

CONFERENCE REPORT

Pathways to

100%

Renewable
Energy

 Toward Electrification in All Sectors

2nd International Conference

Beckman Center of the National Academies of Sciences and Engineering

Irvine, CA | May 11-12, 2017

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About this Report

The report was published by the Renewables 100 Policy Institute, a 501(c)3 non profit organization. Our mission is to study and accelerate the global transition to 100% renewable energy in ways that are efficient, ecological, and benefit the most people.

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INTRODUCTION

The 2017 Pathways to 100% Renewable Energy conference was convened to address the opportunities and challenges of transitioning to 100% renewable energy across sectors in California and beyond. The event focused on the urgent need for this transformation to protect our climate, strengthen economies, and drive innovation. It also examined the increasingly central role of the electricity sector, which is not only needed for its traditional functions in the energy systems of the future, but also for cutting edge purposes like powering electric transportation and producing renewable heat, gases, and fuels.

When the conference launched in San Francisco in 2013, it was the first international forum in the Americas to focus on 100% renewable energy targets and solutions and brought together participants from four continents and ten countries to learn from top thought leaders across multiple disciplines. Widely acknowledged as a watershed event, the conference catalyzed new non-profit campaigns in the US and around the world, several 100% renewable energy commitments, such as from the City of San Diego, and the concept of 100% renewable energy to become more embedded in the mainstream lexicon.

The 2017 conference opened to more than 300 participants over two days from seven countries and four continents and featured dozens of prominent keynote speakers and panelists from many disciplines, including government, industry, universities, the workforce and non-profits, who are leading the way on supporting and developing best practices for transitioning to renewable energy. Among the speakers were **Maria Eugenia Di Paula**, Coordinator of the Environment and Sustainable Development Program for the United Nations Development Program; **Paloma H. Gonzalez**, US State Department Political and Economics Chief for the Consul of Recife; **David Hochschild**, California Energy Commission Commissioner; **Harry Lehmann**, German Federal Environment Agency General Director; The Honorable **Chris Lee**, Hawaii State Representative; The Honorable **Kevin de León**, California Senate President Pro Tem; **Peter Light**, Business Innovation at Google X; **Marcelino Madrigal Martinez**, Mexican Energy Commission Commissioner; **Andrew McAllister**, California Energy Commission Commissioner; **Janet Napolitano**, University of California President; **David Olsen**, CAISO Governor, and many others.¹

1 For the full list of conference speakers and a detailed program, please visit www.renewables100.org/en/pathways-2017/

INTRODUCTION

This report aims to distill the main takeaways and new ideas shared by the forty experts who spoke at the conference. The topics covered in presentations and panels are grouped under three predominant themes.

I. Focus on Sectors

- Electrification of Transportation
- The Building Sector's Role in the 100% Renewable Energy Future
- The Energy Grid of the Future
- Keynotes by Industry Leaders

II. Subnational and International Leadership

- California Local Leadership
- International Leadership on the Energy Transition
- Keynotes by California State and Local Leaders

III. Additional Accelerators

- Women Accelerating the 100% Renewable Energy Transition
- Innovation & Disruptive Technologies Changing the Energy Landscape



Hawaii State Representative Chris Lee with R. Rex Parris, Mayor of Lancaster, CA



University of California President, Janet Napolitano



Kevin de Léon, California Senate President Pro Tem with Jennifer Kropke, Director of Workforce and Environmental Engagement IBEW Local 11, Angelina Galiteva and Diane Moss, Founders of Renewables 100 Policy Institute



California Governor Jerry Brown's Senior Advisor Ken Alex with Maria Eugenia Di Paula, United Nations Development Program, Deep Badrinarayana, Chapman University and Angelina Galiteva, Renewables 100 Policy Institute

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Several common threads emerged out of the discussion, with six big takeaways.

6 Top Takeaways

1. **The overarching consensus was that the conversation on transitioning to 100% renewable energy is quickly maturing, attracting new voices, and ready to engage in constructive debate about challenges, opportunities, and best practices for how to get there at scale across sectors and across various regions.** The continued mainstreaming of 100% renewable energy, as a concept and as a commitment, is moving beyond earliest adopters to new actors across the US, emerging markets, and the corporate sector. This trend is being driven faster than many would have thought even a few years ago by multiple forces, including continually falling costs of clean energy technology, outpacing of clean tech job growth compared to conventional energy employment, growing familiarity with clean energy technologies across all strata of society, growing subnational and corporate leadership, and ever rising concern about the environmental and health impacts of continued dependence on conventional energy sources.
2. **The energy grid of the 100% renewable energy future will be cross-sectorial, decentralized, integrated across regions, and able to balance a diverse supply** that largely originates with wind and solar power. It will succeed in maintaining reliability, cost-effectiveness, and low or zero emissions through the optimization of a broad range of flexible, decarbonized technologies including storage, distributed energy resources (DER), and other cutting edge grid solutions.
3. **Powering the electricity grid in populous regions like California with all renewable sources is challenging, but feasible and unleashes opportunities to extend the full benefits of renewable energy to decarbonizing the transportation, building thermal, and industrial sectors.** Electrification solutions like plug-in electric vehicles, heat pumps for hot water, and other technologies powered by 100% renewable electricity can increasingly help achieve zero emissions transportation and building, while helping to balance the grid and providing grid services during peak demand. Very high penetrations of renewable electricity up to 100% will bring new technical requirements for large scale seasonal storage, and 100% renewable energy across sectors presents challenges to decarbonize applications that are difficult to electrify (e.g. aviation, shipping, long haul/heavy duty vehicles, certain industrial processes, etc.), but these problems are solvable. One exciting area of development that can address these challenges is repurposing over-generation of renewable power to produce zero-emissions gases and fuels that can replace fossil energy with zero-carbon energy in these tough applications. Policy and regulatory support is needed now to fully realize the full breadth opportunities for decarbonizing the energy system across sectors and to open markets to a broad playing field of low and no emissions solutions.

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4. Transforming energy systems to be 100% renewable energy reliant requires leadership and coordination across all levels of government, from local and sub-national to national and international, and across multiple areas of expertise, including policy, technology, finance, workforce and social justice. Knowledge exchange between leading experts and decision makers across jurisdictions, regions, and skillsets unleashes innovative breakthroughs and speeds progress.
5. Inclusivity across gender, cultural, and socio-economic lines raises the chances of large-scale, long-term, and just success that fully reflects people's needs and values region by region.
6. Setting firm 100% renewable energy targets is critical to galvanize focus, spur innovation, and open economic opportunity and will be essential to the deep decarbonization necessary to mitigate climate change. Roadmap and milestones are important, however, it is not necessary, or even possible, to have all the answers at the start.



David Auston, Institute for Energy Efficiency, University of California Santa Barbara;
David Hochschild, California Energy Commission Commissioner;
Marcelino Madrigal Martinez, Mexican Energy Commission Commissioner



Tour of UC Irvine Campus Advanced Energy Projects



Harry Lehmann, German Federal Environment Agency General Director;
S. David Freeman and Angelina Galiteva, Renewables 100 Policy Institute

CLOSER LOOK AT CONFERENCE HIGHLIGHTS

The following is a deeper dive into each of the conference panel discussions and keynote addresses and the highlights from each one.

INTRODUCTORY KEYNOTE:



S. DAVID FREEMAN – It's Time to Take the Offense on Renewable Energy

The conference kicked off with an introductory keynote address by utility and renewable energy veteran S. David Freeman, who shared insights from more than forty years of experience on why now is the time to make bold mandates to advance 100% renewable energy and mitigate climate change.

We've come so far, yet there is so much still to be done. The progress made on renewable energy has been faster than most even in "the movement" expected and is one of the most significant achievements of our civilization. As a CEO of five utilities, Freeman declared that it's remarkable that renewable electricity technologies like solar and wind are essentially harnessing free energy, with minimal operation costs, and he believes these will follow a similar pattern as legacy hydro dams, which supply very cheap power with nearly no maintenance expenses. Meanwhile, however, the planet is still warming, and the problem is far from solved.

The technology we need is there to get to 100% renewable energy, and now we need more mandates. All new power plants, for example, Freeman said, should have to be zero-emissions to save on costs and to protect the environment. Cars should have to be zero-emissions, as California started to require in the 1990s. Building efficiency and storage also need ambitious mandates. The RPS has worked to increase the share of renewables, evidence that mandated targets can work.

We are on the path to 100% renewable energy, but are moving at a snail's pace.

We need to gallop.

It's not enough to shut down old conventional power plants, they have to be replaced by new renewable energy. The vision to shut down the Diablo Canyon nuclear reactors and replace it with renewables will be a good yardstick, if it gets through the required regulatory hurdles Freeman said. If PG&E can see that solar PV and storage are cheaper options than continuing to operate a nuclear power plant or to build new gas power plants, said Freeman, then it's time for everyone to see that renewables are the least cost way to go.



PART I: FOCUS ON ENERGY SECTORS

The conference then focused on three sectors that will continue to play central roles in the energy transition of the 21st century: transportation, buildings, and the energy grid. Complementing these discussions were keynote presentations by technology leaders from the renewable energy development and electrolysis industries, who are helping bring these various sectors together in innovative ways.

Panel 1:



The Role of Electric Transportation in the 100% Renewable Energy Future

The first panel was moderated by **Alejandro Zamorano-Cadavid**, Specialist in Advanced Transportation for Bloomberg New Energy Finance (BNEF). He was joined by **Matt Horton**, CCO of zero emissions bus manufacturer Proterra, **Steve Chadima**, Sr. Vice President, External Affairs & Director of California Initiatives at Advanced Energy Economy, which is a national coalition of businesses focused on clean energy, and **Ryan McCarthy**, Science & Technology Policy Advisor at the California Air Resources Board, which regulates air quality and greenhouse gas emissions in the State of California. Below are highlights of their discussion on the role of battery and fuel cell electric transportation in the 100% renewable energy future.

Policy & Regulatory Elements

California's policy framework for accelerating battery and fuel cell electric vehicles consists of greenhouse gas reduction mandates that require the state to reduce emissions 40% below 1990 levels by 2030 and 80% below 1990 levels by 2050 – with transportation accounting for 40% of emissions in 2015. The state also has an Executive Order calling for 1.5 million ZEVs to be on state roadways by 2025. The California Air Resources Board estimates that 5 million ZEVs will need to be on the state's roads by 2030 to successfully reach its greenhouse gas reduction target.

Two parallel tracks of strong policy support are needed: incentives for both manufacturers and consumers to propel adoption the vehicles and the infrastructure. Both battery and fuel cell electric vehicles need longer term mechanisms to ensure the necessary incentive funding, if these vehicles are going to scale as quickly as is needed to curb emissions. Public or semi-public charging infrastructure is especially necessary for plug-in vehicle drivers who can't just rely on plugging in at home, in order to successfully address range anxiety.

Underscoring the essential role of policy, about a third of Proterra's early adopter customers are in California, and this is driven by the state's policy commitments to accelerate zero emissions transportation.

Federal funding, such as the US Department of Transportation's Low or No Emissions Competitive Program², has played a key role in helping cities adopt zero emissions buses, which besides being a new concept for cities, currently have higher upfront capital costs that payback over time, due to lower operations and maintenance costs.

Encouraging adoption now of zero emissions public transit buses is essential to cleaner air and reducing fossil fuels. Conventional buses run highly inefficiently on diesel, getting only 4 miles per gallon. By contrast, Proterra's battery electric buses run on California grid power, which consists of partially of renewable sources, and get about 22 miles to the gallon equivalent. Accelerating adoption of ZEV alternatives now is not only critical to cleaning up emissions in the present, but also in the long term because approximately 5000 public buses are replaced annually in the US, each certified for 12 years of minimum life.

The philosophy of California's freight plan is to go zero emissions wherever possible and near zero emissions with renewable fuels everywhere else. This means that agencies take a broad view of technologies that includes batteries, hydrogen and renewable fuels derived from organic waste, with incentive programs to support them that are designed on an emissions performance metric basis.

² <https://www.transit.dot.gov/funding/grants/lowno>



Utility rate design can play a strong role in accelerating electric vehicles. For example, mitigation of demand charges helps to support adoption of electric public transit buses. With passenger vehicles, rate structures that incentivize people to charge at times that are most beneficial to the grid, such as when there is over-generation of solar power in the middle of the day and not when people are all coming home and using their appliances, is also of value. In California, electric utilities have begun over the past couple years to show significant interest in cooperating on rate design that encourages vehicle electrification. But there is still much to be done. Panelists pointed out that rate design ought to, for example, be more consistent and supportive of vehicle charging across different utility territories. Currently, someone charging their car in PG&E territory, for instance, pays about as much for electricity as gasoline, whereas Sacramento Municipal Utility District customers get the electricity for free. Making rates for vehicle charging simpler, more transparent, and more certain to be less expensive than petroleum fuels across the entire state will better capture its value to the public and help speed up transportation electrification.

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The rapid pace of technology advancement poses a particular challenge for designing long term policies. For example, when California adopted its most recent Zero Emissions Vehicle rule in 2012, the state's vision to 2025 was based on vehicles that were coming available on the market at the time - that is, a group of 80-mile range battery electric vehicles, a handful of few hundred-mile range fuel cell electric cars, and some plug-in hybrids averaging around 20 miles of range. Five years later, what is actually happening is that with the drop in battery costs, 200-mile range all-electric vehicles are coming on the market that are vastly cheaper than what had been projected for even 2025, along with several fuel-cell vehicle models. As the state looks to create standards beyond 2025, it will again be a challenge to envision what the market will actually look like and design policy that treats various ZEVs equitably, given the fast pace of market evolution.

The global EV industry, which has surpassed 2 million plug-in vehicles, grew 55% in 2016, a speed of growth that is a sign of success.

Technology & Market Developments

In 2017, many new ZEV models are being introduced to the market, including several sedans, continuing a steady trend over the past several years of increased numbers of options for consumers. BNEF forecasts that about 20% of all car sales around the world will be plug-in electric by 2030.

The dropping costs of battery packs is quickly making battery electric buses competitive with diesel buses. When Proterra started out, battery packs cost \$1200/kilowatt hour, and battery electric buses were projected to become competitive with diesel buses when the cost of battery packs dropped to \$700/kilowatt hour. In 2017, battery packs are about \$300/kilowatt hour, that is, less than half the previously projected competitive cost. When battery packs cost \$150/kilowatt hour, industry projects that diesel could be free and still be more expensive to own and operate than battery electric buses.

