100% Clean Energy Goals:

What will it take to get there?

A white paper by Larry Sherwood

Interstate Renewable Energy Council, Inc.

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MORE THAN 90 U.S. cities[1] and 140 large corporations[2] have established 100% clean, carbon-free and/or renewable energy goals in recent years. California, with its new mandate that 100% of its energy power must come from non-carbon sources such as solar and wind by 2045, joins Hawaii, which previously established a similar goal. In several other states, newly seated governors campaigned in 2018 on goals of 100% renewable energy, and congressional representatives were sent to Washington positioning for a like-minded national proposal.

In order to avoid long-lasting and irreversible changes to the earth's ecosystems, human health and well-being, the Intergovernmental Panel on Climate Change[3] found that net human-caused carbon dioxide emissions need to decrease by 45% from 2010 levels by 2030 globally, reaching 'net zero' around 2050. Achieving these dramatic reductions in carbon means that we must *both* reduce the demand for energy, by improving the overall efficiency of homes, buildings and transportation sectors, *and* supply renewable and carbon-free energy to meet remaining demand. By some estimates, renewable energy will need to rapidly scale over the next 30 years (supplying up to 85 percent of electricity globally by 2050 compared to the 25 percent today).[4]

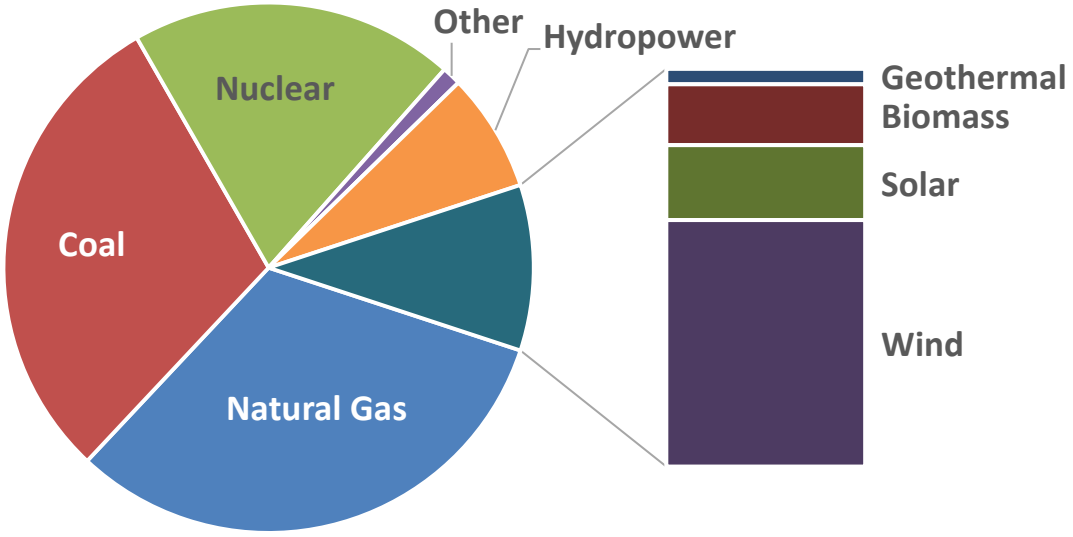
Setting 100% clean energy or renewable goals is a significant step, but the question remains: what *really* has to happen to get from here to there, and what are the benefits such a transition will bring?

Today's U.S. Energy Snapshot

A LOOK AT HOW FAR we need to go offers a useful reality check on what needs to happen to achieve ambitious renewable energy goals. Currently 18% of all U.S. electricity generation comes from the following renewable sources:[5]

- Wind – 6%
- Biomass – 2%
- Solar – 2% (including 1% from distributed solar)
- Hydroelectric – 7%

[1] https://www.sierraclub.org/ready-for-100/commitments
[2] http://there100.org/companies
[3] Intergovernmental Panel on Climate Change, *Global Warming of 1.5°C – an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty: Summary for Policymakers*, October 2018.
[4] Chestney, Nina and J. Chung, *Rapid, unprecedented change needed to halt global warming - U.N*, Reuters, 7 October 2018, available at: https://www.reuters.com/article/us-climatechange-ipcc/rapid-unprecedented-change-needed-to-halt-global-warming-u-n-idUSKCN1MI022
[5] Energy Information Administration, Net generation for all sectors, available at the Electricity Data Browser, https://www.eia.gov



Nuclear energy constitutes 20% of the current resource mix, and the remainder (62%) comes from natural gas, coal, petroleum, and oil. The debate around nuclear power continues, and although it is a source of carbon-free electricity, there are other challenges that may impair its future growth trajectory (namely, high capital costs, long lead times for permitting and construction, concerns regarding waste disposal, and water consumption). Large-scale hydroelectric generation also faces growth challenges.

