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Residential Decarbonization Energy Bill Impact Analysis Public Workshop
Zoom Transcript
June 16, 2026

0:04
Tiffany Mateo: All right, good morning. My name is Tiffany Mateo. I'm a Senior Mechanical Engineer in the Equitable Building Decarbonization in the RREDI Division, Reliability, Renewable Energy, and Decarbonization Incentives Division at the California Energy Commission. Welcome to our technical workshop on residential decarbonization energy bill impact analysis. This is a technical workshop focused on energy data and modeling analysis.

Next slide, please.

So here's today's schedule. In Pacific Time, we have 4 main topics. We will have time for Q&A at the end of each panel. Please use the Q&A function to type a question, or you can wait until a designated Q&A period to ask a question. And please also put the presenter's name or the presentation title in your question so they know who the question is for.

OK. And I'll just briefly go over the flow of today's schedule. After opening remarks from Commissioner McAllister, we'll get a background on the equitable building decarbonization program and an overview of building decarb analysis types and uses. Then over the next three panels, we'll hear about model-based energy bill impact analysis, meter-based analysis, and then a validation analysis and beyond heat pumps. We'll close it out with the final Q&A comments. We're aiming to end at 1:00 PM. Might go a little longer if there are a lot of questions or shorter if there's less questions. So with that, I'll welcome Commissioner McAllister to provide some opening remarks.

2:05
Commissioner McAllister: Well, thank you, Tiffany. And really just want to say thanks to you and to Larry and just the whole team that have been doing a lot of this work and in the RREDI division and really drawing across the much of the Commission. And we'll hear from Jason Harville and his team and Rahm and from the Efficiency Division. And, and then a bunch of, you know, a number of contractors that have that the Energy Commission has engaged and, and they're doing really pioneering work and how to leverage AMI and other data for, to inform policy, to evaluate programs, to do predictive analysis, a whole bunch of other really powerful tools that I think the Energy Commission really is, you know, leading the globe on.

2:56
I would say, you know, I don't think that's too. It's not hubris to say that. I think we're really pushing forward and bringing the policy environment, the policy work that we do into the 21st century and really leveraging modern tools to, you know, fundamentally gain intelligence, gain knowledge, and also take care of ratepayer and public money, right? Which is incredibly important. And it's really core with what we do with the Energy Commission.

And so over time, over the last 10 years or so, well, we're really closer to 15 years actually, you know, we've been developing the informational analytical, you know, data infrastructure and the tools to be able to get where we are today. So I just want to reflect a little bit on that, on that trajectory, very intentional over the last, you know, 12 to 14 years to create the systems that can adjust large quantities of data and really use it to understand patterns of energy consumption, buildings, forecasting, electrification, and really be intentional about our policies. And, and, and one important aspect of that is to understand the impacts of electrification and the clean energy transition on consumer bills. And so I want to, this is really a staff workshop. It, it doesn't yet, you know, focus on sort of policy implications. It's really sort of doing the blocking and tackling to make sure that as we manage programs, we understand the potential impacts on bills and manage those right.

So the Equitable Building Decarbonization program is the flagship initiative that's kicking off now. You'll hear from Diana Maneta about that. The team and RREDI and, and with assistance from other divisions are doing a great job implementing that program. It's really just early days, but it's a huge opportunity to refine and develop, develop and refine the kinds of tools that you'll hear about in in the workshop today. To be intentional about how we implement those programs so that they do the most good that they can really help under resourced communities, California residents to benefit from the electrification trends and energy efficiency and really inform all these efforts that we're doing to the Commission and other agencies such as the PUC and the Air Resources Board and others. So I think this is really foundational, this work.

And I just want to commend again, Tiffany, you and the and the whole team, Larry frozen and the analytical work ready. I think we don't talk about it probably enough, but the, the analytical chops that we have at the Energy Commission and you know, much of that is enabled by the work that Jason Harville and his team are doing in the executive office, really managing the data enterprise across the Commission and all the divisions are benefiting from that work. But I'd say none more so really then then our programs, let's say BAD the assessments division and the and ready are the two divisions that I think really can utilize or in a position to utilize the develop and utilize these tools that that leverage, you know, highly granular data that we have with the Commission now.

So we take this responsible this this, we take this work incredibly seriously. And, and you know, we're committed to very responsible curation. We have all the, you know, all the tools in place. And Jason, I'm sure we'll talk about that to, to protect the data and, you know, privacy and really, you know, incorporate those protections into everything we do. And, and so I think we're really setting ourselves up for success.

And last thing I'll say just to this is a staff workshop. So when I kind of get out of the way here, but the access to this data, you'll hear from some of our sort of the growing, let's say, group of analytical firms who are working with this data. We developed a, a legal structure that provides access to, you know, interval meter data under strict conditions of protection. And so these are vetted firms, you know, that, that utilize the data with, you know, a lot with a number of conditions and as sort of agents of the of the Commission. And so they come over to our side of the firewall, access the data and, and you know it, it does not leave. So I think I wanted to be very clear about that, that, you know, the access to data is fundamentally important for a modern set of tools and programs at the grid edge. You know, we would need to be utilizing, I need to be understanding DE Rs and energy efficiency and building electrification at the, you know, the meter level and behind the meter level. But we also have to make sure that that does not compromise the privacy and the and just the seriousness of the curation of the data.

So, so we've put together a system that does that and I think, you know, want it, want just everybody to know how seriously we take that. So really pass the, I'll pass the baton back to you, Tiffany and to get going on the on the agenda. But some really exciting developments that you'll hear about, you know, the energy bill impact Tiffany and team have been working on. It's great that we have the PUC and Guidehouse in the mix as well here. And then in the 10:30 and 11:55 sessions, some of the extended work that we're doing that's super exciting, the predictive analysis and impact assessment and really looking at the taking a more integrated view that even includes transportation, electrification and the like to understand sort of the long term trajectory of our decarbonization transition. So just super excited about this and really kudos to everyone who's presenting and all the great work that's behind these presentations. And thanks.

Thanks, Tiffany, and back to you.

9:33
Tiffany Mateo: Thank you, Commissioner McAllister. OK, I will pass it on to Diana Maneta from the Energy Commission.

9:47
Diana Maneta: Great. Thank you, Tiffany. Thanks so much, Commissioner. Hi, everybody, my name is Diana Maneta. I'm the policy and technical Lead for the Equitable Building Decarbonization Program here at the CEC. And in this presentation, I'll use the Equitable Building Decarbonization Direct Install Program as an example to illustrate the different ways that bill impact analysis can inform the design and the implementation of decarbonization programs. We're very lucky to have access to a wealth of data and sophisticated analysis to make the EBD program as effective as possible. And several of the presentations we'll be hearing later this morning will describe analysis that are supporting the EBD direct install program in various ways.

So in this presentation, I'll just provide a little bit of background on the EBD program itself and then situate how these some of these various types of analysis are supporting the program and how they're being used to inform the program. Next slide please. So first, just a little bit of background on EBD. The EBD statewide direct install program serves low-income households located in under resourced communities. We can serve single family, multifamily and manufactured and mobile homes. They can be owner occupied or rented and the program does include renter protections. Under resourced communities include both disadvantaged communities and low income census tracts. The first phase of the program that's under way now is serving specific under resourced communities called Initial Community Focus Areas. Next slide, please.

11:30
So participating households receive decarbonization upgrades at no cost. We can fund measures listed on this slide. They include heat pumps, heat pump water heaters, other efficient electric appliances, weatherization upgrades, electrical wiring and panel upgrades, and remediation and safety improvements. At a minimum, each household served receives a heat pump for heating and cooling or a heat pump water heater, or both. And at the conclusion of the retrofit, at least two of these foreign uses in the home must be electric, these four being heating, water heating, cooking, and clothes drying. Next slide, please.

12:11
So the EBD statewide direct install program is being implemented in three regions by three regional administrators. They are the Association for Energy Affordability in the Northern Region, the Center for Sustainable Energy in the Central Region, and Los Angeles County in the Southern Region. All three regional administrators are partnering with many other organizations including dozens of community based organizations across the state to provide culturally appropriate outreach and support for participating households and communities. The budget for the statewide direct install program is just under $500 million. It's funded through a combination of the state Greenhouse Gas Reduction Fund and the Federal Home Energy Rebates program and the funds are allocated among the three regions in proportion to the population of under resourced communities in each region, as you can see here in the table next slide.

13:06
So this slide shows at a high level the stages of the program. First, there's the program design and the selection of the initial community focus areas. Second is outreach and enrollment conducted by community based organizations in each community. Third, once households enroll in their eligibility is verified. The regional administrators conduct a home assessment and identify the specific measures that are recommended for that home. Then qualified contractors are brought in to conduct the retrofit itself. And then finally, throughout the program, we'll be closely tracking outcomes and using that information to inform improvements to the program design and the program implementation. Next slide.

13:51
So this slide illustrates here in the green boxes the ways that we're using data and analysis to inform nearly every stage of the program. So first, at the program design stage, the CEC staff conducted a bill impact analysis using the California Building Energy Code compliance software to estimate the impact of decarbonization on households utility bills with different scenarios based on measures installed, building type, climate zone and utility rate. And Tiffany Mateo will talk about that analysis in detail and in just a few minutes in the context of the EBD program. That analysis was so useful to help inform the design of the program, the eligible equipment, and the selection of the initial community focus areas.

Second, to inform outreach, we're able to use household level meter data to identify the specific homes within each initial community focus area that are likely to be the best candidates for EBD based on their likely bill impacts and greenhouse gas reductions. This analysis informs the outreach to specific homes that's conducted by the CBOs, the community based organizations in each community. This analysis was conducted by Recurve Analytics and Adam Shear from Recurve will discuss it in detail later in the workshop today.

Third, at the home assessment stage, the regional administrators conduct energy modeling based on the outcome of the home assessment and the households meter data to estimate the impact of the recommended measures on the households energy use and utility bills. This is important to help ensure that households are fully informed of likely impacts before committing to move ahead with the retrofit.

Snugg Pro is one of the tools used in all three regions to conduct this energy modeling and we'll hear a presentation about Snugg Pro later today from Robert Buchanan. And then 4th at the stage of tracking outcomes, we'll use interval meter data to measure energy savings and bill impacts for each retrofit project. These results will be considered alongside other program data including measures installed costs and participants survey results to inform program improvements. We'll also share data publicly while protecting participants personal information to help inform other programs and to advance the field more broadly. Next slide.

16:18
So before I close, I want to share a few photos here to celebrate some of our recent progress in the statewide direct install program. The first EBD funded multifamily retrofit project was just completed a couple of weeks ago. It's a senior affordable housing complex in San Diego in which residents received induction stoves and heat pump water heaters through EBD. And several of these photos are from a ribbon cutting held for that project a few weeks ago.

The second multifamily retrofit is under construction. It's also a senior affordable housing complex. It's located in the Northern Region in Gilroy. And then beyond these first two projects, outreach and enrollment of households is underway in all three regions. And we'll be seeing the pace of retrofits accelerate over the next couple of months. Next slide.

Thanks so much. Here's my contact information and I would be happy to take any questions when we get to that point.

17:20
Tiffany Mateo: OK, thank you, Diana. All right, so hi, I'm Tiffany Mateo, Senior Engineer at the Energy Commission. I will kick off the model based analysis panel and I will present on a model based energy bill impacts technical analysis performed by CEC. Next slide please.

17:51
The report titled Low-income Residential Energy Bill and Tax Analysis is now available online and I

believe I will be sending a link in the chat. Hopefully in this presentation, I'll explain the statewide modeling analysis that was performed by myself and my CEC colleagues, Erica, Chuck and Larry Phrase. And we did this to understand the potential impacts from new decarbonization measures on home energy usage and cost for low-income customers. I'll give an overview of our modeling analysis methodology, share some charts, summaries and going to our high level takeaways and then finish with next steps. Next slide please.

18:48
So this is a graphic of the analysis methodology we used CBECC, the California building energy code compliance software to model existing residential buildings. CBECC creates hourly energy use for each of the 8760 hours of the year. We call it the 8760 profile. The baseline prototype is modelled as a home with gas appliances and that's compared to the retrofit the home models with a heat pump and various combinations of energy efficiency and weatherization measures. We used utility rates from the calendar year 2024 to calculate the utility bill to the residential customer.

In this analysis, we included PG&E, Southern California Edison, SoCalGas, SDG&E, SMUD and LADWP rates, specifically low income qualifying rates in the IOU. This is called care rates. With the CBECC outputs of annual energy use, we were able to calculate energy efficiency and by applying. Greenhouse gas emission factors we were able to calculate avoided GHG emissions for the heat pump retrofits. Next slide please.

20:20
This shows the CBECC modeling scope for our analysis. Listed on the left are the residential building types we modelled, which includes single family, multi family and manufactured homes. In the next slide, I'll show details of these prototypes. The middle box lists the electrification measures we modeled as this analysis supported the EBD direct installed program. These are eligible measures in the EBD program in each of the heat pump HVAC retrofits. We also included duct sealing as that is required by code for HVAC upgrades. On the right is a list of envelope measures we've modeled, which includes attic insulation and air sealing. In this analysis we did.

We did not model solar PV or electric vehicle charging and we modeled each building type with all combination of retrofit measures that included at least one heat pump, either heat pump, water heater for heat pump, each vac. And we modeled each one of these scenarios in all 16 of California's Title 24 climate cells. So this resulted in hundreds of thousands of model files and results. Next slide please.

21:51
OK. This table shows more detail of the residential building types we modeled. So for each prototype it shows the condition, floor area, number of floors or stories and then number of bedrooms. Next slide please.

22:17
OK. This table shows the bottling assumptions used for the single family and multi family prototypes. The baseline prototype assumptions were developed by NORESCO under contract with some California Edison and overseen by a technical advisory group which included CEC and CPUC. NORESCO used data from the Residential Appliance Saturation Study or RASS and the US Census Bureau. These prototypes are meant to represent the typical home for each building type and vintage in California. In our analysis, we included three vintage categories, Pre-1975, 1975 to 1983 and 1984 to 2005. The smaller, lighter text above in each cell are the assumptions used in the baseline and then the larger, older, darker text below are the assumptions used in the retrofit.

In the retrofit model, we changed ceiling or attic insulation envelope seal HVAC system and water heating system for searing heating seasonal performance factor 2 number. Because we modeled standard heat pump HVAC equipment as well as higher efficiency heat pump and consistent with

RAZ, we assumed existing air conditioning in all climate zones except in climate zones one which is the northern coast and five Santa Maria area and then in climate zone 3 the Bay Area just for pre 1975 baseline. So no existing air conditioning. Next slide please.

24:24
Those the modelling assumptions we use for the manufactured home prototypes. These vintage categories are different from the ones used for single family and multi family. The baseline assumptions for manufactured homes are based on the Federal Housing and Urban Development HUD standards. Since manufactured homes are not subject to Title 24 Part 6, the assumptions for HVAC and water heating are similar to those that we use for single family. Next slide, please.

25:04
So this table shows the utility rates we included in this analysis, which are the low income qualifying rates. We included rates from the state's five largest utilities and looked at tiered rates, time of use for TOU rates, and electrification friendly rates. Electrification friendly rates have higher fixed charges and lower cost per kWh, which tends to benefit residents that electrify their homes or use more electricity. The electrification rates were applied only to the retrofit models as customers qualifying for these rates and qualify for these rates after they have a heat pump and for the equitability decarbonization program. The assumption is homes are starting with a space for water heating appliance that uses gas or propane. In applying rates to the 8760 energy outputs, we accounted for baseline usage allowances both for gas and electricity and tried to match utility climate zones to the corresponding Title 24 climate zone. In calculating the customer bill, we also included the fixed charges.

