CLEAN ENERGY SOLUTIONS CENTER
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Leveraging Open Data and Analytics toward Universal Access: New Open Source Tool Supports Better Electrification Planning

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Webinar Panelists

Dimitris Mentis	KTH Royal Institute of Technology
Yann Tanvez	World Bank

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Host

Today's webinar agenda is centered around the presentations from our guest panelists, Yann Tanvez and Dimitris Mentis, who have joined to discuss the electrification pathways application.

Before we jump into the presentations, I'll provide a quick overview of the Clean Energy Solutions Center. Then following the panelists' presentations, we will have a question and answer session where the panelists will address questions submitted by the audience. At the end of the webinar, you will be automatically prompted to fill out a brief survey, so thank you for taking a brief moment to respond.

The Solutions Center was launched in 2011 under the Clean Energy Ministerial. The Clean Energy Ministerial is a high-level global from to promote policies and programs that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. 24 countries and the European commission are members covering 90 percent of clean energy investment and 75 percent of global greenhouse gas emissions.

This webinar is provided by the Clean Energy Solutions Center which focuses on helping government policy makers design and adopt policies and programs that support the deployment of clean energy technologies. This is accomplished through support in crafting and implementing policies relating to energy access, no-cost expert policy assistance, and peer-to-peer learning and training tools, such as this webinar.

The Clean Energy Solutions Center is co-sponsored by the governments of Australia, Sweden, and the United States with in-kind support from the government of Mexico.

The Solutions Center provides several clean energy policy programs and services including a team of over 60 global experts that can provide remote and in-person technical assistance to governments and government-supported institutions; no-cost virtual webinar trainings on a variety of clean energy topics; partnership-building with development agencies and regional and global organizations to deliver support; an online library containing 5,5000 clean-energy-policy related publications, tools, videos, and other resources.

Our primary audience is made up of energy policy makers and analysts from governments and technical organizations in all countries, but we also strive to engage with the private sector, NGOs, and civil society.

The Solutions Center is an international initiative that works with more than 35 international partners across its suite of different programs. Several of the partners are listed above and include research organizations like IRENA and the IEA; programs like SEforALL; and regionally-focused entities such as the ECOWAS center for renewable energy and energy efficiency.

A marquee feature that the Solutions Center provides is the no-cost expert policy assistance known as Ask an Expert. The Ask an Expert service matches policy makers with one of more than 50 global experts selected as authoritative leaders on specific clean energy finance and policy topics. For example, in the area of rural electrification, we're very pleased to have Ibrahim Rehman, director of social transformation division serving as one of our experts.

If you have a need for policy assistance in rural electrification, or any other clean energy sector, we encourage you to use this valuable service. Again, the assistance is provided free-of-charge. If you have a question for our experts, please submit it through our simple online form at cleanenergysolutions.org/expert. We also invite you to spread the word about this service to those in your networks and organizations.

Now I'd like to provide brief introductions for today's panelists. First up is Yann Tanvez who's an energy specialist at the World Bank. His work focuses on energy access strategies globally and large scale renewable energy investments in Sub-Saharan Africa.

Our second speaker is Dimitris Mentis, who is a lead researcher at the division of Energy Systems Analysis at KTH Royal Institute of Technology. His work focuses on linking geographic information systems and electricity planning to estimate investment and capacity needs to provide access to electricity to the unserved.

Now, with those introductions, I'd like to turn it over to Yann. Yann, perhaps you're on mute?

Yann Tanvez Good morning. Can you hear me?

Host Yes, thank you.

Yann Tanvez Okay fantastic. Good morning everyone. My name is Yann Tanvez. I'm an energy specialist at the World Bank Group based here in D.C. I'd like to thank both Stephanie and Eric for the organization of this webinar. Before we jump into the topic of today—which is a training on a new _____ for electrification pathways—I'd like to provide a bit of context to the role of the United States in the energy sector as well as introduce a new open analytics program ____ here at the World Bank.

As you may have seen, data is everywhere. It's opening up to a lot of the _____ lately. It's always mentioned as the driver of the digital economy, and the way forward. This is extremely relevant for energy sector and increasingly relevant for _____.

Key drivers of the transformation are exponential availability of data. By the end of next year, the world will have created as much data as it has created until today. This is driven by the internet of things and more and more connected device that collects that data in a real-time basis. At the same time, we have increased computational power. Especially as increased interest in the cloud allowing to extract more information from this exponential amount of data. Software capabilities of hand in hand with this computational power and also increasing fast. And complex algorithms are responding to this big question thanks to analytics. Open source algorithms are even more impactful in the sense that anyone can use them.

Also long-term drivers create opportunities in various sectors. Opportunities in cost savings in analyzing such data—time savings as well. It brings new insights that were difficult or impossible to extract before. They also can drive operational efficiency when that analytics are used in real-time to drive businesses' processes.

When it comes to development or development context, that analytics are on a different pace. If you are in a developing country, you might know that data to start with is often an issue. We often face situation where there is no or limited data or data is of poor quality when it's available. We see also a phenomenon that is fragmentation of that data where data can emerge from various sources and it can be difficult to compare and to use for the end-users.

