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A Regional Energy Market to Achieve California's Renewable Energy Goals

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Abstract

The intermittency of renewable energy poses challenges for California's energy stability and reliability as the state pushes towards its goal of reaching 100% renewable electricity by 2045. Electricity generation from solar and wind power is increasing rapidly, but energy storage technology has not yet reached the levels of capacity to enable California to maintain energy stability on its own. California should merge into a regional energy market because this would solve the issues posed by renewable energy's intermittency, and it would simultaneously enable renewable energy to stimulate the market for the entire region. A regional energy market could accelerate transitions to renewable energy beyond California's borders and further California's ultimate goal of mitigating climate change. The western region is already trending towards integration as more states join California's Energy Imbalance Market every year, and the new federal administration could usher in a new era of climate action. California should capitalize on the current regional and political momentum to pass a bill in the state legislature to merge into a regional energy market.

Author's Note

As a resident of California, I live in a state that is leading efforts to address climate change. This is empowering and inspiring, and yet, California cannot curb climate change on its own. If my generation is going to have a future on this planet, then it is not solely about California achieving 100% renewable electricity, but about all regions reaching 100% renewable electricity. That is why the idea of a regional energy market stands out to me – it facilitates collaboration and change on a larger scale. This is the type of action that we need, and there is no time to spare.

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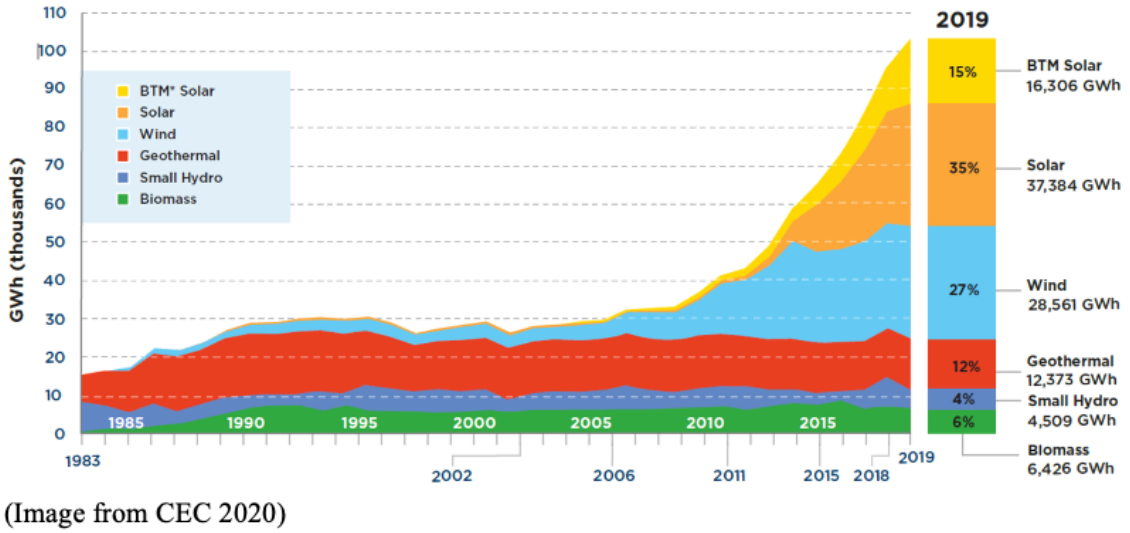
Keywords

California, Renewable energy, Intermittency, Energy Market

Introduction: Challenges posed by the intermittency of renewable energy

California has long been a leader in action on climate change, and in September of 2018, the state set a goal of reaching 100% renewable electricity by 2045. Transitioning to renewable electricity is critical to California's efforts to curb climate change, and the benefits of this transition are visible in the 40% reduction in greenhouse gas emissions from the state's electricity sector in the last decade (Petek 2020). California was not the first state to set a goal of 100%, but it has the 5th largest economy in the world (Domonoske 2018). Therefore, powering California with 100% renewable electricity is an ambitious goal and, given the size of the state's economy, California will face new challenges to reach 100% at this scale.