In 5-10 years, the game will be over for diesel vehicles in the heavy duty transit space.

There is a wide range of potential approaches to zero emissions heavy duty vehicles, including hydrogen and batteries, and there is room for a mix of technologies. Among other advantages, hydrogen can make sense because it requires fewer fueling stations and is lighter than batterie. For batteries to be able to manage long haul trucking, there would need to be technology evolution and significant cost breakthroughs.

Because it is difficult to make money with charging infrastructure, a better way to look at its value is the service it can provide to the grid. By charging or not charging at the right time, electric vehicles can be a tool for grid operators to integrate renewable electricity generation and ensure efficient build-out of renewable power generation. The technology is there for EV chargers to communicate with the grid and realize this function. It's just a matter of deploying it properly.

Battery and hydrogen fuel cell vehicles can help to bring more value to renewable generation by preventing curtailment, but there are also challenges, such as cycling the batteries for different uses than what they were made for, and creating new rate and market structures that support low cost fueling. OEMs, regulators, utilities, and customers are all trying to grapple with what the best way is to use and maximize these assets.



Service agreements for EV batteries are one pathway that has potential mutual benefits for many stakeholders over the long-term life of the batteries. In these agreements, OEMs strip out the battery at the time of sale and provide battery service over the time of use of the vehicle (with the cost of the battery lease and charging being akin to fuel costs for diesel), reduce upfront costs and provide a favorable financing structure that is similar to what customers are used to. Utilities are starting to show interest in owning the batteries and financing their lease to end use customers. At the end of their useful life in vehicles, utilities can use them as “second life” batteries to provide grid storage and/or disaster response.

Marketing efforts for electric vehicles have room for improvement, such as focusing more on the favorable lifecycle costs of zero emissions vehicle ownership and motivating more car dealers to be better at selling these vehicles.



Panel 2:



Building Sector's Role in a 100% Renewable Energy Future

Moderated by Commissioner **Andrew McAllister** of the California Energy Commission, which leads the state's roll out of its net-zero energy building policy³, the second panel of the day brought together the following experts to discuss how the building sector fits into transitioning to 100% renewable energy: **Merrian Borgeson**, Senior Scientist for NRDC's Energy Program; **Matt Eggers**, Vice President of Yardi Energy, which is a leading provider of building energy management software; **Bill Kelly**, Vice President, Commercial Americas at Sunpower Corp., which is a global leader in solar PV manufacturing and development; **Jennifer Kropke**, Director of Workforce and Environmental Engagement at the International Brotherhood of Electrical Workers (IBEW) Local 11; and **Michael Strong**, Senior Project Manager at Pankow Builders, which specializes in sustainable commercial building.

Panel Highlights:

Buildings are a platform on which a lot of the clean energy revolution is actually going to take place. We have to incorporate them, as we transition to 100% renewable energy.

Buildings are the shock absorbers of the electric system. Another analogy is that they are like a living organism, taking in energy and using it over time.

Buildings that maximize efficiency and clean, renewable energy use may be full of complex parts, but in basic human terms, they are simply better. They cost less to operate, have higher valuations, provide healthier and more pleasant environments, and are potentially more resilient to grid outages. The technologies that enable these improvements, like LEDs and efficient appliances, are better products.

³ California aims to have all new residential buildings be net zero energy by 2020 and all new commercial buildings be net zero energy by 2030.

Building managers have tended to think about energy usage and costs the way we think about death and taxes, but that doesn't have to be the case. Software solutions to manage building energy use, for example, can lead to significant cost savings, as much as 15-20%. Given that energy accounts on average for nearly a third of building expenses, this translates to a welcome drop in utility bills, the value of the building also goes, and rental rates tend to increase by about 5%. Buildings that use Yardi's energy management software tend to enjoy a net income increase per square foot of about \$3 and an increase in building value of about \$40/square foot. Additionally, improvements in everyday comforts like climate control help people in these buildings to be happier and more productive.

Building managers have tended to think about energy usage and costs the way we think about death and taxes, but that doesn't have to be the case.

User-friendly solutions are key because people get “compassion fatigue.” Net Zero Energy solutions will be much harder to implement, if it is just something to add to the list of “shoulds.”

Big price plunges in technologies, like solar power, are propelling adoption of advanced energy solutions for buildings. The cost of solar power has dropped 63% in price over the past 5 years – 19% last year alone - with utility scale solar falling to less than 3 cents per kilowatt hour in some sunny locations.

Even the fossil fuel industry projects that solar power will grow exponentially as a dominant energy source over the coming decades, which will be key to enabling buildings to become energy producers, not just consumers.

There are several ways to provide heat to buildings using cleaner renewable resources, including heat pumps, solar thermal and renewable gases, such as biogas from organic waste or hydrogen made using renewable power. The winners will depend on performance, emissions profiles, and available resources over time, as well as choices about policy and market design.



Heat pumps are excellent, energy saving storage devices that can help buildings absorb excess load from the grid when renewable generation is high and that need support in overcoming market bumps, if they are to scale. Similar to how co-ops in the South have used hot water heaters as demand response appliances for decades, the same can be done with heat pumps, which are 300% more efficient than standard water heaters. While there are significant hurdles to building a market for heat pumps in states like California, including increasing availability and consumer awareness, the technology in and of itself is proven and promising for heating hot water. One example given of scaling up this technology is the Association of Energy Affordability, which has installed or is planning to soon install about 1500 heat pumps in affordable housing projects in California, with funding coming from state cap and trade money that is available because of the technology's greenhouse gas reduction capability.

Among the numerous examples of net zero energy buildings in the US, the largest commercial retrofit is the Net Zero Plus Electric Training Center in Los Angeles. Recognizing that a well-trained workforce is essential, the center educates thousands of workers in state of the art energy technology installation and operations. The facility's net zero retrofit, which was completed in 2016, has allowed it to cut its energy consumption in half and to produce 1.25 times more energy with solar panels than it annually consumes. The building also uses batteries to store the excess solar power – enough to maintain 72 hours of operation during blackouts or natural disasters. This essentially makes the facility energy self-sufficient, if and when the grid goes down. The excess electricity can also be fed into the grid when there is high demand, making it ready to participate in a demand response market, which the state of California is actively working on developing.

Building codes are a critical state tool for advancing clean energy solutions for buildings. Challenges include ensuring they are not overly complex for builders, dealing with the limitation of federal pre-emption, and making sure that codes don't get in the way of marketplace innovation and momentum. One trend that California may try to incorporate into its building code is “triple bottom line” – that is, a framework that accounts for financial, environmental, and social benefit.

Performance based standards like Energy Star for appliances or benchmarking for buildings are powerful drivers in the marketplace toward greater energy efficiency. As one panelist observed, “No one likes to suck.” Having to adhere to performance based standards also requires building teams to have to think about what the best solutions are for a given situation.

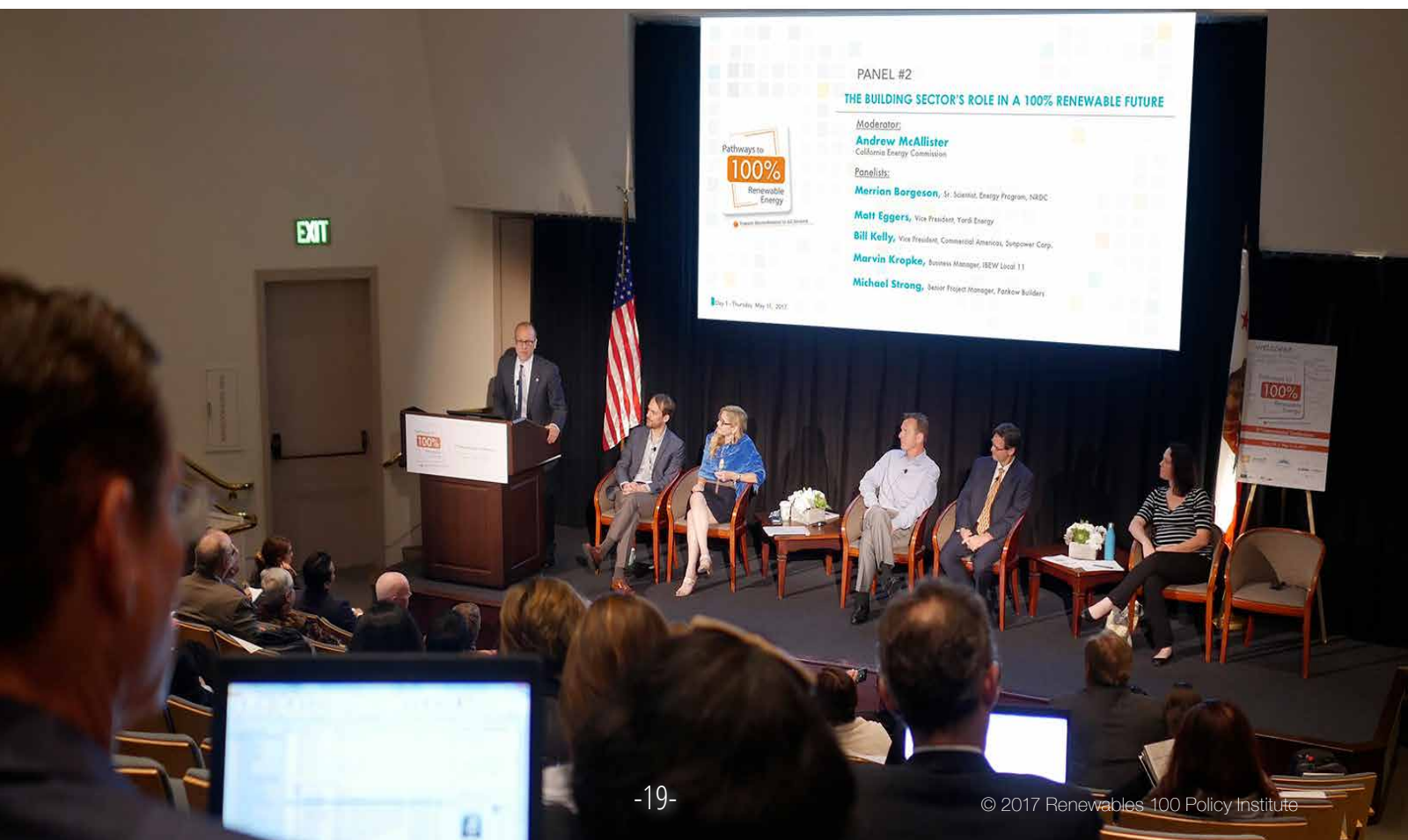
EVs make vehicles more integral to building energy systems than ever before. Electric cars often compel the purchase of solar panels, they have the potential to provide electricity storage for buildings, and they can also potentially add to buildings' grid balancing capabilities. Policies and regulations ought to keep such cross-sectorial pairings in view with a holistic approach. The approach also ought to maximize opportunities across economic strata, including in disadvantaged communities, multi-family dwellings, and lower income commercial areas like strip malls.

Regulators need to set pricing signals that capture the value of various building-related solutions – such as hot water heating and electric vehicles - that can help balance the grid and integrate renewables into the energy system.

As we think about buildings as part of a 100% renewable energy future, it's important to think not just of individual buildings, but also of communities and networks of buildings. If the grid, for example, is searching for load, it is much easier to find in a group of twenty buildings that are networked through software than in just one building.

Cities can and do lead the way on being earliest adopters of clean energy building solutions. In California, for example, there are many examples of cities that have enacted policies that go beyond state requirements or timelines for efficiency, renewable energy integration, and zero net energy requirements.

Using 40% of the nation's energy production, the building sector has long been the biggest energy consumer in the US, but as buildings deploy efficiency and renewable energy solutions, rather than just consuming energy, they also become clean energy producers and can participate in new ways, as balancers, stabilizers, and sellers, in the broader energy system.



Panel 3:



The Energy Grid of the Future

This panel was introduced with a keynote by **David Olsen**, a member of the Board of Governors of the California Independent System Operator (CAISO), and followed by a discussion moderated by Mr. Olsen among thought leaders with a diverse range of expertise. Panelists included **Dr. Jack Brower**, Associate Professor at University of California Irvine and Associate Director of both the National Fuel Cell Research Center (NFCRC) and Advanced Power and Energy Program (APEP); **Dr. Keith Casey**, Sr. Vice President of Market and Infrastructure Development at CAISO; **Dr. Steve Davis**, Associate Professor at University of California Irvine; **Dr. Harry Lehmann**, Division I General Director at the German Federal Environment Agency; and **Janice Lin**, Executive Director of the California Energy Storage Association.



INTRODUCTORY KEYNOTE:

DAVID OLSEN, CAISO GOVERNOR

The following are highlights from Mr. Olsen's keynote address.

The CAISO, which operates California's transmission grid and wholesale power market, believes the future of the electricity grid is decarbonized and decentralized.

The CAISO has identified several trends and tasks, in view of California's heading toward approximately 60% renewable energy by 2030 (50% RPS plus other sources like legacy hydropower). For example:

- Efficiency will remain the primary focus.
- Gas generators will run much less frequently, and California urgently needs a plan for the orderly retirement of gas-fired generation that can help minimize stranded fossil fuel assets, while ensuring the financial viability of the gas generators that the state will need for some time.
- Demand will become as important as supply in balancing the system. Distribution grid operators and energy providers will manage more flexible and controllable loads.
- The grid of the future will be shaped by the variable output of wind and solar. As California progresses beyond 60-70% renewable electricity, ready access to a much larger pool of renewable sources than what is available in state becomes essential.

Progressing toward 100% renewable energy will require changes in traditional policy and regulatory thinking. For example:

- Renewables, in addition to simply providing power supply, are capable of supplying a range of grid services to balance the system. To realize this potential, regulators at the Public Utility Commission are going to have to come up with ways to compensate renewable generators for non-power services, such as reactive power and frequency response.
- It will be necessary to go beyond the Renewable Portfolio Standard, which is an artifact of fossil-based grids. In an all-renewable powered grid, all clean resources will need to be incorporated on a comparable footing. This includes large and small scale renewables, demand response, and storage, among others.



Panel Highlights

Fossil fuel infrastructure for electricity is still expanding around the world, including in California, with decades of lifespan ahead of them, creating risk of stranded assets, as we try to decarbonize the sector.

Cheap natural gas tends to curb coal use, which is a win for the climate, but also to slow down development of renewables, so policies that support renewables are therefore key.

Renewables can supply essential grid services and in many cases, do so faster and more precisely than conventional power plants.