As touched on earlier, we assumed for this analysis that the customer qualifies for low income rate, which for IOU customers is a 20% discount on the gas bill and a 30 to 35% discount on the electricity bill. This is because EBD direct installed program serves low income qualifying customers. Next slide please.

26:57
This chart shows the annual, excuse me, the annual bill savings of the heat pump retrofits by climate zone. Annual bill savings is on the Y axis and the climate zones are on the X axis. The vertical blue line. It looks solid but it's actually made-up of dots. Each dot represents a retrofit scenario. For example, AA1250 square foot pre 1975 single family home in climate zone 12 that got a heat pump, HVAC installed with duct, ceiling, air sealing and attic insulation. That would be 1 tiny dot on the 1212 line.

Each scenario has at least a heat pump, water heater, or heat pump each fact, but might also have any combination of the other measures I listed earlier. All residential building types listed earlier are represented in this chart. The dots above the blue dots above the 0% line represent bill savings meaning the modelled post retrofit bill is less than the baseline pre retrofit bill and the dots below the 0% line represent modelled bill increases meaning the retrofit bill is more than the baseline. Now I want to remind everyone this is not a probabilistic forecast to fill impacts, rather a scenario analysis based on modelling. Our model based analysis shows like the high bill savings in Central Valley which is climate zones 11/12 and 13. This is attributed to energy savings and cooling efficiency in the hotter climate of the Central Valley.

There are also bill savings gained by switching to electrification friendly rates with where all energy uses charged at a lower rate. The plots for climate Zone 5 is which is Santa Maria area and Climate zone 16. The Sierra Mountain areas show many scenarios with potential bill increases. This could be due to the cooler climates with a higher heating load and not much cooling load. These models retrofits are not gaining savings from cooling efficiencies and a relatively large amount of gas space heating is switched to electric heating. Next slide please.

29:46
This figure shows the range of percent annual bill savings by electricity rate. And to reiterate, the rates used in this analysis were from 2024 and the bills are calculated with low-income discounts applied in this chart. Values to the right of the 0% represent bill savings and values to the left represent bill increases. The bars at the top SMUD and SDG&E TOU elect rates show the highest annual percent bill savings with most modeled retrofit scenarios achieving bill savings and generally the electrification friendly rates show higher bill savings than their counterparts like SDG&E’s TOU elect rate and Edison's prime rate. Next slide please.

30:50
OK. So the previous charts were showing results of annual bill impact. So that's annually. This is a look at the bill impact by month. This particular scenario is for 1750 square foot 3 bedroom pre 1975 home in climate zone 6 which is in Southern California coastal area. The models retrofit is a replacement of the gas furnace with an electric key pump HVAC and the rates were SoCalGas and Edison's prime rates. So you can see in the chart there's bill savings in the summer months, June through October, but bill increases in winter and shoulder months. But overall, the annual bill savings for this model scenario is 5%. Utility bills are typically paid each month, and it's important to understand potential monthly bill impacts for customers installing heat pumps. In implementing building decarbonization programs, it'll be important to educate residents about potential seasonal impacts to their energy bill and utility programs that can help alleviate large fluctuations in bills each month. Next slide please.

32:17
So this chart shows the model annual energy efficiency of the electrification and envelope measures by climate zone. The prototype used for this example is a 1750 square foot 3 bedroom, single family, 1975 to 1983 vintage category. The modeled annual electricity and gas usage are both converted to M&V TUS and the retrofit prototype energy usage is compared to the baseline prototype energy usage.

In each scenario, there is positive energy efficiency, meaning the retrofit models use less total energy than the baseline, and high energy efficiency is shown with heat pump HVAC retrofits in the colder climates, mainly the North Coast and mountain areas as seen with the high bars for climate zones 1 and 16. Next slide please.

33:21
OK. Now similar to the previous chart, this chart shows the models avoided GHG emissions of the electrification and envelope measures by climate zone. And like the previous slide, this example is for 1750 square foot 3 bedroom single family home, 1975 to 83 vintage category. This shows the annual avoided GHG emissions in metric tons of CO2 equivalent, and it's not a percentage Avoided GHG emissions are achieved by replacing gas fired appliances with electric appliances. For electricity, we used the long run marginal emission factors developed for the 2022 Building Energy Efficiency Standards. The blue bars show that switching from the gas water heater to heat pump water heater avoids GHG emissions fairly consistently across all climate zones. A little less than one metric ton of CO2 equivalent per year. Replacing a gas furnace with heat pump HVAC shows more avoided GHG emissions in colder climates than milder climates, as seen by the high bars for climate zones 1 and 16, the North Coast and the mountain areas with more than four metric tons of CO2 equivalent per year of avoided GHG. Next slide please.

34:55
This chart shows the incremental bill savings achieved by measures added to a heat pump HVAC installation, again by Climate Zone. The results shown here are averages of the single family prototypes. Those 3 prototypes are a 1250 square foot two-bedroom, a 1750 square foot 3 bedroom, and a 2252 story 4 bedroom. If you can see the red part of the bars just at the bottom, this represents the model of annual bill savings achieved with just a heat pump, a track retrofit which does include duck sealing.

As expected, warmer climate zones with higher cooling load are showing bill savings. The warmer Central Valley and Desert areas climate zones 11/12/13 and 15 are showing bill savings over 10%. The green part of the bars are the additional bill savings that can be achieved with a high efficiency heat pump HVAC in the modeling going from a 15 to a 16 SEER and a 8.8 to 10 heating season performance factor. Adding air sealing and attic and or floor insulation to the heat pump HVAC incrementally increases bill savings as shown by the light blue and yellow parts of the bars. Next slide please.

36:25
OK, So what have we learned from this analysis? Based on the modeling results, we saw that climate and utility rate are two primary factors determining energy bill impact. Heat pump water heater retrofit prototype showed bill savings in most scenarios. Keep Up HVAC retrofit prototype showed bill savings in warm climates in Southern California, the Central Valley, and desert areas, but they showed bill increases in cooler climates in the Santa Maria area and mountain areas. We also saw that higher efficient equipment and envelope measures incrementally increase bill savings, energy efficiency, and avoided GHG emissions. The calculation showed that electrification friendly rates resulted in five to 10% higher bill savings than the default TOU rates, and we also saw that the bill impact varies by season, so this information is not surprising.

The statewide analysis confirmed hypothesis and anecdotal evidence about heat pump HVAC and similar analysis that looked at bill savings, impacts of electrification, and energy efficiency home retrofits. This information did inform implementation of EBD as Diana was talking about earlier. One example is the program requirement for regional administrators to assist participants in signing up for the most beneficial utility rate available after the retrofit. These results also informed the packages of measures developed by each regional administrator Please.

So what's next? There are a number of updates that can be included in this analysis such as adding solar PV and battery storage prototypes, updating utility rates which can include bill structure changes, and including non care rates which many utility customers are on. Another path for this analysis is to compare the CBEC modeling results to actual meter data for retrofitted homes that match each prototype. Comparing the models results to meter data will help us identify modelling gaps and improve the models. This can lead to adjusting modeling assumptions to improve the accuracy of CBEC, especially when it comes to modeling impacts from energy retrofits in existing homes. Next slide, please.

39:10
OK, this concludes my presentation. Here's some contact information and the link to the report. I'll pass it now to William Graswich from CPUC and Karen Maoz from Guidehouse for the next presentation.

39:34
Karen Maoz: Good morning and thank you for having me today. Will Grasswich is attending the workshop. Feel free to communicate with him via chat or you know, questions to either one of us. He is overseas. This work from the California Public Utilities Commission. I will be walking through the customer electrification estimator. It is a tool being developed to help California customers better understand how electrification decisions could impact the utility bills.

Before I begin, I do want to emphasize that this tool is still in draft form and not yet publicly available, So what I'm sharing today reflects the current development status. Please note the analysis methodology here results in estimates, not forecasts, and they're based on representative load profiles rather than actual customer usage. Next slide please.

40:28

Here's an overview what I'll cover today. I'll start with purpose and project overview, then walk through how the calculator is structured. From there I'll go step by step through the methodology and key inputs. Finally, I'll wrap up with how the calculator works in practice and what types of outputs it produces. Next slide, please.

40:51
At a high level, this tool is designed to help IOU residential customers estimate how electrification or fuel substitution may impact their utility bills. The core objective is to enable customers to view their specific options in the context of their home, existing appliances, bill rate and more. And more specifically, what happens if they're to their bills if they switch from gas to electric technologies. Another key goal is to develop ACPUC owned tool that can be regularly updated as rates evolve over time.
This work has been highly collaborative across CPUC teams, the building decarbonization team, the rates team and energy efficiency. And we've also coordinated closely with the CC, particularly around the data inputs and load profiles. And as Tiffany explained, very detailed around the Energy Commission's load profiles and how they were modelled. We leverage the same model outputs. Next slide please.

42:01
This tool is built around enabling the use of large scale calculations across multiple permutations to allow for flexibility in defining the existing conditions of specific home scenarios. We generated millions of bill estimates across combinations of home characteristics, things like location, EG climate, zone, utility, home size, appliances having solar and or storage and rate structures. The web tool itself is planned to function as a lookup engine. Users provide inputs about their home and planned upgrades and the tool would return estimated bill impacts before and after electrification. Again, I'll note that the web interface is not yet ready for public release and what we're focusing on today is the underlying analytical framework. Next slide please.

42:59
This tool is made-up of three main components. First, the rate engine which calculates monthly bills using hourly load data. The rate engine is designed to be flexible to accommodate most any rate structure for residential and non residential. Each billing component is entered to all for all, the granular differentiation of each rate and potential future analytics options for the CPUC. Second, the bill calculator, which applies these rates across many load profile permutations to estimate costs.

The Bill Calculator includes outputs for every unique load profile and every analyzed gas and electric rate. Additionally, the tool is designed that it could be configurable to any set of 8760 low profiles. And 3rd the web tool which will present results in a user friendly way, but its design is to be determined. A key feature of this framework is flexibility. It can accommodate different race structures, incorporate new and updated tariffs, and handle detailed billing components like demand charges and baseline tiers. This module set up also supports future updates as policies and rates evolve. Next slide please.

44:21
This slide shows how everything fits together in the workflow. We start with inputs. The grey boxes, the rate tear sheets are used to input into the rate setup workbook, the load shape libraries from the Energy Commission and supplemental data. These feed into the rate engine and are processed through an R based workflow. The bill calculator produces outputs a structured data set, data sets which are then used for two purposes, supporting policy analysis, empowering the massive look up table for the planned web tool. The system is designed to be low maintenance, such as the rates can be updated semi annually and the tool can ultimately be handed off to the CPUC for full ownership. Next slide, please.

45:16
The methodology follows 5 primary steps. First, we ingest rate data and build a comprehensive rate

library used for calculating bills at the different building components and at the hourly level. Second, we ingest low profiles and tag them with detailed characteristics such as climate zone, building type, technology type, etcetera. Third, we integrate additional data sets like ZIP codes from mapping to climate zones and building baseline tiers as appropriate and solar generation profiles. 4th, we calculate bill amounts by applying rates to hourly load data. And finally, we structure outputs for various use cases. This structured process ensures consistency and scalability across millions of scenarios. Next slide, please.

46:12
In the first step, we compiled rate data from the four major IOUs. The analysis includes all relevant billing components including basic service charge. So you can see some screenshots of the IOUPDS we take from each of the PDFs and pull out those components into the right setup workbook. However, we also apply a number of simplifying assumptions. For example, we focus only a monthly charges, not any annual charges and excluding items like California climate credit. We incorporate multiple NEM frameworks, NEM 1.0, 2.0, and 3.0 with treatment of imports and exports to be tied to the year of installation. Additional assumptions include standardized billing cycles, only use calendar months, application of care and fairer discounts and exclusion of certain cases like medical baseline customers. Next slide please.

47:14
So in Step 2, we rely on the CEC low profile library that Tiffany described in more detail and you can see we have the similar structure of the three categories we using. This library provides a wide-ranging representation of building types from single family to multi family and across different vintages. We also modeled 4 different electrification measure categories, heat pump, heat pump water heaters and induction cooking and clothes drying using the heat pump clothes dryer. In addition, envelope improvements like insulation and air sealing are captured are included to capture broader efficiency impacts. We did not include the full library. For example, window film, which is in the Energy Commission's low profile library, is not included in this analysis. Note that these standardized low profiles from the CEC represent typical behavior patterns for different building types and vintages. It does not capture individual household behavior variations such as thermostat preferences or occupancy patterns. This is a key limitation and sometimes something we clearly aim to communicate. The tool provides representative, not personalized behavior modelling. Next slide, please.

48:39
Step three, we ingest and we integrate additional data sets to ensure geographic and customer specificity. ZIP code mapping is used to assign climate zones, utility territories and apical tariff regions for the baseline tiers. We also incorporate climate zone specific solar and storage impacts by adjusting low profiles accordingly. This includes accounting for different NEM structures and applying export credits under the net billing tariff for NEM 3.0. Next slide please.

49:16
For step four, we perform the bill calculations using an R based workflow. This process combines rate data, low profiles and supplemental inputs. We clean and align all the data sets, then apply the rate structures to hourly consumption data. The output is a set of structured CSV files containing bill estimates across all models scenarios. These outputs form the backbone of both the policy analysis and the web interface. Next slide, please.

49:51
In the final step, we structure the outputs for use in the web tool. Each record includes key, customer, and building characteristics. This allows users to input their specific conditions and receive tailored estimates. The goal is to make the tool intuitive while still grounded in detailed high resolution analysis behind the scenes. Next slide, please.

50:20
So to close out, at its core, the tool is designed to balance three things, analytical rigor, scalability

across California, and usability for both policy makers and customers. So I want to thank you for your time and happy to take any questions or discuss how the tool could be applied in different ways and feels. Please feel free to reach out to me or will directly if you'd like to follow up afterwards.

50:45
Tiffany Mateo: Thank you, Karen. OK, so I can open it up to our first Q&A session. I invite Diana to get back on camera and OK, thank you to the first panelist, Erica or Larry, do we have any questions to be read and answered live?

Larry Froess: Yes, we have a couple. The first one from Pete is asking are we in California planning to implement a heat pump friendly rate? I know of several East Coast states that are doing that and looks like Erica is going to answer that online.

Another one from Anonymous is the slide showing annual bill savings of heat pump retrofit auto type scenarios. What is the reason behind negative bill savings? What specific scenarios are those?

51:48
Tiffany Mateo: OK, I think they were referring to Katie. Here we go to slide 19. I think that would be helpful to look at the chart.

So the in the negative for the scenarios that showed negative bill savings and most of that was in climate Zone 5, which is Santa Maria area and climate Zone 16 the mountains. So a lot of the gas heating was switched to electric space heating. So that was part of that. We also these scenarios also all include combinations that have electric clothes drying and electric cooking and which also when switching from gas to electricity in colder climates was leaning more towards fill increases. And we also this could include people who scenarios where the customer did not switch their rate and so they were still on tied rates and rates that were not necessarily electrification friendly.

53:17
Larry Froess: OK. And we have another one from Anonymous. If I understood correctly, the model assumed that homes in LA County have AC. However, the lack of AC in LA County is so widespread that the county has passed an ordinance to require landlords provide cooling. And the city of LA is also considering that. I think that's more of a statement than a question.

53:40
Another one from Anonymous. I'm sorry I might have missed it. How were gas cost estimated? Were they based on average, and did they include the impact of tiered rates? Lower rates for under, lower rates for usage under a certain quota and higher rates for excess usage.