In terms of analytics whereas investments in analytics has never been that high in developing economies, in developing countries they are pretty low. Meaning that governments and private sectors do not invest as much into developing analytics and answering developing countries' questions. So the number and capabilities of firms working in those markets are so limited. Finally, to governments' capacity—which is of interest to the World Bank—to analyze and leverage the analytics is very low. This references a phenomenon that is called today as "digital divide" making it increasingly difficult for developing countries to leverage the digital revolution as some call it.

As I was mentioning, open data analytics is becoming critical to the development agenda. It can help on various fronts including strategic level decision making; investment identification and policy and regulation design; it serves as a private investment incentive and help private sector decision; this is possibly linked to the inability of ____ in markets—the risk of investment. It can lead to more accurate and dynamic infrastructure planning—that's one element of today's presentation—as well as operational efficiencies, and finally, transparency. Overall, what we're looking at is how data analytics can make better, faster, cheaper, and more transparent decision.

The World Bank Group has developed a new Energy Sector and Open Data and Analytics Program which has for high-level objective to accelerate progress toward sustainable development goal number seven of universal access to clean energy through improved access to data and analytics.

The program launched the Data and Analytics Platform last April 2017. It's a platform that is solely focused on the energy sector _____. It takes a _____ approach to make more data analytics available with having 14 partners including the UN, and the World Resource Institute, Facebook, Bloomberg, all the logos are on the bottom. So far, those partners have contributed more than 300 data sets on developing countries that were not available before. So this data has been available for free on an open _____ _____ license and available for all to use. Those data sets include, for example, more than 50 electricity grid maps including one for every Sub-Saharan African country.

While data is great, the availability of analytics to extract information and knowledge from data is also important. _____ and its partner made available already 10 data analytics apps that draw on this data in order to provide analytics tool for end-users. So far it accumulates 60,000 users from 153 countries.

In terms of data, I took a few examples of the type of data that are available on the platform so you can see on the right-hand side an electricity transmission and distribution grid map of the Sub-Saharan African continent, which is today the most up-to-date and complete open data set on electricity infrastructure in Africa. What the World Resource Institute contributed, for example, a data set with mini-grid locations in Tanzania. What you can see on the right-hand side is a map data set comprising of all the mini hydro potential sites present in Madagascar; very useful for private developers as well as for the government.

At the bottom of the screen you have a high-resolution sediment layer provided by Facebook. That is looking at Burkina Faso and providing the structures and sediment as _____ resolution. Very important for designing, for example, access program as well as citing renewable energy on land where sediment can be an issue. It has also more traditional data sets. You can see in the middle-left of the screen, for example, a key data set of the World Bank, which is Utilities, Technical, Financial, and Tariff Database for African countries.

In terms of data analytics, I'll go over fairly quickly, they're all available on the platform, and I encourage you to look at them. But, to give you an example, we have the Least Cost Electrification Strategies which looks at providing scenarios for universal access for every Sub-Saharan African country as well as in America.

India Night Lights is analytics which is highly innovative looking at satellite imagery to identify progress on rural electrification using nightlights. We have been marking _____ _____ before Africa that _____ various _____ layers to provide a high-level of _____ _____ of the _____ _____ of that solution at the Sub-Saharan countries. Global Solar Atlas is an application that provides you with solar radiation measurement for every part of the globe in a couple of clicks. ClimateScope gives you an overview of clean energy policies for the group and compares between them. _____ is similar.

We have an application focused on Myanmar provided by the _____ Institute in German that provides information of the off-grid markets in Myanmar. The Global Tracking Framework is a visualization of progress towards _____ globally. The Africa Grid Explorer lets you explore electricity, creating faster tracking in Africa.

Most of the analytics available are made available on an open source. Open source means that users have open access to codes that are free to modify and use. This supports innovation in the space as well as transparency. Innovation because if a research or firm wants to build ___ ____ ____ ____ ____ development work that have gone to developing such analytics can do so and not start from scratch, but already improve what is already existing.

As case study—and this will be my closing slide—to introduce the electrification _____ application that was used by the government of Zambia in recent months. Basically, uses electricity pathways to inform the country's strategy for electricity access. The government of Zambia has 96 percent of the completion within access to electricity and didn't have any _____ plan that could provide them with information on the type of technologies that could help the country achieve reversal access at a faster pace. By using the tool that we're presenting today, the government was able to re-center their strategy on the development of off-grid solution for the country. That's mainly due to the fact that the country's very _____ and a _____ solution made sense for them in order to achieve _____.

All in all, it saved them three months toward developing that new electricity access program as well as additional resources they could have needed to deploy or get that information. While this is a preliminary step to elaborating a strategy, additional data collection and modeling is not planned to improve on the plan that was provided to them and identifies specific investments that will be part of such program.

So I will stop here and hand over to Dimitris to present the tool and explain how it works. Thank you.

Host Great, thank you very much. Dimitris?

Dimitris Mentis Hello everyone. Can you see me?

Host Yes.

Dimitris Mentis Okay. Let me set up the presentation. Excuse me for that.

Host No problem at all. Looks great.