Across the U.S., states vary in the types of renewable generation deployed. Wind power is the dominant renewable resource in Texas and many Midwest states – for example, Iowa, Kansas, and Oklahoma generate about a third of their electricity from wind. However, nearly every state has large-scale wind resources deployed, with the exception of a handful of states in the southeast.[6] Solar energy, both large-scale and distributed, is prevalent in a number of states, with several leading the pack in terms of total capacity installed. As of September 2018, California, North Carolina, Arizona, Nevada, Texas, New Jersey, Massachusetts, Utah and Georgia are the top 10 states for installed solar.[7] In California, almost 25% of the electricity used within the state comes from renewables, including solar power generated and consumed on-site (distributed energy).[8] Hawaii generated 27% of its total electricity from solar and other renewables last year.[9]

Across all states, energy efficiency serves as a critical energy resource that helps reduce overall demand for new generation, transmission and distribution investments.

[6] https://www.awea.org/resources/fact-sheets/state-facts-sheets
[7] https://www.cnbc.com/2018/09/19/the-us-states-leading-the-way-in-solar.html
[8] https://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf
[9] https://www.hawaiianelectric.com/hawaiian-electric-companies-achieved-27-percent-renewable-energy-in-2017

Clean Energy Growth Must Accelerate

BLOOMBERG[10] RECENTLY PROJECTED that 50% of the world's electricity will be generated by wind and solar in 2050 and total zero-carbon electricity will be 71%. One can debate details of various clean energy scenarios. But it is clear that to meet goals of 80-100% clean energy, solar and wind power must increase many times over, even in the states with the highest current use of renewables.

Not to be overlooked are future dramatic increases in overall electricity usage, as applications that are now fueled by fossil fuels (including vehicles, space and water heating and industrial applications) convert to electricity. The Electric Power Research Institute estimates that in an efficient electrification scenario driven by technological change, consumer choice and policy, electric use will increase by 49% compared with use in 2015.[11] As the use of electricity grows, the growth in renewable energy generation will need to be even greater to move toward a clean energy future. Likewise, technologies and strategies already in use to reduce energy consumption in the built environment and transportation will need to be more widely deployed.

Challenges to Using 100% Clean Energy

WHILE 100% RENEWABLES is a goal IREC has worked toward for decades, we still face many challenges. The good news is that these issues and challenges are coming into focus, along with exciting, viable solutions. And decision makers in nearly every state are listening.

When a city government or corporation sets a goal of using 100% clean energy for their needs, it is a significant stretch that will require strong commitments. But it is attainable even today, by connecting to the larger regional and national electric grid and using it to maintain reliable electricity supply when clean energy is not available. Net use of 100% from renewables can be achieved even if renewable sources are not available all of the time, by relying intermittently on traditional fossil fuel. Some companies have begun to address the issue of intermittent fossil fuel usage. Google, which already gets 100% of its energy from renewable sources, is now diversifying its purchases so rather than just averaging 100% renewable energy annually, it can use 100% renewable power every hour of every day.[12]

It will be much more challenging for large urban areas and entire states to reach a true 100%. California's clean energy goal depends on generating large volumes of energy from solar and wind, which are intermittent resources that do not always produce electricity at the same times that consumers use it. To get all energy from clean sources will require fundamental changes to the grid. All of the clean energy generation sources will need to work together with storage and demand response, a change in the power consumption of a customer to better match the demand for power with the

[10] Bloomberg *New Energy Outlook 2018: BNEF's annual long-term economic analysis of the world's power sector out to 2050*, June 2018.
[11] G. J. Blanford, *U.S. National Electrification Assessment*, presentation at EPRI's Electricification 2018 Conference, August 2018.
[12] Google website, 100% renewable is just the beginning, https://sustainability.google/projects/announcement-100/

current supply. Integration of these technologies maximizes all clean energy resources, while also increasing the reliability of the electricity grid.

Integrating the currently installed capacity of solar into the grid is currently straightforward in most states, but becomes more challenging as the amount of installed solar increases. As we add more renewables to the energy supply chain, we are adding more intermittent resources, and as we add electric vehicles, we are adding a potentially large intermittent electric demand. Integrating and optimizing these technologies will require a new way of thinking about the electricity grid, and perhaps most importantly, electricity planning.