Tiffany Mateo: To answer the second question, yes, we included the impact of tiered rates and gas costs were estimated similarly to electric bill, except there you know there's no time of use for gas. So we took the monthly gas usage and that the rate for that month and calculated the gas bill. It also included any fixed charges and the low income discounts. So 20% all in the IOU for the IOU customers.

Go ahead Karen.

54:40
Karen Maoz: Yeah, so for our calculator, we also we use the average of, so let's say we have the March 2026 data and March 2025 and we take the average of the gas rate between those two years for that month to calculate the gas costs on a monthly basis. So they do the monthly gas rate changes and also includes tier rates.

Tiffany Mateo: Yeah, and for our analysis we just took, it was basically a snapshot of the rates for the calendar year 2024.

55:30
Larry Froess: OK, we have the next question, Dylan. Baseline allowances and electric rates seem to have an outsized impact on electrification. For instance, climate Zone One Home show greater efficiency gains from heat pump HVAC retrofits but show bill increases. Generally PG&E territory T has some of the lowest baseline allowances resulting in higher rates applied to energy using increased due to fuel switching. Will baseline allowances and the impact of different rates and rate structures be studied in detail?

Tiffany Mateo: I know that baseline allowances vary by territories within utilities, so they have their own different climate baseline allowances. They also differ for a home that has a heat pump, so the electricity baseline allowance for a home with the heat pump gets higher than one without I and that was all considered in our analysis.

56:50
Larry Foress: OK, we have one from Scott. Would it be amazing to get the climate zone data in tables to allow for additional analysis and context? Is that available?

Tiffany Mateo: I know we have a lot of charts in the report and we have tables of the rates that we used. I'm not sure we have the resulted data in tables. So it's a lot of data. So maybe we can follow up on that.

57:28
Larry Froess: OK. We have one from Brennan. This is directed to Karen. Karen, do you expect to provide an API interface to this excellent tool? Any thoughts on timing of release? Thanks.

Karen Maoz: I defer that question to Will, if will you want to speak up.

Will Graswich: Yeah, yeah, yeah. At this time, again, we we've had a lot of work done on this tool and we're really excited to get it public, but unfortunately we don't have any firm timeline that we can share at the moment. I think there's a few questions about the timeline.

And then for API interface, I'm not trying to understand what API stands for.

Karen Maoz: Yeah, we don't have, yeah, we haven't designed the tool to have an API interface, but if it's released, there's the Excel workbook and an R code with the user guide. So. So that would be a CPUC decision.

58:36
Larry Froess: OK, Thanks Karen. We have another question from Jennifer. I may have missed this, but is there an ETA for the calculator to be ready for public release?
Will Graswich: Yeah, Again, we're, we're working on it and we're trying to get it public as soon as possible, but we do not have a firm timeline at the moment. When we do, we will make sure to share with everyone with all folks on this call as well as post it publicly through our service list.

59:07
Larry Froess: OK. And Barry has a question in the Guidehouse tool also modular for updates in prevailing equipment slash measures over time example today many installers include strip heat today in heat pump HVAC systems. This is likely to go out of fashion as the market matures and

service optimization becomes prevalent. Measures may need to involve as often as rates and maybe just a statement.

Karen Maoz: Well, right now the tool only includes the energy Commission load shape library, but the way the R script has been designed could incorporate an different sets of 8760. So. So in this case there is no electric strip heating in the baseline.

1:00:02
Larry Froess: OK. And Dylan has another one for Karen. Any interest in integrating open AI or other rate databases? These can have problems without. With out of date data, but can also provide opportunity for users depending how the rate data is planned to be maintained.

Karen Maoz: That's something we can talk offline if possible. Dylan, I appreciate that.

Larry Froess: David has one. Do you recommend any resource to guide ratepayers on the best electricity rate to choose the best rate for electrification?

Tiffany Mateo: That is a good question. I believe some utilities have a online resource available to help customers pick a rate that's most beneficial to them and Diana I don't know if you want to speak to how that will work with EBD participants.

Diana Maneta: No, I don't think I have anything to add there, Tiffany. Yeah, that's my understanding as well. Some utilities do offer that. And for the EBD program, the intent is that the regional administrators and their teams as part of the energy modelling would identify the most beneficial rate for the customer, advise them and assist them in switching to that rate if they'd like to do that.

1:01:30
Larry Froess: OK. And last question, how did you obtain the monthly gas usage? Did you collect that information from the customer?

1:01:38
Tiffany Mateo: So for the analysis in this panel, the model-based analysis, the electricity and gas usage is part of the CBECC, California Building Energy Code Compliance software outputs. And for each hour of the year, there's a total gas use and total electricity use. That's part of the outputs. So that's what we use the CBECC results.

1:02:13
Larry Froess: OK, so that's it. I guess back to you, Tiffany to for the next guest.

1:02:18
Tiffany Mateo: OK, yeah, I think we can close out Q&A for this panel. Thank you, Diana and Karen. I will pass it to Jason Harville from the Energy Commission to kick off the meter based energy bill impact analysis. Thanks, Jason.

1:02:39
Jason Harville: Good morning, everybody. I'm Jason Harville, our Director of Enterprise Data and Analytics. I'm really here today to just to kind of describe the data that we're all talking about, get you a better feel for what we're working with and where these analyses are coming from.
So next slide, please.

1:02:55

It gets called interval meter data a lot. It has multiple names though. So I'm going to talk through what we currently have this year. A couple months ago we approved updates to the regulation that governs the collection of this data. So I'm going to talk about the changes that are coming to the data that we have, and then Commissioner McAllister teed it up for me.

But we have a program called the Energy Data Analysis Program that allows local governments to effectively conduct analysis on confidential Energy Commission data while protecting customer privacy. So I'm going to put a plug for that, kind of describe how it works and how you can reach out to us for more detail. Next slide.

1:03:35
Great. So the interval meter data. Next slide.

1:03:42
It goes by IMD. You'll also hear it called AMI. For our purposes, the regulation is Title 20, Section 1353 and it actually covers a lot more than just those interval readings from electric meters. So Section 1353 collects data from our six largest utilities, with one coming, I'll talk about that in a minute.

It collects billing level data. So we have dollars, therms, and kilowatt hours from every bill for every retail customer in these utilities. We collect the interval data. Of course this is only from smart meters, so that rules out LA, SoCalGas because they don't have electric at all.

So this is the interval readings from electric smart meters at whatever interval those meters collected. So for residential, that mostly means 60-minute intervals, but there are commercial and industrial customers who have 15 or even 5 minute intervals. We get those energy readings at whatever interval the utility collects it at. And finally, there's a whole bunch of data to glue all of this together: The location, the address for where the customer is, different IDs for meters or for a service account.

There are properties of a customer: What is their rate schedule? Are they in a levelized billing program, NICS codes, all sorts of associated information like that. So our authority to collect this data began in 2018. And so we currently have data for from sometime in 2018 depending on utility all the way to present, although I think we've only loaded up through the end of 2025 at this point right now. So we're looking at roughly 8 years of data. This is 40 terabytes compressed, which comes out to be something like 300-350 uncompressed terabytes of data, the huge majority of which is coming from those interval readings. It's just very granular time series data. There's a whole bunch of it.

And so that's been a real boon for us and also a challenge in getting that data to the Recurves and Guide Houses and whoever of the world who need to analyze it for us. So all told, mostly interval readings, but we have about one and a half trillion records in our data warehouse right now. Next slide.

1:06:08
Great. So what's changing? I have a few categories of changes that are coming to the collection of data.

First is that we currently collect it quarterly and they have 90 days from the end of quarter to give us the data. So when we receive a batch of data, it's a quarterly batch and the data within there is somewhere between 90 and 180 days old. We are cutting down both of those parameters. So these are now monthly reports and the time frame to report that monthly report is only 45 days instead of 90. So this is going to make the freshness of a particular batch of data, which will be a monthly batch between 45 and 75 days. The data inside that batch which is significantly fresher. And we're trying to continue moving in that direction so that we can support, you know, analysis that are more sensitive to how recent the data was.

We are now going to be collecting natural gas interval data. This will work just like the electric intervals, it's whatever interval the utility submits data to us. However, there aren't a lot of five-minute gas meters out there is my understanding. So we think this is likely going to be daily readings for most customers. But still, currently we just have billing level, which means monthly or bimonthly in some cases. So a huge improvement in the granularity of the gas consumption data that we'll be collecting.

And then finally, there's a handful of other tweaks and adjustments and some new fields that we've put in there. We are improving the quality of the address data at the location. That's been a challenge for us internally and for our contractors. We are basically structuring how the utilities need to report that to us and that they report latitude and longitude coordinates also. We are including an additional ID for the customers, although we're not collecting any individual customer information. We don't know their name, their number, or anything about them. We just need to be able to tie together different service accounts and understand when multiple accounts, multiple meters, are tying back to the same customer.

And then there is a hodgepodge of a few other fields having to do with identifying what type of customer we're talking about, what type of billing they're going on and joining their rate information with a system we have called MIDAS, which collects rate information from the utilities. So those changes are all coming to the existing collection.

At the same time, Imperial Irrigation District now meets the threshold for reporting to us under these regulations. So they're going to be on boarded as the 7th utility reporting to us. We're working on that right now. Hopefully they should be reporting data by the end of the year and for all of the changes above, we're looking at sometime around the new year before utilities start submitting under the new regulations. And for a handful of utilities who need more time it may be pushed out even further than that.

Next slide, please.

1:09:01
Great. The energy data analysis program EDAP.

Next slide.

1:09:07
This is going to be a bit of a busy slide. We're missing a graphic here. Maybe you could try advancing? OK, cool.

All right, a bit of a busy slide, but essentially EDAP solves two problems that were that were in contention with one another. One is that local governments have all sorts of valid and interesting use cases for working with customer data. However, state law doesn't let the Energy Commission release confidential data to local governments. It's just not one of the defined entities under law that we can give data to. So they need confidential data to do analysis on their customers. We can't give it to them.

And obviously the Energy Commission doesn't have the bandwidth to be doing, you know, county or city level analysis for all these, all the different local governments we have in the state. So that was the problem. EDAP is the solution and here's how it works.

We use an intermediary, which we call an agent that's actually a legal term and an agent of the Energy Commission is a term in law which allows an entity to work as the Energy Commission. We place them in the middle. So a local government identifies an analyst that they want to do the work with Energy Commission data. We evaluate the analyst or analytical firm applies to the Energy Commission to become a formal agent of the Energy Commission. Assuming they pass that application process, they are then allowed to use Energy Commission data. We still can't give anything confidential to the local government. So having the agent give to the local government doesn't work.

Instead what the agent does is they perform the analysis on the confidential data. They generate non confidential results, results that could be publicly released or with a limited number of exceptions, they can provide confidential results if that's one of the small categories of data we are allowed to give to a local government. And then the agent gives that to the local government.

So you can see this flow chart here at the bottom where the governmental entity on the left finds a firm in the agent. I'm looking at the top arrows here. We approve them and the plan for this particular project. The agent request data, which the Energy Commission is, has an oversight role there also ensuring that the data request is appropriate for the analysis that we're not, even though we can give the agent confidential data, that we're still minimizing the amount of confidential data passing to anyone. And then the agent gives the results that are appropriate to the governmental entity at the end of the analysis. And the Energy Commission also has an oversight role in ensuring that the results that pass to that local government also pass legal muster and protect government privacy. So this is our solution.

Next slide please and all.

1:12:09
Right, some resources for you. We have just some links up top here for Section 1353.

If you would like to see the updated regs or the existing regs, there's our docket, the energy data analysis program, a link to the home page for that, and finally a link to the e-mail to reach out to us.

This is still pretty darn new. We are looking at our first project to come on board with SMUD and Recurve is in the final stages of becoming a formal agent for the Energy Commission, our first one under this program. And so this is essentially our pilot project.

And if you are looking to get on board too, we would love to work with you. Go ahead and reach out to us at that e-mail, check out the information on the website and we will talk. Next slide.

1:12:56
Thank you very much.

1:13:03
Tiffany Mateo: Thank you, Jason. I think there's a, it'll be a lot of interest in all this data.

OK, I'll now open it up to Ram Narayanamurthy from CEC. Go ahead, Ram.

1:13:21
Ram Narayanamurthy: Hey, Tiffany, thank you and thanks to thanks to Diana and, and you and the whole team for putting this together.

So it's this is a very interesting topic because this is something I think many of us have been chasing and trying to get our arms around for many years.

Just to give a little bit of a background. So I'm the manager for the Existing Buildings Branch within the Efficiency Division. And part of our, our, our task is actually to manage the heat pump partnership, work on advancing heat pump adoption within the state, but also looking at overall building decarbonization strategy, looking over looking onwards to 2045.

So within that, our interest is actually looking at it from a viewpoint of cost effectiveness of heat pumps and within California. And just from a little bit of a background perspective, this is an area that we've been working on.

My interest goes back to my time at DOE where working in the Building Technologies office, part of my group was working on the red stock models, the Energy Plus models. We did a lot of work around evaluating heat pump cost effectiveness around the country for IRA for the RECI program. So there's a lot of underlying analysis and data.

I don't keep on cost effectiveness. So then as we focus on California and if you can advance one slide, please, one of the focus areas for us right now is trying to understand.So there's a lot of public information that's coming out, whether it's in, in media, newspapers around heat pump cost effectiveness. They cost more, they cost less, they operate well, they, they, they have their useful life is less than for instance, etcetera. So there's just a lot of information and there's a lot of clutter in the information too.

So part of what we're doing is actually looking at many of the studies that have been published around heat pumps and heat pump bill impacts both nationally and California specific studies to understand what is the difference. Why are why is there information that is not aligned maybe sometimes conflicting? And part of a lot of it goes down to the fact that these many of these studies use different input assumptions, different modeling approaches, different approaches for rate estimation.

As we know, California has a very wide variety or very large variation in the rate structures between IOUs and the POUs. But we also have a lot of variation in heating and cooling loads around the state because of the weather. And in that way, California is quite different from most of the other states where the rates are pretty calm standard or across the state.

So what we have been doing is we have been looking at more than 20 studies that have been published. There are studies from Rocky Mount Institute, there are studies from LBL. There are studies from NREL, now known as the National Lab of the Rockies. There is a study published by Harvard University. There are studies that have been published by California, but there are IOU codes and standards team. So we're looking at all these studies and trying to understand what are the underlying assumptions and underlying models and how they lead to different end results.

So again, there's also different rate assumptions. The energy use calculations, some of these studies are using just annual or some of them are using really heating, heating season loads. Some of these studies are looking at whole home energy impacts, someone looking only at HVAC or someone looking at water heating analysis. So we're trying to do a compilation and understand why and what variation we are seeing. Next slide please.

1:17:38
So as we look through these studies, what we are finding is that there is again different rates being used, especially on the rate structures studies that have been done that are more national or even being done by entities outside of California. They don't account for the complexity of the rate structures in California. So many of them use like an EIA average rate structure for the analysis. Some of them use flat rates. Some of them are actually diving a little deeper into using time of use rates. But as I think Karen talked about, there's a lot of complexity in the California rates with fixed charges, with the electrification rates, etcetera. And many of the studies we find that they don't actually have that complexity built in.

One example of a study is the I think the Harvard study that was used for, that is used as a basis for articles in LA Times and the Chronicle. And what we found is that the Harvard studies using the heating load from EIA data.

So it's almost like an average heating load for the state, not specific to the areas of the state and also the rates where based on some statewide averages divided by heating loads.

So, so when you use an analysis like that, what can you end up with is a very broad blend, but it might not be very specific to the fact that even within California, heat pumps are going to have positive and negative bill impacts depending on the area of the state. I think we saw that with Tiffany's, Tiffany's work too.