California residents are largely supportive of a transition to renewable energy. A state-wide survey conducted in July 2020 found that 77% of California residents support the goal of 100% renewable energy by 2045 (Baldassare 2020). Despite strong public support, some critics of California's policy tried to capitalize on the rolling blackouts that California experienced in August 2020 to argue that renewable energy is unreliable and will cause more blackouts in the future (Olsen 2020; The Editorial Board 2020). These blackouts were the first that the state had faced in almost twenty years. Shortly after the blackouts, the California Independent System Operator (CAISO), the California Public Utilities Commission (CPUC), and the California Energy Commission (CEC) sent a joint letter to Governor Newsom stating, "Collectively, our organizations want to be clear about one factor that did not cause the rotating outage: California's commitment to clean energy. Renewable energy did not cause the rotating outages" (Batjer et al. 2020). After spending months completing a "Root Cause Analysis" report released in January 2021, the organizations concluded that the blackouts were caused by three factors: 1) a rare extreme heat wave caused by climate change, 2) insufficient planning targets, and 3) market design issues that obscured the supply-demand imbalance (CAISO et al. 2021). The blackouts were a public reminder of how critical reliable energy is for California's residents and businesses.



(Image from CEC 2020)

Figure 1. Renewable generation serving California each year.

Wind and solar power generation have increased dramatically in California over the last decade (illustrated in Figure 1), and both of these sources are intermittent (Albright et al. 2019). These sources are not dispatchable as needed because they are dependent on changing conditions that cannot be controlled, like the environment (Hanania et al. 2020). Transitioning to renewable energy is not simply about producing sufficient energy, but about matching the timing of energy production with energy use.

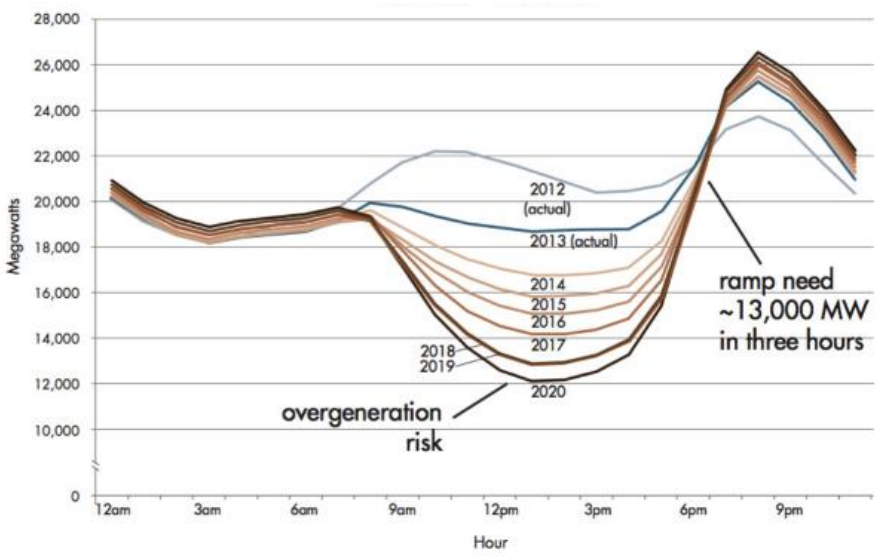


Figure 2. The "Duck Curve" on a typical spring day in California.

Renewable energy poses an interesting challenge by producing too much energy at some hours of the day and not enough energy at others. The "duck curve" is a well-known graph of a 24-hour period on a standard spring day in California that illustrates the difference between the demand for electricity and the available solar energy at each hour of the day (see Figure 2). The mismatch between supply and demand forms the shape of a duck, with excess energy produced during most daylight hours, and a deficit in supply as people return home in the evening, after the sun sets. The "belly" of the duck curve grows larger every year as California's solar energy capacity increases (Jones-Albertus 2017).

Sending an excess of energy supply to the grid depresses prices (Schulte & Fletcher 2019). To avoid the market consequences of an excess of supply, California is often forced to curtail its solar energy production during the day, intentionally reducing the output of generators. The amount of renewable energy curtailed in California has been increasing rapidly over the last few years. In 2019 alone, 922,000 megawatt-hours of solar energy were curtailed, compared to 432,000 megawatt-hours in 2018 (O'Shaughnessy, Cruce, & Xu 2020). This energy is essentially wasted (Schulte & Fletcher 2019).

