49 -1.30
2030	0.00 77.09	-2.37 -5.75	0.81 12.30	-3.60 8.64
2040	0.00 100.38	-2.87 -7.55	2.97 52.11	-2.55 47.68

50X growth

Figure 2: CEC IEPR demand forecast: greatest impacts on baseline consumption by BTM PV, AAEE, and AAFS for any hour of the planning year, SCE territory. *Source:* CEC Docket 22-IEPR-03.

Figure 2 shows that in 2024 the pace of energy efficiency outweighs the incremental load of electrification. However, by 2040, the maximum impact of AAEE and AAFS reach upwards of 47.68% of the planning year's total load in SCE territory. The baseline consumption appropriately captures behind-the-meter solar PV and battery storage. While arguments could be made about the needed penetration of AAEE and AAFS, the level of granularity in the method requires attention. With a growing concern about the need to upgrade the transmission and distribution system, a more precise geographic estimate is needed to understand where customer resources can avoid costly grid upgrades. The demand forecast and IRP process would benefit from being performed simultaneously with an analysis reflective of the grid topology. Additionally, behind-the-meter (BTM) solar PV will satisfy 44% (at its peak production hour) of the baseline consumption in 2024, increasing to 100% in 2040. It cannot be assumed that all BTM solar PV will be self-consumed. Load-serving entities and distribution system operators both need regulatory avenues in the IRP process to account for and plan for this resource. As virtual power plants and demand flexibility gain traction, the excess power from buildings may only grow and require discussion as a candidate resource in the IRP process.

Figure 3 below shows a level of geographic granularity that does not reflect the grid topology ultimately affected by the upstream decisions on transmission and distribution grid investments, and at the same time ignores the value of EE and local DERs to avoid those grid upgrade costs. If we see 50% of the baseline load increasing because of electrification, maximum grid investments would inevitably occur on circuits and substations. Instead, investments in community solar and customer load reductions would be the alternative approach. This should be the new loading lane: procure all local IDSM solutions as a first option in resource planning. Alignment of the demand forecast inputs with capital-intense decisions resulting from the IRP must occur to create a more accurate forecast of total system impacts. It should be acknowledged that other downstream activities exist that simulate power systems. The CPUC High DER proceeding[13] is currently performing that analysis and those methods would benefit from further stakeholder input on how to harmonize load forecasting and resource planning.

Figure 3: The 28 CEC IEPR demand forecast zones.

Unlocking the Power of Decentralized Energy

The BAAEC project represents a unique scenario where income-qualified customers receive free installation of energy efficiency, electrification, solar PV, and battery storage. The project highlights a scenario where the loading lane concept successfully achieves household-level decarbonization at a rapid pace and scale. Once the loading lane concept scales, the next threshold decision focuses on how to integrate newly created prosumers into energy markets. The market structures, or at least an accounting reflective of the true potential of decentralized energy must seamlessly integrate into the integrated resource planning (IRP) process. Our recommended changes include: setting minimum thresholds for relying upon behind-the-meter assets as critical inputs to the CEC demand forecast, inputs and as candidate resources to the IRP process, as well as performing demand forecasting and IRP analyses at a finer level of granularity that reflects the grid topology and future grid architecture. Such a grid architecture must acknowledge that in a network of structures,[14] physical, digital, controls, regulatory, and other elements must all coordinate in order to be effective.

The disconnect between a high-IDSM future and system planning widens when the IRP process uses these inputs but then ignores behind-the-meter resources, specifically rooftop solar. Although behind-the-meter rooftop solar decreases the magnitude of the demand forecast model, it is not reflected as a candidate resource in the IRP model. As the BAAEC project clearly demonstrates, electrified homes equipped with demand flexibility, solar PV, and storage will

[13] This information was presented by the CPUC Energy Division's Data Portals Workshop in the High DER Proceeding on July 26, 2022.
[14] This concept was created by the Pacific Northwest National Laboratory (PNNL) and promoted through the Gridwise Architecture Council (GWAC).

become both consumers and producers of local energy needs, capable of either energy self-sufficiency or supplying power to the community. In a high DER future, ideally with a high saturation in income-qualified homes, this power cannot be ignored in the IRP or power flow models. Furthermore, if additional demand flexibility results from the highly anticipated dynamic tariffs, granular locational marginal pricing, and the emergence of virtual power plant 3.0 (VPP3.0) (Guerrero et al. 2020), or as the loading lane concept proliferates, these valuable electrons require a localized market (vs. the larger Independent System Operator) and capable power systems to accommodate an affordable energy transition. We recommend setting a minimum procurement goal for virtual power plant resources, just as state statutes have set for energy efficiency, battery electric storage, and demand flexibility. These targets unlock the market—both through incentives and through voluntary adoption—to rapidly decarbonize.

Smart Local Energy Markets (SLEMs)

In a future where a high penetration of behind-the-meter and community-based generation exports serves a majority of local energy demand, there must be a framework to manage and facilitate such power flows. As this paper identifies, a gap exists in the forecasting and planning for these existing resources. At the same time, an unprecedented growth of electrification and decentralized energy resources are anticipated, but do not have a line item in the system planning process. Unlocking this potential depends on the simultaneous pursuit of energy efficiency, electrification, and DERs at a rapid pace. The concept of smart local energy markets provides a solution to this disconnect.

