June 24, 2022

The Honorable Liane Randolph

California Air Resources Board

1001 I Street

Sacramento, CA 95814

Dear Chair Randolph,

Bloom Energy (Bloom) is pleased to provide comments on the 2022 Scoping Plan Update to Achieve Carbon Neutrality by 2045 (Scoping Plan). The Proposed Scenario strikes an appropriate balance in adopting a 2045 timeframe for carbon neutrality in California given overall cost, feasibility, and uncertainty considerations. These comments illustrate our support for the Proposed Scenario (Alternative 3) and provide guidance on how advanced energy technologies can and should play a more significant role in the Scoping Plan to help achieve our climate and clean air goals.

Hydrogen Assumptions

The Proposed Scenario modeling reflects an increasing transition from combustion of fossil fuels to low and zero carbon hydrogen. However, there are three points to consider as the draft Scoping Plan is finalized.

1. The Scoping Plan states, "There is a high degree of uncertainty, however, around the availability of solar to support both electrification of existing sectors and the production of hydrogen through electrolysis."[1] While the uncertainty of available solar is valid, the Scoping Plan must consider the rapid pace at which hydrogen production technologies and costs are improving, therefore alleviating the solar concerns. For instance, research and development in solid oxide electrolyzers, which convert water and electricity into hydrogen without any carbon dioxide emissions, have resulted in substantial technological improvements and cost reductions in the journey to making hydrogen production a clean energy solution. The chart below illustrates the findings of a comprehensive "expert

[1] Scoping Plan, pg. 69

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elicitation" study of the three key electrolyzer technologies:

Attribute	Alkaline	PEM	Solid oxide
Electrolyte	Aqueous potassium hydroxide (e.g., Nafion)	Polymer membrane	Yttria stabilized Zirconia
Cathode	Ni, Ni-Mo alloys	Pt, Pt-Pd	Ni/YSZ
Anode	Ni, Ni-Co alloys	RuO2, IrO2	LSM/YSZ
Stack efficiency (kWh/kg)	48 - 63	48 - 58	36[7] - 46
Operating temperature (°C)	60 - 80	50 - 80	650 - 1000
System response	Seconds	Milliseconds	Seconds
Stack lifetime (hours)	60,000 - 90,000	20,000 - 60,000	9,000 - 70,000[8]
Uninstalled capex cost today ($/kW)	$500 - $1000[9]	$700 - $1400[5]	~$900[10]
Capex learning rate (%)	9%[11]	13%[7]	28%[6]
Maturity	Mature	Commercial	Demonstration

As seen in the chart, Bloom, as the world leader in solid oxide technology, has seen a 28% learning rate over the last decade.[2] Put another way, every time our cumulative production has doubled, our hardware costs fell by 28% (on average). This steep learning curve is twice as fast as the learning curves of alkaline and PEM technologies. This dynamic has led to an average product cost decline of 10-15% per year, or approximately 60% since 2015. Moreover, Bloom's work in the hydrogen field has already yielded 19 patents, and Bloom's dedicated team of scientists and engineers are rapidly making solid oxide electrolyzers a scalable solution.[3]

In addition to Bloom's ongoing advancements the U.S. Department of Energy (DOE) initiated the Hydrogen Shot initiative on June 7, 2021, to seek to reduce the cost of clean hydrogen by 80% to $1 per 1 kilogram (kg) in 1 decade (referred to as "1 1 1"). The initiative's interim target is $2.00/kg by 2025. These goals are to be met through several efforts such as developing more efficient technologies and increasing the operational life of electrolyzer cells.[4]

2. The Scoping Plan relies on conservative hydrogen technology and fuel cost assumptions made in the California Energy Commission's (CEC's) "2021 SB 100 Joint Agency Report" ("SB 100 Report") and "The Challenge of Retail Gas in California's Low Carbon Future" report

[2] Learning curves, a tool widely used in energy to chart cost reductions, refers to the percentage change in costs per cumulative doubling of production volume.
[3] Bloom Energy, May 2021. *The Role of Solid Oxide Technology in the Hydrogen Economy: A Primer.* The Role of Solid Oxide Technology in the Hydrogen Economy (bloomenergy.com), pg. 7
[4] For more information on the Hydrogen Shot initiative, see Hydrogen Shot | Department of Energy