As California moves toward its goal of 100% renewable energy, the intermittency of renewable sources becomes even more challenging. The state will no longer be able to rely on sources such as natural gas to fill in the gaps when the sun sets or when the wind stops blowing. This report will examine the policy option of a regional energy market that could enable California to mitigate the risk of intermittency from renewable energy, pursue its goals to reach 100% renewable energy, and act on climate change.

Diagnosis: technical problems with system-wide solutions

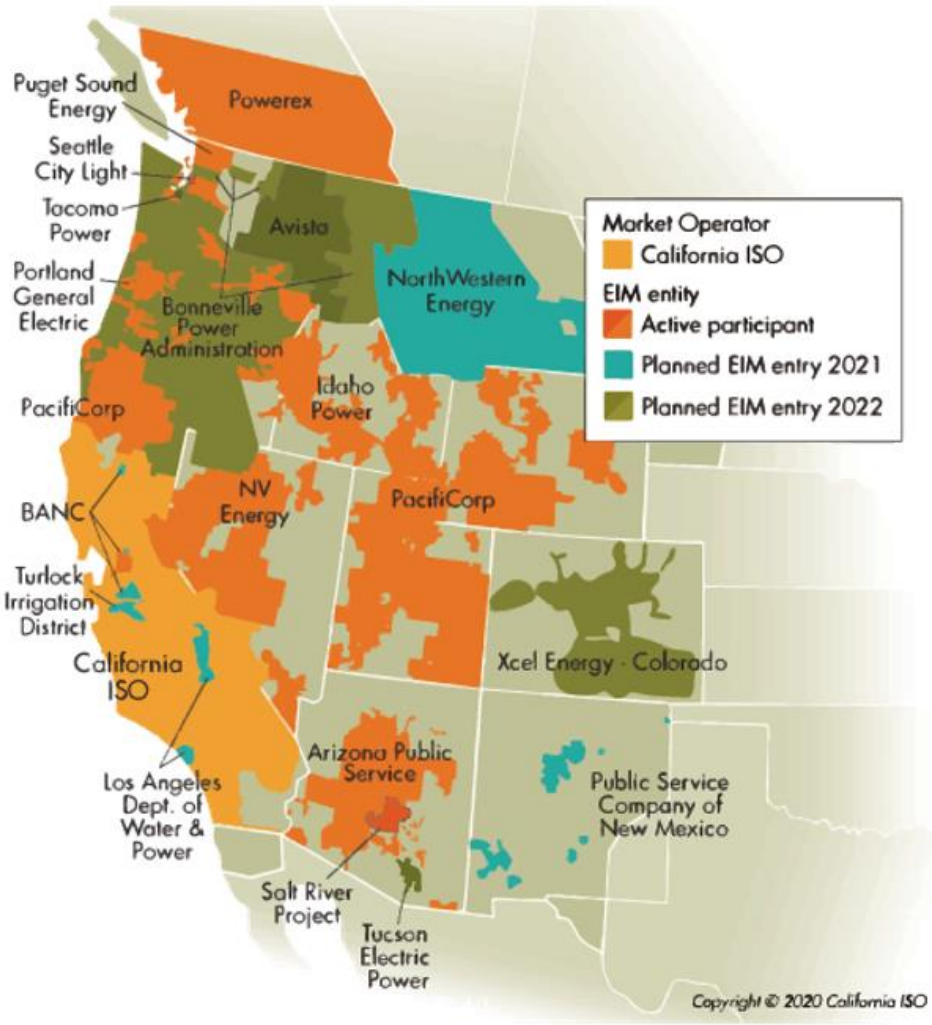
Multiple factors contribute to the challenge California faces from intermittent energy. First, there is a lack of diversity in the state's renewable energy sources. Solar energy made up about 50% of California's renewable energy in 2019, and wind made up about 27% (see Figure 1) (CEC 2020). This lack of diversity hampers the state's ability to balance the grid when one source stops producing (e.g., when the sun sets). Further, since California extends north to south geographically, the entire state is in one time zone. Therefore, it lacks diversity in both the timing of solar energy production and in the timing of demand patterns. Due to the lack of diversity in sources, production timing, and demand patterns, California may still face the issue of intermittency even if it significantly increases its renewable energy generation (Schulte & Fletcher 2019).