Dimitris Mentis Okay. Can you see it?

Host Yes.

Dimitris Mentis Okay, perfect. So hello everyone. It is a pleasure being virtually here and many thanks to Clean Energy Solutions Center for holding this webinar. My name is Dimitris Mentis and I'm working at KTH Royal Institute of Technology in Stockholm, Sweden and more particularly in the division of energy systems analysis. Yann has just introduced the importance of open data and analytics for energy access and I couldn't agree more. Energydata.info is a significant ____ that has already created ways for practitioners to share aggregated, updated, and publicly-available data with using high _____ costs of data aggregation. This in turn has helped us in mainstreaming the user space in analytics for the energy sector.

Moving towards open data and analytical tools, we have developed together with colleagues and partners an open source electrification tool that aims to identify investment and capacity needs for providing electricity for down served. And why is that? Nowadays we have around three billion people who don't have access to modern energy services and almost 1.1 billion people that lack access to electricity. The vast majority of these people are located in rural areas in Sub-Saharan Africa, developing Asia, and some parts of Central and South America. They rely exclusively on traditional _____ to cover their daily energy needs, which in many cases causes horrible effects to themselves and their environment. This culture _____ towards sustainable electricity. The tool we have developed focuses on electricity as it can be converted into other forms of energy such as heating, lighting, and mechanical energy. It can be easily transmitted from one place to another with conductors.

Electrification has proven to be a key enabler for socioeconomic development. Several stats point out that the level and the quality of health services, education, gender equality, daily activities, can all be upgraded with access to modern energy services. The importance of energy services for economic and social development is recognized in the Agenda of 2013 for Sustainable Development, a set of 17 goals that use sustainable energy as a goal in its own right. The seventh goal focuses on the _____ level to ensure access to affordable, reliable, sustainable, and modern energy for all by 2013 and talks of the elimination of energy poverty.

Proper energy planning should be carried out in order to match the supply with the growing demand in the most cost-effective way without compromising energy security and reliability of supply. In addition, energy planning is necessary if we are to move from centralized and expensive

energy carriers towards fluctuating, decentralized, and cost-effective renewable energy production.

Systems in the energy systems should be appropriately planned in order to have effective results. Until now, typical energy system models have namely focused on optimizing the ____ grids in the electricity supply and have failed to bring the model properly off grid electrification. Why is this? Traditionally, energy systems model requires data and parameters in order to solve optimization problems. In order to keep models soluble in reasonable time and to reduce calibration in the data requirements, most conventional energy system models consider spatially-aggregated _____. However, the spatial dimension is important. There is several data related to energy consumption, distribution, and generation technologies which comprise spatial attributes and need to be considered in order to calculate system and costs and conclude to optimal set of technologies.

This includes information related to intermittent energy resources, power infrastructure, demand nodes, and economic activities. Two years straight, the wind power is determined by wind speed which varies from one location to another. Similarly, solar power depends on solar radiance. Hydropower on rainfall patterns and topologies, the diesel cost, and pump price in proximity to the pump.

The simplifications employed by conventional energy system models call for more integrated and granular solutions. Ground levels are special data out of key importance to help identify effective electrification strategies and carry out regional access analysis. However, in more developing countries as Yann mentioned, energy-related data at this level are usually scarce. Here is where geographic information systems can complement existing energy system models and help incorporate spatial and temporal dynamics to enable ethic electrification planning while considering a growing mix of energy technologies.

Geospatial analysis is an effective tool for supporting the planning, implementation, and monitoring of basic terms of delivery in developing countries. However, the GIS data and the tools to conduct strategic energy planning remains at the early stage. Yet, it has multiplied in recent years to support public and private sector stakeholders in prioritizing and rationalizing decision-making related to energy infrastructure.

There are several examples in the literature where GIS has been used as a planning tool for renewable energy infrastructure. More specifically, the addition of suitable locations and a mapping of renewable energy resources have been widely expanded from local to national and regional assessments.

However, most of the studies focus on renewable energy supply without considering the location _____ _____ and the cost of delivering energy services. Within a context where energy services are increasingly delivered in a decentralized manner, and through no state actors, energy planners and researchers gradually use GIS analysis in order to define national or subnational electrification plans and subsequent strategies and policies.

The majority of the previously developed GIS methods or tools have one or more of the following implications. They only function how rural area should be electrified and do not provide an overall electrification expansion plan for an entire country. They deploy a limited number of electrification technologies, they use a lengthy number of GIS data—some of which probably _____—they use a limited number of demand notes, and they lack a good expansion-costing algorithm. Finally, they do not account for a dynamic change of the bulk grid electricity supply mix.

Our objective has been to develop further integration with GIS and energy planning, address the mentioned limitations, and provide insights on investment and capacity leads in order to provide electricity to the unserved.

To do so, we have introduced a simple cost model and integrated it with GIS (geographic information systems) to calculate the cost electrification mix based on electricity demand, grid connection characteristics, and energy resources in specific locations. This integration forms the basis of the Open Source Spatial Electrification Tool, OnSSET, which was developed at KTH in collaboration with United Nations Department of Economic and Social Affairs, World Bank, ABB, our industrial partner, and other partners in order to carry out electrification analysis.

