EVOLVED ENERGY RESEARCH

Observations on the Implementation of the 2022 California Scoping Plan

Evolved Energy Research

December 12, 2022

Summary

The 2022 Scoping Plan Update is an impressive achievement that describes, in a single document, multiple dimensions of California's path to net-zero greenhouse gas emissions, based on several different modes of analysis and a variety of stakeholder perspectives. It lays out the general direction of economy-wide decarbonization with admirable clarity, and improves treatment of previously under-analyzed sectors, for example the carbon sink on California's natural and working lands. It appropriately highlights equity in the energy transition, and addresses climate vulnerability through an equity lens.

As the Scoping Plan itself states, its release marks the beginning, rather than the end, of a process. There is an immediate need for further analysis, new policies, and new programs to guide the next steps in climate progress in California. Our comments below are intended to inform those next steps, especially with regard to the energy sector. They are organized according to the topical areas and policy proceedings to which they are most relevant: (1) **electricity**, under the CPUC Integrated Resource Planning (IRP) and interagency SB100 processes, (2) **carbon management** (including negative emissions and carbon capture, utilization, and storage (CCUS)), for which ARB is developing a governance framework to implement SB 905, and (3) the **drawdown of fossil fuel extraction and refining**, for which the planning and regulatory framework is being developed under a new interagency process.

The Scoping Plan functions well as a statement of policy objectives and as an emissions balance sheet, but implementing the state's goals will require a detailed, spatially explicit blueprint. For each of the three categories above, we have highlighted areas in which clarification or modification of Scoping Plan findings and guidance could be needed. Our recommendations are based on four general observations across different components of the Scoping Plan:

First, the Scoping Plan mixes existing policy requirements (e.g. net-zero by 2045) with proposed policies (e.g. accelerated 2030 emissions reductions) and implementation strategies (e.g. 100 Mt of negative emissions, no new gas power plants) in ways that turn these assumptions into apparent results and make it difficult to assess the need for, and cost and benefits of, different components of the plan. It is critical to separate the content of policy proposals, some of which may indeed be good for California, from the analytical process, which requires that all underlying assumptions and implications be carefully examined and explained. We point to a number of areas in which policy proposals and modeling assumptions require additional analysis prior to making binding decisions based on them.

Second, much more work is needed to identify the geographic locations of proposed energy infrastructure and timelines for its construction. Extensive geospatial analysis will make the Scoping Plan's guidance and subsequent policy development more realistic and help the state to anticipate critical questions that are not addressed in the current plan. The process of assigning infrastructure to specific geographic locations to be completed by a certain date raises questions that can be overlooked but must in fact be answered to proceed. In some cases, this may lead to significant modifications of Scoping Plan strategies and portfolios.

EVOLVED ENERGY RESEARCH

Third, further analysis is needed to explore alternative pathways in case events unfold differently from what is currently assumed. This is especially true for the years beyond about 2035, for which uncertainties are especially large. Uncertainties are frequently acknowledged within the Scoping Plan, but there is little that actually addresses the implications of these uncertainties and what options the state will have if events do not go according to current plans. We recommend that ongoing proceedings subject policy decisions to a much wider range of scenario and sensitivity analysis to demonstrate their robustness, and to flag important potential decision points on the path to net-zero. The decision to highlight a single scenario in the final Scoping Plan, versus four cases in the draft plan, may have simplified communications but leaves decision makers with less guidance at future forks in the road.

Fourth, more should be done to explore opportunities for greater regional cooperation in meeting emissions goals. Unlike 2008 when the first Scoping Plan was adopted, the majority of western states are now pursuing aggressive emissions reduction and clean energy goals of their own. This is partly a measure of California leadership in providing an example for neighboring state action on climate change and going forward state actions are likely to be furthered by the powerful incentives in the federal Inflation Reduction Act. However, the current Scoping Plan scenario implicitly assumes a "California goes it alone" framework that doesn't illuminate the potential benefits of greater cooperation between California and its neighbors, the inherent advantages or disadvantages of different states with regard to different kinds of mitigation measures, or what the state's policy priorities should be in this area.