Electricity storage technology would be the logical solution to intermittency because excess energy that is currently being curtailed could be stored and used at times when demand is higher than supply. However, current technology is not able to provide the capacity and affordability necessary to accommodate California's needs. According to CAISO, which manages 80% of California's electricity, approximately 15,000 megawatts of battery storage will be required to reach 100% renewable energy by 2045. To put this in context, CAISO had only 550 megawatts of storage capacity as of February 2021 (Balaraman 2021). Technological advancements led to a 65% – 85% decrease in storage costs between 2010 and 2019 (Phadke et al. 2019), but the cost of developing a sufficient system for the state of California still makes this option unfeasible as a standalone solution. Leaders must move quickly to prevent the catastrophic impacts of global warming and cannot simply wait for storage technology to improve (Leahy 2019). Therefore, alternative policies must be devised, in conjunction with storage technologies, to achieve California's goal without sacrificing energy stability or reliability.

To develop a solution, an analysis of the system in which the problem takes place is essential. This involves looking at the structure, relationships, and incentives within the larger electricity system in which California operates (Stewart & Ayres 2001). California is part of the regional entity called the Western Electricity Coordinating Council (WECC). The WECC region is notable in that it has the greatest size and geographic diversity out of all six regional entities under the North American Electric Reliability Corporation and the Federal Energy Regulatory Commission (WECC 2015) (see Figure 3 in the appendix). Within the WECC, there are 38 separate balancing authorities, which are each responsible for operating infrastructure in their area to balance supply and demand (see Figure 4 in the appendix).

Since 2014, CAISO has run a voluntary market within the WECC called the Western Energy Imbalance Market (EIM) (CAISO 2020a). The market enables real-time trading, balancing supply and demand at five-minute intervals using the lowest cost energy in the grid (International Renewable Energy Agency, 2019). This real-time trading allows participants to make up the difference between the demand and supply that was predicted and the demand and supply that occurred. The governing body of the EIM is now working on developing an Extended Day-Ahead Market (EDAM), which would enable further integration and trading (Zichella 2019b). Whereas only about 5% of total power is traded in the EIM, EDAM would enable trading of almost 100% of the region's electricity (Trabish 2021). However, the EDAM does not achieve full integration. Unlike a regional energy market, the EDAM does not centralize control and would not be able to assess transmission costs or dispatch generation directly (St. John 2019). The fact that an EDAM would not have regional transmission planning is important because that is where most cost-savings come from in regionalization (Roberts 2018).

Integration of entities in the WECC through the EIM has been very successful. The efficiency of the market can be seen in the $1.11 billion in savings that the EIM has generated for its members since it was initiated in 2014 (CAISO 2020a). These savings are especially impressive considering the EIM only accounts for approximately 5% of total volume, since the only type of trading supported is in real-time (Trabish 2018b).



(Image from CAISO 2020a)

Figure 5. Participants in the Energy Imbalance Market.

Figure 5 shows the regions that are already part of the EIM, as well as those that are planning to enter the EIM in the coming years. The figure illustrates the trend towards integration that is already taking place. By the end of 2022, 21 balancing authorities will be part of the EIM (CAISO 2020a).

Proposal: integration into a regional energy market

To address the issue of intermittence inherent in California's solar and wind energy, the state should merge into a wholesale regional energy market, which would enable full integration and electricity trading within the region. This policy option addresses the roots of the problem by diversifying the supply of renewable energy, thereby increasing stability. This solution spreads out electricity demand, reducing variability and increasing the entire system's reliability. A regional energy market would enable renewable energy to stimulate the market for the entire region, reduce reliance on fossil fuels, and increase the diffusion of renewable energy beyond California's borders. The stability of a regional energy market would also allow other states to transition to renewable energy more securely, accelerating transitions in neighboring states and further supporting California's ultimate goal of mitigating climate change (Paulos 2018).

The elements needed to develop a regional energy market include collaboration, investment, and political effort. CAISO must continue to build partnerships with other balancing authorities to establish a unified energy market for trading renewables. California must invest in technologies that increase transmission efficiency and resiliency while decreasing initial capital costs and maintenance costs. California and other states must build on existing infrastructure to develop and maintain stable, high voltage electricity transmission systems and a smart grid that can balance and redirect electricity supply and demand.