OnSSET is an open source tool based in a GIS software and Python, which is an open source programming language. The code behind the toolkit, its implementation, and the data sets are publicly available. Further, OnSSET is a model implementation tool, which means that it is a technology-driven model the effect of which is to increase access to electricity in the least cost manner.

OnSSET has demonstrated the importance of opening energy modeling to the open source community as it allows additions made by external contributors. It enables replication, which is one of the main principles of the scientific method. Users can repeat an analysis of the code and data sources are publicly available. Lastly, it allows users to carry out new applications and further develop the tool.

How does OnSSET work? Covering un-electrified areas requires investments in new generating capacity. This can be added to the national electricity grid, which can be extended to these areas. Alternatively, new off-grid capacity can be added operating either in the form of mini-grids or standalone systems. More specifically, grid electricity is generated in a centralized manner, usually from large power plants which due to ____ are able to offer low generating costs.

Electricity enters households through the transmission distribution network at relatively low costs if the network is well-developed. However, the expansion of grid infrastructure requires high-demand levels to be economically viable. Mini-grids are an important alternative to grid expansion. In this case, electricity is generated in a decentralized manner—usually from power plant with generating capacity up to a few megawatts. Mini-grids are usually

deployed based on locally-available energy resources such as solar, hydro, wind, or can be based on commonly-available fuels like diesel.

Mini-grids based on renewable sources have usually high up-front cost but lower operational fuel costs. On the other hand, grid generators are a mature, low-cost technology subject to operational costs depending on diesel pump price fluctuation.

Lastly, the third option available for electrification is Stand Alone Systems. These systems are usually based on local energy resources in order to produce few kilowatt hours per day, able to cover the electricity demand of a single household. Stand Alone Systems do not require transmission and distribution networks and therefore their capital costs depend only their size.

Now, how do we compare the options listed in the previous slide? The selection of the optimal technology for electrification, and each location is based on the least cost option. In other words, the technology offering the lowest level of generated electricity generated through its lifetime is considered as the cost ultimate option. Onset calculated the level of the _____ generating electricity for several of the electrification technologies based on electricity demand, grid connection characteristics, energy resource reliability, in specialty locations. More specifically, also the continuous population density, in this _____, and the electricity consumption levels to define the electricity of the month. Based on the month, the existing _____ power structure, and other economic activities, as well resource availability, onset last _____ algorithm.

Based on the characteristics of its location, the algorithm decides whether a grid expansion is the most viable solution to provide the electricity to the outsourced populations, or an off-grid solution should be preferred. New connections for technology are intensified as with the required additional capacity and investments to reach full access electricity.

To determine size, OnSSET aims of contributing _____ planning approaches and energy resource assessments using GIS, geographic information systems. A number of a _____ have been used to submit knowledge, including high impact peer-reviewed _____, and _____ publications, such as the World Energy Outlook, the State of Electricity Access Report, the Global Tracking framework, and we contribute in this year's World Energy Outlook.

Now, moving onto to electrification pathways. The high interest in electrification, expressed both from academia, international organizations and industry, created the _____ developing online application made electrification pathways. Electrification pathways, as Yann mentioned, is one of the apps on Energy Data dot-info, and is based on OnSSET, the _____ I briefly presented earlier on. In collaboration with World Bank and ESMAP, we have developed this application that provides insight to electrification planning in three Sub-Saharan African countries: Nigeria, Tanzania, and Zambia. It can be used by anyone with access to Internet.

The development of interface involved _____ in _____ computers. Recently, the three countries were divided in one square kilometer size. This gives us approximately 2.6 million locations in the mentioned countries. For all these cells, and for values scenarios, we compared seven _____ electrification technologies, and determined the least cost technology to reach full access to electricity. We found [inaudible] the next slides. The technology decision depends on several [inaudible] spatial _____ available for download on Energy Data dot-info. These include, among others, population density, difference from existing plant and transition infrastructure, proximity to world network, nighttime light, as well as energy resource availability.

The landing slide of the application introduces us to the importance of spatial analysis in supporting electrification planning. Here, we have three options. Option number one is to navigate through the model underlying datasets, and explore model outputs. Option number two—access the code on the _____, which is basically the online repository for storing, making, and tracking changes in the code. And option number three, [inaudible] including how to use sections. Now, you can click on explore the model. We are asked to select among the three studied countries. I'm going to select Nigeria. Once in the counter base, a brief overview of the country's _____ in terms of demographics, economy, and electricity access is provided.

This data includes _____ and urban/rural splits, the total area of the country, the gross domestic productivity of the country, and the population, the total population that access to electricity, as well as urban and rural electrification rates, and, finally, the current electricity mix of the country. To demonstrate, Nigeria, which is the most populous African country above 180 million inhabitants, has the highest option of deficit, and increase the access, which exceeds 75 million people. Electricity is mainly based on natural gas, and oil fuel power plants. And the significance of the current conjunction comes from hydropower. After this initial overview, we can continue to explore further with the application.