Electricity System: Integrated Resource Planning and SB100

Below are several key areas in which Scoping Plan assumptions and findings need further development with regard to electricity system planning.

- There is an immediate need for further **study of how the passage of the federal Inflation Reduction Act (IRA) can help accelerate a transition to clean energy in California** to inform the state's planning processes.[1] In the Scoping Plan, natural gas combusted in power plants decreases only 8% between 2023 and 2030. Capitalizing on the incentives offered by the IRA can lead to a substantial increase in renewable generation by 2030 and a commensurate decrease in gas generation. The ability to reduce natural gas emissions from electricity below the Scoping Plan level is assumed in the 2022 IRP process with the investigation of plans that reduce 2030 emissions by an additional 9 Mt.[2] This is not only important in itself, but it also shows how the 2030 emissions target can be reached without the need for potentially sub-optimal actions such as installing carbon capture equipment on retiring refinery infrastructure (see Page 8).

- **Several key types of infrastructure in the Scoping Plan – for example, wind and solar farms, transmission lines, carbon capture facilities, and CO_2 pipelines – need to be provisionally assigned physical locations so they can be scrutinized for potential environmental and social impacts**, and the technical and economic feasibility of current portfolios better understood. Several recent decarbonization studies illustrate the importance of geospatial analysis for understanding the potential socioeconomic, land use, and biodiversity

[1] https://repeatproject.org/docs/REPEAT_IRA_Prelminary_Report_2022-08-04.pdf

[2] https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2022-irp-cycle-events-and-materials/2022-filing-requirements-overview_ver2.pdf

tradeoffs involved in different energy choices. These include the Princeton *Net Zero America Project*[3] at the national scale, The Nature Conservancy's *Power of Place West*[4] study at the regional scale, and the San Diego County Regional Decarbonization Framework[5] at the local scale. California has begun to incorporate these types of analyses in energy planning processes at the CPUC and CEC, but Scoping Plan guidance related to infrastructure should be revisited after extensive geospatial analysis lest it lead subsequent proceedings in the wrong direction.[6]

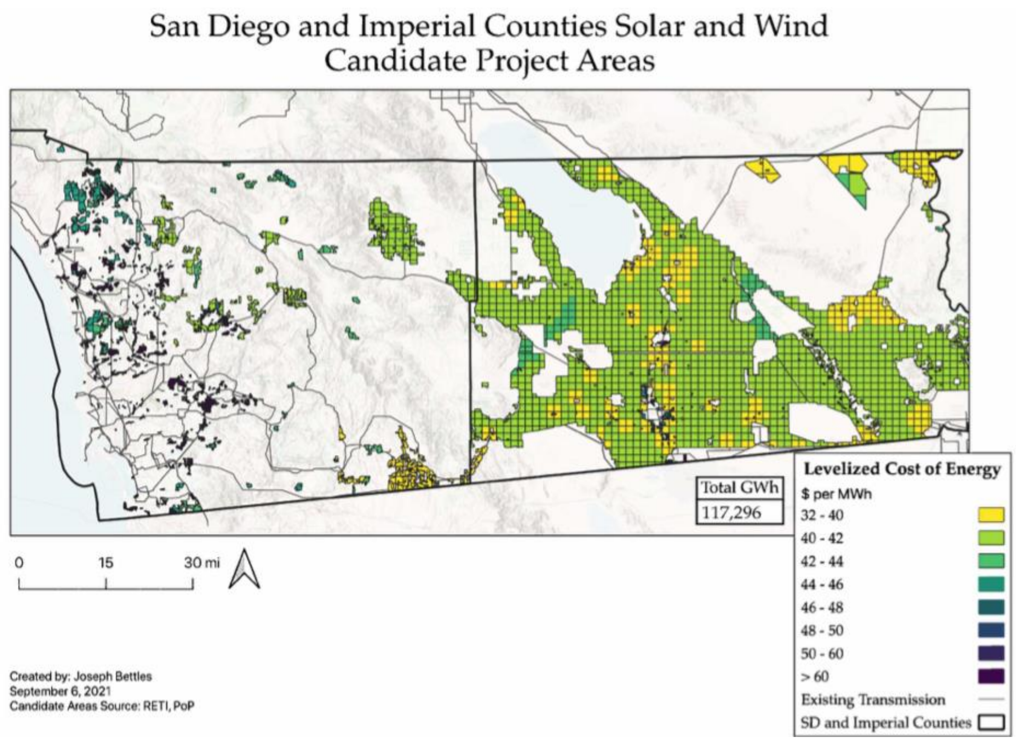

Figure 1. Candidate wind and solar project areas in San Diego County Regional Decarbonization Framework study identify potential locations for development subject to environmental and social limits, along with the estimated cost of energy produced in these areas.