3. ("E3 Report").[5] The Scoping Plan uses inputs and assumptions for the cost and performance of new hydrogen fuel cell generators from the SB 100 Report that do not consider current, ongoing solid oxide advancements in the industry and DOE-sponsored hydrogen projects – these must be considered in order for the Scoping Plan to more accurately forecast the degree of hydrogen penetration in the economy. Table 32 of the SB 100 Report Inputs & Assumptions document lists the following:[6]

Table 32. Hydrogen Fuel Cell Cost Assumptions

Hydrogen Fuel Cell Cost Assumptions	2027	2030	2035	2040	2045
Capital Cost ($/kW)	$1,381	$1,290	$1,187	$1,026	$917
Fixed O&M Cost ($/kW-yr)	$27	$27	$27	$27	$27
All-in Fixed Cost ($/kW-yr)	$138	$131	$123	$110	$101

The costs used in Table 32 far exceed 2020 costs reported in Bloom's white paper, as seen below, where the last column titled "SOEC" illustrates solid oxide electrolyzers:[7]

TABLE A1: COST AND PERFORMANCE ASSUMPTIONS FOR ALKALINE, PEM, AND SOLID OXIDE ELECTROLYZERS

Product	ALK	PEM	SOEC
Year	2020	2020	2020
Cost Build			
Cost ($/kW)[21]	$716	$1,227	$917
Margin	30%	30%	30%
Price ($/kW)	-	-	$1,192
Install ($/kW)[22]	-	-	$110
Total Upfront Price ($/kW)	$931	$1595	$1,302
Starting system efficiency (kWh/kg)[23]	54	52	36.5 - 41.5
Capacity Factor	50%	50%	50%
Electricity Costs	$0.02 - $0.04	$0.02 - $0.04	$0.02 - $0.04
O&M (Annual $/kW)	$36	$61	$69
O&M (% of Equipment Price)[24]	5.0%	5.0%	7.5%
Cost of Capital	7.00%	7.00%	7.00%

Bloom asks that CARB staff consider these cost improvements for new hydrogen fuel cell generators in revising the Scoping Plan inputs and assumptions.

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[5] Appendix H of the Scoping Plan, pgs.12-13.
[6] CEC Staff, June 2020. *Inputs & Assumptions: CEC SB 100 Joint Agency Report*, pg. 43
[7] Bloom Energy, May 2021. *The Role of Solid Oxide Technology in the Hydrogen Economy: A Primer.* The Role of Solid Oxide Technology in the Hydrogen Economy (bloomenergy.com), pg. 14

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Additionally, the Scoping Plan relies on hydrogen fuel cost trajectories from the E3 Report, which includes optimistic as well as conservative cost scenarios. Bloom appreciates the complex and thorough modeling and reporting done by E3 and the CEC and reminds CARB staff that since publication of the E3 Report in April 2020, the European Union has placed increased urgency and reliance on hydrogen due to Russia's war in Ukraine. The European Union's REPowerEU plan is a plan to expedite Europe's transition to renewables and hydrogen, which, especially when combined with efforts in California and nationwide, will undoubtedly put downward pressure on hydrogen technologies and fuel.[8] As more information becomes available and the hydrogen market transforms, CARB staff should be prepared to update the Scoping Plan accordingly to ensure California is on the most effective and efficient path towards carbon neutrality.

4. Bloom urges that hydrogen considerations in the Scoping Plan are made based on a carbon intensity framework, rather than making the error or only considering hydrogen production methods and "colors," such as "green hydrogen."[9] The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) published a working paper that outlines a proposed "methodology and analytical framework to determine the GHG emissions related to a unit of produced hydrogen."[10] The proposed framework considers the impact from a "well-to-gate" lifecycle basis and ensures emissions are not double counted.

   Bloom recommends that the CARB Scoping Plan adopt a carbon intensity framework that sets a technology-neutral foundation upon which all hydrogen production options can be fairly assessed, rather than prematurely selecting preferred hydrogen fuels. By considering carbon intensity, CARB will foster the development of low and zero carbon solutions.

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[8] European Commission press release, March 8, 2022. Joint European action for more affordable, secure energy (europa.eu)
[9] Green hydrogen is mentioned on page i of the Scoping Plan.
[10] International Partnership for Hydrogen and Fuel Cells in the Economy, October 2021. *Methodology for Determining the Greenhouse Gas Emissions Associated With the Production of Hydrogen*, pg. 9

The Role of Fuel Cells and Hydrogen

The Scoping Plan outlines the transformation needed in three key sectors in California: transportation, the electric grid, and sustainable manufacturing and buildings. Bloom provides the following comments regarding how fuel cells and hydrogen should be increasingly considered in each sector.

1. Transportation

   Considering that in 2019, the transportation sector accounted for over 50 percent of statewide GHG emissions, the Scoping Plan finds that California must continue to promote zero emission vehicles (ZEVs), such as battery-electric and hydrogen fuel cell electric vehicles, to achieve our climate and clean air goals.[11] Bloom agrees with staff's assessment and is encouraged to see the promotion of private investments in hydrogen stations and incentivization of private investment in new zero-carbon fuel production in California as strategies in the Scoping Plan.[12] As California experiences wide deployment of electric vehicles, technologies like Bloom's fuel cells have the potential to serve as a high capacity local energy generation resource specifically for EVs, avoiding the need to draw from the distribution system.

   While the Scoping Plan mentions that by 2045 some gasoline and diesel will still be in demand by users such as the marine industry, it should be noted that Bloom has already made significant progress in reducing marine emissions. Bloom has designed and developed the ability to power marine vessels with fuel cells. Internal combustion engines (ICEs) are the most common form of propulsion and power on large sea vessels. ICEs have traditionally run on heavy fuel oil, which is extremely polluting and harmful to our planet. While heavy fuel oil is a plentiful resource, it is also one of the dirtiest fuels in the world. Published studies have recognized the impact that burning heavy fuel oil has on the climate, prompting both governments and maritime organizations to set emissions standards in an effort to curb the negative effects. The International Maritime Organization (IMO) has established guidelines for all cargo ship operators suggesting that by the year 2050, CO2 emissions from cargo ships should be half what they were in 2008. This has left the marine industry searching for ways to meet this goal.

   By adopting land-based fuel cells for maritime applications, proposed designs of fuel cell-powered ships would have more than enough power to keep a working vessel powered. Natural gas fuel cells significantly reduce CO2 emissions and decrease smog-forming

[11] Scoping Plan, pg. 147
[12] Ibid, pgs. 150-154

pollutants and particulate matter, like NOx and SOx, by more than 99 percent compared to entrenched power sources. Furthermore, because our fuel cells are fuel-flexible, they can run on readily available natural gas, hydrogen, biogas or blends of any of those, thereby reducing harmful pollutants and CO2 emissions.

2. The Electric Grid

Since California experienced rolling blackouts in August 2020, there has been plenty of ink spilled on the need for clean, reliable energy resources to meet net peak demand. As staff is aware, approximately 30 percent of California's power is imported from other states.[13] Imports "are comprised of 62% zero-carbon energy and 38% non-renewable and unspecified energy."[14] As noted in the Final Root Cause Analysis report by the California Independent System Operator Corporation (CAISO), the California Public Utilities Commission (CPUC), and the CEC, "During the extreme heat wave, given the similarly extreme conditions in some parts of the West, the usual flow of net imports into the CAISO was drastically reduced."[15] Layered with Public Safety Power Shutoff (PSPS) events—when utilities temporarily turn off power to specific areas to reduce the risk of fires caused by electric infrastructure—it is clear that California must prepare its energy portfolio to better meet net peak demand with clean, in-state generation, especially as regional heat waves are expected to be more frequent. Solid oxide fuel cells are a proven solution to meet the increased need for clean, firm power in California.

As of May 2020, there were 24,403 back-up and emergency generators in California, with approximately 89 percent of them being diesel-powered.[16] Fuel cell technology such as Bloom's solid oxide fuel cell technology produce always-on, reliable, resilient, and cost-effective electricity ***both behind-the-meter and in-front-of-the-meter***. We have deployed almost 300 MW of clean, firm power to Californians to date, and are proud to be a California company, with manufacturing facilities in the Bay Area, that is exporting leading-edge energy technology worldwide, including fuel cells and hydrogen electrolyzers. Fuel cells are the only solution that can provide 24x7x365 power at the distribution level today and act as a bridge with limited to no modifications from our current reliance on fossil fuels to renewables, and eventually hydrogen. Even when running on natural gas today, the non-combustion, high-efficiency technology has fewer

[13] Ibid, pg. 157
[14] Ibid.
[15] CAISO, CPUC, and CEC, January 13, 2021. Final Root Cause Analysis. Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf (caiso.com) Pg. 22.
[16] Steven Moss and Andrew Bilich, May 2020. Hidden Grid: More Than Eight Gigawatts of Fossil Fueled Back-Up Generators Located in Just Five California Districts, pg. 6.

CO2 emissions than the combined cycle and natural gas peaking units that typically comprise marginal generation on California's grid. For comparison, the WECC California Grid emits 0.86 lb of NOx per MWh, while a Bloom Energy Server emits 0.0017 lb/MWh.[17]

Senate Bill 1339 (Stern) declared that, "The [PUC], [CAISO], and State Energy Resources Conservation and Development Commission must take action to help transition the microgrid from its current status as a promising emerging technology solution to a successful, cost-effective, safe, and reliable commercial product that helps California meet its future energy goals and provides end-use electricity customers new ways to manage their individual energy needs."[18] As such, it is imperative for CARB and other state agencies to consider that fuel cells are non-combustion energy resources that make for optimal anchor generation for microgrids. Efficient and cost-effective fuel cells such as the Bloom Energy Server provide a critical foundation for building microgrids of varying complexity and can provide significant benefits to the communities and utilities they are part of. The Final Scoping Plan must consider the contributions of microgrids in reducing load (demand) on the grid as well as generating clean electrons to the grid.

3. Sustainable Manufacturing and Buildings

Bloom agrees with the ARB that fossil gas combustion in industrial processes should be reduced to improve our air quality goals and supports the findings that an increased use of hydrogen in industrial manufacturing is needed. Bloom encourages the consideration of solid oxide fuel cells in California's industrial sector, as they are a superior electrolyzer technology thanks to efficiency pickup from electrolyzing steam. The heat generated from the furnace can be used to create steam, lowering the amount of electricity required for hydrogen production.

Additionally, Bloom believes the Scoping Plan should consider that clean on-site distributed generation resources provide reliable primary power for manufacturers and industry and can replace diesel gen sets that are currently used for back-up power. For example, Bloom has several data center customers that use our high reliability fuel cell systems as primary power resulting in avoided real estate and monetary investments that a fleet of diesel powered back-up generators would have required with the significant co-benefit of reducing environmental impact.

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[17] WECC California Grid data from https://www.epa.gov/egrid/download-data and Bloom Energy Server data from https://www.bloomenergy.com/wp-content/uploads/es5-300kw-datasheet-2022.pdf

[18] California Legislative Information. 2018. SB 1339: Electricity: microgrid: tariffs. (SB 1339, Stern, Chapter 566, Statutes of 2018). Bill Text - SB-1339 Electricity: microgrids: tariffs. (ca.gov)

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Bloom also agrees with staff's claim that, "Microgrids powered by renewable resources and with battery storage are emerging as a key enabler of electrification and decarbonization at industrial facilities"[19] and, as stated in the previous section, urges staff to more explicitly consider the impact of microgrids in the Scoping Plan.

In closing, Bloom respectfully requests that the Scoping Plan be revised to account for the conservative assumptions in the CEC's reports as well as the work already underway to increase hydrogen production costs and efficiencies. Furthermore, the role of fuel cells both behind-the-meter and in-front-of-the-meter cannot be overlooked during California's monumental grid transformation, when we've had one too many "all hands on deck" instances. By virtue of their non-combustion process, Bloom Energy Servers produce on-site or distributed power at world-leading efficiencies, reduce greenhouse gases, ***and do so with virtually no criteria air pollutants***. Rather than making exceptions for diesel back-up generators and permitting dirty power, California should turn to the clean energy solutions already exempt from air permit requirements, such as fuel cells.

Bloom appreciates the opportunity to comment on the Scoping Plan and encourages staff to take this opportunity to highlight innovations in advanced energy technologies that are occurring now and will absolutely continue to advance and improve over the next decades. The Scoping Plan contends that in developing this draft, "...it is paramount that we continue to build on California's success by taking effective actions and doubling down on implementation activities."[20] Bloom agrees. That is why staff must maintain a broad scope of potential opportunities for technology neutral solutions, and recognize the value that advanced energy technologies offer is critical in implementing the best solutions to come to market and be a key part of the future grid.

We appreciate CARB's leadership towards meeting our mutual climate and clean air goals and look forward to working with you further.

Thank you for your considerations,

Christina Tan

Sr. Energy & Environmental Policy Manager

[19] Scoping Plan, pg. 166.
[20] Ibid, pg. 9.

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