IREC is working tirelessly with multiple states to inform and encourage the use of new methodologies and planning tools to enable and effectively integrate more clean energy on a more modern electricity grid. Storage and demand response technologies allow renewables to be available for more time. Storage now adds hours to availability of renewables. Eventually, storage systems and demand response will have to add days and then seasons. And both must be able to easily connect to the grid, so consumers and utilities receive benefits.

The grid must not only work for high amounts of intermittent distributed energy resources, but also be developed in an equitable way for all consumers. The clean energy economy will need to include those who cannot afford large capital purchases, such as their own rooftop solar, or the addition of energy storage, or demand response, (). IREC is expanding our efforts to develop policies and programs that allow renters and other low- and moderate-income consumers to receive the benefits of solar and other clean energy technologies. And IREC is ramping up our workforce programs to help ensure that the workers who install these new technologies represent all segments of our society.

Another challenge is that the voltage on the electric distribution system varies based on the location of a distributed energy installation – whether a home or business is at the beginning or end or middle of a transmission system. Smart inverters can support more even voltage along the distribution network, which means a utility can avoid more expensive distribution upgrades to their system to equalize these inconsistencies, an expense eventually passed onto the consumer.

Inverters convert electricity generated from an on-site installation, such as PV solar panels, from DC current to AC current, so it can be used in traditional AC appliances. Inverters are also the connection point between the on-site renewable energy generator and the larger electric grid.

Historically, most inverters disconnect the solar system from the grid when abnormalities occur. This procedure made sense when the number of PV systems was small and their impact on the grid had not yet been significantly studied. But now, with larger numbers of PV systems, these systems can and should help provide support for the grid. For example, new inverters stay connected to the grid during short power failures. If all the solar systems disconnected during short outages, they could precipitate a larger power failure. New smart inverters have ride-through capability and can allow solar installations to support grid abnormalities elsewhere in the system.

Along with our other critical work, IREC is helping develop regulatory rules for the deployment of new smart inverters, as their use will allow for higher percentages of distributed renewables in a way that ensures rather than threatens the reliability of the growing, evolving grid.

As the capacity of distributed renewables grows, more of the support for the grid will need to come from these resources, rather than from central power plants. And these distributed generation sources will need to effectively coordinate with storage, electric vehicle charging and demand management, so the electric grid works well as a system, and the use of clean energy is optimized.

New Issues to Reach Aggressive Clean Energy Goals

AS MORE RENEWABLES COME ONTO THE GRID, new issues are arising and others are transforming. Regulatory rules should be re-tooled to support consumers' choice to use clean energy technologies. The importance of anticipation and planning can't be overstated. Both "simple" and foundational changes will need to be embraced, some by utilities, others by consumers. Fully analyzing and evaluating potential solutions will be key to avoiding costly mistakes and delays. And from there, best practices can be created and replicated, so more states can get ahead of evolving issues as they work toward meeting the comprehensive challenges associated with the transition to increased clean energy.

Ownership and control. In order to optimize a clean energy grid, a number of features will need to be controlled, including: (1) when renewable energy is put on the grid and when it is put into storage; (2) when storage is used to serve customer load versus providing energy to serve the grid; (3) when appliances or energy loads are turned off; and (4) when vehicles are charged or discharged. Who owns and controls these assets and the decisions regarding their operations are challenging issues that policymakers, regulators and technology providers will need to address. In addition, the appropriate price signals, tariffs, and incentives will need to be in place in order to ensure there are sufficient economic incentives to operate flexible technologies for their intended function.

Protecting the security of the electricity grid. As more energy systems with software controls are connected to a central grid system, there will need to be a more concerted focus on cybersecurity. Consumer information, data sharing and privacy are other considerations. Ensuring grid security and adopting appropriate protections will be integral to ensuring new clean energy technologies can be connected with confidence.

Storage, curtailment, and matching load in real time. As more renewable energy and distributed energy resources are connected to the grid, the grid will need to become more flexible and responsive to real-time conditions – both changes in load as well as changes in output. There may be times when generation will need to be modified or curtailed in order to address changes in grid conditions. In addition, energy storage technologies will need to be set to store renewable energy for later use, during periods of low production or high-energy demand. It is inevitable that at times, more renewable energy will be produced than can be used or stored at that time. In this case, some flow of this energy from the customer to the utility grid will need to be curtailed. Who decides which production is curtailed, where and at what time, will be an important issue to address. And, to the extent there are customer impacts, there will need to be sufficient customer protections and/or compensation mechanisms in place to avoid major negative economic impacts on investments.