So what we are finding is that when we look at these studies and when we are trying to use them for further, for quoting or for further usage that we have to be very, very careful about what the underlying assumptions are, especially with regards to the underlying models that are used in those studies. Also, one of the other things that we find is that if you're using model say, Energy Plus versus CBECC, there are variations between the two.

For example, with CBECC, you have a cut over temperature from heat pump operation to backup operation that is around 35°. That's actually fixed in the software. With Energy Plus you get to move that a little bit. Same thing with indoor and outdoor set points. Energy Plus has a little bit more flexibility than CBECC.

So we have to essentially what we're finding is that we are we, we have to be really considerate about how and what assumptions are used so that we can actually have an apples to apples comparison of the different studies. So this is the work that's ongoing around heat pump bill impacts and we will hopefully be able to work through this and understand better all these different studies that are being published and hopefully provide some more clarity to the larger public as a whole.

Another area that we are also working on is looking at the heat pump bill impacts from dual fuel heat pumps. This is with a consideration of converting air conditioners to heat pumps leaving the furnace in place so that we can understand if by doing so we are actually able to optimize operation so that the furnace is operating when it's when it's cheaper to operate on gas and then operating on the on the heat pump and it's cheaper to operate on electric. Figuring out what is the optimal cut off, cut over points, etcetera, but using the dual fuel as a measure to be able to optimize heat pump operation and ensure that we are able to at least stay cost neutral for pretty much everybody in the state.

So there's a lot of this different efforts going on. I'll jump over into one specific area that we are doing some more analysis on.

Next slide please.

1:21:46
This is around the usage of the IMD, the interval meter data that Jason discussed at length.

Next slide.

1:21:52
I'm not going to dive into what the data is. Jason's actually done a great explanation on the data itself. So the vision is that the we have a multi divisional working group working on the interval meter data. We are looking at different use cases so that we can understand how to apply the interval meter data, things like heat pump analysis, understanding heat pump penetration in the state. We are also looking at how do you use the meter data for asset ratings. So this is the application side of all the work that Jason and his team have done to set up the database.

Next slide, please.

1:22:34
So some of the use cases that that we are exploring at the Commission and you'll see that I'm using IMD and AMI interchangeably. It's, it's just the way, the way it's referred to different places. So one of the use cases we are looking at is the residential heat pump count. How many heat pumps are in the state and how can we detect heat pumps using the interval meter data?

We are also looking at Geo-tagging. And one of the interesting use cases is can we use Geo-tagging? That is being able to use a universal unique building identifier for each building so that we can actually correlate the meter data with safe program data, whether it's for the energy efficiency programs, whether it's for the permit data.

So how do we correlate different data sets so that we can have more utilization of the IMD data, understanding both savings from energy efficiency, electrification, the work that Tiffany mentioned.

We're also looking at use case around energy core performance verification, really understanding if models represent reality and how well do they represent reality so that when a building is newly commissioned, trying to understand the operation of newly commissioned buildings.

Another area we are focused on is benchmarking automation verification energy analysis. Part of our team is working on the energy benchmarking program for buildings greater than 50,000 square feet, which requires building owners to do to provide energy use data obtain from the utilities to the Energy Commission.

So the question is like how do we actually correlate the data that's provided, understand data quality, improve data quality by being able to use the IMD data in correlation with the data being provided by the building owners.

And then home energy ratings and labeling is another use case. And then further down the line, looking at distribution grid impact so that you can actually look at meter to transformer mapping. So we can understand loading on the distribution circuits and the grid edge using the energy data from the meters. And ultimately also looking at the evaluation of demand flexibility potential. Just touch on a couple of these use cases.

And then of course, if there's more questions, we'll address it at the end. Next slide.

1:25:05
So for the heat pump detection so that we can look at the heat pump penetration within the state and we are seeing greater and greater penetration supported by our building codes with the with the residential codes advancing the last few years.

And what we're trying to do here is use signature detection of both the electric and the gas data. The gas data, for example, you can easily detect if there's been an electrification switch. You can look at, for example, what would a normal mixed fuel home be, compare that to the actual gas usage and then use that to correlate that back with the electric data.

And one of the things with the electric data is that if you have a heat pump, you should be seeing a signature where the electric energy use trends upward as it gets colder, whereas with the mixed field home, you wouldn't see that kind of a trend. So being able to understand and be able to mine these large data sets to be able to identify these trends will help us with the detection for heat pumps.

So still a work in progress. It's a very large data set and we are working through it county by county.

Next, Next slide, please.

1:26:29
So this one is the other use case we are looking at actively working on right now is Geo tagging.

One of the things we notice is that data quality is a challenge, whether it's programmed data, whether it's IMD data and address matching is a very important criteria. For example, we were able to improve the address matching from 50% to 80% by using Geo tagging.

But to do a Geo tagging, you pretty much have to go to every line in the IMD data set and be able to allocate a geotag, essentially latitude, longitude to that building so that you can actually correlate that with other data sets. So this is part of establishing the unique building identifier.

This is something that was initiated by DOE through the Pacific National, Pacific Northwest National Labs. And we're using the concept of UBID to be able to improve program verification and correlation of data.

Next slide.

1:27:32
Another use case we're exploring right now is automating benchmarking. For example, can we actually have IMD data be able to feed right back into Energy Star Portfolio Manager using some kind of a connection so that we can actually automate benchmarking? These are use cases to be to be explored down the line.

Next one please.

1:27:59

Verifying accuracy of benchmarking energy reports. Again, being able to use the IMD data with the data being reported by the building owners. This would be again be used to improve data quality in the various program databases that are being used across the across the CEC and maybe even outside of the CEC. Next slide

1:28:17
Energy code compliance is again the goal here is to look at new construction, for example on commercial and look at how they are performing at startup compared to their code model performance.

This way we can identify things like for example, if their controls commissioning wasn't set up properly, can we identify that get the get the buildings recommission retuned so that they are operating the way they are supposed to. So it helps us ultimately by doing this kind of analysis, it helps us improve the operation of these buildings. And last slide.

1:28:56
Finally, use cases, home energy rating and labeling.

This is again an effort going on at the Energy Commission, I think, but it's going to talk about it later. Being able to collect the data, it's around, it's around asset benchmarking.

It's being pursued in many different countries, especially in Europe, being able to use the meter data so that we can benchmark our assets, our building assets so that I will wrap up and turn it over and turn it, turn it back to Tiffany.

1:29:33
Tiffany Mateo: Thank you, Rob. OK, well, we'll keep going. I'll invite Adam Scheer from Recurve.

1:29:43
Adam Scheer: Thanks, Tiffany, and thanks everyone for being here. Thanks to the CEC for hosting this and inviting us to present. It's been a pleasure working with you all over the last several years.

So Recurve, just by way of a quick introduction as a technology provider really focused on AMI data analytics and product delivery to help folks not only understand the impacts of their distributed energy resource programs, but also to optimize them and to scale them and define the customers that can benefit the most from those programs. So at the heart of all this is meter data and methods.

So we can go to the next slide by the way, I'll have a little bit of custom animation throughout this presentation. So I'll just say, you know next or click forward and that'll help us progress according to the deck.

1:30:31
So at the core of Recurve software is the open DSM, open source methods and code. And if we this has been in existence since 2015, roughly, the original goals of that project are still alive and well today, which is really to establish an open source weights and measures for demand side programs so they can compete and scale with settlement quality baselines and settlement quality measurements.

Ram just mentioned, you know, in the world of bill impact measurements or in in the world of bill impact studies, there are many different, you know, approaches to this. And the same thing is true when it comes to the measurement of load impacts.

So we're trying to put forward a set of open-source methods that folks can say we're going to leverage this, it's all documented and let's move forward and move past all of the sort of judgment calls and assumptions that can change results from study to study.

So we can go move forward.

1:31:34

So the open DSM, as I, I mentioned really began in 2015. At that point in time it was called CalTRACK for those who may be more familiar with that that term. And at the initial stages of that project there were hourly methods for when you had AMI data available and there were also monthly and daily methods for when that was the granularity of the data available. In 2020 or thereabouts, we obviously had a global pandemic. We all lived through that. And so we added comparison group settlement to that suite of open source packages. At the time it was called GRIDmeter. We're now folding that in under open DSM as well.

And then just in the last several years, we've gone back and we've revisited the core daily, monthly and hourly models and we've rebuilt them largely from scratch. Travis Sykes has really led that project.

And all of this has led to a new suite of open-source tools that with modern machine learning methods that can handle building by building cases in a way that's adaptive to the data that is actually exhibited in the consumption patterns. So we're really happy about where this is all landing.All of this is part of the Linux Foundation Energy and again forms the core of our software stack.

So we can go forward.

1:32:57
Just a really quick primer on how these methods work. You have a baseline period which typically is the year before an implementation of a of a project. So it could be the installation of a heat pump, for example, and click forward.

In that baseline period w develop a model that says this is how this building is responding to temperature and now solar irradiance as well as the consumption patterns that we're observing that's unique to every single customer.

And then you can click forward just a couple here.

1:33:30
We then build a counterfactual based on the baseline period model which represents the prediction of what that customer would have used either electricity or gas in the absence of the intervention. And then we compare that counterfactual.

You can click forward to the actual observed consumption in that post implementation period and you can click forward.

1:33:52
The difference between the counterfactual and the observed is the measured load impact. So all this is at a meter by meter level and it's based on the actual consumption in the building throughout this measurement period. So we can move forward.

1:34:08
Now this is just an example. Recurve has measured every project in the TECH initiative. So TECH is this large California-based building electrification initiative in the residential sector. We're partnered with Energy Solutions to bring forward these measurements to the public and say, hey, look, this is how these projects are all performing at the meter. And what I want people to understand is very simply that we're very used to saying, OK, this is what a heat pump does. But when you look at customer by customer measurements, you see a wide distribution of outcomes both on the electric side and the gas side. So well, yes, most customers are increasing their electric consumption. Most customers are decreasing their gas consumption. We see a huge range that of impacts.

Some of this is due to the program, some of it is due to other effects like kids going off to college or customers getting a hot tub or whatever it is. But the program effect is buried in these distributions. So this is going to be important to keep in mind as we as we go forward here.

1:35:08

So now if we go to the next slide, the question really becomes how do we tie all of these meter based load impacts at an hourly level by every meter to the gas and electric bill impacts that these customers are actually experiencing.

1:35:25
So let's move forward. In a nutshell, bill impacts are complicated, customer bills are complicated. And so when we want to take an actual measured load shape impact for electricity or gas and then calculate a bill impact from it, the way we go about doing that is first to use the counterfactual consumption pattern. That's the model's prediction of what that customer would have used in the absence of the program and then use that very same trace and funnel that into a bill, a bill calculation. And we do the same thing with the observed consumption pattern, post implementation from that reporting period. So we're calculating in the same way we did for load impacts. We're calculating a bill impact. And so we have a counterfactual bill and then an estimated observed bill. The difference between those two things are the bill savings or the bill increase that a that every single customer that we've measured is experiencing.

And it's important to note that it's not enough. Obviously everybody here is an expert on this. It's not enough just to say, oh, the average, you know, dollar per kWh is 30 cents or the average dollar per Therm is $1.50. You really need to know what are the volume metric rates, what are the fixed rates, What are the, you know, the actual rate schedules, the CCA status specifics on net energy metering customers, whether customers have baseline allowances. I'll just say our, our, our methods account for all of those factors.

So we can now move to the next slide.

1:37:04
And this is just a quick note to say we've validated this approach using meter data and calculating these bills against actual bills that are part of the data set that we have available across all the gas and electric utilities that are part of the TECH data set. And we see, you know, very high rates of successful replication of bills. So this gives us confidence that we're on the right track, we're doing these calculations correctly.

All right, we can go forward.

1:37:33
So Ram just talked a little bit about electrification bill impacts.

Just to emphasize, you know, conceptually you're going to by and large have electricity increases, gas decreases when you electrify gas end-uses and the electric bill will tend to go up because of that and gas bill will tend to go down. However, you also have customers, for example, that the heat pump is not just replacing a gas furnace, the heat pump is also replacing an old, inefficient. energy chugging air conditioner. And when you have that, you have savings on the electric side, especially during those peak period time of use rates in the summer where you get a lot of air conditioning savings because the heat pump is a more efficient air conditioner.

So this is a big effect and can make the difference between whether a customer gets bill savings or bill increases in in California.

All right, so we can go forward.

1:38:34
Let's just take a look at TECH program water heaters that were installed through 2024 roughly. And these are, this is just kind of a distribution of all of the customers on the electric side that had a water heater replace a gas water heater, so a heat pump water heater replace a gas water heater. And what we observe is 80% of those customers experienced an increase in their electric bill, which is intuitive.

If you click forward, we saw that 89% had a reduction in their gas bill. And then click forward one more time, we saw that right around half, about 51% of customers had a bill reduction and the median was around 6 bucks. You know, so it's almost in the noise. Well, basically it is in the noise, right. So we were very close to just bill neutrality across the state of California for water heaters.

Now there are many drivers behind this that some you can say some customers are going to do well, other customers are going to do poorly. But we can go forward to the next example here. When we now look at customers where Recurve detected from their AMI data that they had previous air conditioning equipment. So a lot of these customers are getting an air conditioning upgrade.

When it comes to efficiency, now we see that only 67% have electric bill increases, 83% have gas bill reductions and now more than 2/3 of these customers are experiencing total annual bill reductions. So the details matter. All right.

We can go to the next slide.

1:40:12
So now the question is we've got the load impact measurements, we have the bill impact measurements. Now can we make some predictions based on the data set on an individual customer basis. So this is what we call at Recurve measurement-based forecasting.

We can go to the next slide.

1:40:31
The way this works is we take all these actually let's just go to the next slide.

1:40:36
We take all of these load impact measurements and Recurve is measuring the bill impacts, but we're also measuring gas and electric load impacts for measuring total systems benefits and greenhouse gas impacts. So all of those are things that you would want to predict.

So yeah, thank you. You're, you're reading my mind. Thank you. Now we can just click forward a couple here.

What we use then to predict these outcomes are things like customer consumption patterns that we're observing the disaggregation of heating and cooling loads, Other types of consumption patterns like how much are customers using in the summer peak period, how much of that is attributable to air conditioning. And then metadata like their location, demographics, are they on CARE rates, what utility territory are they in and so forth.

And you can click forward a couple more.

We funnel all of that information into a machine learning pipeline and then we get predictions for all of the customers that would be in a future set of participants. So we've done this now for the CEC and I'll get to that in a moment to help with their Equitable Building Decarbonization Program.

So let's go to the next slide.

1:41:47
This is just a quick demonstration. Click forward one more.

When we forecast total systems benefits, this is an example of where we've taken the data set, we've separated it into test and train splitting and we're looking at the test set results.

So this is a model prediction on data that the model has not yet seen for the individual customer total system benefits that they are delivering from these electrification projects. And what we see is there's a lot of scatter because every customer has their own set of circumstances. But when we look at the top quarter of customers that we forecasted to have the highest total systems benefits, we observed that they achieved 3.2 times the total systems benefits as the bottom 3/4 of customers. That's an amazing stat when you think about that.

So there's a ton of predictive power in these consumption data and the metadata that can help you say these are the customers that are likely to save the most on their bills and do the best by the climate and save the most for the energy system.

All right, we can go forward.