UCI modeling of reliability of the US electricity system, in scenarios using just solar and wind resources, shows that some dispatchable resources – natural gas temporarily and zero-emissions fuel hopefully in the future – will be needed to maintain reliable, cost-effective generation, as the grid transitions to renewables.

- With just solar and wind, a national integrated grid, and no storage, about 75% reliability is shown to be achievable.
- Add to that 12 hours – or about 5 terawatt hours of storage - reliability jumps to 85%. To put the magnitude of the amount of battery storage that would take, it's equivalent to about 150 years of production at Tesla's gigawatt factory. In reality, the system would also need seasonal storage, which is a vastly higher amount.
- With a 50% overbuild of wind and solar and no storage, about 85% reliability is achievable. If that is coupled with a cross-continental, integrated transmission grid, near total reliability is possible. That amount of overbuild of wind and solar, however, comes at high cost.
- Adding dispatchable resources to these scenarios allows for a more cost-effective pathway toward reliability.

Integrating different sectors of the energy system – e.g. electricity, transportation, buildings, existing gas infrastructure - will be critical to achieving 100% renewable, decarbonized energy across sectors. This is especially so for meeting tough challenges like heavy duty trucks, aviation, shipping, trains, and some industrial processes. Globally these difficult sectors account for about 20% of carbon emissions.

As grid operators and utilities have become more experienced with renewables, their apprehension is being replaced by growing acceptance. In California, for example, the state's 20% and 33% renewable procurement mandates for electricity IOUs were first met with great worry by the CAISO,

but experience led to greater understanding of the technology, better forecasting, and development new market mechanisms, which have resulted in the CAISO becoming a world leader on integrating renewables into the grid. Growing confidence does not mean there are not still major challenges that grid operators like the CAISO face with managing high penetrations of renewables, such as days when unexpected high ramping or lack of expected availability of resources.

The next evolution of managing increasing penetrations of renewables on the electricity grid is about managing the grid with renewables instead of working around them. It's about using renewables also to provide essential grid services, such as load balancing, maintaining frequency, and voltage regulation. A First Solar PV project studied by CAISO and NREL demonstrated that a 100 MW solar plant can supply essential grid services and in many cases, do so better than conventional power plants. Coupled with onsite storage, solar power plants have the potential to provide grid services even when the sun is not shining. In order to realize this potential fully, however, regulations and policies will need to move beyond their current paradigm to develop market mechanisms that value the grid services renewable generating facilities can provide, and not just the power generation through mechanisms like renewable energy credits.

Energy storage enables taking advantage of under-utilized assets. 5% of distribution, generation and transmission in California is utilized less than 50 hours a year. 25% is needed less than 10% of the year. Energy storage, a large asset class comprised of a multitude of modular technologies, many of which are geographically flexible and quickly installed, is going to be increasingly key to running a more efficient, environmentally sound energy system.

While the cost of solar and wind technology has plummeted, it can still be costly to manage the dynamics of high percentages of these resources on the grid.

Batteries are the best technology for short term, daily load shifting, but long term, seasonal storage requires other solutions, such as pumped hydro and electrolyzers that use renewable power to make hydrogen. Batteries are susceptible to self-discharge, which greatly dissipates their efficiency, if they need to store energy over long periods. Pumped hydro, on the other hand, can store large amounts of energy over a long period economically. Electrolyzers, which use electricity to split water into hydrogen and oxygen, can also shift load seasonally, and don't have the geographic limitations of pumped hydro. They also have inverters that can be used to provide other essential grid services. At high levels of renewable power penetration where large amounts of storage become needed, electrolyzers become more economical than batteries.⁴

⁴ In Ivo Steklac's keynote address following this panel, he quotes the European Commission's conclusion that at large volumes, hydrogen made using electrolysis will also be more cost effective than pumped storage.



The 100% renewable grid will need both small-scale distributed storage (e.g. batteries), and large-scale storage (e.g. pumped hydro and electrolyzers that produce hydrogen).

The German Federal Environment Agency has determined that 80% greenhouse gas reductions below 1990 levels (2 tonnes per capita) in Germany will require 100% renewable energy at least in the electricity sector, and if the agency goal of a 95% reduction (1 tonne per capita) is to be met, there will need to be a surplus of renewable electricity to supply energy to other sectors. Already Germany has 1.5 million renewable power installations, primarily intermittent wind and solar, making up about 30% of the nation's power portfolio, and this is expected to grow to at least 80%-100% of supply by 2050. Germany has a very reliable grid despite the rising renewable power generation, and grid operators have grown increasingly confident in their ability to integrate penetrations of 100% renewable electricity in their service territories.

The German power grid of the future will look different from the traditional design, and this raises questions of how the new technologies will be valued. In the traditional grid, power flows in one direction, and from high to low voltages. In the electricity grid that relies on renewable resources, there will be bi-directional power flows, voltages that go from high to low and from low to high, greater flexibility, and many new actors, such as storage and demand response. How these actors will be paid and what their responsibilities are must be worked out, just like in other frontrunner regions like California.

Germany has determined that to reach their deep greenhouse gas emissions reduction target, cross-sector coupling will be essential. This means that sectors will intersect in various ways, such as renewable electricity supplying power to and storing power in buildings and electric vehicles, renewable electricity being used to make hydrogen for industry, transportation, and building uses.

Surplus renewable electricity used to make renewable hydrogen through electrolysis, that is then transformed into jet fuel through the Fischer-Tropsch process, is a drop-in fuel that holds a potential key to scaling up decarbonized aviation. Germany is leading on researching and developing this "power to liquid" technology. Other solutions, such as biofuels made from organic waste or energy crops, are limited by the amount of sustainable supply that can be made available, and solar and batteries will not be able to manage the demands of commercial jets. Power to liquid, if costs can be brought down – e.g. by technology improvements and rate design for electrolysis – has



the potential to meet the large-scale demand of the aviation industry. The German aviation industry has determined that up to 50% power to liquid can be mixed with conventional jet fuel without any system changes. Getting from 50% to 100% will only require optimizing existing turbine technology.

Power to gas, in which renewable hydrogen is created using electrolysis, is also a priority in Germany for providing long term, large scale electricity storage without having to build new infrastructure. The current German gas grid is the equivalent of an electrical battery with 3 months of duration.

The transition to a renewable grid has been gaining popular support across the US and internationally, but this doesn't mean that there is not still resistance, especially among entrenched interests. The rapidly growing popularity in California of Community Choice Aggregation programs, which allow communities to procure and sell power to their ratepayers in competition with local investor owned utilities, and which in California has been used as a means to procure renewables more aggressively than competing investor owned utilities, was brought up as one example of evidence that people in the state recognize the social, environmental, and economic benefits of renewables and are eager to accelerate the transition to this type of energy resource. As renewables have become the least cost resource in other Western states, as well as in parts of Texas and the Midwest, utilities and communities in these regions are also pursuing renewable targets of up to 100%. In regions with progressive politics like New England, similar trends are emerging. Many regions and countries in Europe and elsewhere around the world, are also embracing renewables. This is not to say, however, that there are not some regions where the climb is not still steep to gain political support for renewables, as one audience member from Kentucky made clear. The panel agreed that everywhere, those with entrenched interests will and do fight change. But there was also consensus that renewables are the future, and those who don't get on board with that, will inevitably eventually lose out.

One of the most cost-effective ways to make high penetrations of renewable electricity generation cost effective is regional integration. As renewable power increases past 50% to 100%, this approach is important to help offset the cost of installing massive storage to keep the grid balanced. Europe has been embracing this approach for some time.

Storage technologies will need multiple revenue streams to become cost effective and offset high capital costs. Policies like California's mandate that utilities procure 1325 MW of storage by 2020 have gotten state utilities to begin investing in storage and studying various use cases. Adding revenue streams like grid services and scaling up battery use in transportation are essential to make the daunting economics work for storage. Policies that support these developments have begun in frontrunner regions like California and must be strengthened with a long-term commitment, so that similar to how PV prices have plummeted with strong policy support, so too will the cost of storage.



Jennifer Waterhouse Pietro; David Olsen, CAISO Governor; Skyler Peak, Mayor of Malibu, Ca



Harry Lehmann, German Federal Environment Agency General Director; Peter Light, Business Innovation at Google X



Paloma H. Gonzalez, US State Department Political and Economics Chief for the Consul of Recife; Dr. Mischka Lysack, University of Calgary



Jim Hawley, Lawrence Berkeley National Laboratory; Wendell Brase, UCI



Rob Sargent, Environment America; Dan Jacobson and Michelle Kinman Environment California



Janet Napolitano, University of California President; with Students from UCI, and UCSB

INDUSTRY KEYNOTE I:



IVO STEKLAC, CEO AQUAHYDREX:

The Cutting Edge of Renewable Hydrogen Solutions

Ivo Steklac, CEO of AquaHydrex, shared thoughts about how hydrogen produced with electrolysis, powered by renewable electricity has the potential to provide clean energy solutions to multiple sectors. The following were among the highlights.

Hydrogen is one of the most abundant elements on the planet, has the highest energy per mass other than nuclear elements, and when produced with greenhouse gas/carbon free electricity is inherently clean - meaning there is no way to combust or use the hydrogen and create greenhouse gases or other climate pollutants. However, the conventional way of producing hydrogen, is via the process of steam methane reforming, which uses fossil fuels and generates significant amounts of carbon dioxide. Currently, this is how most of the 62 million metric tons of hydrogen made annually in the world – and the 10 million metric tons of hydrogen made annually in the US – is produced.

Electrolytic hydrogen provides a pathway to harnessing carbon-free electricity in sectors that have traditionally been hard to electrify. Electrolysis uses a small amount of energy to split water into hydrogen and oxygen, with no additional byproduct.

Because hydrogen has 160 times more power per unit of weight than lithium ion batteries, it is likely to be a more cost-effective solution for certain transportation applications like heavy duty trucks. Similarly, as mentioned in the previous panel, synthetic fuel derived from hydrogen makes sense for light commercial aviation and shipping.

The European Commission has determined that hydrogen made from electrolysis – i.e. “power to gas” – is more cost effective for large scale storage than pumped hydro or compressed air. For this, among other environmental, economic, and social attributes, the European Union is supportive of power to gas as a storage technology, and their proposed definition of energy storage specifically allows for power to gas.⁵

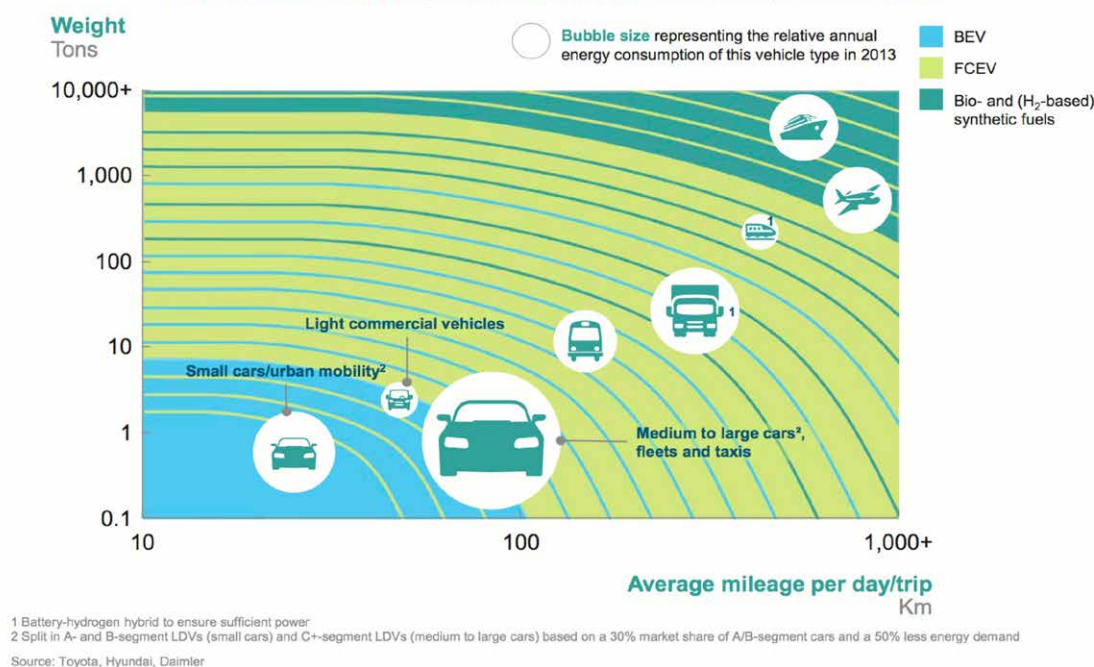
Because hydrogen has 160 times more power per unit of weight than lithium ion batteries, it is likely to be a more cost-effective solution for certain transportation applications like heavy duty trucks.

Electrolyzers have been around for more than 200 years, with current innovations allowing for greater efficiency and cost competitiveness. Historically, machine efficiency has only reached, 60-70% but recent breakthroughs are allowing achievement of 85+% efficiency. This brings electrolysis in line with the efficiency of conventional steam methane reforming methods of producing hydrogen. If the cost of the renewable electricity to power electrolysis can be less than the natural gas needed to power steam methane reforming, there will be a pathway to renewable hydrogen production – and to decarbonizing the various end uses for which hydrogen is needed, like industry applications and heavy duty transportation - that is economically viable.

Renewable hydrogen is a multi-sector solution that can provide energy for buildings, transportation, industry, and electricity generation.

Hydrogen in Transportation

Projected Economic Attractiveness of Alternate Transportation Fuels



⁵ For EU definition of energy storage, see: <https://ec.europa.eu/energy/sites/ener/files/documents/Proposed%20definition%20and%20principles%20for%20energy%20storage.pdf>

INDUSTRY KEYNOTE II:



MARTIN HERMANN, CEO 8MINUTENERGY RENEWABLES

Energy in Abundance- Clean, Affordable and Sooner Than You Think


The CEO of 8minutenergy Renewables, a privately owned solar development company based in California, shared his perspective on the solar PV market and future potential. The following are some of the key points he imparted.

In recent years, research and development, among other influences, are bringing more efficient and greater variation of solar technology on the market (e.g. N-type, bifacial, etc.), which is pushing pricing down even further than they already have fallen. In previous years, the price drop was due more to increases in production, with only two basic types of module available on the market. There is a great deal of room still for evolution of solar technology, and this as well as the cost decreases it will bring ought to be planned for.

Solar is becoming the cheapest energy technology option, despite far lower subsidies over time than fossil fuels.


