

This brief discusses findings that emerged through a series of interviews held in the spring of 2021, and a virtual workshop held in June 2021, in which over 115 stakeholder participants discussed Pathways to Carbon Neutrality in California.

2045 is Closer Than You Think

California has the goal of achieving net zero carbon by 2045, leaving only 24 years to get the job done. That might seem like plenty of time, but there is much to be accomplished, some of it unprecedented in scale and scope. We observe that the net zero goal requires essentially reengineering most of California's energy system. One participant likens this to a "moonshot".

THE CHALLENGE OF BUILDING IN CALIFORNIA

Many participants expressed the sentiment that it is difficult to build in California. Observing China's electricity expansion, one participant believes that the "build out is physically doable" but "It takes too long to build things in California". Participants indicate that a gas plant which can be built in a couple of years in Texas takes at least five years in California. ***Can California build quickly enough to realize decarbonization goals in 24 years?***

Existing regulatory structures are devised for the existing system. Participants are not optimistic that these structures will be able to accommodate the dramatic buildout and upgrades required for electrification. ***How can California ensure that regulatory and governance mechanisms can enable the infrastructure necessary for decarbonization in 24 years? How will a regulatory system that is meant to manage incremental change handle what amounts to reengineering the entire system?***

UNDERSTANDING THE CHANGING ENERGY LANDSCAPE

The current way of doing things is well-established. This includes permitting, conducting environmental impact analyses, and modeling electricity and, more broadly, energy systems. These systems are changing and the pace of change will be increased by decarbonization. ***How can California's systems for understanding, evaluating, building, and regulating energy systems enable decarbonization in 24 years?***

The conversion of residential and commercial fossil-fuel appliances to all-electric, and of transportation and industry from fossil-fuel systems to all-electric will cause changes to the nature and timing of loads. The advent of consumer-owned generation and storage is changing the nature of the load curve. The retirement of most fossil-fuel generators while substantially increasing the grid to meet new transportation, buildings, and industrial demands will impact economics, reliability, and resiliency.

Does California have adequate understanding and appropriate analytical tools to address the future nature and performance of electricity infrastructure?

THE ROLE OF INNOVATION

California is famous as a source for innovation, and innovation of all aspects of the electrical system will be important for decarbonization to succeed. One optimistic participant stated "we are going to innovate our way out of this", meaning that new solutions and technologies must (and will) be discovered, commercialized, and deployed. ***Is California prepared to rapidly evaluate and exploit innovations that have not yet been invented?***

THE RISK OF MOVING GOALPOSTS

Setting goals in the face of technological and economic change is inherently challenging. Ambitious goals can stimulate the creativity of the private sector and attract investment. However, overly ambitious goals can create unrealistic expectations and inevitable recrimination. This dilemma may become more challenging.

GOALS CAN BE CHANGED, WHICH CAN CAUSE SEEMINGLY GOOD INVESTMENTS TO BECOME USELESS

Participants point out that when change happens, sometimes "the goalposts move away" meaning that regulators change the rules of the game such that long-term investments based on one set of rules can be harmed or rendered uneconomic. Participants point out that this can undermine support for the purpose underlying the goals.

Goals can be changed when unobtainable. Participants indicate that regulators will posit aggressive goals to incentivize innovation and investment. But if it doesn't work out, they will "move the goalpost back" and declare victory. However, this won't work for the state's net zero decarbonization goal. ***How can California set expectations that enable firms and consumers to invest and support decarbonization in 24 years?***

ELECTRIC VEHICLES

California has about 14 million internal combustion cars. If proposed transportation goals are to be met, they will all need to be replaced by electric vehicles. These additional electric vehicles will need to be charged. Participants point out that this will require a massive increase in the number of charge points, which need to be sited, permitted, built, and supplied with electricity. Providing EV charging for people without garages or with inferior wiring poses challenges. A participant with knowledge of the trucking industry reports that it is very challenging and slow to try build a charge point at a truck depot. ***How can California provide large-scale EV charging capability in a way that works for all people and businesses in 24 years?***

RESIDENTIAL RETROFITTING

California has around 14 million existing residences. Almost all use fossil fuel for space heat, hot water, and cooking. These residences will need to be retrofitted. Many existing residences have financially-attractive opportunities to increase energy efficiency, but have not been retrofitted. Participants point out that the scale of this challenge is unprecedented. ***How can California decarbonize millions of residences in 24 years?***

INCREASED ELECTRICITY GENERATION

Net zero requires that consumers and businesses replace most fossil fuel usage with electricity, necessitating significant amounts of new generation. Participants estimated that California's electricity consumption will at least double.

MASSIVE BUILDOUT OF SOLAR AND WIND

California will need to build renewables both to meet the new demand and to replace existing fossil fuel generation. Based on current costs, this will be dominated by solar and wind. Participants indicate that due to climate change (long term drought), hydropower may be less available for electricity generation, and that new renewable resources will require "a lot of sites in a lot of places" with a "sizable physical footprint". ***How can California ensure that enough land (and sea) is dedicated to renewables in 24 years?***

BUILDOUT OF ELECTRICAL TRANSMISSION LINES

Participants point out that there are potential large-scale renewable generation opportunities offshore, in California's southern and southeastern desert areas, and in other states as far away as Wyoming. A grid that is widely connected geographically can improve system reliability. That electricity must be transmitted over significant distances to load centers which are primarily in urban areas, necessitating the construction of new transmission lines and/or upgrading existing lines. Participants view this as very challenging, with one stating "many have tried and failed to build transmission", and indicate that acquisition of right-of-way and obtaining permits from multiple jurisdictions is particularly difficult and time-consuming. ***How can California ensure that enough transmission is built to enable electrification in 24 years?***

INTERSTATE RENEWABLE ELECTRICITY TRADING

Participants indicated that it can be very attractive to use renewable resources from other states, not only because they can develop capacity, but because the timing of wind to the east may align with California's electricity demand. Some of California's goals may be impeded by other states' own renewable goals, which could limit California's access to this generation during peak periods, such as regional heat waves. ***How can California coordinate with other states to ensure renewables supply in 24 years?***

UPGRADES TO ELECTRICAL DISTRIBUTION SYSTEMS

As demand increases from the growth of electrical vehicles and residential conversion from fossil fuels to electricity, distribution systems will require upgrades. This will include new and additional transformers to handle peak demand for charging EVs, etc. There will also be a need for development of cyber-secure system management technology – telecommunication systems, monitoring and measurement devices, artificial intelligence – to address peak demand, peak generation and load shifting on a distributed system level. ***How can California manage and implement distribution modifications to enable electrification in 24 years?***

Much to Build and Not Much Time

Participants noted that much remains to be done to ensure that California has the ability to identify, plan, permit, construct, and commission massive infrastructure projects across much of the state's economy, geography, and jurisdictions.

Our observation is that if we knew everything to do, we'd still have to do it – which is a daunting challenge; the challenge is greater because we don't fully understand what is to be done.