1:42:58
Now let's try to use these forecasting results to actually optimize the program. All right. Next one, when we look at something like the TECH initiative, we have a ton of objectives. It's not only that we want to save GHG, but we want to have customer bills savings. We want to serve low-income customers, hard to reach customers, customers and disadvantaged communities. We'd like total systems benefits to be as high as they can. Not all of these objectives are aligned and some of them are slightly misaligned. So the question is now, can we balance these multiple objectives using the forecasting framework that I talked about earlier?

All right, next slide.

1:43:41
So the question that I would pose to everybody here is if you had 100 pennies to spread across all of these goals, where would you actually put them? so we can click forward. Well, we worked with the folks at Energy Solutions and we came up with this weighting that we used as a demonstration in a recent report that we wrote with them. And we put a lot of pennies into let's maximize peak period consumption or peak period savings on the electric side and customer bill savings. But we also want to reward finding low income and disadvantaged community customers that can achieve those very outcomes.

1:44:18
And when we do this, go to the next slide and click forward, we can then take all of these various goals, measure the results that program that the program is delivering for each customer and then funnel those results into a comprehensive metric that we're calling the electrification potential score that can then be the basis for outreach, program outreach.

So customers that have a high electrification potential score are those that have the best ability to deliver across all of these program objectives holistically. So when we look at the outcome of applying this, we can go to the next slide. We see that the top quartile of customers in the electrification potential score yielded $556 of annual bill savings versus an $88.00 bill increase from the bottom quartile. They had three times higher total systems benefits, about 80% higher GHG savings and they had a higher representation among these equity communities, low income and hard to reach.

So this should absolutely just put to rest the myth that if you want high savings, you have to target high income customers with big homes. Not true. You can do both.

All right, let's go to the next slide and I'm , I'm about done here.

1:45:43
I'll just summarize this quickly if I'll just read this. If we can shift 10%, just 10% of heat pump electrification projects from the bottom quartile to the top quartile of the electrification potential score, we will achieve $525 million higher TSB and save low income customers an additional $20 million annually on their energy bills in California. All right.

1:46:10
Last thing I'll say, next slide, is we've helped now the CEC prioritize outreach for the EBD program using this electrification potential score for the CEC, we've used 50%, they put 50% of their pennies, we can go to the next slide, 50% of their pennies into bill savings and 50% of the pennies into GHG savings. And what we observe here is based on the forecast, the annual bill savings of top quartile customers is going to be $340 versus about a $60 bill increase for an average customer in the bottom 3/4. And the GHG savings would be 32 tons over the life cycle of the heat pump versus 9 tons in the remaining population.

So if anybody wants to walk away with one single take away from this presentation, I would encourage it to be: use the AMI data, make these measurements and then figure out the individual customers who are out there in the population. There are millions and millions of them who would benefit the most and benefit the energy system and the climate the most. We can sort of have our cake and eat it too, if we're smart about how we use the data. So I'll stop there and look forward to questions later on.

1:47:28
Tiffany Mateo: Thank you, Adam. Yes, it's great work. I like the pennies analogy.

OK, so we're about halfway through this panel and a little over halfway through the work, the plan, workshop presentations. And I think maybe it's a good time for a break. We'll do about a 10-minute break.

So we'll be back. Maybe we'll say 9. So it's like exactly 11. Yeah. I wonder if Katie could put that in the slide, the time. And yeah, when we get back, there's two other presentations in this panel and then we'll do Q&A before our last panel of the day.

1:48:20
We're now recording.

1:48:22
Tiffany Mateo: Thank you. All right, welcome back. Thank you for your attention. I will pass it to Lisa Schmidt from Home Energy Analytics.

1:48:35
Lisa Schmidt: Thank you, Tiffany, and thank you everyone for attending. This has been really enlightening and I appreciate the chance to participate in this webinar. So we're going to take a very different approach to electrification and the issues around it. We come from the point of view of the customer because we are providing analysis and support for individual customers doing electrification in their own homes. I think it's very important that we have to come at this problem from both ends.

One, doing outstanding analysis, as Recurve demonstrated, before to target customers, but then when customers actually go through electrification, they have to make a decision based just on their home. So that's the perspective we're coming from and I'm going to share a couple of examples from PG&E customers where we've been working.

OK, next slide please.

1:49:23
Just by way of introduction, my company Home Energy Analytics was founded by me and my husband in 2011 and we wanted to use the widespread introduction of AMI data to do better analysis to help individuals reduce the energy use in their home. It has evolved into a program called Smart Audit, which is a web app that we first deployed in 2012 and it's now being used in a program for PG&E customers called Home Intel. And in Home Intel, we provide both Smart Audit, the web app and access to energy coaches. And so far we've, we've treated about 100,000 people in the PG&E territory to help them reduce their energy consumption.

OK, next slide please.

1:50:14
Electrification is complex from the customer point of view. So when you start to work with a customer, they have all these issues to consider. And in most cases, it's not going to be like the EBD project. It's going to be the customer has to make the journey on their own and figure out what to do on their own. And our approach was the more data, the more we can analyze the home before they get started and provide them information to make some of these decisions, the better they'll have a better outcome.

So next slide please.

1:50:48
First let's talk a little bit about the customer steps and where we really provide value is in step one and two. We start from the premise that if they understand how energy use is current, energy is currently used in their home, they'll be able to start making better decisions. And I'll, I'll give him an example of that.

So then at looking at it electrifying, most people are doing it as a step by step process. They're not electrifying their home and all their appliances. That does happen. But we frequently run into people that want to do just one thing. So how do you approach electrifying? What appliances do you plan to do? How do you plan for maybe electrifying in a year from now? And you set up your, your panel so that you can support everything you want to electrify.

So we also help people in Step 2, step three and four, it continues their journey. It also is important to understand the electrifying, how do you find incentives and qualified contractors and that's something other people like TECH are providing help for. And finally, how do you optimize your rate plan? We've touched on that a little bit.

So in our program, the smart audit software analyzes and then we have an energy coach to help assist them. So let's look at some examples here.

Next slide, please.

1:52:04
The first step that we take people through is understanding the energy use in their home. When we first introduced our program, it was pretty straightforward. We wanted to help people reduce their energy consumption and homes and energy rates. The electric rates were pretty straightforward and they've changed so much since 2017.

We now have a lot of EV deployment, much more, so we have to learn how to support that. PV and battery support, how do we support that? And people who want to electrify, how can we analyze the electrification or each appliance so that we can help them with electrification?

So looking at the chart on the right is the yearly energy profile, a energy use profile for a home. I just picked one that registered recently. You can see the nice light blue is air conditioning in the summer. The other energy categories are listed below. So we have some good knowledge about how energy is used in their home. And what we'll highlight here is every single home is unique. It's great to look at a large population and make some very good and educated guests on how to pursue it. But when the person starts doing it on their home, they want to know how to proceed.

OK, next slide please.

1:53:20
So after we teach people about the energy use in their home, we help them learn how electrifying individual appliances will affect both their energy use and the greenhouse gas reductions. We care a whole lot about that. So we find also a lot of customers care about that. So an example of what we do in Smart Audit, on the left, is we ask them some information about their home heating. We get an estimate of when the HVAC system was put in. Helps us do a better job of estimating the efficiency of the system. And so we say if you plan to upgrade your HVAC to a heat pump in your home, here's what we expect to happen. That's the screen on the right. Your gas use will go way down. Your energy use will also plunge. Your emissions will go way down. And then we can help them make some estimates on if you do that for this particular appliance, how will that affect your energy bill? So, and we also can do some analysis on if you switch to different rate plans and maybe do some load shifting, you can save even more.

OK. Next slide please.

1:54:27
And let's look at the example of electrifying your water heating, very similar process. We ask some

simple questions about what they have in their home so we can make in some estimates about how much the impact of putting, of switching to electricity will do.

On the right hand side is again the panel that we would show them after they've answered those simple questions. And then the information that we would also provide them is on the left hand side. So what we've given the customer is they enter a minimum amount of their information about their particular circumstances. We can make some good solid estimates based on what we know about their energy use and rates and then provide them with information so they can help decide what to do next.

OK. Next slide please.

1:55:15
Another important consideration for customers is their panel size because there's been a lot of talk about how we're going to have to replace millions of panels in the state to support electrification. We really haven't found that to be true. And I'll show in the next slide how we we've found this to be across a big population of customers, why we believe the panel upgrades are not going to affect us very much. So we asked the customer how big is your panel size? Most people can figure that out by looking at their panel. And once they get that in, we can base, we can tell them how much capacity with their panel with adding this new electrification. So do they have enough room to put in these new devices? And in this case they have a lot of room, so you'll be able to easily electrify based on this panel. We're using 220.87 NEC standard. So this is based on national standards for using AMI data to make an estimate of their panel size.

OK, next slide please.

1:56:24
And here, just to back up the claim I made about panel capacity is not an issue. We looked at 3800, excuse me, 3800 homes that we had information about their panel size and their energy use. And we looked at the oranges, the panel size that the customer provided from I think the one down there is 75 up to a 4000 or 1000 amp panel, which is pretty incredible. And then the blue lines are how the actual panels, the capacity that the their appliances we're using, it relates to the panel size. So you see nearly all of the installations can easily support electrification and that's an important concept to realize that we're not looking at this great cost because we have to upgrade panel size.

OK, next slide please.

1:57:19
So let's look a little bit at how electrifications look inside of homes. So we take AMI data or receive AMI data for each customer every day. So we're constantly updating what we know about their energy use and constantly providing this information for them. So many of our customers have been in our system for 3-4 years. They've gone through some significant changes in their energy use. And this example here is an example that has completely electrified. So we're able to give people really detailed information all the time on what's going on. On the top graph is a representation of their energy use base broken into various categories. So the top line is their baseline use for the first year. The second line is weather normalized, and then the third line is the current 12 months. And this is the same home. You can see where this home that their electricity use has gone up as you would expect because they electrified, if you look below at the gas chart, very similar format. The top line is their baseline, their initial is weather normalized and then the bottom line is what they're currently using for gas. So this home electrified both their hot water and HVAC and as you would expect, their use plummeted. So we can show this to customers all the time. They get to see the impact as it happens.

Next slide, please.

1:58:48
And this is the same customer and we want to present to them how their energy bill has changed because that's what really matters to customers. So a very similar chart looking at their bill on the top

line is the baseline, then whether normalized, than their current yearly bill. So this customer saved about $2000 for their current year. That's really great outcome. They probably engaged in some energy saving or energy efficiency activities as well. But they now know what their impact is personally, it's very positive for them and they probably took advantage of a coach to help with that. But the whole process they've understood from the beginning to the end how this is going to affect them and, and what they should expect and how they are going forward.

OK, next slide please.

1:59:39
But not everybody saves money. Here's a couple of more examples. It's on the left is a household that did particularly well. They cut their energy bill in half by electrifying. They probably did a lot of other energy saving activities at the same time. But it's all worked out really well and now they have a very much lower bill, a 50% reduction in the bill. House on the other side did not see a bill reduction. This is not a typical, there's probably things they could work on to reduce their bill, but just an example of both types of, of outcomes that we can see. But how does that roll up into our overall population of people who've electrified?

So next slide, please.

2:00:28
So we've had 176 people fully electrify in our program and we ran bill analysis across all of them. As you can see, the average change down is about $158 per year. So what we're seeing is similar to Recurve, it breaks pretty close to the middle and you see some outliers on both sides both up and down. We do think there's a chance to move more people to the downside by suggesting some energy saving tips that apply to their homes. So they may start to see their bills go down as they implement more of those. But it is, I think, really gratifying to see that in general people are saving money. I will also mention that our population is very different from the populations that been analyzed for EBD. We're talking to the general customer in PG&E territory. In fact, we're not talking in general to low income customers because ESA customers are not qualified for our program. So the information we're gathering is kind of probably complementary to what the EBD people are looking at. And we, we think it's really good to see that all people can save money on average, which is, which is really encouraging.

Thank you for your time. Appreciate it. I'm happy to answer any questions.

2:01:54
Tiffany Mateo: Thank you, Lisa. This looks like a great resource for customers. OK, We'll go to our next presenter, Robert Buchanan from Snugg Pro. Go ahead, Rob.

2:02:10
Robert Buchanan: Hey, yeah, Hi, Rob, everybody. Rob here. I'm with Snugg Pro. I'm a senior building performance engineer here and I've been working on this program for about two years Prior to that I spent 13 years working as a product manager for utility efficiency programs and prior to that I was an energy auditor. So that's why I'm here today and I'm here to talk about Snugg Pro.

Snugg Pro is an energy modeling is an energy modeling software for existing homes that is primarily intended for use by home energy, home performance contractor profession. So this is not necessarily intended for use by the general public.

We can go ahead and click forward.

2:03:00
And so my agenda is I'll first talk about inputs and calibration, how Snugg Pro utilizes inputs acquired the field and how it uses that to build a representative model of how of what the house performs. Like today we'll talk about using how usage data and billing data gets used to develop that model and also talk about savings projections for individual residences and results from a sample job.

I want to emphasize that it feels like most presenters prior to me have talked about homes in aggregate, and we're talking about homes on an individual level, modeling them and projecting an individual residence potential energy and bill savings on this one.

So we can click forward again.

2:03:59
So model calibration we want to click again.

The 1st objective is we want to collect 12 months of historical energy data and weather normalize it. And so we'll use zip code data to find a local weather station, find a local weather station, and then based off of the use, based off of the read dates from the usage data, we will take that information and build around that what expected energy use would be for an individual home.

Want to click again?

2:04:41
Then we also collect data on the home. So we're going to collect length, width, surface area, wall height, mechanical performance specifications. And if we click again, we're going to braid those together to try to create a representation of the home today and how it uses energy.

We can go on to the next slide.

2:05:04
Historically, we do need 12 months usage. That includes 355 days of usage history for all fuels, including secondary fuels. I do want to specify when we're talking about all fuels, talking about all fuels used significantly inside the home. So if you have, if a, if a resident has a propane, excuse me, a propane grill that's used outdoors or a pellet smoker or a wood fire pit, we don't need that information. We only need data for significant end uses inside the house. We and we do see some houses that in other programs that use wood or pellets to heat and so that that can be a common, it can be a heating fuel and we are capable of modeling that. And we can go on to the next slide.

2:05:57
And next, we also want to collect data on the home. We want to focus. There's, there's really kind of two categories of data for those homes. There's actual measurements. Some examples of that are going to be the home's length, the home's width, the number of stories above grade wall height and if we're running blower doors measured CFM 50.

There are also some observation-based estimates that can be that can provide ranges for some of those inputs. For example, thermostat settings, insulation levels both in walls and attics and in the absence of blower door tests of loader tests, Stub Pro can estimate CFM 50 based off of vintage surface area and other features of the home.

So let's go on to the next slide and we're going to click a couple times to get all the text up.

2:06:57
So our users utilize ranges for imprecise observations. For example, wall insulation. Users are going to make educated guesses as to whether the walls are insulated, and if they are, how well insulated are there, and that provides a range for Snugg Pro to iterate around.

Same for attic insulation. If a user, if an auditor goes into the attic and notices there is roughly 4-6 inches of insulation, but it's higher in some place and lower in other places, then we can create a range of five, then we can input a range of five to seven inches of insulation for attics. Excuse me. And then Snugg Pro calibrates that model utilizing a whole building physics model against where the normalized utility builds.

So we're going to build a model around what the energy use looks like, run up to 1000 permutations based off of those ranges that users have input and try to align that usage data with those, with that range of inputs and really dial in where that weather normalized utility, where that home's, what that home's infrastructure looks like today. Snugg Pro use it can use BPI 2400 calibration to try to ensure the existing home's features are reasonably precise. BPI 2400 basically provides a tolerance around calibration to ensure that the inputs are a fair representation of the use to ensure that any that the existing home is modeled correctly, but also any projected savings are also representative of what the home's existing infrastructure looks like today.