Politically, California must pass a bill in the legislature in order to merge into a regional energy market. This element will likely be the most challenging. Previous attempts to pass a bill merging California into a regional energy market have repeatedly failed in the legislature. Assembly Bill 813 is the most recent bill that would have expanded CAISO into a regional energy market. The bill was rejected by California's legislators in August of 2018 (Trabish 2018b), which marked the third consecutive year that regionalization failed in the legislature (Sangree 2018).

Some of the strongest opponents to previous bills were labor unions, which argued that merging into a regional energy market would cause job loss in California. Proponents argued that a regional energy market would result in around 9,900 to 19,300 new jobs in California by 2030 (CAISO et al. 2016). Neither side was necessarily incorrect, and this debate highlighted the tradeoffs of regionalization. Labor unions were focusing on jobs specific to renewable energy construction that could move to other areas of the region outside of California. Proponents were evaluating the number of new jobs across sectors that would likely be created due to the reduced cost of electricity from regionalization (CAISO et al. 2016). While studies showed that overall job numbers would increase due to regionalization, this did not resolve the concerns of the labor unions regarding renewable energy construction jobs within the state (Trabish 2018a). When amendments were introduced to keep jobs in California, the bill advanced slightly but ultimately lost the support of renewable energy advocates and environmental groups.

While the potential of renewable energy jobs moving outside of California can be a downside of regionalization, it is important to remember that the reason California is pursuing these policies in the first place is to address climate change. Building a sustainable future also means finding ways to make an equitable transition, and alternative pathways should be created for those workers whose jobs may leave the state. It is possible to simultaneously address the needs of stakeholders and pursue bold action on climate change. Merging into a regional energy market will benefit many of California's communities—the reduced price of electricity will be especially beneficial to low-income communities, and the benefits of the resulting job creation will be widespread. Further, the creation of renewable energy jobs in other states is ultimately beneficial to California as well.

Lawmakers' opposition to ceding control to a regional entity is another barrier to the passage of a bill in the state legislature. Currently, CAISO's Board of Governors is appointed by the governor and approved by the senate. If California merged into a regional energy market, the board of the regional entity would be independent of California's government. California would have a place on an advisory committee of state representatives, but this would be significantly less authority than the state is accustomed to (Trabish 2018a).

Some fear that giving away this control would put California's progressive policy at risk as states still supporting fossil fuels would have significant decision-making power. However, analysis of regional markets in other parts of the country shows that regionalization is beneficial to renewable sources and detrimental to fossil fuels. Regionalization increases market competition, and low-cost renewable sources have caused many coal plants in regional markets to shut down (Paulos 2018). CAISO's EIM has already led to increased use of renewable energy and a decrease in the use of fossil fuels (Zichella 2019a).

Although previous attempts to alter the governance structure of CAISO have failed, the context in which California would make this change is shifting. The new federal administration is unlikely to subsidize fossil fuel plants or pass legislation favoring fossil fuels, as the outgoing administration has over the last four years (The Economist 2018). The Biden Administration seeks to make the United States a leader in clean energy technology (Biden For President 2020), and a significant portion of the president's upcoming $4 trillion recovery package is dedicated to accelerating a clean energy transformation (Friedman & Tankersley 2021). Additionally, states surrounding California are increasingly adopting ambitious goals for renewable energy (Zichella 2019a). These changes suggest that relinquishing some authority now would not be as consequential as it might have been in the past.

Further, recent increases in competition between CAISO and other system operators for power providers illustrate that a change in CAISO's governing structure may be necessary for CAISO to stay competitive in the future. CAISO recently won the participation of power provider Xcel Energy over another system operator, Southwest Power Pool (SPP). Xcel Energy decided to join CAISO's market because studies showed CAISO offered greater cost savings than SPP. However, governance structure has been identified as an important factor when power providers make these decisions (Trabish 2021). As SPP catches up in the cost savings it can provide, CAISO may lose its advantage. In CAISO's current structure, other entities have neither formal membership nor voting rights (Paulos 2018). SPP, on the other hand, uses a governance framework that delegates decision-making power among all members. A change in CAISO's governance structure may be critical to gain the support of other power providers moving forward.

Evaluation of proposal

Criteria commonly used to evaluate a policy proposal include its effectiveness in addressing the problem, its feasibility of being implemented, whether it is an efficient use of resources, whether it is equitable for all groups in society, and its acceptability by the public and decision-makers (Bardach 2015). This proposal will be evaluated under each of the stated elements.