- **Where will the "off-grid renewables" used to produce hydrogen from electrolysis and provide power to direct air capture (DAC) be built?** The electricity powering these facilities in the Scoping Plan modeling comes not from rooftop solar but large installations comparable in size and potential impacts to utility-scale, on-grid renewables. These raise the same kind of siting questions as grid-connected renewables and transmission.
- **Explore the value of using hydrogen production and other large flexible loads to balance grid-connected renewables, versus powering these loads off-grid.** A robust finding from recent decarbonization studies is

[3] https://netzeroamerica.princeton.edu/the-report
[4] https://www.nature.org/en-us/what-we-do/our-priorities/tackle-climate-change/climate-change-stories/power-of-place/
[5] https://www.sandiegocounty.gov/content/sdc/sustainability/regional-decarbonization.html
[6] https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2022-irp-cycle-events-and-materials/2023-2024-tpp-portfolios-and-modeling-assumptions/redlinebusbarmappingmethodologyv1221tov1022.pdf

that overall electricity costs of high renewables systems can be significantly reduced when large flexible loads are part of a suite of balancing solutions.[7] By separating renewables *a priori* into grid-connected to serve conventional loads and "off-grid" to serve flexible loads like hydrogen and DAC, such synergies are not discovered. The result of the off-grid only approach is that both the cost of electricity supply and the scale of other balancing solutions (such as batteries and thermal power plants) may be larger than necessary.

- **The Scoping Plan assumes no new gas power plants, then turns this assumption turns into a prominent finding.** However, in the absence of "gas power plants," by the year 2050 some 9,325 MW of Hydrogen combustion turbines are added in the RESOLVE modeling to provide the necessary capacity to meet peak demand. The emphasis on this result in the Scoping Plan is dubious since a power plant that burns hydrogen can also burn natural gas.
- **The question of whether to build new gas power plants is critical and requires more explicit treatment than it received in the Scoping Plan, considering it from the reliability, cost, emissions, and environmental justice perspectives, in comparison to the alternatives.** The following key points should be borne in mind by analysts and stakeholders:
    - **Gas capacity is not the same thing as gas generation.** Often the debate over whether to build gas power plants revolves around a moral hazard argument, which presupposes that if a gas plant is built, it will be operated extensively, and will damage both the climate and surrounding communities. This is not necessarily the case. The value of gas plants in a net-zero energy system is not providing *energy* but providing *capacity* to keep the lights on when renewables are insufficient. The amount of CO2 emissions and criteria pollutants emitted by a power plant depend on how often that plant runs, which in turn depends on the amount of wind and solar in the system. If renewables are available in a given hour, the gas plant will be turned down or off because the renewables cost nothing to operate; the economics of the system itself dictate very low usage of power plants that require fuel, and therefore cost money, to operate. Our own research has indicated that the average gas power plants in a high (greater than 80%) renewables electricity system will run roughly 5% of the hours per year. Without gas power plants in these hours, the alternative is either an inability to serve load or the use of balancing solutions that are much more expensive.
    - **The electricity system can be more than 99% carbon free even with gas capacity operating 5% of the hours of the year for reliability. The residual emissions can be addressed in several ways to meet the net-zero target.** Net-zero scenarios generally include a small level of gross CO_2 emissions associated with remaining critical uses of fossil fuels that are hard to replace, with limited power plant operation for electric reliability being one. These gross emissions can be offset by negative emissions or avoided using carbon neutral fuels, both of which are already included in principle in the Scoping Plan.
    - **Old thermal power plants have lower efficiencies and higher emission rates for both CO_2 and criteria pollutants than new ones. Many of the plants relied upon during the 2022 September heat wave to avoid rotating outages are very old, inefficient, and polluting,** including diesel backup generators. If thermal capacity is needed for reliability, it is better to replace such units with new and efficient ones.