The challenge is to democratize and decentralize energy markets by allowing new market participants to contribute, while at the same time ensuring system stability and reliability. Transactive energy in the US is thought of as a top-down central command and control signal sent to households or devices, designed through utility-controlled mechanisms and implemented via dynamic tariff solutions. The international community uses the term smart local energy markets (SLEMs)[15], which have three distinct variations: peer-to-peer energy, transactive energy, and community self-consumption. SLEMs reflect the bi-directional nature of multiple homes and devices cooperating to satisfy economic, carbon, and reliability needs. They are submarkets that operate within or alongside traditional energy markets. They share common features in that they involve a form of energy trading or sharing, rely on some form of automation of transactions, are characterized by their promotion and support of the local generation and consumption of energy, encompass both geographically-bounded trading and non-geographically bounded trading, and involve trading with or without intermediaries, with price negotiation mechanisms that reflect the aims of the market (Watson et al. 2022).[16] SLEMs can be designed to benefit local distribution systems in situations where a physical microgrid may be technically or regulatorily infeasible. The nature of local markets is that the bulk power transmission grid need is diminished, and local load and generation are first satisfied within the community, and the transmission network serves as a secondary source of electricity. In this configuration, the community also benefits from avoiding bulk power transaction fees when community self-consumption occurs.

[15] This concept has been championed by the Global Observatory on Peer-to-Peer, Community Self-Consumption and Transactive Energy Models (GO-P2P), a Task of the User-Centered Energy Systems Technology Collaboration Programme (Users TCP), which runs under the auspices of the IEA (International Energy Agency).

[16] The discussion of SLEMs in this paragraph is attributed to Watson et al. 2022.

In the context of a community such as BAAEC, a smart local energy market manifests itself in an orchestrated set of policy recommendations. First, ratepayer funds and program administrators deliver comprehensive IDSM programs at the direction of the CPUC. Each customer engaged in a 'loading lane' program receives solar PV, battery electric storage, weatherization, energy efficiency, electrification, and a home energy management system. The excess energy from any home at any given point would travel along the distribution system[17] and proximate customers will consume local electricity. The fact that the IRP neither accounts for, nor plans on the community self-consumption exposes a growing disconnect in our energy planning activities. The absence of smart local energy markets results in the undercounting of local power flow transactions and overestimates the need for resource adequacy[18] procurement by load-serving entities. That in turn inflates the cost of procurement, and results in missing distribution grid investment deferral framework (DIDF[19]) opportunities. Furthermore, a joint DOE National Lab effort has found solutions to effective management and forecasting of DERs. The FAST-DERMS project proposes a network-level stochastic optimization that can manage the uncertainty in the flexibility offered by DERs within the distribution network and thus can provide a firm aggregate service to the transmission system.[20] Finally, Langevin et al. conclude that, if scaled rapidly, demand-side solutions in the US building sector could achieve deep emissions reductions and avoid over $100 billion in power sector costs (Langevin et al. 2023).

Policy Discussion and Recommendations

As Rita Mae Brown once stated, "Insanity is doing the same thing over and over and expecting different results."[21] Despite our industry's best efforts, a new approach is needed.

Over the last decade, California electricity prices have risen cumulatively between 46.7%–83.5% and 47.8%–104% for the residential and commercial sectors respectively. A recent report from Stanford University indicated similar increases in fossil gas prices rising 154% (to nearly $3.50/therm) in 2035 compared to 2020 rates in a scenario with CARB appliance bans (Ong, Mastrandrea, and Wara 2021). The CPUC, in its latest Annual Affordability Report, found that "essential electricity service is projected to grow less affordable for vulnerable Californians, particularly in hotter regions."[22] Only 30% of Americans feel confident their energy will remain affordable, and most (68%) feel they are doing everything they can to be sustainable. The Ernst & Young Consumer Confidence Index (EECI) reveals an 8-

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[17] In the laws of physics Kirchoff's rule states that current always flows from higher to lower potential making it logical that customer power will remain on the distribution system and not travel upon or utilize the high voltage transmission network.

[18] The CPUC adopted a Resource Adequacy (RA) policy framework (Public Utilities Code section 380) in 2004 to in order to ensure the reliability of electric service in California.

[19] The DIDF is an ongoing annual process to identify, review, and select opportunities for competitively sourced distributed energy resources to defer or avoid utility traditional distribution capital investments.

[20] Federated Architecture for Secure and Transactive Distributed Energy Resource Management Solutions (FAST-DERMS). The project aims to aggregate and coordinate the operations of DERs to support T&D grid operations.

[21] Brown, Rita Mae. Sudden Death. 1983

[22] The CPUC Senate Bill (SB) 695 Report pursuant to Public Utilities Code Section 913.1, requires the CPUC to publish recommendations that can be undertaken over the succeeding 12 months to limit California's Investor-Owned Utilities (IOU)1 cost and rate increases consistent with the state's energy and environmental goals.

point plunge in consumer confidence towards the US energy system, from 64.8 to 56.9 between 2023 and 2024.[23]

In the face of these customer-centric revelations, this paper has discussed the financial and logistical pathways for decarbonizing income-qualified households in the context of a CEC grant which stacked multiple programs, ensuring no debt service accrued to the customer. The paper has also explored the policy background and current market adoption trends of decarbonization technologies. The transition to wide-scale, voluntary adoption of decarbonization retrofits is needed to meet the pace of the very aggressive climate goals across various geographic scales. But naturally occurring retrofits for full decarbonization following an efficiency-first logic may never materialize. Furthermore, low-income households at or near energy burden thresholds require comprehensive resources to participate in the energy transition. However, there are currently not enough public dollars to subsidize every income-qualified household that requires assistance. In the California context, multiple strategies can contribute to catalyzing such market conditions. This paper has identified three categories of urgent reforms in policy and program implementation: (1) the evolution of the loading order approach to one of loading lanes; (2) multiple changes to IPR processes including a more geographically granular approach to load forecasting, the integration of DERs into resource planning, and the establishment of minimum procurement goals for VPP resources; and (3) the establishment of smart, local energy markets.

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