Starting with the left-hand side, the visualization is placed _____ to select among ten alternatives _____, defined by five indicative quantities of electricity conjunction, tiers of access, and, two, raising prices. The current one, which is at a relatively low value, and the projected one, which is higher than the default one. Also note that this is the _____ pricing in major cities, and this changes in remote and rural areas as we account for the consultation cost. As we increase the conjunction scenarios, the world banks—the energy sector management assistance problem has already demonstrated that people's access to electricity cannot be understood about a _____ connected versus not connected, and has vastly introduced and would be a framework for electricity access.

This defines five tiers of access, each tier involving progressively higher demands in terms of electricity and powers of availability. These tiers indicate electricity consumption levels subject from providing electricity to light up, _____, types of phone or power radio have to provide the electricity to a number of—several indicative appliances, like a refrigerator, washing

machine, etcetera. The combination of the population density, and distribution that was shown in the previous slides, and the electrification tier, allows us to calculate the future of electricity demand per location. It should be mentioned that these tiers consider a certain efficiency level, and energy efficient appliances might decrease the consumption level for its tier.

Going back to the visualization interface, and often selected a scenario, we can choose among several datasets to be visualized. The performed dataset is the least cost of electrification technology. Just to remind you, the scenario that we have selected right now is how it is in price, and tier one, where we see the light bump on the left-hand side, on the left _____. Other datasets are grouped in four categories; technology, which includes least cost technology, the level that it's costing to generate electricity; investment costs, investment needs per capita, and audit capacity.

We have demographics-related datasets, which include the population density, urban/rural split, and poverty rates, resource-related datasets, which include solar _____, wind-powered capacity _____, and hydropower potential. And have interest in actual datasets, which includes difference to road and transmission and grid network, cost of generating electricity using generators. As you see in the center of the map, there is a map of the selected country. Right up on the bottom, you see a summary of the model results. This includes for the selected scenario, the set of electrification technology for new connections, investment rates, coverage area, and other capacity.

Now, we can further select a state or a district, and explore electrification pathways for different scenarios. Let's select oil in Southwest Nigeria. After we have selected the state, we can either select further, a local government area for districts, or load oil in states level. So for now, let's remain at state level, and explore electrification mix for oil for the select scenario. Once you have the selected scenario, again to remind you, this can be seen on the left panel. Now, we are on the lowest consumption level, tier one, and the higher in price.

In this case, hydro electrification is accomplished by grid-based electricity for sediments located close to previous electric hydro locations and transmission lines. See that grid scales, while the rest, we gain access to electricity, solar home systems, see light _____. When it comes to area, this changes dramatically, and this is due to high population density in areas with great _____. When the electricity consumption level increases to tier three, gird extension becomes the most economic option for the majority of the needed electrified population.

Standalone systems still remain [inaudible], especially in _____ remote areas. As the electricity consumption increases, many good options start becoming favorable in remote areas as well. And this is even more apparent in the fifth tier, where many grid technologies become economically quite a factor while grid connections expand even further. It is not worth it, but even in tier five, the highest electricity consumption level, standalone systems remain key to electricity access in remote and special populated areas.

If you scroll over specific locations, a _____ pops up on the right-hand side, with information about the model outputs, such as the level of collected electricity, and the investment mix, as well as some of the underlying datasets, such as population density, and the selected solar _____, power availability, proximity to road, and power infrastructure, and so on, which can help us analyze why technology is selected on the cost optimal one. As I mentioned earlier, the performed dataset to be visualized is the least cost technology. But you have the possibility to visualize other model outputs.

For example, the lowest levelized cost [inaudible]. This map shows the lowest levelized cost rate will be increased throughout Asia. Cost increase from green to red. In this analysis, demand is population-driven, so it's essential to map population density and distribution as this drives the demand. See areas with high population density, top of the grid, are more likely to connect to the main grid, and if a grid network is close enough.

Same with demographics, we have not poverty rates in district level. At the same map, of the same _____, we have a look at the investment needs per capita. In district level, we can get an initial level of an idea about the affordability perspective of electrification. For example, looking at_____, _____ west district in Asia, we observe that both poverty rates and investment _____, west district will observe the both poverty rates and investment needs on the higher side of this cape. _____ planners look at more affordable, lower electricity consumptions scenarios, or potentially self-designed subsidy _____.

Moving on to the source of availability. This is essential in identifying the cost-optimal electrification configuration. Here, we saw the wind power capacity factor, which is a measure of assessing the wind power potential in the region. We identify, also, the solar power potential, as well as mini and small hydropower potential on a just special basis. Other essential inputs in the analysis are the road and transmission network, as this influences the cost of expanding the grid, as well as the _____ of transporting fuels, in this case, diesel. Here, we've got the distance to the road network.

Remember, that the datasets are also made available online at Energy Data dot-info. Electrification pathways proceeds new electrification cost estimates, but can be used to inform _____ or electrification strategies, and can bridge signs, technology, and _____ at different levels. So, here, you see the same model output, which is investment needs in different states, local government areas, state level, and country level. However, this tool can help planners and analysts identify investment and capacity needs by location and technology type.