[7] https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020AV000284

- Finally, it is worth noting that from a criteria pollutant standpoint, which is important for environmental justice concerns, burning hydrogen results in more NOx production than burning natural gas.

- **How will energy portfolios, infrastructure investment, and siting requirements change if one or more key elements of the single Scoping Plan scenario do not unfold as currently hoped for?** For example, what options does the state have to maintain a net zero trajectory if electrification of transportation and/or buildings is slower than policy targets envision? Or if VMT reduction targets are not met? A partial solution to this problem is the periodic update of the Scoping Plan, which California will continue to do. However, within a single Scoping Plan study, the exploration of sensitivities around a common scenario can still result in better planning decisions through a richer understanding of California's net-zero path. An example of how changes in one area can affect the whole system is illustrated in Figure 2, which shows the wide range of results for different types of electricity generating capacity in California in our *Annual Decarbonization Perspective*, which contains a number of alternative net-zero pathways for the United States.[8] These results represent different scenarios and sensitivities for key decarbonization variables such as technology barriers or breakthroughs, consumer participation, and constraints on the ability to site wind or solar or to use biomass. The Scoping Plan scenario lies within these bounds across most technologies, but it is only a single point result. There needs to be new analysis of the potential requirement for, and implications of, different portfolio outcomes than the single result to inform future policy making.

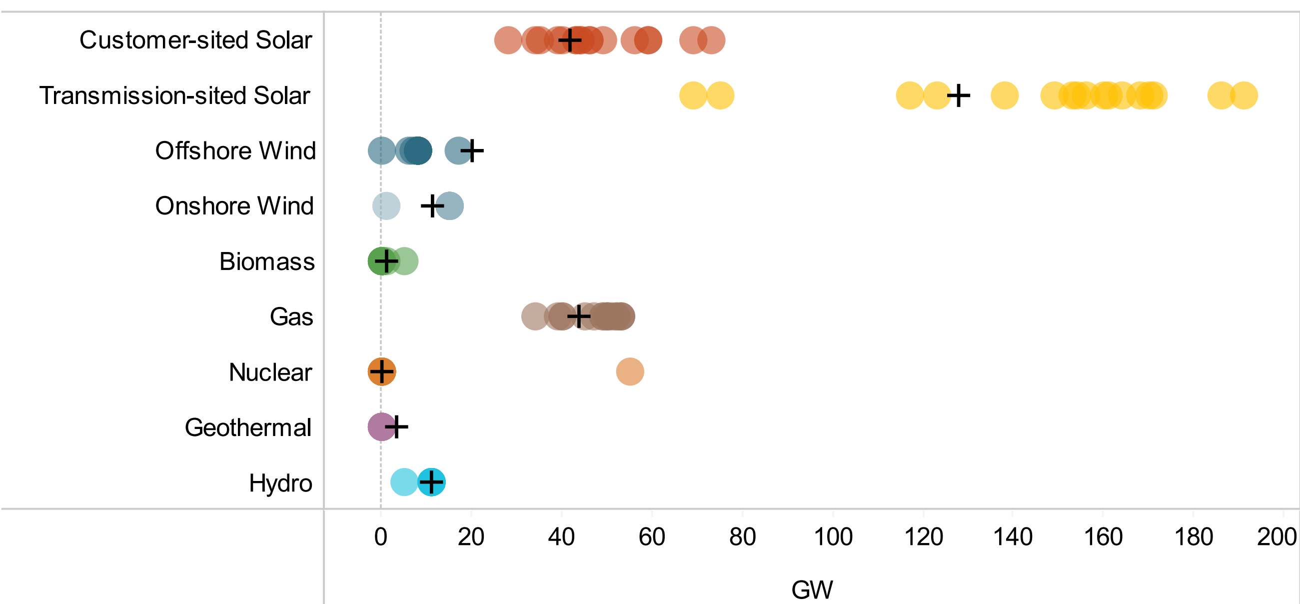

Figure 2. 2050 California installed electricity capacity across seventeen economy-wide net-zero emission scenarios from the 2022 Annual Decarbonization Perspective. The values in the Scoping Plan scenario are marked with a plus sign. Transmission sited solar for the scoping plan includes off-grid solar. Gas for the scoping plan includes hydrogen turbines.