So let's go on to the next slide.

2:09:01
I've created a sample job and this is based off of a house I owned once upon a time built 1939 thousand square feet. I put this in a Fresno zip code and the house currently has gas, excuse me, gas HVAC. It does include central cooling, gas water heat and a gas range.

And so let's go on to the next slide.

2:09:25
I used a representative usage data from a project we had in we had in Fresno. And what this calibration represent, what this represents is that this home specifically is passing calibration. That means the inputs that we've that we've entered into Snugg Pro and the and the resulting calibration based off of that usage data, that the inputs are fairly representative of what the use expected usage is for an individual, for this individual home.

In the events that calibration fails, that is an indicator to the user to make some modifications to some of those, to some of those estimated to some of those estimated or assumed inputs to improve the fit of the usage to improve the fit of the of the performance to the usage.

A couple of examples of inputs that dramatically that can affect calibration results are thermostat set points. By adjusting thermostat set point ranges that can account for room-to-room temperature differentials or extended setbacks from time away from home or even as specific as the difference between dry bulb and mean radiant temperature within a within a dwelling.

Another one we see especially for houses that occasionally get audited in summer is a spike in electric use in the winter for people who use space heaters. Because the homes we're going into especially in support of a lot of these programs are income constrained. And as a result are or and as a result maybe worse housing or I shouldn't conflate those are worse housing stocks. So sometimes there is, there's issues with keeping rooms warm so we can make modifications to uncertain inputs to improve calibration results so we can go out of the next slide.

2:11:38
So given a suite of inputs, these are data points that I left blank intentionally to allow Snugg Pro to make estimates for these values. It estimated an ACH50 of 4120. It estimated the duct location it was in unconditioned space and uninsulated and duct leakage outside of 6%. It estimated wall insulation, walls being UN insulated and a very limited attic insulation as well. And so these are based off of uncertain observations and I left them blank intentionally, but users would be able to go in and make inputs on this.

Let's go on to the next slide.

2:12:24
And then once we have, once we've established a baseline and what the efficiency specifications are for the existing home, then we subsequently make recommendations for improvement. For this particular project, we were looking at full electrification.

So I added some envelope improvements, attic and wall insulation, also modelled converting from a split furnace and air conditioner to a new air source heat pump and recommended a heat pump water heater, fuel switch from gas to heat pump and also change out the food prep from gas to an induction range.

2:13:07

And let's go on to the next slide, similar in concept, but not necessarily in presentation to CEC’s impact analysis. We use the same fundamental inputs. So we're going to have same surface area, same condition volume, same footprint, same foundation. All those are going to be identical between the two home, between the two homes, but we're going to model them in parallel. We're going to model the existing home as it exists, as it is today. And they're going to model effectively the same home with efficiency improvements. So with dense packed wall insulation, with improved attic insulation and with displacing the gas, the gas furnace and the air conditioner with an air source heat pump.

And let's go on to the next slide.

2:14:03
And we're going to compare those results.

So we're going to model, we're going to estimate usage for both the base and improved home using TMY15 data. I'm going to compare the annual energy use between those two, between the two homes, the identical homes modelled in parallel with different efficiency, with different efficiency and performance.

Let's go to the next slide and this is a what these results are.

2:14:32
I do want to call attention to the fact that the that the bill impacts for that are presented here are not localized yet. That was a feature, we've actually added that within the last 48 hours. So I will be able to provide updated comparison results for costs, for localized costs to localized bill impacts as well on this one. And I also want to mention that the carbon savings have not been localized. And so that isn't that, that's not important here, but the comparison I want to make is that, the comparison I want to see is that when we have fully electrified this home we do see a slight increase in electric consumption and but we also see a significant reduction in total energy use.

And let's go on to the next slide and talk a little bit about some of these fundamentals.

2:15:26
So Snugg Pro does interactive and interdependent modeling. So of the when I selected the measures including attic and wall insulation, if the focus is entirely on just gross energy savings, you can hypothetically remove those, remove those measures and remodel and that model will be reflective of having removed those. So you're the HVAC savings, even the water heater savings are dynamic with respect to envelope improvements. So we can we can make those suggestions and make those improvements after that. For the purposes of calculating energy savings, gas and electric use is normalized to BTU. So the BTU from gas consumption plus BTU from electric consumption versus on the existing home versus BTU consumption for the improved home. That ratio is going to be what, the percent savings is what's going to be displayed on there. In our presentation, the increase in electric consumption resulting from electrification demons shows up as negative energy savings. And I want to specify that the usage history is solely used to calibrate the home as it is today. So we use the, the usage data is effectively used to ensure that the modeling inputs and the infrastructure of the home and the current conditions of the home are as representative as possible. And then we make and we model improvements based on based on the assumption that the existing home is fairly well represented within the model.

That's the end of my presentation.

2:17:18
If you have any questions or any follow up that is going to go beyond the scope of what we're discussing here, you can reach out to us at pro@snugghome.com or visit our visit our website and hit us up via chat on there. And thank you again for the time and the opportunity.

2:17:38

Tiffany Mateo: Thank you, Rob. OK, so that is the end of the meter-based energy bill packs analysis panel. I'll open up the Q&A for this panel.

I think it looks like there are no written questions. Yeah, yes, thanks people for answering questions in the in the Q&A. I'll just wait a moment to see if anyone has any additional questions before we move on to our last panel. OK, very thorough presentations then.

All right, so we can move on to the next panel Validation Analysis and Beyond Heat Pumps, I'll invite Mudit Saxena from Xero Home to kick it off.

2:18:50
Mudit Saxena: All right, well, thank you everyone. It's my privilege and honor to present here today. I'm really excited that I am at the position that I'm present, presenting because I have the ability to this opportunity to tie in a few things that we learned from the presentations that we saw this morning. So hi, everybody.

I'm the CEO and founder of Xero Home. And today I'm going to talk about using utility data to improve residential energy modelling and what we've learned from the field.

So next slide, please.

2:19:24
So about 20 years ago, I kind of saw that our industry kind of split into two camps here. And this is my kind of funny take on this, is that there's one side that, that that kind of believed that building energy models is the way to go, right? This is based in, in physics. It's been built over, you know, decades of, of, of modeling information. And, you know, physics gives you the answers that you need.

And then there's the other side. There's like, well, you got show me the real data, show me what's coming out of your meter and then I'll believe you, right. So there's the, the meter side of the equation. And their motto is like reality wins, right?

So if you can click 2 times, please, I'll just pull up all the data. Yeah.

2:20:12
So, so both, both camps kind of are bringing really good information to, to make their case. You know you got the years of development of CBECC and energy plus on this side, the old Title 24 is based on energy modelling and you can get down to sort of measure level savings with these energy models. But the meter side folks are saying, well, we've got OpenDSM that that, you know, we got a great presentation from Adam about we have these very robust statistical analysis that we can bring to the table and, and energy data. So really both sides are, are making a good argument about which is a better way to approach this.

Next slide, please.

2:20:54
But the way I see it, the problem is that I think both the approaches are answering half the, half the, the, the, the, the problem. You know, modeling by itself, it can, can be wrong because if you have the wrong assumptions or if you don't know the equipment or the efficiency of the equipment, that can lead you to the wrong answer. You don't know the occupancy and sometimes some things are unknowable. So how do you, how do you deal with that?

But on the meter side, you know, the meter doesn't know anything about the building itself. So it's kind of blind to the asset base of the home or the building and so it doesn't know which upgrade packages have been installed. And so it's very hard to predict future scenarios with a high level of confidence given all the noise in meter data.

So the way I see it is sort of both sides are right and both sides are wrong, right. Next slide, please.

2:21:54

So why does this all matter? Like is it all just academic? And you know, you know, people can argue about this for a long time, but I think it's a really important question because we here in California starting upon just starting this huge direct install program, perhaps one of the biggest in the country or the biggest in the history. And it's really important that we get these answers right. Like which home should we or should get a heat pump, you know what happens to its utility bills and what savings can we expect? And how do we target homes for, for, for installation of heat pumps with these direct install programs?

And my take on this is that you none of these answers can be perfectly answered by either of the two approaches I talked about. So let me present what the way kind of we've been approaching this the next slide, please. So you know, the Xero Home, we've been sort of bringing out this sort of hybrid approach which uses both modeling and energy data.

Can you click next?

2:23:00
So this basic physics-based energy model is, you know, you, you bring in the input, you hit a button that sort of runs the simulation. It's all white box. You can kind of see what's happening. It's all equations, but it gives you an output. But, and that's, that's basically the, the container of, of, of what a physics based approach or energy modelling based approaches.

Next, like next click.

2:23:26
But if you bring in energy data and you can then calibrate that those inputs that calibrate the baseline model, you can actually tweak the inputs going into the energy model. And that will, that'll provide you better inputs and hopefully that gives you better outputs next click. And then at the outcome, like you can, you can look at the energy savings after a year. And you can also validate those savings against what you had predicted. And if you get it right, that's great.

2:23:55
But if you if you don't get it right, next click, please, you can build sort of a feedback loop and say, yes, now we know that something was wrong. You can look back at what this is in over iterative loops of the sort. You can, you can build a pretty robust approach. And this is what's been happening. And we've, we've kind of this is how we wanted to approach this sort of analysis.

So next slide, please.

2:24:23
And so, so my take on this is that utility data informs the model and then the models explain the utility data. So they're both kind of needed to, to get that right answer. And so when, when you kind of frame it the way I've put it up on the screen here, you can see that these two are not competing with each other. These two approaches or these two camps are not, not opposed to each other. They're actually complementary. And that's exactly how we built our approach with Xero Home.

Next slide please.

2:24:59
So Xero Home is a building modelling and energy analytics based company. And we have, we've been around for about 6 years now and we've had an opportunity to model over a million homes here in California. But outside of California as well, with most of the major utilities and some great clients who gave us an opportunity to really take what we were sort of approaching here with and, and our thoughts and, and put those into play.

Next slide.

2:25:30
So what I wanted to bring for today's presentation is sort of the lessons we've learned as we've

modelled homes and put them out there and compared those models to actual energy usage data and, and what have we learned? What have we brought to the table? So there's five lessons and I'll walk you through all 5 as we go through.

Next slide, please.

2:25:49
So lesson #1 is energy data can be used for calibration as I talked about in the earlier slide. But if you look at that slide, you'd think that energy simulation calibration is the sort of very high labor intensive exercise where you have to bring in information about the house and kind of make, make this very nuanced tweaking of, of energy of, of, of modelling inputs. But it can actually be done at several scales. And one of the scales that that we we've really pioneered some work on is calibration at portfolio scale. So with that, what we're what we're doing is a sort of comparing the modelled and measured energy used across a large stock of houses. And what we learn from that we take back to the modelling framework. So there are modelling frameworks like the Title 24 vintage table, which comes from the single family residential compliance manual, which is a reference that we all use for building energy models and also the DOE house simulation protocol. So this is these references, if you look through them, basically tell you how do you model a home accurately and they based off prior data. But if you can bring energy data for your housing stock, you can then refine these, these vintage tables and these, these protocols to, to have a much better starting point for all of your energy models. So next slide, please.

2:27:20
So how would we go about doing calibration at portfolio scale? Well, we figure out there's four steps to it from the first is you, you group your homes by vintage. We have a large cohort of homes. And then you compare our model energy usage to actual data. You adjust your assumptions and you do it iteratively. And once you're satisfied with the with the changes, you kind of improve your vintage tables that you were referencing.

So to be able to do that, we came up with this idea of a calibration coefficient. You basically divide the actual energy usage by the model energy usage and you create this ratio. And if you do it for hundreds of thousands of homes, you can then create a distribution or a histogram. As you're seeing on the right here, that's sort of a theoretical histogram because energy usage data has lots of noise. You're going to get a spread, right? But what you're looking for is the peak of that histogram should be at 1, calibration coefficient of 1, because that's when you have your model agreeing with your energy usage data. So this is sort of a theoretical graph. Now let me show you what this looks like in the real world.

Next slide, please.

2:28:29
So here's information from 100,000 homes that we modeled with in climate zone 12. This is a project we did with SMUD in the city of Sacramento So this is 100,000 homes. So if you look at the graph on the top right first, this is that same histogram and you can see that it's skewed. You want, you want that peak of that histogram to be near the, the ratio of 1, which is the green line, but it's skewed towards the right. The median is 1.5. So we went through this process of iteratively updating our vintage table assumptions into these energy models and over time making these changes. What we got was at the was at the bottom. So looking at the energy data, we were able to change that. And the histogram now is much closer to the theoretical one I showed you in the previous slides. So the histogram is now peaking at 1. So what that resulted in was a 78% reduction in systematic bias. The median moved from one of 1.5 to 1.1 and a 24% reduction in uncertainty.

So huge change just from building a much better starting point for your energy models, right? So now you have a better starting point, you stand in a better position to do analytics for individual homes.

Next slide, please.

2:29:53
So now we can take the approach that most people think about when they think calibration, which is at the individual model level. And to do that, you have the BPI 2400 process from BPI. It's again four steps here. Start with better assumptions. (See my slide for the calibration at portfolio scale.) And then you bring in site level data, right? You bring in that, that information and even site level data can be brought in at various layers. And that'll be my, my next, next lesson here. But third point is you, you adjust your variables, your unknown variables based off of that, based off of energy data for, for those homes. And what you follow is sort of this BPI 2400 procedure and allows you to calibrate. So what does that look like in real world?

2:30:41
Next slide, here's a screenshot from Xero Home. Our tools, our tool can model this. One of the key features of Xero Home is you can type in a home address. This is a project we did with Silicon Valley Clean Energy. We're currently working with them on this. This is a direct install program.

So in the tool in Xero Home, when you type in a home address, it automatically build an energy model for your home, right when you type the, the, the, the address into the tool and it uses publicly available data to, to, to build that model first. And it uses some of the better vintage tables and better assumptions that I talked about in the earlier stuff. So you're starting off with a pretty good, good point. But then you can bring in information that the energy assessor is bringing in from, from the field in this particular case where you're working with Franklin Energy. And their energy advisors would go into to the field with our tool in their hands and they would bring in this information and replace some of the inputs that we had for, for the model. So if you look at the, the, the graphs on, on the top right again of that screenshot, you see these four, four sets of bar graphs, which is heating, cooling, base electric and base gas. And this is our process of trying to calibrate the home.

So before calibration, you can see that the model, the energy use was higher than metered, which is the light blue was higher than the dark blue. And the savings you were getting from a heat pump, heat pump HVAC, for example, for this home was about $923 and 1.49 tons of GHG reduction, which is the tool outputs. So next you go to this process of, of calibrating the home so you can adjust these inputs.

Next slide please.

2:32:26
So now we've, we've calibrated the home right now we've, we've adjusted these inputs to get a much better fit to energy usage data. So post calibration you see all the, the bars line up and the savings have changed. In this case they've gone down about 15%, but they, they can go up or down based on once you've calibrated the energy usage. So it's it, it really depends. We're seeing anywhere between 15% up/down on average in, in terms of post calibration energy usage, but it could be as high as 30-40% as well. But a lot of the times you know, you're, if you're starting off with, with having calibrated at portfolio scale, the adjustments have to be minor. So both these calibration approaches really work well together and we've kind of built a tool around being able to do both these things in in in a very simple sort of easy format.

Next slide, please.