A regional energy market is an effective option to address the intermittency of renewable energy because it resolves root issues of reliability and stability. The quantifiable measurements to evaluate the effectiveness of a regional market integration would include the following: 1) the reliability of electricity for California's consumers, 2) the cost of electricity, 3) the percent of California's power system that transitions to renewable sources over the following five- and ten-year periods, and 4) the percent of other WECC states' power systems that transition to renewable sources over the following five- and ten-year periods.

This option is feasible because regional energy markets have been successful in the rest of the United States. Two-thirds of electricity demand in the U.S. is already served by regional transmission organizations, yet California's ISO is the only regional market in the WECC (Paulos 2018). The feasibility of a regional energy market is also increased by the fact that the West is already trending towards integration.

A regional energy market is efficient. Studies have shown that a regional energy market is the most cost-effective way to incorporate renewable energy into California's power grid, and it produces financial benefits for all participants (Paulos 2018). Studies conducted in 2016 showed that California ratepayers would have been expected to benefit in the amount of approximately $55 million annually by 2020 and $1 billion to $1.5 billion annually by 2030 had California merged into a regional energy market at that time (CAISO et al. 2016).

The proposed solution is equitable in that a regional energy market would provide stability and affordability to all of California's residents and businesses. Low-income communities would receive the greatest benefit proportionally, as a greater portion of their budgets is spent on utilities. Low-income households spend an average of 8.6% of their gross household income on energy costs, which is almost three times higher than households that are not low-income. In some areas of the U.S., households spend up to 30% of their gross income on energy costs (Office of Energy Efficiency & Renewable Energy). A reduction in the cost of electricity would lessen this burden on low-income communities. A regional energy market would also likely speed up transitions to renewable energy, therefore reducing pollution from non-renewable sources that disproportionately impacts marginalized communities (Ash et al. 2009).

Merging into a regional energy market is acceptable in the sense that there is wide-ranging public support for a transition to renewable energy. However, political acceptability is likely the biggest obstacle to putting this policy in place. Proponents of a regional energy market must engage stakeholders and design alternative pathways for those whose jobs would move outside of California. Discussions with legislators should emphasize the growing prominence of renewable energy policy both on the federal level and in California's surrounding states in the WECC. Proponents should highlight the importance of engaging in collaborative action to combat climate change that is inclusive and extends beyond the state's borders.

Conclusion

California should merge into a regional energy market to enable the state to achieve 100% renewable energy by 2045 while maintaining reliability for its businesses and residents and simultaneously increasing the development of renewable energy beyond its borders to mitigate climate change. States are increasingly committing to renewable energy and integrating into the EIM every year, and the new federal administration may usher in a new era of climate action. California should capitalize on this momentum to form a regional energy market. The first step in doing so is gaining the support of unions and building the political will to pass enabling legislation in the California legislature. While merging into a regional energy market is not a silver bullet to solve energy challenges or climate change, it is a step that puts California and its neighbors forward on the path to a sustainable future.

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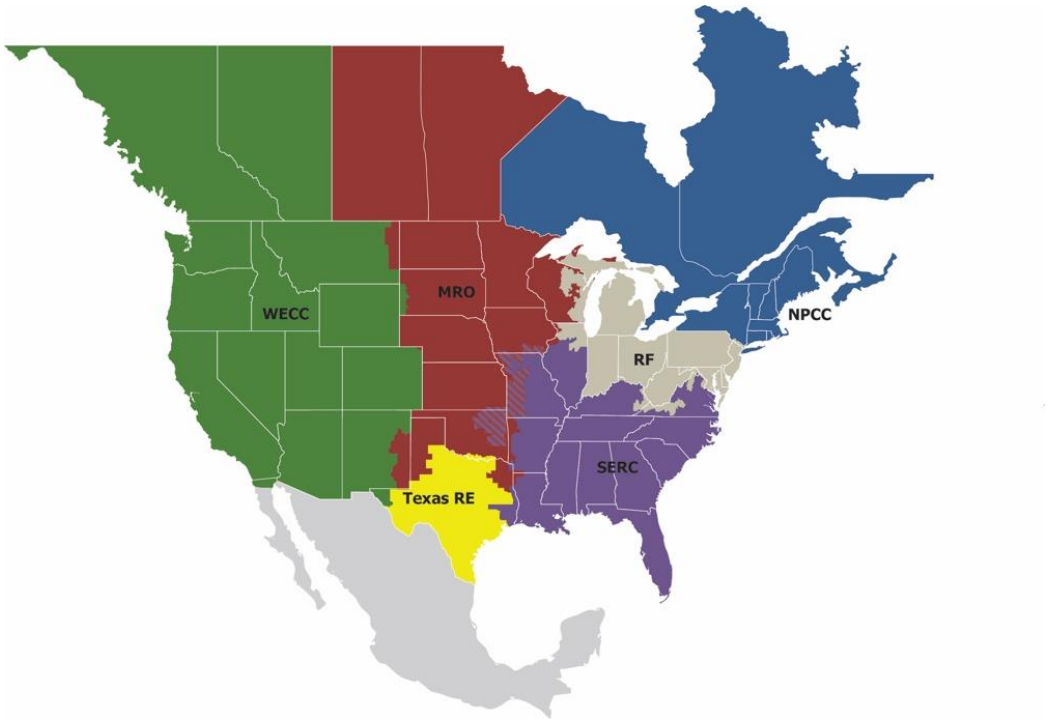
Appendix