[8] https://www.evolved.energy/post/adp2022

- **CCS retrofits on gas power plants do not appear to be model results, but instead are assumed *ex-post* in order to reduce electricity emissions, leaving important unanswered questions.** This is further discussed below in the section on negative emissions and CCUS.
- **Regional power system reliability and coordination.** Many states with whom California shares the Western grid have adopted similar climate or clean electricity goals. Since a decarbonized grid is a key strategy for all these states, it is in the common interest to move in that direction as a region. This could be greatly facilitated by greater coordination in planning and operations, which could in turn lead to considerable cost savings and reduce barriers to building new clean generation with support from the IRA. Creating an environment conducive to such coordination may require California to participate in give and take with its neighbors. One area of particular concern is California adopting a "no gas plants" policy without consultation with states that could be affected by California's dependence on them for imported energy and reliable capacity at times of high grid stress. This could lead, for example, to new greenfield gas power plants being built on the borders of Nevada, Arizona, or Mexico to meet California's reliability needs. This would be an undesirable outcome for the region's collective climate goals, and a missed opportunity for productive engagement.
- **Regional agreement on renewable and transmission siting criteria.** Decarbonization goals throughout the West will result in high levels of demand for wind, solar, and transmission throughout the region. To protect ecosystems and communities while building the needed low-carbon infrastructure requires detailed geospatial analysis coupled with stakeholder engagement and incentives or regulations to avoid disturbing land with high conservation value, as illustrated by The Nature Conservancy's *Power of Place West* study and California's own land use protection process within its Integrated Resource Planning proceeding.[9] By engaging with other states to develop common strategies and standards for land and ocean protection during energy infrastructure development, California can help avoid the unfortunate outcome in which different states have inconsistent standards, with some allowing development in locations where it should not occur. California has the opportunity to make its emerging approach to siting into the model for national and international standards that marry climate mitigation with environmental preservation. This begins at the regional level.

CCUS and Negative Emission Strategies: SB 905

Below are several key areas in which Scoping Plan assumptions and findings need further development with regard to CCUS and negative emissions strategies.

- **Defining the physical location of the CO_2 sources and sinks for the carbon capture and storage (CCS)** will help clarify what CO_2 pipelines will be required and better inform the feasibility and desirability of adding CCS to different facilities in the state. Some carbon capture projects will end up being more difficult or costly than others when analyzed with high spatial granularity. Knowing these differences will clarify the level of public support and private investment required to reach the amount of CCS called for in the Scoping Plan.
- **A policy goal of 100 Mt of carbon dioxide removal (CDR) per year, initially predicated on overly optimistic assumptions about the incremental land sink, was still applied in the Scoping Plan modeling even after it**

[9] Wu et al, "Minimizing conservation impacts of net zero energy systems in the western United States," *Proceedings of the National Academies of Sciences,* (accepted, in press).

was determined that the incremental sink is likely to be small. Retaining this goal in the modeling has resulted in measures that no longer make physical or economic sense. For example, 25 Mt of the CDR goal is applied to carbon capture on sources that *do not result in negative emissions* when sequestered, i.e. no CO_2 is removed from the atmosphere. The remaining 75 Mt is met with DAC and with bioenergy with carbon capture and storage (BECCS). Having notional targets in the Scoping Plan is valuable for the long-term development of technologies and markets, and California can and should play a role in leading the global development of essential mitigation strategies. However, the scale of these technologies is better determined by extensive scenario and sensitivity analysis that derives DAC and BECCS capacity as a result, not fixes them as an input. Within the Scoping Plan itself the 75 Mt of negative emissions assumed was more than was required, by 10 Mt, to reach net-zero emissions in 2045. Achieving and maintaining negative emissions is a commendable goal for California but should be approached carefully given that most of the net cost of the energy transition in the Scoping Plan comes from installing DAC.