2:33:29
So let's move on to lesson #2 which is every new input data layer reduces uncertainty in an energy model. So one of the criticisms of energy models is that you have a lot of uncertainty because you have a lot of information that's unknown or unknowable, and you're taking guesses at those inputs, right? So the way we approach this is to be able to reduce this uncertainty, you can bring higher and higher levels of input. So we start, as I said, in Xero Home, you type in a home address, it automatically builds an energy model for you. And that's with public data such as square footage, your build, public records about your building, permits for the home, including 3D geometry of the house from GIS databases. So we bring all of that, we build an energy model, but we're taking a lot of assumptions at that point because we haven't knocked on the door or gone into the home. So at

that point we call that the white badge model. So we represent this with three badges at this white badge level, the uncertainty is high as you would imagine, but then when we go to the site, the energy assessor goes to the home and starts collecting input or even the home. The homeowner can answer questions. You start to go from white to green badge, which is data collected on the site. As you build that layer into the energy model, your uncertainty drops, right? It's getting lower. And then finally, we, we have this blue badge, which is when you've calibrated to prior year's energy usage data and that input is, is perhaps the highest level that we can, we can provide. And that's where the uncertainty has dropped to the lowest point. So now you've got a, a well-calibrated energy model to do your, your counterfactual work where you can do the predictions more accurate and more confidently because the uncertainty on that model is much lower. So this is this sort of three badge process is how we envisioned our data collection should be done. And that's we built that into our tool.

So I want to show you what sort of a lesson from the field here. What does this look like in in real world?

The next slide, please.

2:35:37
So we had an opportunity with Southern California Edison for a project we were working with them on for their codes and standards project. And we, we were able to send an energy assessor to seven homes and do an energy audit for these seven homes. And this again has, has great, yeah, I'll build this up. So seven homes that we send these energy audit auditors to and we collected their energy audits. And then we modeled these homes in Xero Home first looking at just publicly available data that's wide badge. Then we looked at the inputs that the energy assessor brought into the table and then we looked at calibrator and see how did the needle move from white to green to blue.

Next slide, please.

2:36:25
So this is the final answer here. So if you look at this graph, it's the Y axis is changed in EUI from the energy model and each of the seven homes is represented in groups A through G and then the three dots are white, green and blue badge model. So white, everything is normalized by white. So everyone's white badge dot is at the 0%. So everything is compared to the white badge. So if you look at home, home A, for example, Xero Home using publicly available data said it's going to be certain EUI. And then when the energy assessor showed up, suddenly we had a big change. 84% difference. Like, Oh my God, we got that very much wrong with the publicly available data. But then finally, when they calibrated, the energy model actually came closer to what our starting point was, which is very interesting.

So that was home A, but you can see home B and C, the bringing in calibration and also assessor data didn't quite move the needle too much, only about 10%. Same thing with home E and G, not much change at all.

But home D was very interesting. When the assessor went into the home and dropped data, it moved the needle by a bunch. But then when they calibrated, they actually came back to kind of close to where we were at the starting point. So it's very interesting how that worked out. So really a lot learned from here. Small data sets, there's only seven homes here, but still quite, quite intriguing.

We're working on a couple of more projects which are much larger data sets at this point, but I don't have permission to, to discuss those yet. And, and one of them is still ongoing. So maybe we'll, we'll have even more data to present in a few months hopefully. But this is, this is sort of a taste of how we are. We were able to kind of look at how bringing energy data can be valuable.

Now this has real consequences to home energy rating and labeling program, for example, because every time you bring in more information, there's a cost to that. You're sending someone over, you're, you're getting that information from the field, you're populating an energy model. And if we can, if we can minimize the amount of work needed at the at the site, we can, we can scale better.

So this is this is kind of work that, that that's really exciting. And thanks to Southern California Edison, we were able to do this first project.

Next slide, please.

2:39:02
So this is just those seven homes again A through G and if you're, if you're curious, what happened to A so it was really interesting. What happened is that we missed the fact that it had solar in the public data. So usually, you know, permit data, you capture that, but somehow that home didn't we didn't capture it. And so as soon as you added solar, the energy was changed, that was home A, but you can see B, C, D, and E these are fairly close between the three bars. The three bars are white, green and blue again. So white is energy model based with automatically developed in Xero Home. The second bar is the energy assessor giving us input and 3rd bar as calibration. So very encouraging that that five out of the seven homes we got pretty close. So that's, that's kind of how we're approaching this next slide, please.

So lesson #3 is that using energy data can be a great way to do some probabilistic analysis of the assets in the home. Like you can detect whether a home has no cooling. Central AC or room ACs or whether they have electric gas heating and you can use that to model, do a better job of modeling your homes. And just we do that by looking at the magnitude and the seasonality and the consistency of weather sensitive loads. And to do this, we could, we could have gone down to the sort of hour level or minute level data, which starts to become a, a, a pretty big undertaking by itself. We stuck with just monthly data for this.

And next slide, please.

2:40:49
So here's what it looks like in the real in the real world. So this is data from another project we did with Southern California Edison. This is the city of Long Beach. And in Long Beach we have this because it's a very mild climate, lots of homes do not have cooling. So we want to identify those homes. So what we, what we did is we sort of built a way of identifying monthly usage pattern for homes with no cooling, gas heating, no cooling, elect heating, elect cooling, gas heating, like cooling, like heating. And you can see this is very intuitive if you look at the way these monthly graphs are. And then we just built that into a statistical model that predicts whether a home has the levels of uncertainty, whether the home has cooling elect or gas elect or sorry, gas heating or elect heating.

Next slide, please.

2:41:44
And then here's the proof. They say proof is in the pudding. So this is this is the there are two graphs here on the left. We model everything first with a really sort of dumb assumption that everybody has central AC and everybody has gas heating. And you can see the histogram. Again, this is the same histogram I shared earlier. The histogram is skewed to the left in this in this, the orange line is where you want the peak to be. And then when we modeled everything based off of the, the type of HVAC system we detected from the energy data, the modeling agreed much better with energy data. So the, the peak came much closer to the, the orange line, which is exactly what we wanted to see. And this was proof that our, our detection was working accurately.

Next slide, please.

2:42:38
So my 4th lesson is that as you might start to think about this as, as you know, you've seen these histograms that they have these long tails that spreads of data. Our lesson #4 was that utility data comes with built in variance. There's a lot of noise in utility data and you kind of have to build tools to be able to, to work with that and, and kind of expect that one of the, one of the things that that builds in this variance is weather impacts. One year can be very different from the other. This graph is just showing the degree days over a period of time and you can see how much variation there is. And the trend is think is going towards harder because you know our climate is heating up. But

effectively one, one year compared to the other can be, can be very variant, can be, there can be a lot of variance.

So that's one next slide please.

2:43:37
And that can result in a lot of difference in energy usage as you can imagine. So just year over year cooling can vary between 8 to 10%, heating is around that same around 9 to 10%. So this is we did some analysis on this just to see how much variance you can expect just from year to year. The other is behavioral impacts. You know, homeowners are going to behave differently. Your children may go to college the next year or some in laws may come visit you and start living with you. Or you might want to change your set points or your set point preferences can change. So just between just for set point preference, we did this, we kind of did the theoretical study. If you change set points +/- 3°, that results in 10 to 17% change in energy usage. Same thing with +/- 5%, it's much higher, about 20-30%. So that that goes to show that we can expect a lot of variance in, in, in energy data just because people are working from home, they're using their set points differently. People operate windows differently and you know, the number of occupants can change and so on.

Next slide, please.

2:44:52
So well, effectively what I'm my final slide here, which is better decisions require both models and measurement and building energy models can explain why a home uses energy and data reveals how a home actually uses that energy. So our take on this is that neither approach can provide the complete picture and what we really need is to combine both these to create a more actionable, accurate and scalable decarbonization analysis. So we believe that that's what's needed for our California programs to be spectacularly successful.

So I'll leave it at that. Thank you very much.

2:45:38
Tiffany Mateo: Thank you, Mudit. Thanks for walking us through your calibration process. It’s a good tie between model based.

OK. I will pass it to Tom Hoff and Brittany Farrell from Clean Power Research to give their presentation the last one of our workshop today.

2:46:02
Tom Hoff: Thank you, Tiffany. Hi, I'm Tom Hoff and I'm the founder and Chief Research Officer at Clean Power Research. Our vision at the company is a clean powered planet and our mission is to provide enterprise-grade software for utilities, the energy agencies and companies involved in the solar business. Today's focus of our workshop is on the bill impacts an analysis of the bill at packs of residential decarbonization. And we've heard very nicely from all the speakers so far that a very key thing in this is customers need to actually purchase technologies to accomplish the decarbonization.

2:46:44
I'm going to, if you move the next slide today, I'm going to agree with that and then also extend it. And so first of all, I'm going to take for an example, I'm going to take a house that we've been monitoring for over a decade that's gone through the electrification. We'll show it's a full electrification including transportation, solar and building electrification. And I want to use this as a baseline, but there'll be nothing not much new in that part of the presentation just reinforces what we've seen. But then it's going to get to my second point where it's there's two things. It's not just what the customers buy, it's how they operate their technologies. And in particular, we'll see how affordability and bill savings effects depends on rates, information available to customers and decisions. And in particular, this whole idea of demand flexibility, how much customers can use these technologies to greatly affect their bills.

We'll then extend this and say when the right price signals are sent to the customer, we'll extend to the grid analysis and look at how does this affect the grid when we get it right to not just get low bills for customers, but actually low impacts on the utility grid and which means benefits for all customers. And we'll conclude off with Brittany talking about a New York case study of how to address this difficult question of how much money do you invest in building shell versus how much money do you invest in building electrification and how do you do this at scale for utilities and agencies.

Next slide.

2:48:11
So the first thing is this, we're going to give a baseline.

So next slide please.

2:48:17
We're going to take a home as an example. And then this is again one we've been monitoring for more than 12 years. It's a pretty typical home if you compare to what Tiffany presented, 45 years old, bigger, a little bigger than what she had, maybe 50% bigger located in climate zone 2. So from a building perspective, it's one of the more challenging climates, not nearly as not the hardest, but the more challenging to make the heat pumps work in this climate.

Before in the electrification, this customer had 6400 kilowatt hours of electricity, a typical use of natural gas and gasoline. And when you put all these units together and say well, let's give let's put everything in the same units, you convert it to kilowatt hours and it's 50,000 kilowatt hours' worth of electricity.

What did the electrification do?

As we see on the next slide that this conversion eliminated all the natural gas through the building electrification, all the gasoline through the electrification of the vehicles, EVs and also efficiency investments on both the electrical and thermal side as well as PV.

2:49:25
And so after investments, this house went down to a net consumption of close to 0. So very successful and see, this just expands what we've seen earlier to add EVs and solar into the picture. So a little bit of interesting, but let's look further at the impacts of this. The greenhouse gas emissions are nearly eliminated. And you know, if we look at what Tiffany presented for this climate zone, the building savings are fairly comparable to what Tiffany presented. And the benefit is the electrification dropped the 12 tons of carbon down to about 3 and then the PV dropped it down to near 0. So how did this house accomplish this?

2:50:08
The next slide shows a little bit of the information and this is where we're going to see. We're going to take all the things that Diana mentioned in the EBD program of heating, cooling, building envelope, water heating, cooking, laundry. We'll also take the stuff Tiffany mentioned of adding insulation, floor insulation, air sealing, and Lisa touched on this a little bit of some of the base load reduction.

So we first of all start with electricity was 6400 kilowatt hours in 2012. Then very simple energy efficiency investments were put into place of some lights, but mainly base loads. And again I was really glad to see in Lisa's presentation the power of reducing idle loads. This more than cut in half of this home the electricity consumption. Then the transportation electrification took about 3000 kilowatt hours to eliminate the gasoline used for transportation. And then the building electrification of limiting natural gas was a heat pump water heater, a heat pump space heater combined with building shell efficiency and electrification of the laundry and the cooking. And the effect is this reduced this down after PV down to near 0.

So again this is a little broader in terms of the technologies what we've seen, but consistent what with what we've seen from other presentations. So let's move to the next section.

2:51:37
This section I want to really emphasize, while it really matters what customers purchase, it also really matters how customers operate their technologies. And in particular the demand flexibility is one way to maximize savings. And so I want to make this illustration.

2:51:56
So let's go to the next slide and we'll take this home. And the value of this home that we've been monitoring for a long time is we're going to have a nice case study to see what the impact is of customer behavior on bill savings. So when this customer started they were on a NEM rate structure and back in 2016 their bill was about $550 under NEM. And because the customer had had solar for long enough, they were at, they hit the 20 year term and were moved off NEM to the solar billing tariff.

And the impact of this was very large because with net energy metering, customers don't need to pay much attention to when they consume energy. The solar billing tariff, however, requires customers to pay close attention to when energy is consumed. And in fact, if you take the 2016 load data under the NEM structure, it was a $550 bill. If the customer would have done nothing, they would have had a bill that was four times as high of $2000. So let's look at on the next slide how this begins to stack up.

Next slide, please.

2:53:03
So with the first information is again we looked at, Jason talked about the AMI data that we have, which is very valuable data for us to understand what's going on. That AMI data however is net load data. And so we can see on net what happens to customers, but we don't see all of the full picture what's going on behind the meter. So on that net load data, we can see this customer consume $2300 of energy from the utility and the utility gave a $242 credit. So this is where we get our $2000 bill.

Now what we want to do and I appreciate Mudit's example of the customer with solar, how that kind of messes up the analysis with these things. We want to take the load data, the net load data and we want to reconstruct to add solar back in and we can do this is on the next slide. We can do this in a couple of different ways. One, we can measure the PV output at site. Second thing is we can take some of our tools, take specifications of PV and simulate the output and then add it back in based on some of the other tools we run for utilities, our power clerk tool of where PV specs are, or third, we can infer this information directly from the net load. And when you do this, we can see that this customer when we expand a little bit, they were saving about $771 from the PV and spending $2300.

So not quite the benefit the customer would like, but still it's hard to make a decision of what can the customer do about this. And this is where we take our FleetView tool on the next slide and expose the information deeper. And we disaggregate the key components of the load of the HVAC, electric vehicles, TV and other and into how much load is consumed. And now we can see this customer. The most interesting part of this graph is the customer used was paying almost $1000 for EV charging to the utility, but was only charging $118 with the EV, the green area in the top of the chart. And that said, there are actually things the customer can do about this.

So next slide and one and one more.

2:55:22
So the utility bill of 2016 was $2000. Based on this information, starting in 2025, the customer altered consumption patterns and specifically made sure water heating was charging during the middle of the day, precooled the air conditioning, used air conditioning to precool the home to have that basically solar powered and to charge the electric vehicle on excess solar production rather than charging it randomly throughout the day. And as we can see, this is a huge impact for the customer. So a $2000 bill is cut to $1000. And I think this is really important because a lot of our analysis only look at what the customer purchases, but it doesn't look at how the customer can operate these technologies. And with technologies that have flexibility, especially electric vehicles and water heating, but to some

extent air conditioning, there's a lot of flexibility we can then have if the right price signals go to the customers. In this case they were, we see a huge reduction in an energy bill. So let's extend this a little bit farther.

And next slide, please. And one more.

2:56:40
So this is very interesting from the customer's perspective by behaving in a certain way, they can experience large savings on their bill. Well, let's put our hat on for the utility and look at for the rest of the grid of what did this do for the rest of the grid. So we go back and this is, this is hourly load data, hourly net load data in starting in June 2016. The red area is summer months and the blue is winter and we can see that these 8760 hours go up and down and up and down with especially during the summer. There's lots of seven kilowatt peak loads in there and if those seven kilowatt peak loads occur at the wrong time, this will stress the grid and our concerns about electrification forcing a lot of investment on the utility side could come true.