Some key takeaway messages regarding electrification pathways that I would like you to remember while leaving this webinar. This tool introduces a complementary approach to existing energy planning models, which do not consider geographical characteristics related to energy, such as resource availability, location-specific infrastructure, and location-specific demand. Further, electrification pathways improve upon the over-simplified dichotomy

between on and off-grid systems by comparing the two in cost terms after considering local energy characteristics.

Moreover, this tool uses existing publicly available data, provides new GIS-based energy related information, and is based on the open source and modular tool. And having access to Internet may navigate through and download the results of electrification analysis. Note that the tool does not implement the identified _____ exists, nor does it provide the necessary finance.

But it helps us with policy and decisions makers with the implementation of the sense of the development goal, and allows their knowledge of _____ between competing demands and financial resources, and as part and prioritization of the available financial resources. I will stop here. And I would like to project my screen, and so the application online and where you can actually find it. Can you please confirm that you can see my screen?

Host

Yes. And just a reminder to attendees to go ahead and enter questions into the question pane, if you haven't already. Yes, they can see your screen.

Dimitris Mentis

Fantastic. So we are here at the main page at Energy Data dot-info, where we see that the datasets have been growing from day-to-day. Yesterday, it was 300; today, it's already 308. And if you scroll down, we'll be able to find the available applications, which is the electrification pathways. So you can click on electrification pathways, which is one of the ten applications. We come to the landing page of the application.

Previously, we selected to explore the model. We can also scroll down to explore, to go through the methods and read about the tool through the methodology, and see how we can actually—how this knowledge did, how can we use it to mix basically what we discussed in the brief presentation. And, finally, we can explore the model. Now, we can select Tanzania, itself. Again, the country overview, which is very useful if we want to get insight about the current status of the country with regards to electricity access, and electricity _____.

We have the possibility to select states. So, previously, we loaded all the states. So, right now, we can select a further district, but we see here that the majority of all new connections, in this case, a majority of the new connections, actually in this case would be collected for a low electricity conjunction scenario, will be connected with a solar home system. But if we are to increase the electricity consumption level, we see the gray spots penetrating and getting even more favorably.

If we have the maximum electricity consumption level that is considered in this analysis, the majority of population gets electrified soon to be for the grid. And this, again, the least cost technology, so we have the possibility—so our datasets, for example, the investment costs. And we can scroll over to the demographics, and it helps us to understand how population density affects—influences the technology decisions. So we see here that [inaudible] with high population density, and it will go back to our technology decision. We see

that these areas are—the areas of high _____ density are grid connected. We can also examine how the solar _____ looks like, which is pretty high in this district.

And I'm trying to show the _____ on the right-hand side, the _____ webinar. Yeah, okay, so here you receive the thing I was referring to earlier. So if you scroll over to the district, we have a possibility to zoom this in, and treat all information that we see on the dataset, so technology, demographics, resources, infrastructure, information is available for each standard cell. So this analysis has been colored down to [inaudible] cells, and have this information for all these things on the level, and all of the _____ and energy data info. So maybe I can stop here with my presentation.

Of course [inaudible] the help mode, where you get some directions here is technology, what is technology, and here's what the grid is going to present the least cost electrification option for its geographic _____ scenario, and _____, and so on. We can ask _____ for explanations when needed. We can take questions now.

Host

Great. Thank you very much. Yeah, thank you to both of you for those presentations. As we shift to the Q&A, just another reminder for attendees to go ahead and submit questions to the questions pane. We have a few coming in already. But as they come up here in the Q&A, feel free to enter them there. We'll also keep—well, to keep the tool up here in case there are any questions that we'd like to walk through live. All right. So the first question is just about what future expansion plans look like for the tool to other countries, or if there's other functionalities that folks are asking for.

Yann Tanvez

Okay. So this analysis has been—or similar analysis has been carried out for all of Sub-Saharan African countries, 44 Sub-Saharan countries to be precise in the same resolution. So these are available, but these have required an additional effort to have these additional countries online. When it comes to extensions of this tool, in general, I will talk about the electrification of tool is we previously mentioned that this is—the objective is to provide electricity to unsettled population, meaning provide electricity to residential sites, to households. The idea is to—often, we are working towards this direction to add other users of electricity, which would ramp up the demand, and influence the technology decision under the global energy mix.

In cooperation with this other resource of electricity, so-called productive users constitute a significant addition to this planning process. And these productive users are usually the ones that boost income and welfare, and typically in the sector of other cultural global enterprise self-education. Another addition is what you see right now is basically a snapshot in time. So you do not get an idea about how potential electrification timeline will look like.

To do show, we would have to determine priority areas that we believe _____ first. So this is another addition that we are—KTH is working on at the moment. And if you want, we can take more questions and we can discuss this later. This gentleman would like to ask specifies of the tool.

Dimitris Mentis Yeah, so in terms of expansion and plans going forward, I think the point here was to demonstrate as a value and the use of these kinds of tools, as well like the research done at _____ University that will involve more [inaudible]. So the results are actually good from all points of views being used, and by government has been quite useful for the first three countries. So there are discussions how to perhaps take this work, and extend it to additional countries with _____, as well as improving on its function [inaudible] users, for additional scenarios, having new mentors, and that as Dimitris was saying. So that's an offside. So a quick point is by providing this tool as a true predictor, meaning open source, anyone in institution, in the organization, or just IT proficient users _____, can take it, and adapt if for new countries as a very national _____.