- **A wide range of negative emissions technologies exist in addition to DAC and should be explored.** These include a higher level of BECCS hydrogen, which plays a larger role than DAC in recent studies from Lawrence Livermore National Laboratory[10], Princeton[11], and our own work[12]. Other CDR options include new onshore and offshore bio-based sequestration strategies such as kelp farming, and additional geological strategies such as accelerated weathering. Also promising but insufficiently studied is biochar, which if paired with a strategy of forest thinning could be a win-win-win for farmers, carbon sequestration, and wildfire management. Most net zero studies rightly acknowledge that some combination of these technologies will be required at large scale, but none of them are yet proven at the scale that might be required, and all face their own development and siting challenges. For DAC, some of these are mentioned below. For BECCS hydrogen, outstanding questions include cost, air pollution, the sustainability of biomass supplies, and the scale of demand for hydrogen. It is premature to name winners and losers for California, and to say exactly how much CDR is needed. Deeper exploration of the options can help shape plans for the rest of the system, including how BECCS hydrogen interacts with the energy system.

- **How will the state's plans for CCUS/CDR and other technologies need to change if setbacks or technology breakthroughs occur?** How can California be set up to pivot quickly in such circumstances? What steps can be taken ahead of time to create plans that are maximally robust? Prudence demands more modeling of scenarios and sensitivities to be prepared for future contingencies.

- **Where would the DAC in the Scoping Plan be located?** It is not specified that DAC would be located within California; however, regardless of the DAC technology chosen, California could be a particularly bad fit for DAC at scale, despite having favorable geology for sequestration. Of the two leading DAC technologies sorbent technologies work best in cold, dry climates, likely unsuitable in much of California.[13] Solvent technologies do best in hot, humid climates. In hot and dry climates like the California desert, energy use is low, but water use can be very high (see Figure 3). Using the climate in Palm Springs as an example, water consumption is estimated at 10 tonnes of water per tonne CO_2 captured.[14] If DAC was located in California and captured 65

[10] https://gs.llnl.gov/sites/gs/files/2021-08/getting_to_neutral.pdf
[11] https://netzeroamerica.princeton.edu/the-report
[12] https://www.evolved.energy/post/adp2022
[13] https://pubs.acs.org/doi/pdf/10.1021/acs.iecr.2c00681
[14] https://www.sciencedirect.com/science/article/pii/S0306261922011588

Mt CO2 per year (Scoping Plan total), the amount of water required would be 172 billion gallons, roughly equivalent to the annual water sales from LADWP.[15] This would prove challenging, to say the least, unless desalination can be sited far faster and at larger scale than is currently being contemplated.

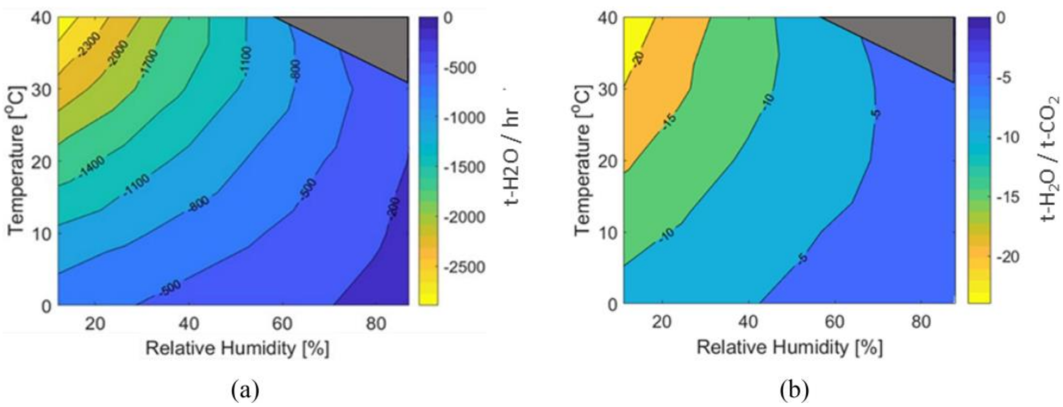

Figure 3. Direct air capture water requirements as a function of ambient temperature and humidity.[14]

- **Because negative emissions technologies can be deployed anywhere, California needs to look closely at where best such strategies can be scaled** and what positive role California can play for advancing negative emissions technologies more broadly. For example, under the LCFS, DAC located outside of California can be used to lower the lifecycle emissions of transportation fuels sold within California.