Table 1: Abbreviations

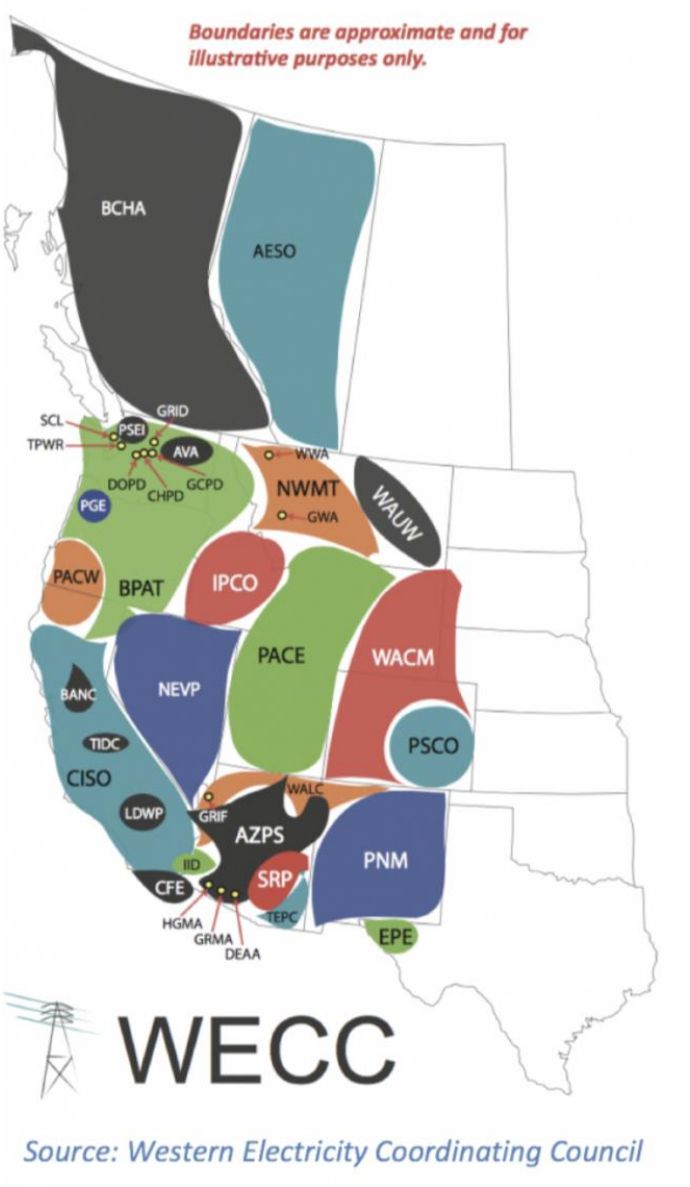
Abbreviation	Full name
CAISO	California Independent System Operator
EDAM	Extended Day-Ahead Market
EIM	Western Energy Imbalance Market
ISO	Independent System Operator
WECC	Western Electricity Coordinating Council

Figure 3: The six regional entities under the North American Electric Reliability Corporation and the Federal Energy Regulatory Commission