The number of solar module companies will likely come down from hundreds to a few in the years to come. There are currently hundreds of module companies, but comparable to the semi-conductor industry, there will probably be boom and bust cycles until this number comes to about 10 companies in total.

Solar is an exponential technology that develops quickly. Forecasts for solar deployment, such as by the International Energy Administration, far underestimated the speed of actual deployment.



Solar is becoming the cheapest energy technology option, despite far lower subsidies over time than fossil fuels. According to Lazard, solar is already second only to wind power, and will be the lowest in five years in absolute price. Taking into account the high value of daytime power, one could already consider solar the highest value option. The good news for consumers is that both solar and wind power costs are continuing to decline. Despite centuries of subsidies, no policy will be able to completely reverse the comparatively unattractive economic profile for conventional electricity options like coal. In non-subsidized energy markets like India, solar is already cheaper than coal. This is why India is poised to become, as China already is, one of the largest solar installers.

Envisioning what a solar-powered electric passenger vehicle future could look like, several inflection points could make this a major disruptor. One would be the price of longer-range electric vehicles reaching parity with internal combustion engine vehicles, which Bloomberg predicts will happen in 2022. A second is producing electric vehicles at mass volume, comparable to conventional vehicles. A third is shared vehicle models taking off, which if they decreased the 96% of the time passenger vehicles typically go unused, could greatly reduce the number of vehicles needed, saving money on resources. Lastly, autonomous vehicles could also reduce the number of vehicle accidents, adding further value to the proposition of vehicle electrification, by saving substantial costs on damages and insurance.



PART II: SUBNATIONAL AND INTERNATIONAL LEADERSHIP

Momentum on 100% renewable energy is presently happening around the world most quickly at the subnational and international levels. In view of this, the conference featured leading voices from these arenas. Among them were

- **California Senate President Pro Tempore Kevin de León**, who authored the state's groundbreaking climate legislation SB350 that sets ambitious climate, efficiency, and renewable energy targets, including a 50% by 2030 RPS, and in 2017, introduced a first-time bill for California to speed up its 2030 RPS goal and get 100% of its electricity from renewable and zero carbon sources by 2045.
- **Hawaii State Representative Chris Lee**, who authored the first 100% Renewable Portfolio Standard in the US for his state, which requires the state's utilities to procure all electricity sales from renewables by 2045. This is a model for the world, where many of the quarter of the world's population that live in locations with official government pledges to go 100% renewable in at least the electricity sector are in island nations that are most vulnerable to climate change and urgently need the know-how that Hawaii is creating.
- **California Governor Jerry Brown's Senior Advisor Ken Alex**, who shared highlights from the state's international coalition building effort on climate and clean energy, which has developed partnerships with hundreds of subnational and national governments on critical efforts.
- **City of Lancaster Mayor R. Rex Parris**, who is one of the nation's most visionary leaders on advancing renewable energy and clean energy jobs at the local level.
- **University of California President Janet Napolitano** who engaged in a fireside chat with California Energy Commission Commissioner David Hochschild about the university system's carbon neutrality initiative and aim to get 100% of its campus' electricity from renewable sources.



Two panels rounded out this part of the program, one concentrating on California city leadership and the second on leadership in countries outside the US.

SUBNATIONAL LEADERSHIP KEYNOTE I:



THE HONORABLE KEVIN DE LÉON,
CALIFORNIA SENATE PRESIDENT PRO TEMPORE

Highlights

Since Ronald Reagan was Governor of California in the late 1960s and early 1970s, California has pioneered efforts on clean energy innovation and environmental protection out of necessity, not ideology. Californians were sick from breathing dirty air and drinking dirty water, and the consequences were holding back the state economy. As a result, California has led the way on initiatives such as tailpipe emissions standards, lead removal from gasoline, and waivers under the Clean Air Act to pursue stronger policies than the federal government to tackle pollution. In the face of federal efforts to roll back longtime environmental protection, the state is trying now to quickly to enshrine in state law key federal provisions that protect air, water, and endangered species, as well as to protect the state's right under the Clean Air Act to exceed federal tailpipe emissions standards.

California has decoupled economic benefits from greenhouse gas emissions reductions. Since passage of the landmark climate law AB 32⁶ in 2006, which requires California to lower greenhouse gas emissions to 1990 levels by 2020, the state's GDP has grown over 40%. Further climate legislation, such as SB 32⁷ and SB 350⁸ have saved Californians billions of dollars in avoided energy costs. California also has the 4th lowest utility bills in the nation.

6 http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf

7 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32

8 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32

California, thanks in large part to supportive policies, is an epicenter of innovation, including being home to the launch of the electric car industry. At the start of the millennium, there were only two hybrid cars on the market in the US. Today, there is a multitude of cars that are either battery electric, fuel cell electric, or hybrid electric on the market, with hundreds of thousands sold. Moreover, the biggest manufacturing employer in the state is electric car company Tesla. Progress made thus far has not happened due to market forces alone, but because California has pushed the policies that have sent the right market signals to attract the critical capital needed to develop clean, low carbon energy technologies.

California still has a long way to go – for example 6 of the top 10 cities in the US with the worst air pollution are in the state. Each year, more than 3600 people die prematurely due to pollution related illness, and asthma is the leading cause of absenteeism in the public school system.

100% renewable energy is not just a political slogan, but a science-based target with a reasoned roadmap to success.

California is the 6th largest economy in the world, and therefore, what happens in California has substantial global impact.

100% renewable energy is not just a political slogan, but a science-based target with a reasoned roadmap to success. This has been the case for the 50% by 2030 renewable electricity target in California, of which there were many skeptics during its creation. Now only a couple years after passing the mandate, the state's utilities are expected to reach the goal with ease. California's roadmap is based on three main objectives: one, a tax cut for consumers of renewable and other clean energy technology to help scale up adoption and drive down costs; two, decarbonizing the economy; and three, quantifiable job creation and economic growth.

Strong subnational, international, and private industry leadership on climate and clean energy are reasons for optimism, with numerous Fortune 500 companies committed to 100% renewable power, 60% of new electricity being generated last year across the US by renewables, and even conservative states like Iowa and Oklahoma generating at least 20% of their electricity from renewable sources.

Clean energy employs over half a million people in the state – as many as 10 times as many jobs as all the coal jobs in the entire US.

SUBNATIONAL LEADERSHIP KEYNOTE II:



THE HONORABLE CHRIS LEE,

HAWAII STATE REPRESENTATIVE, ENERGY COMMITTEE CHAIR

Highlights

Hawaii is progressing steadily toward its 100% RPS by 2045 goal, with a mix of about 26% renewable power today, and the utilities are not only on track to exceed the 30% by 2020 goal, but also project that they can reach the 100% by 2045 target five years early. The renewable portfolio in the state has doubled over the last ten years. Progress made so far is not only because of the RPS, but many other steps that have supported renewable energy advancement. The long horizon with certain targets helps utilities, the workforce, and other stakeholders to plan ahead for the transition.

While Hawaii's islands are diverse in their energy demands and resources, one common denominator is the strong support for solar, which has been a major driver of Hawaii's pursuit of 100% renewable electricity. Hawaii has six different electricity grids, one on each island, each radically different in resources and size, ranging from about 20 MW for a small population to 1700 MW for more than a million people, but one thing they have in common is ubiquitous solar power and solar thermal installations. About one in three homes has solar power and/or solar hot water heating. About a quarter of building permits in the depths of the recession were for rooftop solar, which was both a boon to the solar industry and to Hawaii's local economy. There are about 80,000 rooftops with solar PV on them, and solar has reached grid parity in Hawaii. The thriving solar industry and the strong public support for solar, especially as the cost for solar power became cheaper than utility power, were the two major influencers that pushed the state to adopt a 100% renewable energy goal.

Hawaii's commitment to renewable energy has been a major driver of economic development and innovation in the state. As of December 2016, renewable power advancement in Hawaii had amounted to about a third of a billion dollars in avoided cost energy savings by replacing imported fossil fuels, especially low sulfur fuel oil with solar, wind, and other abundant, local renewable sources. State policies have also spurred job growth and attracted project investment.

Hawaii is taking a diverse approach to energy procurement, ranging from solar, wind, geothermal, hydrogen, bioenergy, and ocean power. Underscoring how the state is attracting new ideas, the Big Island is home to the first Ocean Thermal Energy Conversion (OTEC) plant, which uses the temperature difference between Hawaii's warm surface water and the cool deep sea water to generate electricity.

If Hawaii can move so quickly "with our broken up, mish mash set of grids that are so out of date, anybody else in the country can that has bigger, more flexible resources, the ability to finance at a far cheaper rate, and the lessons learned from us and many others to be able to install the cheaper options."

Comprehensive clean energy planning, including going 100% renewable is better economically for Hawaii than small short term fixes. With \$4000 being the typical annual amount a Hawaiian citizen pays for this fossil fuels, high costs are driving Hawaii's decisions to replace these resources with renewables. In the energy crisis of the 1970s, Lee pointed out, Hawaii had a chance to do a complete energy system overhaul, but the state opted instead for a short-term, smaller investment of investing in grids. The legacy was continued dependence on expensive fossil fuel imports that has cost the state tens of billions of dollars more than it should have paid – a lesson the state doesn't want to repeat.

Hawaii has a policy of eliminating fossil fuels from ground transportation in the state. Electric vehicles are an important part of state strategy, and EV adoption increased 30% last year, with demand for charging now far outstripping capacity.

Energy storage along with solar PV have been essential for stabilizing the grid and preventing brown outs that risked being caused by aging and faulty fossil fuel generation plants. Hawaii was experiencing island wide outages of 24 hours or more when dependent only on conventional electricity sources like coal, gas, and petroleum.

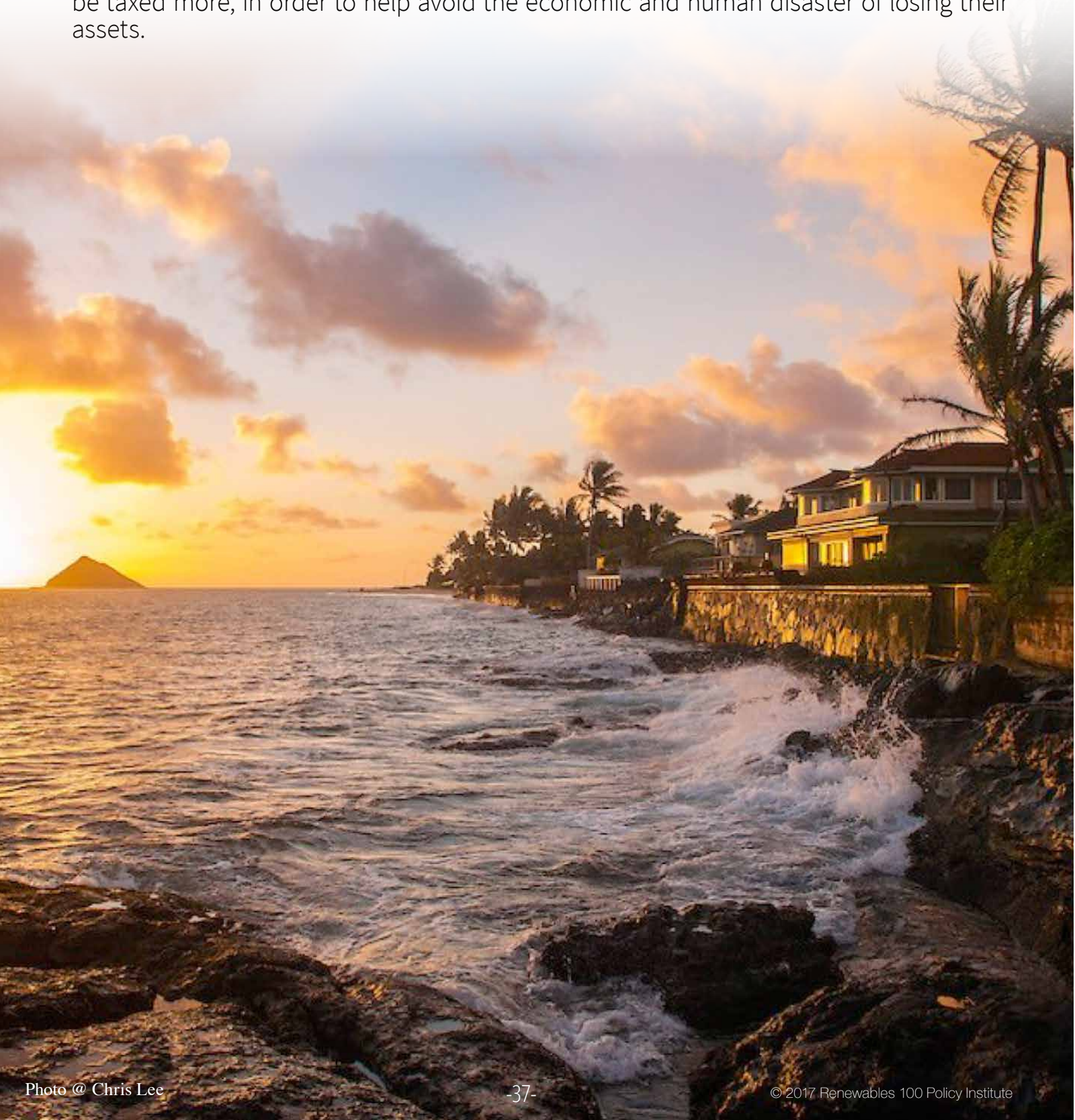
Renewable energy has strong public and political support in Hawaii, but this is not without complexity. 97% of Hawaiians polled support renewables, and the 100% RPS passed by an overwhelming vote of 74 to 2 in the state legislature. That said, utilities have caused public and political frustration over unreasonable interconnection delays and failing over several years to devise plans that satisfy the government requirements

for distributed energy resources, cost savings, and long term planning. The public utilities commission also recently replaced a popular net metering program with one that is not as customer friendly, in order to address grid reliability concerns, which has raised concerns about inhibiting rooftop solar adoption. Furthermore, as solar and storage becomes as cheap – if not soon cheaper – than grid power, there is risk that more and more people will defect from the grid altogether, disrupting the status quo significantly and raising challenges to keeping the grid for resiliency and for the people who need it.