- **CCS retrofits on gas power plants do not appear to be model results, but instead are assumed *ex-post* in order to reduce electricity emissions, leaving important unanswered questions.** While gas plants are needed for reliability, retrofitting existing plants with CCS is not necessarily a good idea. The CCS retrofits in the Scoping Plan CCS should be further explored by asking the following questions: (1) Which gas plants would be retrofitted, at what cost? (2) How many hours of the year would the gas plants operate? If seldom, adding CCS to these plants is an extremely expensive option for marginal carbon abatement. (3) What supporting infrastructure (CO_2 pipelines, etc.) would be required and where would they be physically located? (4) Do the targeted gas plants have the physical space to accommodate CCS equipment? (5) Are the in-plant energy losses from carbon capture accounted for in the electricity system reliability modeling? (6) What will be the operating regime for these plants?

Fossil Extraction and Refining Drawdown: New Interagency Working Group[16]

Below are several key areas in which Scoping Plan assumptions and findings need further development with regard to the future of fossil fuel extraction and processing in California.

- **Making large capital investments in infrastructure with declining throughput, such as oil refineries, makes little sense from an economic or emissions standpoint. It is a balance-sheet correction, not a reasonable action.** Achieving carbon capture rates of 90% at refineries requires large capital expenditures. The Scoping

[15]https://d3n8a8pro7vhmx.cloudfront.net/themes/5595df952213930462000001/attachments/original/1430386934/LADWP_Water_System_Fact_Sheet.pdf?1430386934
[16] This working group is discussed on Page 101 of the Scoping Plan and mentioned in the Scoping Plan press release.

Plan envisions adding carbon capture even with refinery throughput declining by roughly 20% every five years, but this does not make financial sense for refinery owners or investors. CCS should likely only be added to those refineries that would be operated in the long-term (30+ years), either because they continue to process fossil fuels after 2045 or because they are converted to bio-refineries.

- **What would be the lifetime of CO_2 pipelines built for CCS at oil refineries?** How do calculations of the cost of CCS per tonne of CO_2 sequestered change if the pipeline is only used for 15 years (e.g. 2030-2045)? Further, is it physically or economically realistic to assume that the state increases its captured CO_2 from zero in 2027 to more than 13 Mt just three years later, in 2030? Are there labor or other supply-chain constraints that should be considered and planned for accordingly?
- **The constraint on 2030 CO_2 emissions in the Scoping Plan is more stringent than the statutory mandate of 40% below 1990 levels. Reaching the modeled 48% reduction is currently employing highly inefficient, high-cost actions** such as carbon capture retrofits on soon-to-be retired refineries. Reductions beyond the 40% target may be achievable through accelerated deployment of renewables and electric vehicles, as determined by modeling a variety of scenarios and sensitivities.

California Regional Leadership

California has envisioned itself as a leader on climate change from the time of AB32 and the first Scoping Plan. Producing the 2022 Scoping Plan is another example of that leadership. However, there is a danger of compromising that leadership status through insular decision-making that fails to take into account or consult with regional neighbors.

There are several areas in which California's climate goals might be better and more cost effectively achieved through greater cooperation with other states. The Scoping Plan needs to explore the benefits, costs, and risks of greater cooperation through further analysis to help guide policy coordination with its neighbors. Such issues can be highlighted through additional modeling and flagged for discussion and collaborative regional policy development. Key areas of potential collaboration that should be explored in depth include the following, many of which were mentioned in the sections above:

- Direct air capture
- Renewable and transmission siting with environmental protection
- Regional transmission planning
- Western grid reliability, including the future of thermal generation
- Bioenergy resources
- Emissions leakage

Acknowledgements

Support for this analysis was provided by the World Resources Institute (WRI)