Electrification of transportation and heating. Fossil fuels have historically served the other major sectors of our economy – transportation, space and water heating, industrial process needs. In an effort to address the urgent need to shift away from carbon-intensive resources, there is an increasing movement to electrify these sectors. For economic and environmental reasons, this trend is likely to increase in the years ahead. In order to avoid a huge increase in pollution and carbon emissions, electrification will require a focus on expanding deployment of clean, renewable resources to meet this new demand.

New standards for distributed resources and the rollout of smart inverters. States must sooner than later consider new long awaited updated standards published in April 2018 by the Institute of Electrical and Electronics Engineers (IEEE). The *IEEE Standard 1547-2018™ for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces* is a voluntary, nationally-applicable standard that will transform how distributed energy resources interact with and function on the electric distribution system. It requires distributed energy resources to be capable of providing specific grid supportive functionalities relating to voltage, frequency, communications and controls. Once widely utilized, these functionalities will likely enable higher penetration of distributed resources on the grid, while maintaining grid safety and reliability and providing new grid and consumer benefits.

Increased Renewables Require a New Way of Thinking

SINCE ELECTRICITY IS A REGULATED BUSINESS, innovation will not spread in the same way it does within the world of high-tech products – with competitive R&D stages, financing scrutiny, calculated market development, and coordinated marketing launch. In the case of renewable energy and electricity, it is advocates who must be a strong voice at the table all along the development process, from informing regulatory rules and policies, to implementation in communities, states and regions. Ongoing engagement is the only insurance that policies and practices will develop to address the priorities of:

- optimizing and maximizing the amount of clean energy used;
- providing the best deal for the electricity consumer;
- serving all customers, especially those with low or moderate incomes and in underserved communities; and
- ensuring the workforce is prepared to accommodate and embrace clean energy deployment.

Fortunately, in addition to addressing urgent climate and health concerns, meeting clean energy goals provides economic benefits, through both energy savings and increased jobs. In 2017, 650,000 people worked with renewable energy generation technologies in the U.S., and 2.25 million spent some or all of their time working with energy efficiency technologies and services.[13] Increased deployment of clean energy technologies – from solar and energy storage to wind and electric vehicles – translates to increased economic opportunities. Yet, as the percentage of clean energy grows, so too will the number of professionals across numerous sectors need to revamp and update their operations to integrate renewable energy, energy efficiency, and clean energy technologies into their existence.

[13] National Association of State Energy Officials and Energy Futures Initiative, *U.S. Energy and Employment Report*, May 2018.

Fire fighters and building code officials will need to be familiar and trained to deal with distributed generation and energy storage systems. Real estate agents, appraisers and financers will need to understand how to appropriately value buildings that are cleaner and more efficient. Community planners and zoning officials will need to support proactive urban planning and development that is inherently more energy efficient and powered with renewable energy, such as community solar.

Small business owners and large industrial operations will need support with energy management and training to ensure they run their buildings and facilities as clean and efficiently as possible. Utility distribution engineers and grid operators will need to be trained to integrate, optimize and interconnect higher volumes of distributed generation and energy storage on the grid, along with electric vehicles and other distributed energy resources. And the list goes on.

As the economy shifts to one powered largely by renewable energy and energy storage, the workforce will inherently need to adapt and embrace new technologies – just as with the digital age, adoption will come more quickly once the technologies are mainstream and integrated into our daily lives.

IREC's Work is Critical to Meeting 100% Renewable Goals

IREC'S WORK IS PROPELLING effective clean energy policies and practices that will drive the integration of high grid penetrations of renewables in key regions across the country.

IREC enables significantly larger amounts of renewable energy resources to efficiently connect to the grid through the development of unique resources and tools for regulatory and workforce decision makers, industry and advocates.

Through direct regulatory intervention and through behind-the-scenes technical support to decision makers and advocates, IREC is advancing the adoption of scalable state policy solutions, along with best practices for interconnection, grid modernization, transportation electrification, energy storage, smart inverter integration, equitable consumer access, and other foundational clean energy policies and practices. At the same time, IREC's workforce training and accreditation programs enable growth of a large and well-trained workforce to support a clean energy economy.

IREC's unique work is integral to meeting the 100% goals being set by cities, states, corporations and industries.

About IREC

IREC increases access to sustainable energy and energy efficiency through independent, fact-based policy leadership, quality workforce development and consumer empowerment. Millions more Americans are able to enjoy the benefits of clean and efficient energy as a result of IREC's thought-leading regulatory policy engagement and best practice resources.

Working state by state for more than 35 years, our unique work helps make affordable, reliable, sustainable clean and efficient energy possible, including for low- to moderate-income renters and multi-family dwellers, and in underserved communities.

The Interstate Renewable Energy Council | 518.621.7379 |info@irecusa.org

www.irecusa.org