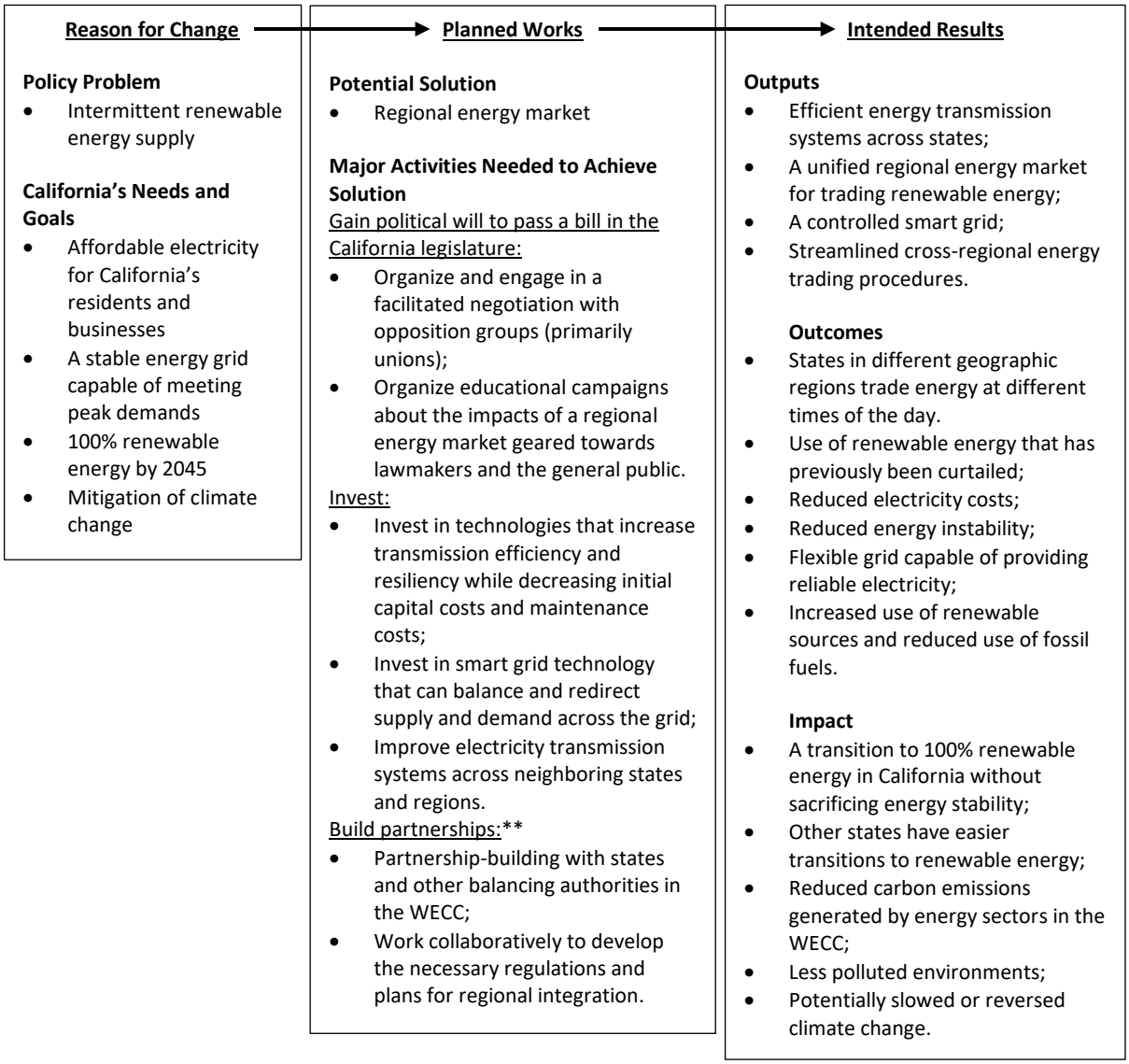
(Image from North American Electric Reliability Corporation 2020)

Figure 4: The 38 balancing authorities in the WECC



(Image from Western Clean Energy Advocates 2018)

Figure 6: Theory of Change



*Conflicts that could result over land for transmission infrastructure are not considered in this project.

**This proposal is based on the assumption that surrounding regions are willing to negotiate a collaborative program to foster the regional energy market.

Credit for the creation of this Theory of Change diagram goes primarily to my colleague Yuning Zhu.