Hawaii's energy transition is focused currently on five priorities:

- **Protecting ratepayers from risk** by aligning utility incentives with efforts like efficiency and improving resiliency.
- **Independent system planning**, which is just beginning. Historically, Hawaii's utilities have managed all grid planning, build out, and operations of the grids, and the state is looking to establish independent grid planning to reduce conflicts of interest, lower costs, and avoid overbuilding and stranded assets, like an undersea inter-island grid that ratepayers poured about a billion dollars into and that is likely no longer going to be needed.
- **Encouraging private investment in infrastructure**, through mechanisms like on-bill repayment and tax credits for efficiency upgrades and distributed generation installation, as well as a community solar program that will open up solar power investment to multi-family housing residents. The state policy here is to put middle and low income citizens first, making sure that distribution of benefits and resources is fair and equitable.
- **Increasing grid resiliency**, which includes legislation passed aiming to make all public universities and K-12 schools across the state net zero energy, generating their own renewable power, by 2035. Because these schools also serve as disaster shelters, this is an important step toward ensuring resiliency for entire Hawaiian communities. These schools would otherwise be projected to spend about \$2 billion over the next 20 years in utility bills. Repurposing those funds to lower schools' power bills and improve statewide disaster preparedness makes sense. The state is also looking into microgrids, with one region estimating it would actually be cheaper to build a new microgrid with renewable power, pumped hydro, and all new grid components than to continue to pay their electric bills.
- **Rethinking the role of utilities, finding ways for them to be partners instead of adversaries** on the transition away from fossil fuels. The state is investing in a \$1.2 billion study to determine what the best utility models are for each Hawaiian island over the long term. In the meantime, different islands are looking at new models – e.g. the Big Island is exploring going from an IOU to a co-op, and Maui is looking to go from an IOU to a municipal utility.

The bottom line is that Hawaii's energy transition is driven also by its vulnerability – e.g. to climate change impacts, species loss, fresh water supply loss and other harm caused by continued dependence on fossil fuel imports. One major hurricane would be a \$40 billion impact on Hawaii's economy and incalculable losses of lives and community resources. Hotels and businesses from iconic beaches actually asked to be taxed more, in order to help avoid the economic and human disaster of losing their assets.





UC PRESIDENT JANET NAPOLITANO

WITH CALIFORNIA ENERGY COMMISSION COMMISSIONER **DAVID HOCHSCHILD**

Highlights

Commissioner on the California Energy Commission, David Hochschild, sat down with Janet Napolitano, former Governor of Arizona and Secretary of the US Department of Homeland Security, and current President of the University of California (UC) to talk about the university system's landmark goal to achieve carbon neutrality on all its ten campuses by 2025. Below are highlights from their conversation:

Benefits of the carbon neutrality goal to the UC system and beyond

- It's an aggressive goal that unites the power of the university's researchers.
- It creates opportunities to educate the next generation.
- It sets an example for the rest of the state, the nation, and the world about how a large institution reaches this goal.
- Despite initial pushback that it would be too expensive, campuses are finding they actually are saving money. For example, 10 MW of installed solar and efficiency upgrades, is helping to avoid energy costs.

What can be done to protect states' ability to pursue climate and clean energy goals

- States can set their own goals and create incentives to partner with stakeholders on meeting those goals.
- Public universities have a large role to play.

- Having a large economy like California does also gives a state power to go its own way.
- Our representatives in the U.S. Congress must be engaged to protect federal scientific research funding that has recently been threatened. The Department of Energy, for example, could experience massive research spending cuts, which is not an easy challenge to overcome. Not only does the science message need to be delivered, but also the economic message that a renewable energy economy is a job creator.
- The commitment to research and clean technology must also broaden beyond the federal government's investments. Especially with a prospect of federal cuts, states and the private sector need to contribute more funding, develop bold ideas and create new partnerships.

The importance of protecting funding for early stage research

It is harder to attract funding for early stage technology research than mature projects, but without it, there would not have been major breakthroughs in renewable energy like Bell Laboratories' discovery of the silicon solar cell in 1954. To that end, the UC system has set aside \$1 billion of its \$100 billion investment portfolio, with another \$250 million dedicated to funding early stage technology projects that have come out of UC research, as part of its strategy for reaching its 100% renewable energy goal.

Getting the narrative right and communicating it to stakeholders is an essential tool in the pursuit of ambitious renewable energy targets. There is power in telling the story of how an investment in research created a technology and how it resulted in benefits like jobs. Such stories are important to engaging government, funders, and the general public.

The importance of effective communications

Getting the narrative right and communicating it to stakeholders is an essential tool in the pursuit of ambitious renewable energy targets. There is power in telling the story of how an investment in research created a technology and how it resulted in benefits like jobs. Such stories are important to engaging policymakers, funders, and the general public. Any facts that undercut myths about renewable energy are also very valuable. The public at large needs to hear in tangible, down-to-earth terms, how the transition is going to impact them, whether it will be in protecting their health and the planet for future generations, or new economic opportunities.

Security benefits of renewable energy

There is mythology circulating that renewables on the grid threaten national security, but the reality is that the grids in renewable electricity frontrunners like California and Germany have been reliable, and in some cases, all the more so because of renewables. The fact is that, unlike conventional energy, renewable resources like sun and wind don't deplete, and that is fundamental to security.

Student engagement on campus

The largest and most diverse class was admitted to the UC system this year, and the students are supportive of the carbon neutrality effort. For example, an all-electric shuttle bus fleet coming online at UC Irvine is student-funded and operated. The number of students majoring in related fields also keeps going up.

Offsets of fossil fuel use vs. direct purchase of renewable energy in UC's carbon neutrality effort

The University of California's hope and aim is to not use offsets to reach the carbon neutrality goal. This will require major investment in energy infrastructure that is currently being planned for

An aggressive goal unites the power of university researchers, creates opportunities to educate the next generation, and sets an example for the rest of the state, nation, and world.



SUBNATIONAL LEADERSHIP KEYNOTE III:



Ken ALEX, SENIOR ADVISOR,

OFFICE OF CALIFORNIA GOVERNOR JERRY BROWN

Highlights

100% renewable energy is an important goal that seems more viable now than it did as recently as five years ago.

The ultimate goal is to achieve deep greenhouse gas reductions, and to this end, California policy has six pillars:

- A Renewable Portfolio Standard that requires utilities to procure renewable power, currently at 50% by 2030 in California (SB 350), with targets of up to 100% being considered;
- Energy efficiency, with the current mandated goal (SB 350) of doubling energy efficiency in buildings by 2030;
- Decarbonizing transportation, with a policy goal of cutting the supply and demand of oil in half by mid-century and putting 1.5 zero emissions vehicles on the state's roads by 2025;
- Reducing short term climate pollutants, with a mandate (SB 1383) to cut them 40-50% (depending on the pollutant) below 2013 levels by 2030;
- Understanding and improving the capacity of natural land to act as greenhouse gas sinks;
- Climate change resilience and adaptation.

100% renewable energy seems more viable now that it did even five years ago.

To broaden California's impact on climate change, the state cooperates internationally with other regions, for example, in the Under 2 Coalition. California only makes up 1.5% of the world's greenhouse gas emissions, so on its own, its global climate change impact is very limited. To amplify the state climate protection efforts, as well as in recognition that much of the work to curb emissions depends on decisions and actions at the subnational level, California partners with regions around the world. A signature initiative to this end is the Under 2 Coalition (formerly called the Under 2 MOU), which is a subnational agreement initiated by California and the State of Baden-Wuerttemberg, Germany, that commits its more than 170 signatories – representing more than a billion people and about a third of the world's GDP – to cutting greenhouse gas emissions reductions 80-95% below 1990 levels or to under two tons per capita by 2050.

Each Under 2 Coalition signatory also has committed to specific 2030 goals and actions that are consistent with the 2050 target, focused on three main areas:

- Greenhouse gas inventories that are transparent and reported through an official UN process;
- Renewable energy and complementary energy technology adoption that enables a pathway to deep decarbonization;
- Other industry-specific actions and international strategies, such as working toward sustainable rainforest economies, reducing ocean acidification, and cutting emissions in dairy and healthcare industries.

To amplify the state climate protection efforts, which on its own have limited global impact, as well as in recognition that much of the work to curb emissions depends on decisions and actions at the subnational level, California partners with regions around the world.

Facilitating Roundtable Kickoff of Subnational "Under 2" Memo of Understanding (2014)



SUBNATIONAL LEADERSHIP KEYNOTE IV:



THE HONORABLE R. REX PARRIS,
MAYOR OF LANCASTER, CA

Highlights

- As a newly elected official years ago, researching the undeniable science and urgent dangers of climate change, along with a recognition that the US was largely responsible inspired Mayor Parris to act.
- As one of, if not the most conservative cities in California that until a couple years ago had one of the highest crime rates, Lancaster was among the least likely cities to become a leader on climate and clean energy solutions, and especially to succeed with strong voter support. However, the benefits have been many to the community.
- Lancaster's effort began with installing solar panels, becoming one of the first cities to supply 97% of city operations with solar power nine years ago. As a city in the desert, Lancaster was lucky to be able to leverage its abundance of sunshine. There were also learning curves as an early adopter, such as securing long term solar PV contracts, and along with the rest of the world not foreseeing how cheap PV would soon become.
- In 2009, Lancaster became the site of KB Home's first net zero energy housing project, due to the Mayor's and his staff's proactive, solutions-oriented, collaborative approach and their willingness to cut red tape. The project was inspired by Mayor Parris suggesting that KB Home build an affordable net zero energy house, which the homebuilder initially insisted could not be done. However, when the Mayor agreed to expedite building permitting, they became willing to try. This catalyzed a new proactive way of doing business involving clean energy projects in the city, which also included policies like over-the-counter permitting for solar and wind power projects. Mayor Parris also

brought in BYD as a partner, which he'd met on a trip to China, as part of international travel to gather diverse perspectives on tackling climate change. Four months after starting, with the Mayor continuing to shepherd the project along the way, the first affordable net zero home, equipped with an EV charger, was completed in Lancaster.

We're talking about the destruction of the planet. How can there be too much risk in anything we do? If it makes remote sense, we have to act.

- **Lancaster out-competed numerous West Coast cities in attracting BYD Motors to set up their electric bus manufacturing in the city.** The head of the company was impressed by the city's demonstrated leadership, approach to doing business, and keen interest in clean energy technology. Now the buses are being designed and built in Lancaster and being sold to municipalities like Los Angeles and beyond. The bus battery pack is also capable of supplying emergency energy supply at hospitals, and after its useful life to the vehicle, it can supply storage to the grid. Although the upfront capital cost of the buses is higher than conventional alternatives, when the fuel and maintenance costs are factored in, they become much more cost-effective. To lower the upfront capital cost, and allow cities to maintain the separate accounting columns for fuel and buses that they are used to, the batteries are now leased to customers separately from the bus purchase.
- **Lancaster became the first city in the US to pass an ordinance requiring every new house to have solar panels installed.** The ordinance just requires 1 kw, but this is enough to get people started, and once in the process, they tend to get more.
- **Lancaster recently passed among the first city ordinances requiring new construction to be net zero energy.** This is popular because there is so much savings on energy costs that people can afford to purchase a larger home. This requires a new way of thinking, however, as many homeowners separate the mortgage and the utility bill into separate categories, rather than seeing them as a whole package.
- **The City also took charge of its energy system by buying back the streetlights from the local investor owned utility, allowing them to repurpose major cost savings into converting the lights to LED and adding security controls to the poles.**
- **Mayor Parris was among the first to set a city-wide net zero energy goal, and to help them get there, they became the first city in California to launch a Community Choice Aggregation (CCA) program⁹.** The popular program, Lancaster Choice Energy, has maintained a 94% customer retention rate since launching city-wide in 2016, many opting for the all-renewable package. The program allows the city to buy and sell power to its residents and business owners. The City also formed the California Choice Energy Authority, a hybrid joint powers authority which helps other cities pursue community choice aggregation for their own communities.

⁹ Marin County was the first county - and the first entity - in California to implement a CCA. There are now several cities and counties throughout the state that have adopted or are considering CCA programs.

- The City has accomplished all it has, not by starting out as experts, but by figuring it out along the way, despite not knowing how.



City of Lancaster, CA



Panel 4:



California Local Leadership

The last panel on the first day was dedicated to local leadership, with a specific focus on California, where more than half a dozen local governments have made commitments to achieving 100% renewable energy in at least the electricity sector.

Moderating the panel was **Dr. Mark Gold**, leader of the UCLA Grand Challenge on Sustainability, which is developing strategies for City of Los Angeles to achieve 100% renewable energy, 100% local water, and enhanced ecosystem health by 2050. While the Mayor and City Council of Los Angeles are supportive of a 100% renewable power target for the city, and the Council has asked LADWP to do a 100% renewable power feasibility study, there is not yet any formal commitment or action plan.

In addition to the Mayor of Lancaster in his keynote, representatives from three other leading cities in California with 100% renewable energy targets – San Francisco, San Diego, and Palo Alto - presented on this about their experience, challenges, and progress: **Jonathan Abendschein**, Assistant Director of Resource Management with the City of Palo Alto municipal utility, **Jessie Denver**, Energy Program Manager at the San Francisco Department of Environment, **Cody Hooven**, Chief Sustainability Officer for the City of San Diego, and **Nicole Capretz**, Executive Director of the Climate Action Campaign.

To kick off the discussion, Dr. Gold identified many challenges the City of Los Angeles faces, in addition to its lack of formal commitment to a target, in progressing toward 100% renewable energy:

- **The city has not seen a decrease in energy** (electricity and natural gas) use since 2006, despite efficiency improvements
- **The city has made progress on EVs, but there are not enough charging stations.** EVs now make up 3% of registered vehicles (~190k), far outpacing state and national averages, but there are only 1000 charging stations.
- **Residents spend way too much money on transportation** compared to other cities.
- **Commute times are 69% longer on public transit** than driving one's own car. As a result, public transit use is down.
- **The number of people per vehicle is also down**, which means more people on the roads causing more traffic and pollution and using more resources.
- **Transportation data is lacking** for non-commute times spent in vehicles and for ride sharing businesses, as well as for any positive results of the city's efforts to improve mobility and build bike lanes.
- **The city consistently fails to reach attainment of state and federal clean air standards**, so high asthma rates are not coming down.
- **The city has made only modest improvements on greenhouse gas reductions, and the methane leak at the Aliso Canyon natural gas storage facility was a major setback.** It was noted that very few cities are actually gathering sufficient data, with few regularly keeping a greenhouse gas inventory or creating a Climate Action Plan.
- **LADWP, the city's public utility, is procuring over 20% renewable electricity, which is less than some others in the region.** Neighboring Burbank's utility, for example, has reached 33%, and the local investor owned utility Southern California Edison has reached about 25%.

