Emission Benefits of Energy Efficiency and Renewables

Webinar Transcript

April 18, 2019

Contents

This transcript reflects the statements made during a live webinar on April 18, 2019. The transcript has been reviewed for accuracy. Any grammatical errors or otherwise unclear passages are true to the statements of the presenters.

State and Local
Energy and Environment Program

I. Introduction

Slide 1. Emissions Benefits of Energy Efficiency and Renewables

Operator: Good afternoon ladies and gentlemen. My name is Ryan, I will be your conference operator for today. At this time I would like to welcome everyone to the Emission Benefits of Energy Efficiency and Renewables conference call. All lines have been placed on mute to prevent any background noise. Should you need any assistance during the call simply press star then the number zero on your telephone keypad and an operator will come back to you to assist. It is my pleasure to turn the call over now to Ms. Denise Mulholland. You may now begin the conference, ma'am.

Denise Mulholland: Thank you so much. Good afternoon everyone and welcome to the webinar. My name is Denise Mulholland and I'm with the U.S. Environmental Protection Agency's (EPA's) State and Local Energy and Environment Program. Our program works to support state, local, and tribal governments who are designing, analyzing, and implementing programs that reduce the environmental impacts of their energy use. We know that many of you are thinking about how to quantify the energy and emissions benefits of energy efficiency and renewable energy, and we're hoping today's webinar will help inform your efforts going forward. Before we get started I'd like to turn it over to Alexis St. Juliana who's going to give us some information on how you can participate in the webinar today. Alexis.

Slide 2. How to Participate

Alexis St. Juliana: Yeah. Thank you, Denise, and thank you everyone for joining today. I'm going to go over some quick housekeeping items. The first is that there are two options to listen to today's webinar. The first is through your computer, just please make sure your speakers or headphones are unmuted. The second option is to call into the phone number that is on the screen right now. You may need to mute your computer speakers if you use that option. All participants whether they're connected via the phone or computer audio will be muted throughout the duration of the webinar.

Slide 3. How to Participate

Alexis St. Juliana: There are three different ways to participate today. The first is that you can enter questions into the question and answer (Q&A) box on the right side of your screen. If you could please let us know who your question is for and we'll moderate all the questions at the end of today's webinar. Any questions that we don't have time to answer we will post to the EPA website after the fact.

And one other thing to note about today's webinar software is that all hyperlinks that you see on your screen are active, so if you see a hyperlink and it's something that you would like to explore go ahead and click that link and follow it to the web page.

Slide 4. How to Participate

Alexis St. Juliana: The second way to participate today is through polling questions. It should be fairly simple to participate, but if you happen to be on a mobile device or tablet you may need to exit out of full screen mode and tap on the poll icon which looks like a small slip of paper dropping into a ballot box.

And then the third and final way to participate today is by completing our webinar feedback form. You should be able to see the link to that in our Q&A box, and well also post it at the end of today's webinar. That's all I have, Denise.

Slide 5. Today’s Agenda

Denise Mulholland: Okay. Great. Thanks Alexis. Okay. Well now that you all know a little bit of background about me and our program and you've now heard how you can participate in the webinar, we wanted to start with a poll to learn a little bit about your experience estimating energy and emissions benefits from energy efficiency and renewable energy.

I. Poll Question I

Slide 6. Poll 1

Denise Mulholland: So we're going to pull up a poll question that should be coming to your screen; and essentially we're looking to find out are you new to this type of analysis, have you estimated just energy benefits before, maybe you've estimated just emission benefits, maybe you're familiar with estimating both energy and emissions benefits. So, if you could just take a take a few seconds and answer our poll it'll just give us a sense of everybody's level of experience.

Okay. So it looks like we have good split: a lot considered new to this type of analysis and then some that are familiar with it. So this is a nice range of folks to have on the call and we're hoping that we can increase everyone's knowledge about quantification a bit this afternoon. So, the way that we're going to work from here is that I'm going to start the presentations today by giving an overview of a resource that EPA recently updated called Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments.

I. Denise Mulholland, Environmental Protection Agency

Slide 7. Methods for Quantifying the Emissions Multiple Benefits of Energy Efficiency (EE) and Renewable Energy (RE): A Guide for State and Local Governments

Denise Mulholland: You can use this Guide to learn more about different methods and tools that you can use to quantify energy and emission benefit, and speakers after that will be talking about the methods and tools. We do have a great lineup of analysts that are going to talk about their own experience quantifying energy and emissions benefits from energy efficiency and renewable energy and they're going to be describing how they've used a range of basic to sophisticated methods and tools that are also described in the Multiple Benefits Guide that I'm going to talk about first. So, without further delay I'm just going to jump right into the overview and give you information about the Multiple Benefits Guide.

Slide 8. EPA’s State and Local Energy and Environment Program

Denise Mulholland: So this is just some information about the program that I told you that I work for. Essentially we work with state, local, and tribal governments and we provide tools and information resources to help them, among other things, quantify the impact of their energy efficiency and renewable energy strategies that they're considering.

Slide 9. Quantifying the Multiple Benefits of EE/RE: A Guide for State and Local Governments

Denise Mulholland: The resource that I want to talk to you about today will give you a lot of information about methods, tools, and data sources that you can use to do your own analyses of emissions benefits from energy efficiency and renewable energy. The Guide is divided into two parts. The first part really talks about sort of what, why, and when you would quantify the multiple benefits of energy efficiency and renewable energy. And then the second part really gives you information about how to quantify them, so the different methods, tools, and steps that you can use to quantify the benefits. Our goal is really to make it easier for you to understand the process and help you compare across different methods and tools and choose the appropriate one for your purposes. And I (will) dig in a little bit about each of these areas of the Guide.

Slide 10. Part ONE: What Are the Benefits of EE/RE?

Denise Mulholland: So in the first part we talk about what are the benefits of energy efficiency and renewable energy? So essentially you have: electricity generation is reduced through energy efficiency and you increase the generation of renewable energy resources. That can lead to reductions in emissions, which can improve public health. It can also enhance the electricity system which reduces the cost of electricity service and avoids the need to build new transmission and power generation sources. It can also boost the economy by creating jobs and saving money. And so collectively energy efficiency and renewable energy can generate great benefits to society, and we talk about that in the Guide.

Slide 11. Part ONE: When to and Why Quantify Multiple Benefits?

Denise Mulholland: And then we also talk about when and why you would quantify multiple benefits. So there are essentially two points that we'll talk about. When you're designing policy options, you're considering a whole list of different programs that you might implement. That's a good time to really stop and think about what are the potential impacts of these options that I'm considering and how much will they bring me closer to the goals that I'm trying to achieve, what kind of benefits will they deliver for us? And then it's good to go back after you've evaluated policies and programs or after you've implemented them to evaluate the impact. Did they meet your goals? Did they get you what you were looking to achieve? And if not, maybe you need to modify the design of the policies or programs.

Slide 12. Part TWO: How to Quantify Multiple Benefits

Denise Mulholland: So once you get to part two of the Guide it really talks about how you can quantify multiple benefits. And so from here you have--with any analysis you have - key considerations, so you're going to identify the purpose, the priorities, and the constraints that you have for your analysis. It's important for you to understand the different types of methods that you have available to you, and I'll talk a little bit about that in a few minutes.

And then it's important upfront to map out the strategy for the analysis. From there you'd quantify the direct electricity impact, that's really the foundation for any subsequent benefits analysis is figuring out what are the electricity impacts that you're going to then use to quantify the electricity system benefits, the emissions and health benefits, or the economic benefits; and together you can use that benefits information to support informed decision-making.

Slide 13. Choose a Method for Quantifying Impacts: Key Considerations

Denise Mulholland: Part of choosing a method for quantifying the impact, there's some considerations that you'll think about, and those include what benefits do you care about? For example, in this call we're talking about emissions benefits. What level of rigor is needed: is it a screening level analysis or a more rigorous regulatory impact analysis? What is the time period of the analysis: is it short-term or is it a long-term type of analysis? What kind of data do you need, what kind of data do you have? What are the financial costs or technical expertise required of a particular method, and what resources do you have available for it?

Slide 14. Map Out the Benefits to Quantify

Denise Mulholland: So these are all things that you'd have to consider regardless of what analysis you're planning, but you can then use the Guide to map out the different benefits that you're going to quantify and then look at the methods that are available for you.

So this schematic right here just depicts the different chapters in the Multiple Benefits Guide and shows you how, starting with direct electricity impacts at the top, you can quantify either electricity system benefits, the emissions and health benefits, or economic benefits. And today we're going to be focusing on these top two boxes really or the top box electricity benefits and the emissions benefits. In each chapter you'll find step-by-step instructions, as well as a range of basic to sophisticated approaches that you can use. We have key considerations that give you tips on what to do with your planning and conducting your analysis, as well case studies and lists of tools and resources that are available for your purposes.

Slide 15. Estimate Direct Electricity Impacts

Denise Mulholland: So here is just an example of something coming from the chapter on estimating direct electricity impact. You have options when you're at this point of an analysis. You can either adapt existing studies that others have done for similar programs for different energy efficiency or renewable energy programs maybe in a neighboring state, and then you can just adapt it to your own conditions or your own assumptions. You can also use data from energy efficiency or renewable energy potential studies to sort of set some targets and some goals for what you'd like to achieve through your policy or program.

Or you can conduct your own new analysis using different methods and tools that are available, but essentially there's a range of assumptions that you would need to consider, and you can find more of them in the Guide. But, for example, it's the program period, how long will this program be in effect, what is the target of the program, what is the anticipated compliance or penetration rates? So basically, how many people do you think you're going to reach through your program, how long are there savings going to last? This is particularly important for energy efficiency, these are things that you need to be thinking about; and the Guide describes these assumptions that you need to consider with information about specific ways that you can think about it.

Transmission and distribution loss, there are things that you can calculate into your estimate, so you want to take it into account. And also other assumptions like funding and program administration; how is your program going to be funded and does that take away from the amount of money that you might actually put towards the program? So there's a variety of considerations that would go into your estimation of direct electricity impact, and you can learn more about those in the Guide in chapter two.

Slide 16. Compare Quantification Method(s)

Denise Mulholland: When you get to the point of looking at your methods you want to compare across the different emissions quantification methods that are available; and essentially we have throughout the different chapters--but certainly in the Emissions Quantification chapter--a range of basic to sophisticated methods that you can choose. And so 'basic' includes methods that are relatively simple, static approaches, they're factors that you might multiply by your electricity savings. An example of that is Emissions & Generation Resource Integrated Database (eGRID) that Jeff will be talking about soon after me.

An intermediate approach is a bit more dynamic and has a bit greater level of detail, it gives you a bit more information about the types of impacts that you're going to get from your energy efficiency or renewable energy investment. An example of that is EPA's AVoided Emissions and geneRation Tool (AVERT) model, which you'll hear Eric Shrago talk about his use of that in a little bit after me.

And then at the other end of the spectrum is sophisticated modeling, which is more dynamic, more complex, can be used for short or long-term analysis. And an example of that is JuiceBox, which David Abel will be speaking about his experience using that sometime during today's webinar.

Slide 17. Tables in the Guide help you compare methods in more detail

Denise Mulholland: So there's a range of approaches that you can choose and there's lots of tables in the Guide that can help you compare across the different methods in more detail and tell you what the strengths are, limitations, when you might use them.

Slide 18. Use Flowcharts and Figures in the Guide to Navigate the Process

Denise Mulholland: An example, there are also lots of flow charts and figures that can help you navigate the process and figure out in a stepwise fashion what do you need to do given the approach that you've chosen?

Slide 19. Explore Case Studies

Denise Mulholland: And there are a lot of case studies that you can look to see how others have quantified similar types of policies and programs through their analysis.

Slide 20. Learn About Available Tools & Data Resources

Denise Mulholland: And finally, there is information about available tools and data resources that you can use for each chapter and for each step of the process that we've describe for you.

Slide 21. For More Information About EPA’s Program, Tools, and Resources

Denise Mulholland: So, with that there's a link to the Guide right here that I think you can link to, and we'll be posting the slides so you can certainly find it here or by Googling it or looking at our website. But essentially, I hope that you can look to this resource as something that can guide you in your efforts to quantify electricity and emissions benefits of energy efficiency and renewable energy.

II. Poll Question II

Slide 22. Poll 2

Denise Mulholland: So thank you very much for your time. I think what we have at this point now is another poll. So, we have a second poll, and this poll is just going to help us know a little bit more going forward what you'd like to learn about. So the question here is what information on approaches for estimating energy and emissions benefits would you most like to learn?

So, I talked about the screening level and intermediate level and advanced approaches for estimating energy or emissions benefits. And you can choose as many as you like, I think, for this one, but select which ones that you'd be interested in learning more about and that can help shape future webinars as well as future materials that we developed for our audience, for you.

So far the biggest interest is in intermediate level approaches. So, okay, so we're looking at intermediate for both energy and emissions benefits. Okay. Well great. Well thank you very much, that's really helpful, and we'll use that information going forward.

I. Jeff Haberl and Juan Carlos Baltazar, Texas A&M

Slide 23. Energy Efficiency and Renewable Energy Impacts on Nitrogen Dioxide Emission Reductions in Texas

Denise Mulholland: So at this time we're ready to move on to our next set of speakers and sort of begin the part where the analysts will talk to you about their experiences. So, in the first presentation we have Dr. Jeffrey Haberl, who is the Professor of Architecture and Associate Department Head for Research in the Department of Architecture at Texas A&M University. His work emphasizes building energy modeling, statistical modeling, and many other things, but particularly procedures for calculating air pollution savings from energy efficiency and renewable energy projects. He is also the Co-Principal Investigator (PI) of the Laboratory's Texas Emissions Reduction Program, which he will be talking about.

His associate Dr. Juan Carlos Baltazar is an Associate Research Engineer, and his area of expertise is in renewable energy systems and energy use efficiencies. He's got extensive knowledge of solar thermal systems and over 25years of academic research in this field and he's developed his own software programs for energy analysis and simulation. So they're going to speak to us today about their efforts to quantify nitrogen dioxide emission reductions from energy efficiency and renewable energy in Texas, including through the use of one of the basic methods that I mentioned earlier, eGRID. So with that I will turn it over to Jeff and Juan Carlos.

Jeff Haberl: Okay. Well, good morning everyone.

Juan Carlos Baltazar: Good morning.

Jeff Haberl: We're going to take a few minutes and give you some idea of what we've been doing here in Texas. Just a couple of things, I'm no longer Associate Department Head and Dr. Baltazar is actually a professor in architecture, so I see we've got some web page maintenance to do right there.

Slide 24. Energy Efficiency and Renewable Energy Impacts on Nitrogen Dioxide Emission Reductions in Texas

Jeff Haberl: I'd like to talk today about a project that we've been working on in Texas now for a number of years since 2001, the Texas Emissions Reductions Program; and as part of that I need to acknowledge a lot of input from our staff and students here. The Co-PIs on the program ares myself, Dr. Baltazar, and Mr. Bahman Yazdani, and we've performed different aspects of the work. In addition, we have a number of staff and students.

Slide 25. Acknowledgements

Jeff Haberl: This is an example of some of the people associated with it: I'm on the left there, Bahman's the next to the left, and Professor Baltazar is next to him. We also have Gali Zilbershtein, we have Shirley Ellis, Patrick Parker, and Angela Rowell on our team. And we are privileged to have a number of very talented students that help us out with the work as well. Shown there is Minjae Shin, who's now Associate Professor at the University of Alabama, Farshad Kheiri and Qinbo Li, who both just received American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) scholarships recently, Sungkun Jung, and Chul Kim who's been working with us currently on our program. So this is a privilege to really present the results of a number of people that are working on the program.

Slide 26. Summary

Jeff Haberl: So I really tried to summarize some of the information up front so that you can get a sense of what I'm going to be presenting. So a couple of the questions that we were asked is what policy or program are we analyzing? So if you've heard, we're analyzing the Texas Emissions Reductions Program. This is funded by the Texas State Legislature; which means, of course, we report annually to the Texas Council on Environmental Quality (TCEQ). So everything I'm talking about today is online on our lab's website, if any of you have trouble sleeping at night I would strongly recommend you download the reports and they'll put you to sleep in a jiffy.

The benefits included and why? Well nitrogen oxide (NO_x) emissions reductions are important in Texas, we have ozone problems in a number of our large metropolitan areas and so reducing the oxides of nitrogen is important for clean air in Texas. Our results are used by the Texas Commission on Environmental Quality, TCEQ, for weight of evidence in the Texas State Implementation Plan. Similarly, as part of our program we tried to have outreach, so we've developed a number of conferences for that; our annual conferences so far have been the Clean Air Through Energy Efficiency, the Clean Air Through Energy Efficiency (CATEE) Conference, which we've now relabeled as the Texas Energy Summit to be a little more broad-based.

We've also developed a number of online of web-based tools: an international co-compliance calculator for calculating emissions reductions from building codes, and our NO_x emissions calculator which we're in the process of retooling and we'll have available shortly.

Slide 27. Summary

Jeff Haberl: Similarly, we were asked how do we quantify the benefits within the state here? In general, we quantify each year's benefits as we go forward, and we've been doing this since 2001; and we use the method for actually weather normalizing these savings back to the base year. So, depending upon which entity we're measuring we use change point linear models for weather normalizing, things such as wind energy savings. We use sliding averages on some of the data to give us some idea of how some of the wind farms are producing lately, and then we have special purpose models for things like solar photovoltaic (PV) and solar thermal analysis that were developed by the University of Wisconsin.

The data sources that we get our data from are the participating state agencies, the State Energy Conservation Office (SECO)Public Utilities Commission, TCEQ, and then the Electric Reliability Council of Texas (ERCOT) who provides a lot of electricity data that we use for our basic analysis. We also rely on data from four federal agencies, the EPA provides us with eGRID, National Renewable Energy Laboratory tracks a lot of the installations of renewables, National Ocean and Atmospheric Administration (NOAA) provides us with the weather data, and the Energy Information Administration as well.

So we're having to reach out to a number of agencies and then we turn around and provide results to a number of different agencies. All of this is done very closely in collaboration with the TCEQ; and, of course, we do have a lot of oversight and cooperation with the EPA for our data quality in our annual reporting.

Slide 28. Legislation

Jeff Haberl: So, our work was legislated within Texas. Back in 2001 we were faced with a very strong mandate to improve the air quality within the state, so our original legislation was set forth to enable this work. I'm not going to go through this in detail, but you can see through the years it's been added and modified clear up until the current time where we have a number of specific responsibilities that the lab has to produce as part of our funding for the legislation, part of that is the actual calculations of the emissions reductions.

Slide 29. EPA Criteria for SIP Credits (2004)

Jeff Haberl: Our credit for the emissions reductions follows the EPA criteria for State Implementation Plan (SIP) credits, which have four primary elements. First of all, the emissions reductions need to be quantifiable, so we have to provide a method for quantifying emissions reductions. We need to review that method with TCEQ and EPA, and then we use that method year after year to quantify the emissions. That method needs to make sure that it doesn't account for savings that are already accounted for somewhere else, so we have to be careful of any surplus accounting and abide by that accordingly.

Slide 30. EPA Criteria for SIP Credits (2004)

Jeff Haberl: We also have measures that need to be enforceable; for example, building codes are enforceable. When you install a wind turbine but it's something that actually exists, it's not a hypothetical thing. Similarly, we have to perform the recordkeeping, so if somebody wants to go back and look at the savings in 2013 or 2015 or 2006, all of that is kept online in the format that's required by the TCEQ. This is an example of one of the online reports.

Slide 31. Energy Savings and NO_x Emission Reduction

Jeff Haberl: As I said, this is part of a larger program that does emissions reductions from not only renewable energy but also of energy efficiency. So there's a number of areas that we do the emissions reductions on that I won't be talking about today; however, we do have information available on our website about that. So, for example, single-family construction, multi-family commercial construction; and this is construction to code or above code programs, likewise green power production, I'll be talking about that today.

We also take information from the public utilities’ programs, energy efficiency efforts, and incorporate that into the emissions reductions, energy efficiency programs that are my managed by the State Energy Conservation Office. And one item here--and we've had additional items from time to time that we're tracking--is the air conditioner improvements as people retrofit their houses and commercial buildings around the state.

Slide 32. Savings from Renewables

Jeff Haberl: So today I'm going to be talking about the savings from renewables. So primarily we'll be talking about savings from installations of photovoltaic both on residential, commercial, and utility scale, solar thermal installations, hydroelectric biomass, landfill gas, and geothermal installations.

Slide 33. Savings from Renewables

Jeff Haberl: However, the big-ticket item is we'll see from some of the results coming up is the emissions reductions from the wind farms that have been installed around the state since about two 2004/2005.

Slide 34. Wind Projects in Texas (2017)

Jeff Haberl: So, we'll start with that, looking at the wind farms that have been completed. One of the procedures that we have to do is to carefully map out where those farms are, and then we have to know how those are connected to the grid so the accounting is done appropriately with eGRID. So on this graph, for example, we're showing you where the farms are installed around the state; this is a graph of the completed farms. We also track announced and retired farms, this is as of December 2017. You can see, for example, they're primarily in the western part of the state, as well as the panhandle, and now a little bit more in the southern part of the state. But all those are where we are tracking our wind farms and we basically get the actual data--the 15 minute data-- from ERCOT for each of those wind farms, the Electric Reliability Council of Texas.

Slide 35. Wind Projects in Texas (2017)

Jeff Haberl: This gives you some idea of the success of that program. Beginning a little bit before September 2005 we had less than about a 1,000/2,500 megawatts of installed wind capacity, we're now exceeding about 20,000 megawatts, probably 21,000 as I speak.

Slide 36. Wind Projects in Texas (2017)

Jeff Haberl: So not only do we look at the installed capacity we also track the production of the wind from these wind farms. And as you can expect from your own common experience, the wind doesn't blow all the time, and it blows more in some parts of the year than it does in other parts of the year, so that's one of the issues about weather normalizing and then calculating emissions reductions from wind.

So, this graph with the shaded bars going down the graph shows you the years that we've been tracking the wind farm electricity production. And you can see the dog days of summer, which are the shaded bars, are the periods when we tend to have the lowest consumption of wind. Those are usually during the summer period, unfortunately when the electricity requirements are the highest, so there is a bit of a seasonality to the wind within the state.

Slide 37. NO_x Reductions Using Emissions & Generation Resource Integrated Database (eGRID)

Jeff Haberl: We developed a procedure for that, this is one of several flow charts we use, but I think it's probably easier to think about that in this format.

Slide 38. NO_x Reductions Using eGRID

Jeff Haberl: Okay. So we basically have energy efficiency categories, residential, commercial, industrial users, and we have wind, solar power, and eventually tidal power at some point, renewable energy categories, and then we have our transmission and distribution substations. So the trick really is finding out where these facilities are, linking them with the appropriate crossover back to the power plants--we use eGRID for that--and then running the calculations.

Slide 39. NO_x Reductions Using eGRID

Jeff Haberl: So, for example, I'm reporting today on renewable energy, which is the lower right-hand box; we also track energy efficiency projects, so we're looking at all of those. Where is the energy being consumed, is the project something that's enforceable, do we have recordkeeping on it, etcetera, etcetera--all the EPA requirements--and then tracking that back to the source.

Slide 40. NO_x Reductions Using eGRID

Jeff Haberl: So to do that, of course, we then link it back to which of the power plants during the previous years which actually are producing the electricity used and what would that reduction in energy be?

Slide 41. NO_x Reductions Using eGRID

Jeff Haberl: So if we look at wind energy, for example, one of the early sites where we tried to prototype this was a research facility up in Randall, Texas. And we had an Intertek wind turbine.

Slide 42. NO_x Reductions Using eGRID

Jeff Haberl: And so we looked at the data coming off that wind turbine, and we said, 'Hmmm, there's a pattern to that data'. And you can see that here, for example, the upper orange dots are basically the power coming off the turbine plotted against NOAA wind data; and, of course, the blue dots which are much better defined is this same wind power coming off the turbine plotted against on-site wind measurements. And, of course, one of the problems with that is that it is more applicable to use the NOAA wind data than it is the on-site wind data, so we shifted to the NOAA wind data.

Slide 43. NO_x Reductions Using eGRID

Jeff Haberl: We developed daily regressions, change point linear regressions, which give us the average daily wind savings.

Slide 44. Wind Farms Capacity/Production

Jeff Haberl: We use that to do the forecasting. So, in this case we're actually able to take 2017, back cast it to the 2008 base year.

Slide 45. NO_x Reductions Using eGRID

Jeff Haberl: We've done this now cross all the wind farms in the state, so that looks something like this when you add all those up, and that gives us the total savings for the wind farms.

Slide 46. NO_x Reductions Using eGRID

Jeff Haberl: Here's another example from one of those wind farms, the Callahan Wind Farm.

Slide 47. NO_x Reductions Using eGRID

Jeff Haberl: Here's the actual hourly data, there's the daily average during the ozone season period and non-ozone season period.

Slide 48. NO_x Reductions Using eGRID

Jeff Haberl: And there's what it looks like when you've been tracking data now for 10 to 15 years, you can begin to start answering questions about how reliable is that data.

Slide 49. NO_x Reductions Using eGRID

Jeff Haberl: We know exactly where the power plants are in the state thanks to eGRID and so, we're able to track that and then take it back to the power plants that would have provided the power during the periods that the winds were blowing. In Texas we have four congestion management zones that are showing there and that's how we divide things up around the state.

Slide 50. NO_x Reductions from Wind Power

Jeff Haberl: The results that we've seen here for the wind energy production, for example, in their last year it was about a hundred 22,000 megawatt hours on ozone season day.

Slide 51. NO_x Reductions from Wind Power

Jeff Haberl: The actual NO_x emissions reductions were about 65 tons of NO_x on ozone season day. You can see a dramatic jump between 2016 to 2017 and that was basically a resetting of the numbers within the eGRID.
Slide 51. NO_x Reductions Using eGRID

Jeff Haberl: So, this goes forward, then, for all the renewable energy projects we have a process like that.

Slide 53. Savings from Other Renewables

Jeff Haberl: We roll it up into a final number, which is something that looks like this, the green bar, of course, is the total wind energy consumption the other colors are the PV, solar thermal.

Slide 54. Integrated NO_x Emissions Reduction

Jeff Haberl: That allows us then to account for the renewable energies, we wrap that together with the energy efficiency projects across all the agencies, which gives us the roll up for the total value for the state, this is what that looks like across all the projects.

Slide 55. Integrated NO_x Emissions Reduction (2008 Base Year)Slide 56. Summary

Jeff Haberl: And, of course, results of the analysis we report to the legislature, the outcomes have provided Texas with NO_x creditable emissions that can be used in the weight of evidence. The challenges, of course, are gathering all this data, coordinating across the agencies, and then doing this over seventeen-year period.

Slide 57. ESL Contact Information

Jeff Haberl: Questions?

Denise Mulholland: Well, thanks so much, Dr. Haberl. That was really a very informative presentation. And we're going to actually save questions for the end. And I believe you might be ducking out, so, I believe Dr. Baltazar will be available to answer any questions on this presentation at the end, after our last speaker has gone. So, thank you very much for that very informative presentation.

Jeff Haberl: Thank you.

II. Eric Shrago, Connecticut Green Bank

Slide 58. The Securitization of Solar Home Renewable Energy Credits and Their Emissions Benefits

Denise Mulholland: Great. So, now I'm going to move on to the next presenter, which is Eric Shrago from the Connecticut Green Bank. And at the Bank Eric is responsible for the general management of the operations there. And this includes organization and strategic planning, impact assessment, as well as the evaluation measurement and verification efforts that they have under way. He's also responsible for administration, human resources, and technology function, so, he's got a lot on his plate there. Eric is going to speak to us today about the Connecticut Green Bank's efforts to quantify the emissions benefits of their investments. He'll be talking about the use of an intermediate tool that I mentioned earlier called AVERT. With that, Eric take it away.

Slide 59. Connecticut Green Bank Eric Shrago: Awesome, thank you. So, I'm from the Connecticut Green Bank and I'm going to talk about how we've deployed AVERT overall the organization and then specifically how we used it on a recent transaction. So, this is the Connecticut Green Bank Securitization of Solar Home Renewable Energy Credits and Their Emissions Benefits.

Slide 60. Connecticut Green Bank

Eric Shrago: Connecticut Green Bank, we're quasi-public in the state of Connecticut with a mission to increase investment in clean energy in the state, so, that's renewables and energy efficiency and help reduce the energy burden overall in the state.

Slide 61. Connecticut Green Bank: Delivering Results to Connecticut

Eric Shrago: We were launched in 2011 in our current form, basically using finance to do that. And since then we have mobilized over $1.3 billion of investment into the Connecticut clean energy economy. We've created 16,000 job years, reduced energy burden for 30,000 homes and businesses, and deployed more than 285 megawatts of clean renewable energy.

And I give you those numbers primarily because it's really important on how do we get to those.

Slide 62. The Residential Solar Investment Program (RSIP), Solar Home Renewable Energy Credit (SHREC)-Backed Revenue Bonds

Slide 63. Incentive Business: RSIP and SHREC

Eric Shrago: And I'll come back to all how we get to that but wanted to just pause and first talk about the solar home renewable energy credits that we have earned. So overall, we have a program here administered by the Green Bank Residential Solar Investment Program or RSIP. And RSIP is a declining block incentive targeted at home owners to install solar on their roofs. It has a 300 megawatt cap.

And basically, we had some limits on how much of our funding that we could direct towards RSIP, however, we're seeing a lot of people trying to get through the gates of the program a lot quicker. And so, effectively we lent ourselves money to pay for that, from one side of our business the other. And so we immediately paid the incentives, we administered the program. The issue was we needed some way to cost recover that.

The legislature stepped in 2015 and created a special class of renewable energy credits linked to the solar energy from these systems and gave the Green Bank the right to retain those recs and monetize those through long-term purchase contracts with the phase two investor end utilities and counting towards their renewal portfolio standards.

So, ultimately, the way this works is the homeowner will install solar, they generate credits, the Green Bank gets those, registers those, aggregates those, and then sells those to the utility at a prefixed price intended to recover the costs of the program. And we worked with the legislature to design this basically with the intent that we would securitize these streams of income down the road through some sort of green bond.

Our budget took a hit a couple years ago and some of our funding was diverted and so, our need to monetize these credits in both fashion and securitized just really came to a head. And so, we went out to the capital markets about this time last year with this transaction for two years' worth of these SHRECs and we started working to sell those.

Slide 64. SHREC Creation Process

Eric Shrago: And so, through that process we started getting some feedback that investors really didn't just want the thing to be certified in terms of a transaction, they wanted to know what the impact was. And so we thought this is a great opportunity for us to showcase to impact investors what we're actually achieving through this and what they can achieve by joining in on our transaction.

Slide 65. SHREC 2019-1 Transaction Overview

Eric Shrago: So, this is all just overview of what we did before the SHREC transaction. , this, ultimately, ended up being about $36 or, I'm sorry, $38.6 million we took to market.

Slide 66. What is the impact of the SHREC Bond? What is the impact investors would have?

Eric Shrago: So, what is the actual impact of the SHREC bond, what's the impact that the investors in this would have, and so, we wanted to model that.

Slide 67. Approach

Eric Shrago: So, we at the Connecticut Green Bank have some pre-established methodologies across the organization and so, we didn't just want to use those, we wanted an outside opinion. So, first we went and said, "Alright, let's make sure that we get this rated by an outside verifier." So, we engaged through an RFP process we engaged through verifiers to assess the bond, see to the certification. And we have filed our paperwork, we're still waiting for the official stamp, but we have no reason to believe it won't be certified as a climate bond per the Climate Bonds Initiative Standards.

But, as I said, we really wanted to get that impact quantified we wanted there to be some sort of outside methodology to that in terms of things that would be trusted by the market. So, we wanted to say, "What did these achieve, what were the greenhouse gases that were avoided, how much cleaner is the air, what were the public health impacts, and what were the economic impacts?" So, we engaged with the Climate Action Reserve to do that.

Slide 68. Evaluation Framework

Eric Shrago: And as I was saying a minute ago we have our overall framework of evaluation, so, we have a bunch of different methodologies that we can use and here we're going to focus on our environmental methodologies, obviously.

Slide 69. Environmental Impact Fact Sheets

Eric Shrago: So, we employed AVERT I think about two years ago, it's our new official methodology for estimating the impact of air quality improvements due to our activities. Initially we were doing this when we were looking at larger projects to say, "Okay, if we finance this wind farm, this is what we can expect the large impact to be."

However, the vast majority of our projects, especially in the RSIP program, are small one house rooftop solar projects or an aggregation thereof. And so, we really needed a way to operationalize this because we couldn't sit there and run each project through AVERT. So, through a regression analysis we developed some factors that work in the state of Connecticut that take type of project that it is, if it's energy efficient to your solar, using the standard built and assumptions of AVERT and translate that into factors for NO_x, (sulfur oxide (SO_x), carbon dioxide (CO_2), and particulate matter (PM).

So, we built that in, we've automated that through our data warehouse. And with respect to the SHREC bonds and every other program that we have, we were able to create some estimates.

Slide 70. Green Bank’s Calculations

Eric Shrago: And so, when we were looking at this SHREC offering, we had, hey, look, the energy impact is 109 megawatts of installed capacity. It's going to generate 23,000 and change megawatt hours and 3 million megawatt hours expected over time generated using our jobs methodology. I'm sorry it represents $37.9 million in Green Bank advancement, we need $384 million in private investment creating 5,600 jobs through our job methodology. And from an environmental impact we, using our methodology in how we do that we're getting this emissions by 69,000 tons of CO_2, 71,000 pounds of NO_x, 58,000 pounds of SO_x, 6,000 pounds particulate matter annually.Slide 71. Climate Impact Score

Eric Shrago: But again, we wanted that independent, so, we engaged Climate Action Reserve (CAR). And they put together a report and they said, "Okay, here you go, and your savings in terms of air quality is 749,500 CO_2 over the lifetime of this project, which we said going back to our estimates, well, we're expecting a lifetime savings of one point eight million, why is there a difference?" Is it something to do with methodology?So, we had a long discussion with CAR after we were starting to second guess ourselves and they take it one step further where they used EIA estimates of the grid and how that is expected to change over the useful life of the project. We run this scenario through AVERT based off of a changing grid and projecting out future years. So, they're actually assuming a grid that's cleaner on its own, without these projects in there, whereas we’re assuming that just keeping a baseline year for these projects static, so, that really explained the difference. And it caused us to think of how do we want to adapt our own internal processes going forward, in terms of do we account for changing grid composition, or are we happy with the way that things are?

Slide 72. Take-Aways

Eric Shrago: And it also made us look back at how are we using our forecasts? We had built ours off of a mix of P-50 and P-90 forecasts, which we now adjusted for. And we're also, going to go back and integrate where we have actual generation numbers so that we could see what the actual impact was in terms of air quality on the grid.

And we have built a platform with conjunction with [Locust] who's a monitoring vendor in the solar space. And so, we'll have real-time generation that] we're able to run that through AVERT and say, this is what we're seeing as the savings. So, ultimately, we were able to pitch to investors what these impacts were, and our bonds sold for $38.6 million on April 2nd.. And so, the buyers know what their investments have now achieved.

Slide 73. Contact Information

Eric Shrago: So, for questions, feel free to reach out.

III. David Abel, University of Wisconsin

Slide 74. Quantifying Air Quality Benefits of Power Sector Transitions using Advanced Interdisciplinary Emissions Modeling

Denise Mulholland: Well, thanks, Eric. That was a really interesting presentation and I'm sure we'll get a lot of questions about what you did.. It’s a very exciting effort and I know I've enjoyed watching you and working with you on it as well. So, thank you very much for that presentation.

So, at this point, then, I'd like to turn it over to David Abel, who is going to be our next presenter. And David Abel is working on his PhD or has his PhD from Environment and Resources, Energy Analysis and Policy. He's based at the University of Wisconsin Madison and he focuses on policy relevant analysis of energy systems, air pollution, as well as public health. He explores the intersection between energy and the atmosphere, namely the impact of energy technologies, trends, and behaviors on air quality, climate, and public health.

And David is going to talk to us today about his experience quantifying emissions impacts using at least one more sophisticated tool that he'll talk about, called JuiceBox and a bit of AVERT too. I think he's going to tell us about his experience there. So, with that I will turn it over to David. Thanks so much.

Slide 75. Quantifying Air Quality Benefits of Power Sector Transitions using Advanced Interdisciplinary Emissions Modeling

David Abel: Thanks, Denise. Yeah, again, I'm David Abel. I'm from the University of Wisconsin Madison, I'm a post doc, actually now in the Holloway group within this Nelson Institute for Environmental Studies. And if you couldn't tell from my introduction, this topic is a really near and dear to my heart, it's what I've spent the last five or six years of my life working on, and I've used all of these different methods that are being talked about today, from eGRID to AVERT and today I'll focus on a couple examples of sophisticated methods that we've used.

Slide 76. Thank You to All Sources of Support and Collaborators

David Abel: So, of course, first an obligatory slide, thank you to all of our support and my different collaborator, special thanks to my PhD advisor Tracey Holloway, and also special thanks to a couple names down there, Paul Meyer of Meyer Engineering Research. He actually created the JuiceBox model that I'll be talking about. And thanks to some University of Wisconsin funding sources, as well as the National Air and Space Administration (NASA) Health and Air Quality Applied Sciences team.

Slide 77. Spheres of Measuring Emissions Benefits

David Abel: And so, I like to put this slide up at the beginning of every talk I give just to orient the fact that I really think we often get deep into a single topic, but this entire discussion that we're talking about on this webinar today really has to do with the whole sphere and that changing anything in any one of these little bubbles in climate or on public health or on air quality really affects and reverberates through all of the others.

Slide 78. Research Questions and Objectives

David Abel: And so, the motivating questions behind what I'm going to talk about today and why sophisticated tools were especially good for you know a couple of examples that I'm going to give or one, just the general scientific research question of can we improve understanding of interactions between energy, climate, and health. And then, the big why behind that is can we identify and quantify some win/win solutions across these different bubbles and across the different topics that are cost effective and really benefit everybody.

Slide 79. Emissions

David Abel: And so, just to start and make sure we're all on the same page with some of this, I'm going to be talking about emissions and when I'm talking about emissions what I mean is emissions from power plants and really predominately two different pollutants; sulfur dioxide(SO_2) and nitrogen oxide, or NO_x. And the reason these are the ones I'm talking about is because what we really care about what we regulate in the U.S., at least as far as criteria pollutants go, are ambient concentrations in the atmosphere.

And into two pollutants that are really you know public enemy number one and number two for public health are fine particulate matter $PM_{2.5}$ and ozone, and SO_2 and NO_x both contribute to $PM_{2.5}$ and ozone in the atmosphere. And then, of course, we can't forget about you know CO_2 as a greenhouse gas, we care about it for a slightly different reason, but it's very interrelated with all this work.

Slide 80. Why Care?

David Abel: And then, why do we care, you know why are there air quality regulations to begin with, why is anybody like me doing research, why is anybody funding this type of work? And it really comes down to the fact that this is a big public health benefit to control and manage our air quality in the U.S. and globally. So, in the U.S. we spend about $50 billion a year under the Clean Air Act to achieve standards and the reason why we do that, of course, is because it has huge benefits. And we've shown that there are about thirty to one returns in health benefits from that $50 billion that's spent every year.

Slide 81. Why Care?

David Abel: And I've got these pictures here showing between 2005 and 2016. This is actually just concentrations of NO_x pulled from a satellite instrument called the ozone monitoring instrument. And you can see the drastic improvement we've had in air quality over just the last 11 years or 13 years now. And so, this 100,000 deaths a year in the U.S. is really to make the point that even though air quality has been a big environmental success story in the U.S., that's still the number that we're working with and that's still a big number of deaths and big impact from air quality that we have to address. And, of course, when we zoom outside the U.S., the work that I'm talking about and most of what I have done focuses on the U.S., but if we zoom out, it's a much bigger problem. And I think the number that really epitomizes that is that 91 percent of the global population is exposed and lives in a region with pollution above what the World Health Organization deems as safe.

Slide 82. Energy Modeling & Emissions Quantification

David Abel: And so, I took this nice picture, this is actually from the AVERT website, so it's built around why should be use AVERT. And the big reason there we've just heard what can be done with it and it's a nice intermediate method between eGRID and some of these sophisticated methods.

And I said earlier I've used all of these different methods. But what you can get with a sophisticated method that you really can't get with a basic and intermediate method sometimes is this real simulation of how the grid works based on all of these different parameters and factors that build into every single power plant. So, you have a model that actually simulates reality by taking in fuel prices and environmental regulations and emissions factors and different technologies and combines all of that to then calculate, in this case, dispatch, which power plant is going to produce how much energy and how many emissions and when.

Slide 83. Spheres of Measuring Emissions Benefits David Abel: So, the first thing I want to talk about is actually sort of related to the benefits of energy efficiency and renewables but actually more of a warning. And it's is the fact that this was a long-term project that we worked on a long time through the National Institutes of Health. And it's a recognition of the fact that as the climate warms, one of the first things that we're going to need to do to adapt to higher temperatures is to cool our buildings more and use more air conditioning demand and that means that we're going to have to produce more energy from somewhere to power those air conditioners. You can drive this connection all the way from climate and whether through building energy demand, electricity production, power plant emissions, air quality and then health.

Slide 84. News Articles

David Abel: And that's what we did with a series models, this work was published in a special issue of Pulse Medicine last summer on climate change and health, covered by the Economist and it was a highlight in Nature Climate Change. And the way to think about this study is, I'm a kind of go through this fast, so, I can talk about two different things.

Slide 85. Adaptation of Cooling Demand and Air Quality Impacts

David Abel: The way they look at the studies is really just through three different scenarios. One being present day current reality and then two future climate scenarios, looking at what would be the impact of a warmer climate alone. And then this midcentury adaptation scenario, third one is what would be the impact of climate plus the added emissions from increased air conditioning use.

And again, we used a series a model starting with modeling the weather and climate, future weather, then running a building sector model to estimate what energy demand in buildings actually would be, and then feeding them into the real big model that I want to talk about, MyPower or JuiceBox, which calculates the electricity dispatch and inline emissions from each power plant, before then feeding into a chemical transport model that calculates the air pollution and a health impacts model that then turns it into, why do we care about that air pollution change?

Slide 86. Key Challenges

David Abel: And so, a couple of key challenges with this work is one; how do we link these interdisciplinary tools and how to manage interdisciplinary teams? And this is often a big issue with you know sophisticated energy models because, in many cases, those models were not built specifically to do air quality research or even emissions work at all. Or if they do emissions work sometimes they stop at CO_2 and greenhouse gas emissions because there a little bit easier to quantify. So, connecting all these steps together it's definitely nontrivial.

Slide 87. Abel et al., PLOS (Public Library of Science) Medicine and Meier et al., 2017, ERL and Schuetter et al., 2014, ASHRAE

David Abel: So, the first thing I'm showing here is just to make the case that, yes, in a mid-century climate, the eastern U.S. is warmer. So in the present case, you can see there's actually a small decrease in minimum temperatures by the middle of the century but there's a huge increase in the frequency of high temperatures across the eastern U.S. by the middle of the century and greater variability overall, which just all fits within what we know about future climates.

But what this allows us to do by having this scenario, then, is we built 39 different building prototypes that represent 85 percent of energy demand. And by feeding this new meteorology into that model to recalculate energy demand we can then approximate what energy demand in the U.S. might look like in a future warmer climate.

Slide 88. MyPower Model (JuiceBox)

David Abel: And once we have that information, then we can go to the real the real meat of this topic, right, the actual emissions quantifications piece. So, what we use is something called MyPower or it was actually originally developed by Paul Meyer of Meyer Engineering Research as an educational tool, so, if you look for it is much more commonly known as JuiceBox. And what this does is it was really nice to fill the gap actually between, we've got this whole category of sophisticated models, but it was really meant to fill a gap between AVERT and super sophisticated difficult market analytic type energy models that don't really or weren't really built to do emissions work.

This was built to actually do this inline emissions quantification, so, we can provide it load shakes based on what came out of a building models, as well as lots of different data sets on the types of power plants that are out there and fuel cost and things like that. And they can calculate dispatch and emissions inline using what's called a low duration curve approach. I can talk more about that if there are questions, I'll move on for now.

Slide 89. Abel et al., PLOS Medicine and Meier et al., 2017, ERL

David Abel: So, what do we get out of that model and what we get out that we care about for this type of work is the emissions. So here I am showing histograms just like the temperature of SO_2 and NO_x emissions. And there's a slightly different behavior here than what we saw from temperature. And I think the biggest thing is that there's not really an increase in the maximum number of emissions at any given time over this is one month in the summer.

But there is an increase in minimum emissions and there is a much greater frequency of emissions in this offer50 percent of the range that we might see from power plants.

And the reason this occurs is because what we see in the future climate is not really a dirtier mix of power plants overall but that the dirtiest mix of power plants has to run more often to meet these times of higher demand with greater air conditioning.

Slide 90. Key Findings

David Abel: And then I'm going to jump through these key findings pretty quickly because there's actually another webinar in the middle of May where I'll talk more about air quality and health take aways from this type of research. But what we found was about 16,500 deaths related to $PM_{2.5}$ and ozone exposure annually in a future climate. This fits within with some other work [inaudible] by just examining climate, air quality.

David Abel: But the real new piece here that about a 1,000 of those deaths, 5-8 percent that are $PM_{2.5}$ and ozone are due specifically to increased air conditioning us or adaptation. So why that's really important because that's something we can control right. And the natural question then is how do we address or manage how we use and produce our electricity so that we can minimize air pollution damages.

Slide 91. Key Takeaway for Policymakers and Planners

David Abel: And the key takeaway for people in a planning or policy position is really the fact that as long as we continue to rely on fossil fuels, and especially coal, to provide electricity, then using air conditioning to adapt to warmer climates is important and protects us from heat related damages. But by doing that we're just substituting heat related damages for air pollution related outcomes until we can create a cleaner electricity grid.

Slide 92. Solar Energy for Managing Air Quality

David Abel: And so, you know then the other national question is how do we address this and manage it from the production side. And, of course, one obvious solution is more renewables. So, we decided to take a look at solar energy for managing air quality, what would happen if we got the high levels of penetration of solar throughout the eastern U.S.

Slide 93. The GridView Model

And the way we approached this actually uses a second more sophisticated model that was used in analysis over at the National Renewable Energy Lab.They did a series of studies and work through this SunShot initiative to look at barriers and opportunities to getting high levels of solar across the U.S. And we took a scenario that they ran through this GridView model that was about 20 percent solar throughout the U.S. and what are the barriers and challenges to doing that. And why I really wanted to talk about the GridView model is because it really gets at the fact that not all these models were developed to do air quality research and this model certainly was not.

It's a very sophisticated not all of it but it's meant for more market and economic objectives. And it builds in a lot of detailed representation of the transmission grid and market scenarios and transmission market all kinds of different things, and I'm happy to talk about that more afterward if we want. But I'll keep moving so I can get through everything now. But what it does not do is it does not calculate emissions.

Slide 94. Solar Case Emissions

David Abel: So, we had to then to get the value of that sophisticated model and the sophisticated work that National Renewable Energy Laboratory (NREL) had done in their work, we had to then come up with a way to estimate emissions. And what we ended up doing was to take our two different scenarios, so, one being the space reality case and the second being the high penetration solar case, which over the eastern U.S. ended being about 17 percent solar generation, and to just scale emissions from EPA's national emissions inventory via the change in generation at each power point at every hour.

David Abel: So it's kind of a simple approach, but it's actually much more complicated, and in actually doing this involves first matching all the power plants from GridView with the power plants from the emissions inventory and then taking this hourly data and actually doing the scaling and capturing any extreme changes that might throw off the system. But at the end of the day we get realistic results that show about a 17 percent decrease in traditional generations of non-solar sources gives us decreases in NO_x emissions and SO_2 emissions of 20 percent and 15 percent, respectively.

Slide 95. Comparison Between GridView and AVERT and Varying Solar Levels

David Abel: And one other thing that this study allowed us to do then was actually compare; because we only had one scenario of solar from GridView we were able to compare a sophisticated tool like GridView with an intermediate tool like AVERT to then estimate the impacts at different levels of solar integration. So this plot is just showing the level of penetration of solar from zero to seventeen percent versus the change in emission. And what we can see is that it's approximately linear, and AVERT does a very good job of capturing the SO_2 emissions and a relatively good job of capturing the NO_x emissions from GridView.

Slide 96. What are the air and health impacts of expanding solar (17%)?

David Abel: And then the takeaway, what we actually find; it'd be annoying to present a study and then not actually give any really good results. What we found was that 17 percent solar energy would reduce $PM_{2.5}$ in the Eastern U.S. by about 5 percent on average, and as much as 10 percent in some regions. And this has health savings of about fourteen hundred lives saved annually or $13 billion.

Slide 97. Results

David Abel: And so the answer to this real big research question of can we inform some of the in-between energy/air climate health in these bubbles absolutely interdisciplinary models of varying complexity are all useful for analyzing this type of thing from the eGRID, AVERT work, all the way through the sophisticated tool. And there are definitely cost-effective solutions for energy, air, climate, and health management all at once that exist. So, thanks. And feel free to reach out to me with any questions now or after the talk.

Slide 98. Thank You

Denise Mulholland: Great. Thanks so much David. You did a really nice job of presenting what otherwise could have been very complicated material or was a complicated process, I'm sure, in a very understandable way, so thank you for that.

So I think at this point--so we've received a bunch of questions and we can go ahead and jump into the question shortly. Please, if you have additional questions type them in and send them and we'll try to get to them in this call.

IV. Poll Question III

Slide 99. Poll 3

Denise Mulholland: But in the meanwhile, what I'd like to do is just do one more poll for the audience, and basically to just get a sense of your intent for how you would use estimated energy and emissions benefits from energy efficiency and renewable energy.

So you can choose as many of these as apply, so essentially you might be using it to provide information to policymakers, to provide information to the general public, for use in an energy efficiency cost-effectiveness test, or to determine emission reductions for state implementation plans. So please click on all the ones that would be relevant to what you might intend to do with these types of quantified benefit. So, we'll give folks just a half minute or so.

Okay. Alright. So, it looks like we have a lot of folks that are be looking to inform policymakers, and certainly general public and cost-effectiveness testing are very popular. So that's really helpful to know and certainly we will keep that in mind as we're developing future webinars and resources. So, thanks for that vote.

V. Question and Answer Session

Slide 100. Question and Answer Session

Denise Mulholland: Okay. So then why don't we jump right into the questions, and so what I'll do is start with a question for Texas. I have a question on the Texas presentation. So, Juan Carlos, I assume you're probably still with us and that Jeff might have moved on by now. But I have a question as to is there a reason for the Texas analysis that eGRID was used instead of AVERT?

Jeff Haberl: Yeah. Basically we--this is Jeff, I'm still here--but we used eGRID because it fit the appropriate scale for the sorts of information we're gathering. We would love to use a more sophisticated model but unfortunately the granularity of our inputs is not there yet.

Juan Carlos Baltazar: Also, if I am allowed, it's also that the power industry generation in Texas he's very special; we are really not clustered, we are not sharing much line, we have a network consult that is taking care of all the dispatch in Texas. And with eGRID we generate a particular model from the data that was generated to just for Texas, so it allows us to manage very specific county-by-county what's happening with the integration. So it's a more detailed [unintelligible] that we could do that we could not find the time with another tool.

Denise Mulholland: Okay great thank you. Okay. I have a question now that is directed to Eric. Eric, has Connecticut Green Bank done similar analysis for your geothermal heat pump program?

Eric Shrago: In terms of running it through AVERT we have not. I'm curious to what geothermal heat pump program someone is talking to because we don't have a dedicated program for geothermal yet. But similarly, as we do see the spread of heat humps, this is something we would run through and develop a factor for that we can use for estimation of impact.

Denise Mulholland: Okay, great. Thanks Eric. Okay, here's another question. This one is for you David. I have an audience member who would like to know what is the difference between JuiceBox and the National Energy Modeling System, also known as NEMS?

David Abel: Yeah. So there are a lot of differences. JuiceBox does take some data from NEMS, and I believe NEMS also uses this low duration curve structure, but there are a lot of differences other than that in basically every single way. And we can touch base offline on more detail with that and I can put you in touch with the person that develop JuiceBox as well. I suppose I should say from the development there they're very different in that JuiceBox was meant to be an educational tool, so it's got a big user interface and it's used in classes and things like that.

Denise Mulholland: Okay. Great. Thanks David. Okay, I have a question for all three speakers, or four, in you include Texas not--for all the speakers, how about that. Could you please describe a general or give a general idea of the level of effort to the number of staff or how many month that was needed to conduct an analysis projecting emissions benefits from energy efficiency or renewable energy to air quality ambient emissions? So, basically, what's the level of effort, how many people, how much time, maybe even other resources, money, basically what did it take to do this type of analysis? So let's start with Texas, you want to go first?

Jeff Haberl: Yeah. Originally, we were budgeted at about $1.1/1.2 million a year for this work, legislature some time ago cut the budget in half; has never really restored it, so we we've had to live on fumes for a while here. But we're currently running at about $600,000 a year, and that covers a large portion of the people mentioned on the overhead slides.

Juan Carlos Baltazar: And also, because Texas we do a lot of them include several energy efficient measures, not just renewables, and we do also sophisticated models for simulation on the buildings to the residential level or to the commercial level. A lot of the information that we presented here will simplify it, but there is a lot of also sophisticated models that we did from the energy perspective.

Jeff Haberl: So, for example, we provide web-based code compliance calculator for residential and we're in the process of developing one for commercial, that's part of the mix.

Juan Carlos Baltazar: And it's still active and it has to be maintained.

Denise Mulholland: So, I appreciate that, and before I move on to Eric and to David to answer as well, I guess let's step back maybe a little bit more generally because I know, Texas, you had this program running for a really long time; and it's I know it's fumes for you, Jeff, but it's well-established. And so, I guess if you were trying to think about somebody else that might be just starting out and thinking of them trying to figure out how many people would they need to do an analysis that would project emissions benefits from energy efficiency and renewable energy to air quality emissions,to air quality how many people and how much time should they plan for that?

Jeff Haberl: You want me to answer that? Okay. A lot, I mean how important is clean air? It's plain and simple, it takes a long-term effort, it takes players that are going to be there for years and years. All these things the EPA has put into their guidelines, doing that really requires a significant amount of work, it also requires special expertise and tremendous flexibility; one year you're building up tools in one area, the next year you're building up tools in another.

Jeff Haberl: We're constantly evaluating available tools, the biggest problem we run up against, of course, is very few of the tools are open source, so we usually back down a little bit as soon as we hit a proprietary problem with that. We're currently working with several other states right now to begin to provide the types of calculations that we're doing; so we're happy to get other states up and running and then turn it over to him and walk back to Texas, so to speak, and we're in the process of doing that. So it requires an equivalent amount of staff. Scale-wise if you have a lot of renewable energy installations, if you have a lot of energy efficiency going on then you're going to have equivalent proportions to what we've been doing.

Juan Carlos Baltazar: In our case it's more because it's in a state program, again; it's a big program. For projects in particular where well-established models already exist, so it's very straightforward in some cases.

Denise Mulholland: Thank you so much for that clarification. I think that that's an important note, that it does depend upon the type of analysis that you're doing. If it's for a regulatory purpose you might need to use more sophisticated models, which may require more sophisticated staff with greater expertise and a bit more time than if you're doing something that uses basic methods or intermediate methods because certainly you could use the AVERT model very quickly [crosstalk]. So, I guess I would...I'm sorry?

Jeff Haberl: Actually, I did not say--I did not say that. In fact, my advice is just the opposite; start with the simple models, work and get the sample models working. You start to add complexity you better have a large, large bottle of Tylenol because you might get staff up and running on it; they're here today, they're gone tomorrow. Do methods that are repeatable, seem to work.

Denise Mulholland: Yep. Great. Thank you. Yes, exactly, it depends on the purpose. So thanks so much for that Jeff. Eric, did you have anything you wanted to add on that based on your experience in terms of how much time or how many staff you needed to do this type of analysis, or David any additional thoughts you wanted to add? [Crosstalk]. Okay, Eric, we'll start with you.

Eric Shrago: I was just going to say there were a couple of us on the team that just ran various scenarios through the tool to make sure that it was really capturing the activities that we wanted it to capture for specific activities, like rooftop solar, larger grid scale projects for energy efficiency. And then most of our time was not tweaking with the model or doing anything built off of it, but it was then regressing what factors we should use and figuring out a way to operationalize it which didn't take a huge amount of time.

Denise Mulholland: Great. Thanks. David, did you want to add to that?

David Abel: Yeah. I guess I would just echo everybody's comment up to this point and say that the purpose of why you're using the tool has more of an impact on how long it's going to take you and how much you need to put into it than the tool that you actually used. So the first study that I talked about linking climate to an air conditioning to the health outcomes, that was like a six or seven-year project, over a million-dollar budget; but the solar project we already had some data, NREL invested a lot of money into that, on our end it didn't take very long. I used an eGRID project that took me probably three months to write a report; and it was just me alone, so that's pretty cheap and easy.

And the same with AVERT, I've done a very sophisticated analysis using AVERT and also simplified analyses using AVERT, so it can be anywhere from months to years with any of those tools. And so taking the tool that fits the problem, I think, is going to have a bigger impact on your budget and the expertise and personnel that you need than the tool itself actually, and starting simple is definitely the way to go.

Denise Mulholland: That's great. Okay. I like the 'starting simple' message. David, while I have you speaking, I have a question that's targeting you. So essentially, I have a question here that says what was the future year that you were looking at on high and low SO_2 emissions for the adaptation scenario?

David Abel: Yes. On the high and low, that actually comes from a different study that's published in ASHRAE by Scott Sheeder, et al. And I don't actually remember what they did for high and low, but what we did for that study that carried all the way through--this was a separate thing that they did--was we looked at a series of regional climate model runs that are published in this big database called NARCCAP or the North American Regional Climate Change Assessment Project. And so they used a bunch of different model pairs to project climate out through the end of the century; and we picked a single year, actually a single summer, from the mean model pair that represented the warmest year between 2050 and 2070 from an average model.

And so the reason we did that--and I know this is getting complicated quickly--the reason we did that is we took basically the most realistic or the most trustworthy or at least the most average performing model and picked the warmest year in the middle of the century, so now this is a warm but expected summer in the middle of the century. So, it ended up being 2069, but really it's just representative of the fact that we may have a warm summer in the middle of the century and this is what it might look like.

Denise Mulholland: Okay, great. Thanks David. Okay. So I have a--here's a question for Texas. The question asks how did you determine emission reduction? Specifically, did you assume reductions from specific existing plants, or average reductions, or something else?

Juan Carlos Baltazar: We did exactly per plant. Basically, our model goes through the detail to go through the plants, the plants that are located in each county in Texas. So our emissions calculations are, as I was mentioning before, we have a model that go from the main eGRID in combination with a power generation where we're able to locate in the specific counties depending on the real plant's production what was emissions that were produced, and from that we can forecast the emissions also attach it to those plants that are in it and that county.

Denise Mulholland: Okay, great. Thank you. Okay. I have a question for Eric for the Green Bank. So, what have you found in terms of any results or impacts that you've found from having these program benefits that you've quantified through tools like AVERT? So how has having this benefits information affected your ability to attract and deploy private capital investment, if at all?

Eric Shrago: I would love to be able to tell the story, and I think at some point in the near future we'll be able to tell the story I want to that by highlighting the impact that we're doing we're able to attract capital at more favorable terms than we would be without. But to now we have not seen a pricing difference between the two, between having something rated and not being able to talk about the impact, but that I think that's more of a development of the market.

However, with us going to access capital markets more and more, this being our first public bond transaction, it's more about us getting the habit of doing this so that we have a track record for it so that as the market evolves we're well established with describing to market the impact that we're having. It also helps us on the policy front when we're working with our stakeholders, either from the regulatory perspective or from a legislative perspective here in the state and saying, 'Hey, here's the transaction that we've done, and this transaction which is linked to this program that is mandated by statute, had this impact assessed by a third party', so I think it helps us from that perspective.

Denise Mulholland: Okay, great. Thanks Eric, that's helpful. And I expect it will evolve over time as people get used to and look forward to seeing the information your report.

I have a question for all speakers, and so hopefully folks can just take a few minutes because it could be a long answer, but hopefully you could just take a couple of minutes to answer. But what did you find in the analysis that you described during your experience doing this type of analysis? What have you found to be the biggest challenge, and then how did you overcome it?

So let's start with Texas. In general, for this type of analysis what do you find--or in the analysis that you talked about--what do you find to be the biggest challenge or what did you find to be the biggest challenge and how did you go about overcoming it?

Juan Carlos Baltazar: The biggest challenges have been always to get the real and precise information. In the beginning of project that's what was the main issue try to even, for example, locate the amount of energy produced in all the plants in every particular year and day and time, and try to get the correlated data with the outside environment conditions, that was a big challenge to set it up, and it's still a big challenge.

So for us in Texas probably that was the main point that we have a problem for. After that the challenge were mostly academic or scientifics you wanted to try to really get the real ways to model those or to try to represent what really happened in every county. That should be my point of view.

Denise Mulholland: Okay. Alright. Thanks. Eric, why don't I pass it to you. How about you talk about through this process what has been the biggest challenge that you've encountered and how have you overcome it?

Eric Shrago: We're using the AVERT model in a very simple and straightforward way, I wouldn't say that there were huge challenges in terms of implementing it and operationalizing it, I think we just had to work through and think through how we wanted to do that back when we adopted this model a couple of years ago. In terms of applying it to this we're looking at 28,000 projects, so to run those through in groups in AVERT individually would have been fairly hard to aggregating them and operationalizing it the way that we did made a lot of sense, and I think that was probably the biggest factor although I don't think it was a severe impediment at all.

Denise Mulholland: Okay, great. Thanks. That's helpful. David, how about you? What did you find to be the biggest challenge in either of the analyses or both of the analyses that you talked about, and how did you overcome them?

David Abel: Yeah. I think with the sophisticated tool--and this is actually already mentioned by Jeff and Juan Carlos--these big energy models are generally proprietary, and they're all developed for different purposes even though they're fairly similar. Like I should have said NEMS and JuiceBox, they are fairly similar in what they're trying to do, but the meat of them is totally different; and it's because they were developed by different people, at different places, for different purposes. And in general, most of the models are not cheap, or if they are you have very limited access to them; so making them work with what you want them to do at a reasonable price is the biggest challenge.

Denise Mulholland: Okay, great. Okay, I have a--okay, we've got time for maybe one more question, and this is sort of just to anyone. And I don't know who might have the answer to this one, so you can let me know or let us know. Has anyone analyzed the technical potential air quality improvements from replacing all fossil fuel heat with heat pumps? Has anybody, can you give me a yes or a no? Has anybody done that that's on the panel?

Juan Carlos Baltazar: No, not in Texas.

David Abel: No, not here either.

Eric Shrago: We haven't, but it's something we could consider doing depending on what we're seeing in terms of growth in the market

Denise Mulholland: Okay. And that's David?

Eric Shrago: That was Eric.

Denise Mulholland: Oh, I'm sorry, it's Eric. Okay. So that's something that perhaps Connecticut Green Bank might be a good one to look to in the future. Great. Okay. And then there may be time for one more quick question, just for a suggestion. This, again, is for all speakers. What would be the best model to estimate the impact of changes to fleet from electrification? Do the models take into account more demand due to fleet electrification?

Denise Mulholland: So I know nobody here has spoke about electric vehicles or changes to fleet, we've really talked specifically about energy efficiency and renewable energy resources that are stationary source related, but does anybody have any suggestions for the best model to estimate the impact of changes due to electrification, because first there you'd want to take into account both the mobile as well as the stationary emission changes?

David Abel: Yeah. I can speak to some of that. So, to begin with, from the electricity side, any of these methods could work. You could use eGRID, emission factors, you could use AVERT and just change the demand profiles, or it's very similar to the work that we did where they was added demand for air conditioning except in this case it's add electricity demand for electric vehicles. On the vehicle side the best tool to use is a model called SMOKE-MOVES it's an EPA too for mobile vehicle emissions.

Slide 101. Upcoming Webinar!

Slide 102. Connect with the State and Local Energy and Environment Program

Denise Mulholland: Okay, great. Alright. Thank you so much. Well that pretty much takes us to the end of the webinar, so I'd like to thank the presenters. I'd like to think Jeff and Juan Carlos and Eric and David for your very interesting and informative presentations, as well the answers that you gave to the questions at the end here.

We will be making a recording available of this webinar as well as posting the slides and a written transcript of the webinar. We encourage you there is a webinar feedback form that you're going to see as you exit the webinar, so please give us feedback so that we can improve and enhance the way that we deliver these webinars to you. At the bottom here you can see that you can sign up for our newsletter on the slide that's posted there; you can join our LinkedIn group, you can visit our website.

Slide 101. Upcoming Webinar!

Denise Mulholland: We will also-be having--David mentioned this--we will be having another webinar. This is the first in a three-part webinar series, this one's on quantifying electricity and emissions benefit, we have another webinar coming up on May 16th that will be on quantifying the health benefits of energy efficiency and renewable energy, and then we're planning one to follow that on quantifying the economic benefits of energy efficiency and renewable energy.

So with that I'd like to thank everybody for their time and I will turn it back over to the operator to formally close out the webinar.