2:57:28
Conversely, next slide, let's say what if we implement demand flexibility, which is what this customer did and again it's water heating during the middle of the day, re-cooling with air conditioning and charging the electric vehicle on excess solar, we see a very profound change. And if we draw a line at one kilowatt and we see in 2016 how much energy was needed to meet all load above 1 kilowatt. So basically how much battery would you need? You need 1000 kilowatt hours versus in 2025, you only need 7 kilowatt hours for the entire summer. So basically almost nothing. That's very promising just to see these great load reductions, but let's dive into those peak load days a little deeper. So the first day is the peak load day for 2016. And this is where we see our worst fears come true. The customer charged, probably charged EVs during the middle during the day and they this probably helps stress the grid and a lot of energy would have been needed to offset this effect of the EV charging. In comparison on the 2025 day.

Next slide, we see no impact.

2:58:41
So it looks like nothing's going. Nothing is going on from the utilities perspective of this house, there's nothing above 1 kilowatt. But our next slide shows in fact there's a lot going on in this house.

2:58:51
The solar is producing well in the green line. The water heating is heating water during the middle of the day. The precooling in orange is keeping the house cool and the purple the E VS charging in the sufficient number of amount to go and provide energy for 12,000 miles worth of driving. So this is again a great outcome of that. We can actually see there's potential for customers to make decisions that can actually impact their own bill, but also the grid. And at this point, let's move over to Brittany and oh, actually this is 1 last slide.

2:59:27
If you take a million of these homes and you put them on the grid and said, let's add a million of these homes to Cal ISO on the peak load day, not get rid of them, but add new million homes, there's no impact. There would have been no impact on the peak load day for 2025.

So let's move to the next slide.

2:59:45
And Brittany, why don't you step in and take over? And she's going to talk about the challenging area of how do you balance heat pump equipment purchases versus building shell efficiency investments?

2:59:59
Brittany Farrell: All right. Thanks, Tom. Hi, I'm Brittany Farrell, and I'm a senior researcher at Clean

Power Research. So I've been working with an upstate New York utility for the last several years to model customer energy use. And today, I want to share an interesting case study with you. Next slide, please.

3:00:16
For our New York project, we're focused on the existing housing stock, which has a large range of homes built in different eras under different standards. I want to focus on two homes to demonstrate how we can meet customers where they are with their existing home. So these two homes are both located in the same New York town and are of similar size, format, and build date. These homes both participated in a weatherization program where they had about $10,000 of investments including air sealing, wall insulation, and attic insulation in similar quantities. The contractors estimated that these homes would both save 78,000,000 BTU of natural gas per year, and those estimates are based on calculations and models from the New York Technical Resource Manual based on the build date and square footage, this assumed significant air leakage and uninsulated walls. So let's look at their energy use on the next slide. In the top graph for Home 1, I'm showing the natural gas average use in BTU per hour in the color bars, and the line is the average outdoor temperature. Blue bars preceding the vertical line are before weatherization, and orange data are after weatherization.

For Home 1, we don't see a huge difference in natural gas use before and after the weatherization. There may be a small decrease, but we can see that it was slightly warmer that winter. However, for Home 2, we see a large decrease in energy use before and after weatherization. So let's take a closer look. Next slide, please.

3:01:45
In this slide, I've rearranged the same data to show you the natural gas energy use as a function of outdoor temperature. And those are the orange points. And I've also added the electric use in blue, as well as the models that we developed before and after weatherization for each home. And those are the lines you see.

For Home 1, the natural gas model doesn't change very much, and the model total energy savings is about 6.5%. Whereas in the second graph, Home 2 has a large change in use corresponding to a large change in the natural gas fuel rate, Home 2 had a total modeled energy savings of 32%. Looking at this data, it's a fair conclusion to say that this program wasted quite a bit of money on Home One doing weatherization work with little impact. And this money could have been spent, better spent on electrification measures. Next slide, please.

3:02:38
So how can we avoid that? Well, one way is to utilize a metric based on the home and its actual energy use. So we have a metric that we call the effective R value that's based on the heating rate of the home and an estimate of the exterior surface area. This metric is very similar to R values used to rate building materials, where a window might have an R value of one or two and an insulated wall 15, etcetera. For these two homes, the effect of R value before the weatherization was 7.1 for Home 1 and 3.5 for Home 2. Now I can tell you that 7.1 is reasonably high for 100-year-old home like this one, and I would likely not recommend weatherization measures unless there are specific homeowner concerns.

However, Home 2 has a lot of room to improve. 3.5 is roughly the R value that we would expect from an empty, uninsulated wall and we can see that the R value improved relatively dramatically to 5.7 with this weatherization work. These effective R values are really useful to compare homes, communicate efficiency and serve as a simple noninvasive way to understand a home's needs and qualify customers for the right program. Next slide please.

3:03:48
We've calculated models for over 250,000 New York homes using monthly utility usage data. This graph is a histogram of the effect of R values, and although most homes are above a 6, there are a number of homes on the left side of this graph with low efficiency that could really benefit from weatherization. Homes on the right side of the graph already have thermally efficient homes, and

they can consider electrification measures. These bulk models allow the utility to quickly and relatively inexpensively understand which homes can benefit most from weatherization and can tailor their programs and messaging accordingly. For California, Jason described how the CEC has monthly natural gas data for a large percentage of customers. This data could be used to form perform a similar bulk analysis, determining which customers use natural gas for their primary fuel source, how much natural gas they could save through electrification of that system, and if they should consider weatherization as a first step.

Next slide, please.

3:04:50
So New York has some aggressive decarbonization goals. And of course, they're also trying to balance those with affordability. They're really interested in spending dollars where they can be most impactful and engaging customers where they are to guide them to the right program. The energy modelling and effective R value data helps the utility help their customers make smart energy decisions. And the utility is also able to understand the impact of those programs that target home thermal efficiency improvements through follow up modelling. And so now I'll go ahead and hand it back to Tom for some overall conclusions.

3:05:26
Tom Hoff: Thank you. Next slide.

3:05:27
So as we conclude, we can see that consistent with others in this whole workshop, intelligent investments can cost effectively reduce GHG emissions. We've also shown that there's another step to be taken to take the right information, to not just invest correctly but operate the technologies to the greatest benefit of the customer. And third, we showed that when this is done, this can have tremendous value to the grid as well as the rest of the customers in the grid. And finally, we close off with tools of how to target some of the electrification investments.

And with that, thank you for your time.

3:06:07
Tiffany Mateo: Thank you, Tom and Brittany, that was great. OK, all of the presenters have presented. I will open it up to the final Q&A and public comment period. Larry, are there?

3:06:30
Larrry Froess: Yeah, there's one question for Mudit: During your slide presentation, Meredith is asking you how do you recommend communicating these findings about uncertainty to home residents hoping to make decisions about electrification?

3:06:43
Mudit Saxena: Yeah, great question Meredith, one that deserves a much longer answer than I can perhaps give right now. But this is, this is a very important part of it. So first I would like to say that the way, you got to define like what is the, what was the use case here? If you're, if the idea is to help the homeowner in sort of directionality, like to help them understand that is heat pump, considering heat pumps the right thing for you, given the vintage of your home, given where you are, your location, your climate zone, your utility bills that you're paying? And then even at, at sort of a slightly lower than sort of the highest level of, of, of accuracy and energy modelling can perhaps be sufficient for you to, to make that determination. The way we do that in the tool is using these badge systems. We kind of educate the user about what these three badges are, and we encourage them to go up the badges, right. So if I can answer more of your questions, there's 13 questions that the home owner can answer on our tool. So there's a, there's, I didn't quite explain this, but Xero Home has a home owner facing portal, which the home owner can come in and answer 16 questions that we've curated for them to, to kind of get that green badge. And then they can also give us access to the energy data to, for us to calibrate their home. So we always encourage the homeowner to go up

the badges. They start with the white and they go to green and go to the blue. But it's, it's, it's all within the homeowner needs to understand that if, if they want to get that sort of, a highest level of accuracy, they need to go all the way up to the, to the blue badge. But a lot of the homeowners that we've been able to interview that have used our tool, we do this constantly, we talk to homeowners that use our tool. They, they've, they've told us that they were happy to answer like 5 or 6 of those questions and they felt like they, they were able to put in some input and, and get some, some data out of the tool. So it, it really is about communicating to the homeowner that the more time you spend on collecting more information, doing that a higher level of analysis, the more accuracy you will get. So that's kind of where I would land on this question. But thank you for, thank you for asking.

3:09:13
Larry Froess: OK, great. And Felicia has a question for Brittany: Great presentation and important results. Can you speak to the potential for homes to still benefit from interventions like air sealing from an air quality standpoint?

3:09:28
Brittany Farrell: Sure. So, I think a lot of homes could probably benefit from some amount of air sealing. It's one of like the highest impact but lowest effort things that you can really do, especially if you know that you've got, you know, some drafty windows or can feel air coming from any part of your home. And especially in climates that are more humid, it's really important for to have a good amount of air sealing so that you're you don't have moisture issues. As far as what we're doing with these virtual energy audits where we're using utility data, we can't necessarily see exactly what's coming from the air infiltration versus what's coming from the home's lack of insulation. And so, but we do see that there are trends, right? So most homes that have really good insulation already have fairly good air sealing and vice versa. So I guess that's kind of what I would say is that for homes that are up on the upper end of the scale, it's really sort of a personal choice if they're having, you know, some uncomfortability in their home or they can feel drafts in certain places. And then on the lower end of the spectrum, you should pretty much always do air sealing. Most older homes are going to have air sealing issues. So hopefully that answers the question.

3:10:55
Larry Froess: OK, thank you. And there's another one which I'm not sure we can answer. If somebody knows when will the recording and transcript of this presentation be available to the public?

3:11:08
Tiffany Mateo: I don't know exactly when. It will definitely be made available. I think our turn around goal time is maybe a week, but I'm not sure.

3:11:21
Larry Froess: OK, so that's all of the written questions. Now we can open it up to people that if they want to have a verbal question, oh wait, there's one that's came in. And so if people want to talk, go ahead and raise your hand in the on your list and we can unmute you to speak.

3:11:37
But here's the last question: Building on the previous question, I have a question more generally to the panel. Many analyses were shared today. Which of the analysis are most appropriate to help potential EBD participants understand potential bill impacts from participation? Will that be the guide house customer electrification estimator? Many CBOs I'm working with on EBD have concerns about bill impacts.

3:12:03
Tiffany Mateo: OK, good question. I'm wondering if Diana's still available. I can say, oh.

3:12:17
Yu Hou: Can you hear me?

3:12:25
Tiffany Mateo: Yes.

3:12:26
Yu Hou: Yeah, so as Diana mentioned in that, in the presentation, right, there, there are a couple things happening with the EBD Program from the design, to targeting. I think if I heard you correctly, your question is about individual customer bill impact that I think those will be like the Snugg Pro tool will be used for the EBD Program for all three regions at the customer level to do some bill projection and forecasting for the retrofit package that they're selecting. And then I agree that is also what we want to do. It's to really support customers and to help them understand the impact of their retrofit to minimize their impact.

3:13:33
Larry Froess: So great. Thank you. That's all the questions. So we can open it up to talking. If you want to raise your hand, if anybody has a question, I can unmute you to talk and just make sure you indicate what presentation your question is about. We'll give it like 30 seconds for anybody to ask.

OK, Megan has a question. I will unmute you.

3:14:22
Megan Phelps: Thanks for that. Just a follow up question to Yu’s response. Can you repeat the tool that you referenced that would be used to help customers understand their individual bill impacts?

3:14:40
Yu Hou: Snugg Pro. Someone typed that tool in the chat as well.

3:14:45
Megan Phelps: Thank you.

3:15:10
Larry Froess: OK. Final call for raising hands. OK, Tiffany, I guess it's back to you for the closing remarks.

3:15:23
Tiffany Mateo: OK. I do see one more question in the Q&A.

3:15:24
Larry Froess: OK, will there be continuous validation/calibration of Snugg Pro during the EBD program?

3:15:43
Yu Hou: I, I want to understand why you mean by calibration of Snugg Pro and we also have, you know, the Snugg Pro folks on the call. If you mean calibration of the software itself, as they are collecting, are they seeing more field data or I want, and then that's separate from there is going to be measurement verification work that the EBD Program itself is going to do, to look at the impact. So I want to understand is your question direct to the software itself, the calibration of software itself? I don't know is this can we do a live like a raise hand or?

3:16:42

Larry Froess: No, they're anonymous. I don't know if they can. Oh, there is Meredith. Ok here, unmute. Larry Froess: Hey, Meredith, you're unmuted if you wanted to ask your question.

3:17:25
Yu Hou: I'm not hearing anything. Yeah, it looks like looks like she's still on mute though, from at least from my end. OK, now it looks better.

3:17:38
Larry Froess: OK. Larry Froess: Mark had a question too: How are teams estimating energy bill impacts using the actual rates today as well as the electricity and gas price forecasts? A static escalator may not work and there are high variations by fuel and utility out until 2045-2050+.

3:18:03
Tiffany Mateo: Yeah, I know for our analysis, the CEC analysis, we just looked at, you know, snapshot of the rates. We didn't look at price forecast. I don't know if any of the other presenters want to chime in if they have looked at great forecast in their analysis.

3:18:42
Karen Maoz: So in for the CPUC we did put in, we have pre basic service charge and post basic service charge. So it has been updated using actual rates.

3:19:04
Larry Froess: OK, thank you. Larry Froess: And Meredith's mic is not working, but her question is, will post installed data for the EBD program be used to validate the bill impact estimates while also acknowledging that behavior, use and other variables have a big impact?

3:19:24
Yu Hou: Validation means very different to different people. To me, validation, it's a typical use for model validation, right? You, you, you mathematically verify your answers, then you use field data to validate your, your modeling.

What I'll say it's the EBD Program will conduct M and Vs, and we'll look at our impact and we'll look at, understand different retrofits, building types, measure packages will have impact on energy consumption, GHG reduction as well as bill, but not necessarily go back for example to say Snugg Pro or anything else like you need to use the field data to modify your software in any way and that's not part of the, the, the scope we're considering. I hope that answers the question.

3:20:27
Robert Buchanan: I will add that Snugg Pro has gone through a couple of utility program evaluations and historically Snugg Pro underestimates savings or bill impacts for the highest users. So for, for, you know, the users within the, the, you know, two or three standard deviations in normal our, the, the evaluations of Snugg Pro have borne out that Snugg Pro is fairly representative of those of its, of its energy impacts, modelled energy impacts.

3:21:10
Larry Froess: OK. We're at time, but we got two more questions here. Mark asked: This seems like a very significant aspect of savings that would undercut, undercount the value of avoided fossil gas consumption and those rates potentially outpace electric rate increases for the CEC electric/gas price forecast published in the IPER. So I think that's just a comment

3:21:31
Larry Froess: Then Felicia has one: Given the previous answers about future rates, will the CEC conduct some sensitivity analysis to look at the impacts of future gas rates on the affordability results from the various modeling work?

3:21:59
Tiffany Mateo: I, I don't know if we have plans to do sensitivity analysis but one thing we were thinking about was in our bill impact analysis, was to add the ability to put like a percentage change in rates, both for fixed charges and volumetric charges, both on the gas and electricity side. We, but that was just a brainstorm. So I'm not sure how that will roll out in the future.

3:22:44
Larry Froess: OK, if there's any last quick questions. Otherwise, back to you, Tiffany. And no one has their hand raised. No more questions.

3:22:54
Tiffany Mateo: OK, well, great. I'd like to thank all the presenters. Thank you very much for participating in this workshop and taking the time to make your slides and to be here today. Really appreciate it. Thank you to the attendees for joining. And yeah, that that will close off our workshop. Thanks everyone.