The Big Picture: Where 100% Renewable Local Governments in California are Today

- **100% renewable energy has reached public acceptance** as a concept in California, in large part due to the pioneering efforts by cities.
- **Cities and states need better coordination.** For example, California's State Scoping Plan does not include cities – and should.
- **Social equity is an important piece of city planning on 100% renewable energy** to ensure broad access to economic opportunity and clean energy benefits, but this has a ways to go in most places. Solutions will not only include new technologies, but also strategies like bike-able and walkable cities.

- In addition to electricity, cities are starting to include building thermal energy (heating, cooling, e.g.) and transportation, in their 100% renewable energy target setting, which is important to push to curb greenhouse gas emissions and to ensure a well-designed, efficient, cost effective energy system.

Focus on City of San Francisco:

100% renewable electricity by 2030 and 100% renewable energy sector wide by 2050

As part of the City of San Francisco's deep decarbonization climate goals, the city has set a strategy it calls 0-50-100 roots which sets goals across multiple sectors for 2050:

- Zero waste;
- 50% of transport via sustainable modes, i.e. walking, biking, public transport (which is already achieved and potentially being raise that to 80%);
- 100% renewable energy, including electricity, transportation fuels and thermal uses (heating and cooling);
- the "roots" strategy combines of carbon sequestration, composting, and a solar or living roofs requirement.

Frontrunner cities are demonstrating that increasing renewables and cutting greenhouse gases are not mutually exclusive with economic and population growth.

San Francisco's progress demonstrates that cutting greenhouse gas and economic and population growth are not mutually exclusive. The City reduced greenhouse gas emissions 28% from 1990-2015, while increasing population over 19% and increasing GDP 78%

San Francisco has taken a multi-pronged approach to reducing greenhouse gas emissions that has included:

- Investing in energy efficiency for 15+ years
- Ordinances like the green roof requirement
- 100% regional hydropower procurement by the city's municipal utility (covers public buildings, transit, redevelopment like the new Warriors Stadium)
- a 44% renewable power grid for the rest of the city's demand, with a 100% renewable power by 2030 goal, with an interim goal of 50% by 2020. The target will be implemented through a Community Choice Aggregation Program (CCA) launched in 2016. (More on the CCA below).
- Development of demand side programs, such as energy storage, demand response, dynamic EV charging, and energy efficiency.

- Zero Emissions Vehicle support, which has included a recent EV readiness ordinance that requires all new construction to have enough electricity capacity to accommodate Level 2 EVSE for 20% of parking, among other provisions; a recent EV Fleet Ordinance to flip the city's light duty passenger fleet (400 total) to ZEV by 2022; a federal grant to develop hydrogen (e.g. 3 H2 stations)
- Resiliency programs, such as a DOE grant for storage for resiliency at 12 municipal utilities and partnering on developing of an online, open source solar and storage sizing tool aimed at easing facility resiliency planning.

100% renewable energy has reached public acceptance as a concept in California, in large part due to the pioneering efforts by cities.

San Francisco's CCA program, CleanPowerSF, took 10 years to launch, and is now rolling out by district with over 80,000 customers in the first year, with an opt-out rate of less than 1.6%. The aim is to include more than 380,000 accounts by 2019. The program offers two products: 40% in-state wind or 100% in-state wind. An all wind portfolio, since wind is an intermittent resource, raises the question of how resilient the city's 100% renewable power plan is. Other renewable resources, along with continued effort on its demand side programs will be needed to ensure that the city can provide its customers fully with an emissions free power supply, even when the wind is not blowing.



Focus on City of San Diego: 100% renewable power by 2035

After the City of San Diego first announced¹⁰ its intention to be the next major city in the US to go 100% renewable, a serious and sustained push partnering grassroots activism and city leadership turned vision into mandate. As explained by Nicole Capretz, a grassroots leader who eventually went to work formally for the city to create the Climate Action Plan, the effort took a combination of broadbase coalition building and state laws that helped push the city, which took advantage of CEQA and mitigate emissions requirements for General Plan. Around 75 presentations were made to develop community will. Having an internal champion like a CSO is essential to drive such a focused effort to success.

In 2015, the City of San Diego adopted its Climate Action Plan, which has a binding mandate to reduce greenhouse gas emissions 50% below 2010 levels by 2035 with a strategy that relies on 100% renewable power procurement. The plan includes a longer term plan to cut emissions 80% below 2010 levels by 2050. This mandate was preceded by a decade of energy efficiency improvements, which resulted in a 16% drop in residential energy use, due to the city enabling PACE legislation that offers low cost financing for efficiency upgrades and expediting clean energy related permits, along with savvy residents who are concerned about clean energy and the environment.

The City's 1st annual report recently showed that similar to San Francisco, greenhouse gas reduction and clean energy advancement can go hand in hand with rising population and economic development.

- From 2010-2015, the city population rose ~ 5%
- The City has already surpassed its 2020 greenhouse gas reduction goal.
- The metric tonne of CO₂/GDP has also gone down.
- Green job growth is outpacing regular job growth, 10.2% to 9.5%.
- Underscoring that San Diego supports this concept, the Chief Sustainability Officer position is in the city's Economic Development Department.

The City also shows that 100% renewable energy has bipartisan support. The City's Climate Action Plan, with its 100% renewable electricity target was introduced by a Democrat and passed by a Republican Mayor, who still supports the program. Although San Diego is fairly conservative politically, polling has shown that there is widespread care about the environment and recognition of economy and environment nexus.

San Diego's effort and is inspiring neighboring cities. For example, the nearby City of Del Mar has adopted a parallel 100% renewable electricity goal as part of its Climate Action Plan.

¹⁰ The City of San Diego first announced it would be the next major city to go 100% renewable at the first Pathways to 100% Renewable Energy conference in 2013.

San Diego was the first city to use the Cal Enviro Screen to identify frontline communities that are most vulnerable to environmental hazards.

Further challenges for the city include resistance to the renewable energy transition by the local IOU, proposals for new gas plants, and deciding whether to adopt a CCA to enable greater local control.

Focus on City of Palo Alto: 100% renewable power procurement by end of 2017 with a view toward including building thermal energy and transportation. (More on the City of Palo Alto's experience can be learned by referring to Panel 7).

Palo Alto became a frontrunner on procuring all renewable electricity because its residents prioritize environmental protection, and it is one of the only cities in state to have a public electric and gas utility. This has allowed the city to move ahead faster than the rest of the state.

The City's progress toward 100% renewable electricity procurement took a little over a decade and is expected to be complete by the end of 2017.

- In 2005, the city started to procure renewable power.
- In 2007, Palo Alto adopted the Climate Protection Plan which included an increased share of renewable electricity.
- In 2013, the city established a Carbon Neutral Electric Portfolio Standard, which required 100% of power community wide to come from hydropower and RPS eligible renewables. To achieve carbon neutrality, the city allowed itself to buy offsets, which are being phased out in 2017, when the city will procure 57% of electricity from RPS eligible sources, and the rest from large hydro.
- Along the way, the city also focused on energy efficiency.

To achieve deep decarbonization, Palo Alto is extending its clean energy plans into the transportation and building thermal sectors.

- In 2016, the city adopted a Carbon Neutral Gas Plan, which includes buying offsets for gas use, and a Sustainability Climate Action Plan, that sets a target of 80% greenhouse gas reduction below 1990 levels by 2030 (20 years before the state goal), along with looking at how to decarbonize energy for buildings and vehicles, in addition to electricity and gas.
- As of 2017, the city has achieved 37% GHG reductions over 1990 levels, underscoring that while going 100% renewable in the electricity sector and making progress on energy efficiency for buildings were critical, next steps must include decarbonizing the transportation and gas sectors.

- The transportation strategy focuses on trying to reduce single occupancy trips and reducing emissions by electrifying those trips. Specific policies include requiring a percentage of parking spaces in commercial and multi-family buildings to be EV ready, and leveraging rebates to install electric vehicle charging infrastructure.
- In addition to continuing to working on retrofits and improving existing building performance, the city initiated a heat pump pilot. However, they have encountered market Barriers, as the supply chain is limited, and contractors are just becoming familiar with the technology.
- The city tries to take a collaborative approach to working builders, including supporting those who want to build all electric homes.

Panel Discussion

Do you see local governments mandating ZEV fleets, ride sharing, and public transit?

San Francisco passed a mandate for ZEV sedan fleets by 2022, with a carve out that allows 25% to be plug in hybrid (PHEV). San Diego used their leverage at airports to work on incentivizing EVs and PHEVs for taxi fleets. Los Angeles similarly has been considering several provisions for ZEV fleets, with Los Angeles County setting a goal in the months following the conference to have an all-electric public bus fleet by 2030. The South Coast Air Quality Management District, which includes Los Angeles, Orange, Riverside, and San Bernadino Counties, also mandated earlier in 2017 that on-road fleets within the District must become zero or near zero emissions, pending legislative authority to the District by the State of California.¹¹

In another example of how local aims can be subject to the control of state decision makers, panelists expressed hope that a transition to ZEV fleets would also happen with ride sharing companies like Lyft and Uber, which have over 40,000 drivers in California, but jurisdiction for the shared economy is in the hands of the state's CPUC.

Cities are increasingly looking beyond 100% renewable electricity targets to include the building thermal and transportation sectors in their efforts to end fossil fuel use.

How are your cities handling goods movement?

In San Diego, most ships and planes do not yet run on alternative fuel, but research is happening, and like in the Los Angeles region, much effort is going into pilot testing electrified cargo handling.

11 <http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2017/2017-apr7-001.pdf?sfvrsn=4>

San Francisco's efforts include working with Google, Ryder and others on using renewable biodiesel in their medium duty trucks and is also supporting biodiesel for ferries.

All acknowledged that one of the toughest applications to solve is decarbonizing long haul heavy duty trucks. Several local governments in California are testing grounds for near zero emissions truck technology that can run on renewable gas and that emit almost no air pollutants. Hydrogen fuel cell technology is a possible promising solution for the future.

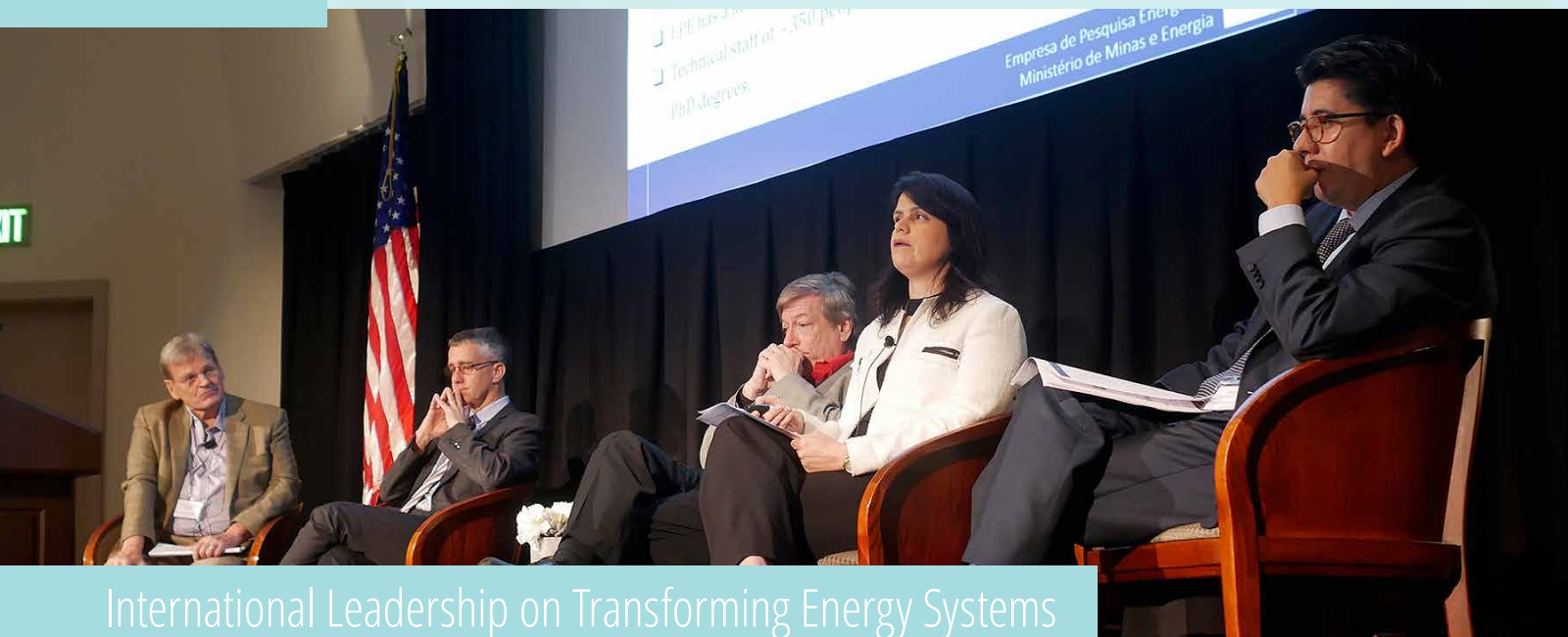
City, regional and state efforts on clean energy advancement need to be better coordinated.

What else is being done to decarbonize existing buildings, other than setting state net zero energy goals?

The panelists acknowledged that more action is needed. Efforts mentioned that are taking place in their cities include working with facility managers to ensure existing buildings optimally function, looking at real estate data for good intervention points, and seeking to leverage cap and trade funds to enable retrofits in disadvantaged communities.



Panel 5:



International Leadership on Transforming Energy Systems

Five leaders from Europe and Latin America came together to share their perspectives on the transition to renewable energy, including moderator **Prof. Dr. Eicke Weber**, who recently left a long tenure as Director of Fraunhofer ISE to the UC Berkeley Education Alliance for Research in Singapore; **Dr. Harry Lehmann**, General Director of the German Federal Environment Agency, **Patrick Hofer-Noser**, Head of Energy Systems at Meyer Burger Technology AG, a global leader solar technology from Switzerland; **Angela Livino**, Advisor to the CEO at Empresa de Pesquisa Energética (EPE), Brazil's national energy research agency; and **Marcelino Madrigal Martinez**, Commissioner at the Mexican Energy Commission.

The transition to 100% renewable energy that has begun around the world is a technology disruption, and such disruptions go faster than most people anticipate.

Introduction

The transition to 100% renewable energy that has begun around the world is a technology disruption, and such disruptions go faster than most people anticipate. As the economics of technologies continue to improve, the process will continue to accelerate. Already, solar PV costs only 2.4 cents per kilowatt hour in some sun-rich places, which is lower than even most experts forecasted not long ago. Industry analysts report that solar is still only in its embryonic state, anticipating that at 2015 installation rates, solar will reach terawatt levels before 2030 and skyrocket to many times that amount by mid-century.

While the world may currently be only getting about 20 percent of energy from renewables, this can change quickly, and we can get to 100 percent. When Dr. Lehmann presented his first 100% renewable energy studies in the early 1990s to scientists, they responded that more than 5 percent was physically impossible. But the world has already proven this wrong and will also prove wrong the naysayers who say that 100 percent is not possible.

Focus on Germany

In looking at what would be needed for Germany to transition to mostly renewable energy across sectors, a pathway the nation has been on for decades, German solar research institute Fraunhofer ISE identified several challenges and opportunities: Renewable power capacity, like wind and solar, would need to be installed in amounts multifold of overall demand to cover peak demand, thermal and electrical storage would need to be in place, and trillions of euros would need to be invested, although the business as usual case requires only 20% less upfront capital investment – or about 0.8 percent less annually of the German GDP – and the renewables route would be a greater economic stimulus.

More than half of Germany's regions have plans to reach at least 50%, and many up to 100% or more, renewable energy in at least one sector.

Several countries in Europe, including Germany, are already being powered entirely or almost entirely by renewables for hours or days at a time, with the grids remaining stable – and must-run thermal power plants causing negative pricing. Germany actually has fewer grid interruptions and more grid resiliency with 35% renewable generation than before, as well as than European countries with less renewable generation like France and the UK, due in part to modernization of the nation's grid technology and operations. Power markets like Germany's have been seeing negative wholesale electricity pricing not because there is too much wind and solar power generation, but because the thermal power plants are not flexible enough to be ramped down, so they have to run in order for the grids to remain stable.

Germany's energy transition has been a fact-based pursuit resulting from the oil crisis of the 1970s, the anti-nuclear movement of the 1970s and 1980s, and the growing awareness of air and water pollution that began during this period, followed in the 1990s by the recognition of climate change. Government environmental agencies and the Green Party, renewable energy research institutions, subnational movements, and other related efforts started up in the 1970s and 1980s, with different hopes among different groups. Some aimed just to break free of dependence on Arab countries and Russia for energy, whereas others, such as the early adopting towns of Aachen and Schoenau, wanted complete energy independence via renewables. Many of the hopes from that period have continued to inform the German energy transition,

such as environmental and health protection, employment, regional added value, institutional research, and energy supply stability. Around the year 2000, Germany made two key policy decisions that catalyzed development of renewables for the electricity sector: the phase out of nuclear power, which is scheduled to sunset in 2022, and the passage of the feed-in tariff law for renewable electricity. Now the country is discussing the phase out of lignite coal generation. Contributing to the ease with which Germany has pursued science-based policies is the fact that many scientists hold government positions, including Chancellor Merkel, who is a physicist and who helped lead the first UN climate talks in Rio in 1992, when she was Germany's Environmental Minister.

The bottom-up grassroots movement in Germany continues to be critical for the phase out of coal, as many federal government officials have close coal industry ties. Underscoring this, when thousands of solar jobs were lost in Germany due to pull-out of federal policy support and growing competition from China a few years ago, federal leaders were silent, whereas protection of the three thousand remaining lignite jobs draws continuous vocal support. A lesson can be learned from the experience with the nuclear phase out, which took a million people marching after Fukushima to push Merkel to not renege on that commitment.

Germany has about 2 million decentralized power plants, close to half of which are owned by private citizens and farmers, and only 5% of which are owned by big utilities. This is energy democracy in action and one of the reasons Germany has broad public acceptance of renewable power installations, including wind turbines. Utilities are restructuring to try to gain a bigger stake in the energy transition, creating new subsidiaries that are pouring into support clean energy development.



Technology Leadership from Switzerland

Over 10 million square feet of solar PV roof tiles, an aesthetic, building integrated solution to increasing onsite solar power, have been installed in Switzerland.

Since 1980, Switzerland has had a program to support building integrated solar PV installations. Over 10 million square feet of solar PV roof tiles, for example, have been installed, which are more aesthetic than traditional panels, and Switzerland's 25 years of knowledge and expertise could be useful to other locations. China, for example, has about 11 gigawatts of building integrated solar potential, and California could also have a strong market.

Switzerland is also supporting a wide range of renewable energy technologies. For buildings, for example, these include geothermal for heating, cooling and thermal storage, and electrolyzers to make hydrogen not only for building use but the car. Nearly all political parties in Switzerland support a referendum to prioritize efficiency and renewables and to phase out nuclear power. A couple weeks after the conference, voters passed this referendum, despite fear tactics by the opposition that it would drive up energy bills and stop hot showers.



Momentum Emerging In Latin America

As renewables increasingly become the cheapest energy options, developing countries can and will take over leadership roles in renewable energy development. This is helpful to the strong global effort that must take place to overcome the threat that incumbents in the conventional fuel industries will slow down efforts to transition to renewables, which would have devastating climate change and other harmful impacts.

Focus on Brazil

Brazil already gets nearly three quarters of its power from renewables, predominantly hydropower, but with increased interest over the past decade in shifting to other renewable sources like wind, biomass and solar. 65% of Brazil's 150 GW of installed power capacity is hydropower, down from 95% in 2004. Reasons for the decline have included lack of financing for new hydropower plants, and a recognition of the need to diversify, as demand grew and as climate change posed ever greater risk to hydro supplies. Plans for expanding hydro in the Amazon have also been shelved, due to controversial social and environmental impacts to, reliance on long transmission line construction, and increasing attractiveness of other renewables. 6-7% of the nation's electricity now comes from wind (more than 10 MW of capacity), which is contracted to expand by 6 GW over the next five years. Approximately 9% (14 MW) comes from sugarcane biomass. The remainder of Brazil's electricity supply comes from thermal power plants and two nuclear power plants. Brazil aims to continue to diversify its renewable portfolio to non-hydro resources, including developing solar, which currently accounts for a very small fraction of generation. 2.6 GW of centralized solar have been contracted to be installed over the next five years, and ways of expanding distributed generation solar are being considered. Wind and solar development are especially important to support Brazil's main climate protection priority, which is preventing deforestation.

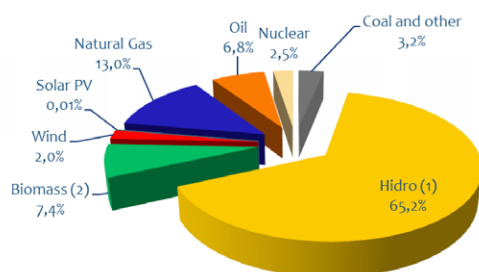
Brazil already gets nearly three quarters of its power from renewables, predominantly hydropower, although interest has risen over the past decade in shifting to other renewable sources like wind, biomass and solar.

Distribution companies in Brazil, like elsewhere, will need to find new revenue sources, as renewable generation and efficiency drives load defection. Similar dilemmas are being worked out all over the world where renewable energy is taking off, including in Europe and California.

Two attributes that Brazil has which favor renewable electricity development are a strong, nationally interconnected transmission grid and a flexible system. As renewables develop further, diverse types of storage will need to be added to maintain flexibility in the system.

ELECTRICITY GENERATION BY FUEL BRAZIL X WORLD

► POWER GENERATION MATRIX (2015)



Fonte: EPE (BEN 2016)

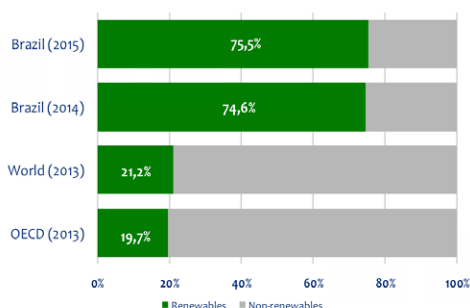
Total geração elétrica: 615,9 TWh

Geração hidro : 394,2 TWh

1 Includes importation

2 Wood, sugar cane and other primary sources

Brazil Vs. World



Sources: EPE [BEN 2016 - Preliminary Results]
and IEA [Key World Energy Statistics - 2013]

Empresa de Pesquisa Energética
Ministério de Minas e Energia



Brazil's main challenge to developing non-hydro renewables currently is the economic crisis it faces. When people have lost their jobs, they are not motivated to install solar on their rooftops. That said, distributed solar is also seen as a pathway to economic development, for example, in poor regions like the arid Northeast, which have suffered drought in recent years and could benefit from the jobs and revenue streams that solar technology adoption could bring.



Focus on Mexico

Mexico has been undergoing deep and wide energy system restructuring, including a new constitutional and legal framework. The core of the restructuring has been a set of laws that put energy targets into law, liberalized electricity generation, and established a comprehensive regulatory body that has broad jurisdiction over regulating electricity, gas, and gasoline. The nation, which has an electricity market roughly the size of California's, has set a 2024 target of 35% low carbon electricity.¹²

Mexico has been inspired by frontrunners like Germany and California to establish long-term energy markets, create transparent and stable distribution and transmission rates, and allow broad and open access to the grid with stable interconnection rates. Transmission grid upgrades also took many technical lessons learned from Germany and Spain.

Mexico is working on putting the policies and market mechanisms in place to take advantage of the low-priced, clean renewable energy for which countries like Germany opened the way.

5 gigawatts of renewable electricity generation projects (wind, solar, geothermal, and a bit of small hydro) were contracted to be developed in Mexico over 18 months of competitive auctions, which if constructed, will equal the amount of renewable electricity that Mexico installed in the last 15 years. Pricing for the contracts came far under the limit that regulators established to protect from rate hikes, which has shifted initial opposition from the industrial sector – which feared that renewables would make manufacturing more expensive – to strong interest, as they see that renewable electricity could actually be far cheaper than what they're used to paying. For the third auction, Mexico is working on letting small and medium sized industrial consumers to participate to help them secured low priced renewable power.

As the second largest Latin American economy after Brazil, Mexico opening up a renewable electricity market has global impact for the renewable energy industry. Mexico also has a mature capital investment infrastructure, and developers are currently able to make greater returns on investment than in countries like Spain. This along with the rich culture and beauty of the country is attractive to investors.

¹² Mexico's low carbon definition includes, along with renewables, nuclear and fossil fuels with carbon capture and storage (CCS). Mexico's two nuclear reactors' license agreements expire in 2029 and 2034, with the economics of expanding nuclear power so far being prohibitive (World Nuclear Association). CCS development is in the pre-feasibility stage.

Mexico is late to the game on renewables and is just starting out, but is advancing quickly and at less cost than early adopters, due to the technology maturity and policy concepts already developed around the world. The speed is a big benefit, as well as presenting a challenge of how to adapt technically to such rapid change.

In the past three years, the number of rooftop solar installations in Mexico rose from zero to nearly 30,000, with the help of a net metering scheme. The country is projecting reaching 2000-3000 megawatts in the next 3 or 4 years.

In-country solar manufacturing is picking up in Mexico. This is more due to private investment interest from all over the world than a policy push, although policymakers are trying to support the supply chain, such as helping to commercialize university technology research. Mexico's policymakers have not so far been as aggressive as, for example, India, which is heavily focused on not importing technologies from other countries.

Going forward, these are the big issues for Mexico:

Policy – The critical question for policymakers is no longer if high renewable power targets can be reached (they can), but how fast.

Financing – The next priority is how to leverage the interest of small businesses that can't commit to big, long-term contracts for purchasing renewable power to speed up adoption of renewables.

Technical – How can Mexico speed up the necessary technical adjustments, in order to reach renewable targets more quickly? Whereas Germany and California took more than ten years to reach around 30% renewable electricity, Mexico wants to do that in just a few years.

Social and environmental – How can the nation maximize solutions for equal and proportional benefits across all of society, as it progresses on renewable electricity?



PART III: ADDITIONAL ACCELERATORS

– Focus on Women Leaders and Technology Disruptors

Panel 6:



Women Accelerating the 100% Renewable Energy Transition

With women underrepresented in the energy profession and also instrumental in advancing 100% renewable energy solutions around the world, the conference cast a spotlight on several women who are leading efforts in the Global South as well as the first female utility CEO in the US to put the utility on a pathway to 100% renewable energy procurement. Moderated by Renewables 100 Policy Institute Founding Board Chair **Angelina Galiteva**, the panelists were **Valerie Fong**, Member of the Energy Imbalance Governing Body and former CEO of Palo Alto Public Utility; **Paloma H. Gonzalez**, Political and Economic Chief of the U.S. Consulate General in Recife Brazil; **Katherine Lucey**, Executive Director of Solar Sisters, which helps women in Uganda install solar energy; and **Maria Eugenia Di Paola**, Coordinator of the Environment and Sustainable Development Program at the United Nations Development Program (UNDP).

Panel Highlights

Under Valerie Fong's leadership, the City of Palo Alto's public utility set on a course to transition to renewable energy (which was also featured in Panel 4), and was able to get to 100% renewable and carbon free sources by 2017 with a rate increase of only .19 cents per kilowatt hour. Ms. Fong explained that the utility had strong support from city leaders and the community and took into account public concerns about ratepayer impacts, especially given that in the early years, renewable power sources were significantly more expensive than conventional sources. The City created a rate increase cap of 0.5 cents per kilowatt hour. Over time, technology costs came down, and the City's electric supply portfolio achieved zero carbon emissions, consisting of all renewable (RPS eligible plus legacy hydro) sources at a rate increase well below the adopted cap. The average customer sees an increase on their monthly bill of less than a dollar per month compared to what it would be with a conventional power portfolio.

Regional grid balancing becomes all the more important as local communities procure renewable power throughout the region. A market solution launched by the California Independent System Operator and PacifiCorp is the Western Energy Imbalance Market. One of the consequences of a city like Palo Alto procuring so much renewable electricity is that it can't do it all within its own boundaries and contracting with intermittent renewable generators that are remotely located can result in supply not synching up with demand in real time. To help manage such imbalance and avoid curtailing oversupply of renewable generation, the Energy Imbalance Market (the EIM) was formed in 2014, which allows balancing authorities in the Western region outside the CAISO to voluntarily transact in the imbalance portion the CAISO's real time market – that is, the 5 and 15-minute real time markets. Through the first quarter of 2017, the cumulative monetary benefits of the EIM since its inception total about \$170 million.

Maria Eugenia Di Paola, who is based in Buenos Aires, shared that Argentina has an opportunity to leverage its recent commitment to advancing renewable energy to alleviate its substantial poverty rate and gender inequality in the workplace. Argentina's electricity grid crisis in recent years, which resulted from lack of private investment during the economic crisis of the 1990s, became an opportunity to start setting renewable energy targets. While modest – the country aims to reach 20% by 2025 – the effort is a start in the right direction, is seen as a beginning not an end, and has been incorporated into law, ministry planning, and presidential support. In its first auction, the nation contracted 2.4 gigawatts of renewable energy projects. Meanwhile, the latest UNDP report shows that the country suffers from nearly 40% poverty and that women represent only about 44% of the workforce. The grassroots multi-stakeholder dialogue that Ms. Di Paola initiated has been advocating for an inclusive approach to renewable energy development that raises up disadvantaged communities, closes the gender gap in the workforce, and ensures the private sector has a strong voice.

Her initiative finally made its way in 2016 into the high-level ministry process for examining pathways to renewable energy adoption, a sign of hope that top decision makers will consider these essential values in its policymaking activities. Notably, since the conference, multi-stakeholder public debate has led to the halting of plans to build a new nuclear power plant in Patagonia.¹³

Solar Sister, which brings solar power to rural women in Sub-Saharan Africa, sprang from its founder Katherine Lucey's philanthropic work in the region to bring electricity for the first time to facilities like schools and hospitals by using solar power. When she started, she met nurses who had to walk a mile downhill every morning to get water, and a mile back up hill with full jerry cans, just to be able to boil water for medical procedures. This took up to 20% of their time every day. Simply adding a solar hot water pump freed up their time and expertise to treat patients.

One solar panel and a light can help an African villager, her entire community, and the next generation thrive. Another story Katherine Lucey shared was of Rebekah, the town pastor's wife, who acquired a 10-watt solar panel connected to three lights. She wisely used one of the lights, which her husband originally wanted to use in their bedroom, for the room where she kept her chickens, knowing the birds only eat when they can see and that eating more would make them more productive. She was able to earn enough income with the extra eggs to buy a goat and eventually a cow, which gave her yet more revenue. Her success garnered so much interest over the years that she opened a school for more than a hundred children, where she also teaches classes on small plot sustainable farming. The room where she had kept the chickens is now a dormitory and evening study room for the children who have to travel a long distance to go to her school. That room is still powered by the original solar panel that started it all.

By empowering women entrepreneurs to reach out to women as customers, Solar Sisters has enabled more than a million sales of solar power in rural Africa.

One of the great innovations that helped rural villagers in Africa get electricity access was resizing solar panels and making them plug and play for simple, necessary functions like powering an LED light or charging a cell phone. This is a good example of developed areas using their sophisticated brain trust to create innovative renewable energy technologies, their purchasing power to bring costs down, and then bringing it to market for millions of rural villagers in developing regions to have as options to buy. Mass level change needs to be market driven, not just driven by philanthropy.

The business case for focusing on women to drive renewable energy adoption is that the problem requires marketplace solutions, and women make most household purchasing decisions. This is true of developing regions like Rebekah's, where women take care of the home utilities, like collecting water and buying kerosene, and also of industrialized regions, where women most often pay the utility bills. Women entrepreneurs reaching out to women customers closes one of the toughest gaps – trust.

In many places in the developing world, the goal is not to transition from non-renewable to renewable energy, but instead to leverage renewable energy technologies to be able to access electricity for the first time.



Microfinancing that allow poor villagers to not have to pay the upfront capital costs of solar and other energy technologies upfront also plays an important role, and women have consistently proven to be more trustworthy in responsibly paying back loans.

Federal government policies can also help to enable all boats to rise together and best practices to be implemented, and one example has been the US State Department's effort in Brazil. The U.S. Consulate General in Recife recognized that the Northeastern part of the country is leading the country in renewables with 80% of the wind farms, 50% of the solar installations, and strong government support. Home to a severe drought, the region also has heightened awareness of the perils of climate change. The State Department decided to focus knowledge sharing on non-hydro renewable technologies, given Brazil's recognition of hydropower's limitations, and began its efforts in November 2015 by bringing Renewables 100 Policy Institute's Founding Board Chair Angelina Galiteva to the region to share her expertise on a speaking tour. That one visit had a swift domino effect. Within two weeks the State of Pernambuco signed on to the Under 2 MOU, followed by seven other Brazilian states. This was followed by an MOU signing between the U.S. and Brazilian national energy regulators FERC and ENEL. The State Department also followed up in 2016 by bringing several more U.S. energy experts, including from the California and federal government, to share their knowledge with Brazilian counterparts, and partnered with the U.S. Department of Commerce to bring Brazilian experts on learning and trade tours to California. In 2017, the State Department secured a grant to work with the Renewables 100 Policy Institute in partnership with the State of Pernambuco on developing an implementation plan to transition the island of Fernando de Noronha, a World Heritage Site off the coast of Recife, Pernambuco, to carbon neutrality and 100% renewable energy across sectors, with electrification of all vehicles and integration of the waste treatment and water systems. It is the first site in Brazil that would become 100% renewable energy reliant. The ultimate goal is for the island to become a job creator both for Brazilian and U.S. citizens, as well a learning laboratory of best practices for the region and other climate vulnerable islands around the world.¹⁴

Inclusion makes for better solutions, not just in renewable energy but in all fields. Women and minorities ought not to be included just because it's the right or moral thing to do, but because diversity will produce smarter systems and results.

If we want to have better solutions, whether in renewable energy or any field, and we exclude 50% of the population, then we're always going to be operating at a handicap. It's not a feel-good or moral issue, it's simple math.

¹⁴ See for more information on this project www.renewables100.org/en/us-brazil-energy-collaboration-2017

Panel 7:



Innovative & Disruptive Technologies Changing the Energy Landscape

Concluding the conference, Bloomberg New Energy Finance Western Market Leader **Rob Glen** moderated a discussion with three prominent members of the impact investment and innovation community: **Nancy Pfund**, Founder and Managing Director at DBL Partners, **Danny Kennedy**, Managing Director at the California Clean Energy Fund (CalCEF), and **Peter Light**, who heads Business Innovation projects at X, Google's "moon shot factory."

One of the reasons 100% renewable energy policy is so exciting is because of all the innovations that will stem from that.

Highlights

Although individual firms have pulled back, there is still a steady amount of venture capital being deployed in the clean energy sector. From 2006-2012, there were many tourists interested in exploring the sector, and who remains now are the ones who are most committed, experienced, and good at it. There are currently three main categories of capital investors: high capital family offices looking for impact investments to match their values, the incumbent energy industry, and overseas corporations.

VC/PE NEW INVESTMENT IN CLEAN ENERGY 1Q 2004-1Q 2017 (\$BN)

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- Early- and late-stage VC funding rounds as well as funds raised privately for the purposes of expansion by companies that are primarily involved in the clean energy industry according to BNEF exposure ratings.



Note: Total values include estimates for undisclosed deals.

Another major category of investor is on the procurement side – for example, a growing list of corporations who are procuring large amounts of renewable electricity, with many now committed to 100% targets. Having signed orders from such entities can be a tipping point for entrepreneurs seeking to raise capital.

DBL Partners started impact investing before there was a name for it. DBL, which started in 2004 with its first fund, the Bay Area Equity Fund housed within JP Morgan, stands for Double Bottom Line, which means they invest for the traditional bottom line of top-tier financial returns and for a second bottom line of driving significant social, economic and environmental impacts in the sectors and regions in which they invest. The firm seeks to be a decade ahead of the curve, investing in disruptive technologies that will become iconic companies that employ a large, diverse workforce. DBL is the first VC firm to use a double bottom line approach to investing for impact at scale. Like other venture capital firms, DBL invests and nurtures high-growth companies with market-changing innovation; unlike other traditional venture capital firms, DBL works with its companies to create positive impacts such as creating jobs in low-income neighborhoods, positive environmental impacts, and corporate community engagement. They have invested in companies that are defining what the 21st century landscape is shaping up to look like - forerunners in the field like Tesla/SolarCity, NeXTracker, Revolution Foods, Farmers Business Network, SpaceX, and PowerLight which was sold to SunPower.

Impact investing is solving multi-trillion dollar problems, and any time you have trillions of dollars lying around, government policy is going to be important.

Working on policy alongside impact investing to develop promising technologies is an important part of the work. A hands-on approach to impacting policy helps ensure that companies impact investors invest in succeed in the long term. When policies are favorable, sometimes companies at early stages actually benefit as much if not more from government grants or favorable tax policies as venture capital. Examples on the US federal level include the US solar investment tax credit and the wind production tax credit, which have strongly driven renewable electricity development across the country from the early adopter to the mature market stage. One of many examples out of California is California Energy Commission grants, which have helped launch many clean technology companies at critical stages. Constant effective effort is needed to overcome the all too common friction between the pace of technology and regulatory framework development. On the flip side, investing in cutting edge entrepreneurship also helps ensure that policymakers who want to advance clean energy goals have technologies ready in the marketplace to turn policy and regulatory frameworks into meaningful action. The bottom line is a trifecta of investment, policy, and technology is needed to make a successful breakthrough.

There is abundant opportunity to drive the trillions of dollars of capital around the world necessary to transition to 100% renewable energy. To put it in perspective, Americans invest a trillion dollars in mortgages every year. The tougher challenge is not raising enough capital, but rather nurturing enough successful entrepreneurs to make it happen.

Declaring ambitious goals is important, even if it is not clear how they will be reached. Google's X has set out to invent and launch breakthrough technologies that can make the world a radically better place. They don't always know exactly how they will get there, but there is power in defining the goal. In 2009, for example, they took on the self-driving car, which many dismissed as crazy talk, and which has quickly come to seem more like an inevitability.

It's not enough to vote at the polls, you have to vote with your portfolio.

Google's on-the-ground experience with pursuing 100% renewable energy procurement and other clean energy goals has fostered insight both on how to succeed and on the challenges that remain to be solved. For example, installing EV chargers at its buildings has succeeded in attracting more plug-in vehicles to Google, along with bringing new challenges like high demand charges and costs that are more volatile based on time of use.



CalCEF is a non-profit that was founded to drive innovation in technology and innovation to get to 100% clean energy in ways that benefit 100% of people, not only in terms of employment and being customers, but also in terms of ownership and leadership. CalCEF consists of three programs: a newly launched \$24 million fund to invest in and provide training and guidance to a hundred pre-prototype startups; a consortium with national labs, labor, and others to continue developing California's leadership on energy storage; and a global network of incubators aimed at knowledge exchange between entrepreneurs from California and emerging market regions. The push to include equity as a key piece of the mission has come in large part from the political sphere, where elected officials who come from diverse backgrounds and ethnicities are leading the way on advanced renewable energy and environmental legislation and want the communities they represented to be supported in the process.

The goal of integrating electricity and transportation is another big opportunity for attracting bright minds and capital to the tasks of scaling up zero emissions vehicles that act as solutions to balancing the grid, and of creating rate and regulatory structures to fully realize this vision.

Looking beyond the developed world, emerging markets are a massive opportunity to deploy renewable solutions, which wealthy markets like California's have helped make cheap enough to be economical for the more than billion people who don't have electricity. This concept is projected to grow beyond the simple kits available today that supply a light or a cell phone into full, turnkey, smart renewable power, storage, and appliance systems developed in technology hotbeds like California and installed in emerging market regions. Some believe this is the biggest entrepreneurial opportunity in the solar industry today. Developed regions also can turn their lack of leapfrogging also may also innovate ideas for which industrialized regions can benefit, such as sharing models for solar PV and block chain currency to enable community owned renewable projects.

Sometimes naysayers worry that clean technologies can't expand beyond California, but MidAmerican Energy's announcement that the Iowa utility will procure 100% renewable power is just one example that renewables are mainstreaming in the US. This is just the beginning.

Historically, the focus was on cost reduction of renewable energy technologies, but now that they have gotten so cheap, there is major opportunity in focusing on **complementary technologies and how they integrate with the grid**. These grid service solutions will be crucial in scaling up renewable electricity from 30% to 50% and 100%.

Microgrids are another disruptive technology that is taking off in the US and elsewhere. They are set to expand all the more, as storage costs come down and as folks become increasingly interested in taking enhanced grid reliability into their own hands, in the wake of natural disasters and blackouts. Emerging markets like the South Pacific are ripe for microgrid technology as a strategy to avoid the high costs of diesel imports, take charge of their energy choices, bolster their resiliency, and express their commitment to tackling climate change.

As the energy markets go through a historic period of disruption, building a strong clean technology workforce is facing both successes and challenges. Clean technology innovation needs a trained workforce to fully succeed, and this is growing around the country, with clean tech employment far outpacing conventional energy jobs - and with more racial and gender diversity. Opportunities like building large battery stacks for electric vehicles and storage will require in-country trained workers to manufacture them, which is already underway, for instance, in Sparks, Nevada at Tesla's Gigafactory. However, there are also challenges and tensions, as with any disruptive business, in the process of seeking to balance expanding the business and growing the workforce.

Opening up data is important to accelerating the pace of implementing clean energy solutions. Making data in the utility system that is currently in a black box, such as the true costs of interconnection and why it takes the time it does, more transparent is key to speeding up innovation. Legislative efforts in California are trying to address this.

Innovation in the distributed generation resource technology and market frameworks are also key to making the system work, as we progress toward a 100% renewable grid. Case in point, not long before the conference, the California grid experienced a rare emergency because solar that was forecast to be available was not, and distributed generation resources saved the day, showing up with 800 MW in ten minutes. This points to great potential of aggregated markets.

While renewable electricity, storage, and other pure electrification technologies are appropriate to develop for the challenges of today, looking ahead to going 100% renewable across sectors – that is, getting to 100% renewable electricity, decarbonizing gas end uses and industry, and tackling transportation applications like long haul goods movement (e.g. heavy duty trucks, shipping, and aviation) – will require new solutions, such as possibly decarbonized fuels and gases made from solar and wind power and ideas that we have yet to imagine. There was consensus that the landscape is changing in fast and unpredictable ways and that no one has the crystal ball for what exactly the best solutions will be, but that having the dialogue now is critical.

The handwriting is on the wall when casinos in Las Vegas and big corporations are paying millions to unhinge from their utilities because they think they can do it better by procuring 100% renewable electricity on their own.

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For conference videos, presentations, and program, please visit the event website at www.renewables100.org/en/pathways-2017/

For more information: pathways@renewables100.org