Host Great. Thank you both. The next question is for Yann, actually. You mentioned that the tool has already been used to inform polices and projects on electrification in Zambia, and that the tool produces rapid analysis in the third of the time, or so. The question is if you've had a chance to validate or compare the outputs of the tool with on ground and more detailed analysis.

Yann Tanvez Yes, we did. So quality assurance is of course key, especially when you're writing such a model and such analysis to the government, and knowing that they will have an impact on their strategy. So we did, in fact, compare as a result of the tool and the model, we used models that we conducted particularly in Nigeria, and we compared the ratchet assessment to an in-depth one-year assessment, which we knew that was customized modeling. And what we found that the variations in results for Nigeria were of the magnitude of, in the range of five to seven percent with a maximum degradation of 15 percent compared to an in-depth planning exercise.

So for us, that meant that as a first pass rapid assessment tool, this was highly satisfactory. So, once again, what I mentioned in Zambia is that this tool is very useful for policing strategy operation. It's, once again, a very quick rapid assessment tool that is provided for free, and as is. But when you move into actual police design, actual police design, actual investment identification, programmer emulator, that monitoring, you indeed may need to do an extra data collection _____, and then some modeling results by adding new data, especially just _____ data, meaning that maps are agreed, better maps of sediment, verifies accuracy of those _____, then you can improve marginally the result of the model, as well as refine the current parameters that needs to be country-specific, and can be further refined. So, once again, this is a first pass strategy result, and it's an opening door to further planning to improvement, but at a later stage.

Host Great. Thank you very much. Our next question is asking about how things are modeled out here. The attendee is curious about how land costs is integrated into the modeling.

Dimitris Mentis How land cost?

Host Yeah, land cost and access.

Dimitris Mentis Okay. So the way land is accounted for here is basically by an input, which is called great penalty factor. And this refers to an additional cost, which is _____, depending on the land use type, which comes from _____ sensing datasets. So different land use types imply different grids, let's say grid expansion costs. And this is the way land cost is being accounted for. So there is a metrics of information, and metrics of just special datasets that are used in order to cultivate the so-called grid penalty cost, or one is the land use type. Another one is the distance from the transmission network, distance from substations, distance from the rural network, and so on. And the topology of slope and the innovation.

And we have, together, we have an industrial partner who has several years of experience in the field, in the big developed _____, but is basically providing information about different classes of—a lot of different classes of differences to the transmission group come with different costs for extending the grid. And this is the way that land cost has been assessed. There was nothing else done in this case.

Host Fantastic. Thank you. The next question is also for Dimitris. The tool provides a snapshot in the future, and shows the cost optimal mix for 2030. Is it possible to look at a dynamic picture with an electrification timeline instead?

Dimitris It is definitely possible, but as I mentioned to do so, you have to determine priority areas, so we have to decide which areas need to be electrified first in order to lead the electrification expansion. And this is critical, and this is something that should be decided before doing the modeling exercise. One way of doing this is by limiting investments in the areas that are closer to the road network because a lot of _____ is the prioritization of investments. Another point that can be reaching equity among districts, or among the states, or among regions. So maybe the government of Tanzania has a plan to have the same electrification rates in all the states to provide equity. So if this is decided upfront, the analysis, this can be incorporated in the model.

The way we were doing—the way we are working right now, and we're trying to be, let's say, agnostic of the prioritizations; prioritization is by accounting for the road network. So the closer you are to the road network, the faster you will gain access to electricity. So, yes, it is possible. You cannot say it's in this particular application, but it is possible to incorporate this electrification expansion analysis.

Host Great. Thank you. So you've touched briefly on affordability, and one of the attendees is wondering if there is a way to understand whether or not consumers in a specific geographic area have the economic power to acquire electricity from the proposed sources that the model outputs.

Dimitris Mentis Okay. This is a great point. In many of the capacity-building workshops that we carry out, or we participate in this affordability, as I mentioned, always comes with—the affordability dimension question always comes up. So as I mentioned earlier on, the tool that we have presented today does not implement strategies, and it does not provide financing. But it can highlight

challenges before policymakers can—outside of the implementation of the electrification. What we can do is combine income data, and willingness to pay for energy services, if available from _____ service with the model outputs, which are the investment costs to reach access to certain conjunction level.

And this will give us the first idea about the conjunction level that would be affordable, and can then have a look at suggesting subsidies either to utilities or to consumers, or even introduce innovative consumer finance models, such as the pay-as-you-go model. So imagine that you are examining how much it will cost to provide access—to provide the highest electricity consumption level to _____. And in the same area, we know—we have information about income levels or information about willingness to pay for energy-related services.

If you combine the two, and you integrate, you know, what is a consumption level that would be affordable for this particular _____. Because different consumption levels come at different costs, different investment cost, different costs that you pay for the electricity, and so on. So if you are able—if you have this information, and you overlay these geographic layers, the answer you will get, the insight you will get is very powerful.

Host Great. Thank you. That was very helpful. Another thing that you touched on briefly, and I wondered if you could expand on, is the tool identifies the cost optimal technology it makes to provide electricity for households, but can you talk about electricity use in other sectors, other than residential?

Dimitris Mentis Sure. So, again, we haven't conducted the usage of electricity, but those income and welfare. Again, while working on designing, and adding functionality in the developed tool with regards to these _____. So, for example, we are trying to identify where we might have potential demand for agriculture, or how much would the electricity demand be for community services such as schools, or health clinics, or even public institutions and facilities. These were community services. And then, again, we will go back to [inaudible], apart from agricultural, we were looking into extending or providing electricity to industrial users such as mines and quarries, and all the commercial activities such as small to medium-sized enterprises, and so on. So if there is this information available on spatial basis, and there are these datasets available online, we can incorporate it, incorporate those in the model, and see how this productive use of electricity influenced the optimization mix, and investment it needs to provide access to electricity.

Host Great. Thank you. One more question before we turn to any closing comments you might have. If you've gotten any feedback so far on sort of who is using the tool, and how, you know, between those three different options, you know, of access in the code, itself, looking through the models, searching by country. And if you haven't got any feedback yet so far, sort of who do you anticipate using this the most, and how?

Yann Tanvez So _____ has been launched a big thing, so we'll wait to hear back from the users as it gets used. But in the meantime, we did a soft release a couple of

weeks ago, and its' been used, as it was mentioned, by Garmin. So, primary, the tool is aimed to inform Garmin, and [inaudible] planning tool to inform their education strategies and plans going forward. And that was the case in _____, and it was very well received, integrated in the strategy operation process, and is leading the way for additional, more granular, different scenario type of analysis as _____.

Interestingly, it was also provided and made available prior to launch to a couple of big companies that used it to identify whether there could be potential in a given country. And they were very pleased with the result, corresponding, in fact, to the figure that they had produced this to make it on their own. So it can be also used by a private sector working on the access in country to get additional data on, for example, the number of possible investment costs, and priority areas, specifically looking at underlying layers that can be displayed on the app.

Host

Great. Thank you. And thank you both for—both your presentations, and a very informative Q&A there. I'll turn it to both of you. If you have any closing remarks to make before we close the webinar. Maybe Yann, and then Dimitris, if there's anything you'd like to add before we close?

Yann Tanvez

Thank you. I'd like to thank you guys, and the Clean Energy Solutions Center for organizing this webinar. As far as closing remarks, and more broadly than this tool, I hope that [inaudible]. We look forward to receiving any feedback, any potential options to collaborate in taking this a step further. But, more broadly, in the _____ session, World Bank [inaudible] approach to this _____ by providing an open _____ platform that is not only for the World Bank, but also for various organization, and individuals to contribute.

So as my main closing remark, I'll encourage participants and stakeholders to please reach out to us to contribute to these things, the initiative if they want to and can. Our address can be found on the website directly at Clean Energy dot-info. Please shoot us an e-mail, and we kickstart the conversation, and hopefully collaborate on the subject. Thank you.

Dimitris Mentis

And then from my side, I would like to add to Yann's closing comments, but you have now seen one, let's say, application of electrification modeling. Too, if you're interested in the code, itself, or exploring other applications, or other projects, and wading through the methodology, and through the _____ publications, you're welcome to visit our website at www.onsset.dot-org. You can go through lots of material, as well as through the code, itself. Again, this is a very powerful application that doesn't provide the final, let's say, numbers. It provides significant insights about electrification planning. And we also get a very good idea about which datasets are important for us to gather while carrying out such an analysis.

So, for example, you see here how much—how important the transmission network and the population density when we carry out such an analysis. At the same time, we talked about affordability. So if we have information about the willingness to pay household surveys, and we opened recently on a _____ basis, we will manage to be able to be one step closer to address the

affordability issue, and provide affordable access to electricity. Because access to electricity, in the grid supply in general, cannot be sustained without development. And on the way around development, and not happen without access to electricity. And on the development side, again, it would be very important to incorporate the avenues of electricity, the good income and welfare. So, again, it was our pleasure being hosted here. Thank you.

Host

And behalf of the Clean Energy Solutions Center, yeah, thank you as well, again, for this presentations and Q&A, and thanks as well to our attendees for participating in the webinar today. We appreciate your time, and hope in return there is some valuable insight that you can take back to your ministries, departments, and organizations. We also invite you to please inform your colleagues and those in your networks about the Solutions Center resources and services, including that no cost policy support _____ expert service. Please check the Solutions Center website if you'd like to view the slides and listen to the recording of today's presentation, as well as previously-held webinars.

You'll also information on upcoming webinars and other training events there, and we're posting webinar recordings to the Clean Energy Solutions Center YouTube channel. Please allow about a week for the audio recording to be posted there. And, finally, I'd like to kindly as you to please take a moment to complete a short survey that will appear when we conclude the webinar. Please enjoy the rest of your day, and we hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar.