



May 3, 2022

Liane M. Randolph, Chair
California Air Resources Board
1001 I St.
Sacramento, CA 95814

Re: 350 Humboldt and 350 Silicon Valley Comments on Elements of the 2022 Scoping Plan, draft presented April 20, 2022

Dear Chair Randolph:

Thank you for the opportunity to comment on several more aspects of the Scoping Plan draft.

350 Humboldt and 350 Silicon Valley, with more than 6,000 supporters throughout California, are pleased to submit these comments on aspects of the Scoping Plan draft.

Our overall comment is that all of the four Alternatives identified by CARB are inadequate to the climate crisis California faces. The IPCC Sixth Assessment Report (IPCC AR6) gives the world roughly until 2025 to begin to significantly reduce greenhouse gas emissions and until 2030 to turn our greenhouse gas emissions around; the scoping plan anticipates a comfortable 23 years of gradual change, not accounting for the large fudge factor offered by reliance on direct air capture.

Bafflingly, as we shall show, the alternatives presented by CARB seem to be completely divorced from the world context. It is clear from IPCC AR6 that warming temperatures (1.5, 2.0, 3.0 degrees C) will be tied to the speed at which we decarbonize. It would surely help California policymakers if staff presented the four alternatives in the context of the most recent IPCC scenarios or redid the alternatives to coincide with IPCC scenarios.

At the end of this comment document we have added two appendices we hope the staff and Board will consider: 1) A diagram from IPCC AR6 showing the most cost effective measures to take before 2030, and 2) a collection of headlines about the climate catastrophe found in US publications from April 27 through April 29, 2022. One shows us the ways forward; the other shows what awaits us if we delay.

We recommend that the Board instruct staff to reconsider the current approach and create *one* plan that will put California on track to meet the IPCC emergency instructions¹ for how to limit global heating to 1.5 degrees Celsius. If we don't take these actions, demonstrating to other states and countries that California will actually follow the science, we will have missed our only opportunity to reduce the risk of catastrophic tipping points that include even more extreme drought and wildfires than California has experienced to date; collapse of our agricultural sector; sea level rise inundating our coastal population centers; population displacement and economic devastation; and destruction of our cherished land and marine ecosystems.

SUMMARY

The Alternatives supplied by CARB contain most of the serious options for climate action, but their distribution among the proposed configurations, and the focus on only two target dates (2035, 2045) instead of projected trajectories with benchmarks along the way, make them more of an impediment to planning than an aid. Here are four suggestions, consistent with IPCC AR6, for synthesizing the important time periods and actions:

- **In the period leading up to 2030, use the assessments summarized in Appendix 1 to guide vastly expanded mitigation efforts.** Since both effectiveness and cost are provided by the IPCC, it is relatively easy to focus on the most effective, least costly approaches. The most effective early action is to increase solar, wind, and storage as well as developing a smart grid so electrical power can be moved over long distances if necessary, and the grid can be run on 100 percent renewables before 2035.²
- **Due to their high GWP, abatement of methane and HFC leaks should be primary early goals.** If they could essentially be eliminated before 2030, it would buy us time to reduce carbon dioxide emissions.
- **We must substantially increase the price of carbon allowances under cap and trade.** Revenues can be used for climate mitigation; the cost of reducing pollution will be recovered in avoided health costs.
- **Aim for 80 percent reduction in all greenhouse gas emissions by 2035 and use the final ten years for the remaining industries and transportation subsectors that are challenging to decarbonize.**

¹ IPCC, 2018: Summary for Policymakers. In: *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* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp.*

²“ For the coming decade, rapidly reducing coal electricity and building extensive wind, solar and storage systems are low-cost strategies in many places, regardless of how much energy might or might not eventually come from renewables.” *New York Times* April 10, 2022, *We Are Wasting Time on These Climate Debates. The Next Steps Are Clear.* By John Bistline, Inês Azevedo, Chris Bataille and Steven Davis.

Overarching recommendation

Our primary recommendation is that CARB develop a single plan, guided by and consistent with the IPCC AR6 report, with 5-year benchmark targets, regular review, and provision for adding stringency to the actions if interim targets are not met. to be.

COMMENTS PART I: MACROECONOMICS

1. Flaws in the assumptions behind the four alternatives

- The stated assumptions show high growth in economic production and jobs, when they rightfully should reflect a range. It seems unlikely that the assumptions take into account current inflation and possibility of an inflationary spiral and/or depression if the Fed overreacts; or potentially globally destabilizing consequences of the Ukraine war. A NYTimes headline from May 1 reads: "Growth Slows to a Crawl as War and Covid Grip the Biggest Economies." More egregious is the failure to consider the inevitable consequences of accelerating climate change, including migration pressures and increasing zoonotic-borne disease. It is unrealistic to have only one model for job and economic growth/change. It is doubly unrealistic to have one *rosy* model.³ As one pundit has stated, "There are no jobs on a dead planet."
- Why are the IPCC climate models not incorporated into the CARB/Finance assumptions? ***If the Scoping Plan is published and its climate-related projections do not include the current Sixth Assessment it will already be hopelessly out of date.*** The IPCC has consistently been highly conservative. If CARB/Finance are using Fifth Assessment projections we are building our Scoping Plan on sand that has already washed away. If warming is 2 to 4 degrees Celsius by the end of the century, which we seem to be on track for now, the latest IPCC projections should be built into the model.
- Assumptions about feedback loops are missing from this analysis. In fact, the very conditions explored in the April 20 workshop interact with the alternatives presented. For example, the economic benefits of reducing fossil fuel pollution, by some estimates, pay for all carbon mitigation measures (see below, footnote 8). Even in CARB's document, major health benefits from reducing pollution are noted, but apparently not incorporated in the macroeconomic assumptions. In other words, ***the economic growth in these models seems to be a constant rather than being also a function of the relative results of decarbonization.*** On a world scale, the IPCC adaptation cost estimates (e.g., from sea level rise and forest fires) are far lower for a world that warms 1.5C compared to 2.0C or more. By delaying necessary mitigation measures we increase the costs of adaptation. This calculation does not seem to be included in the macroeconomic projections. We can spend the money up front and assure a tolerable world, or spend it later, on adapting to one that is intolerable for billions.

³ "The White House Office of Management and Budget (OMB) has released its first report describing the financial impact of climate inaction in the U.S. The analysis outlines the taxpayer cost should [climate change](#) remain unchecked, and it amounts to over \$2 trillion per year by 2100.

- Choice of alternatives: If the economic impact of the most aggressive Alternative, Alt. 1, is so minimal (a little over 1 percent of economic productivity) then of course we should try to achieve that set of mitigations. California’s spending on climate mitigation is quite low, even with the budget surpluses of the last two years.

2. The realism of the Alternatives, especially related to direct air capture, is questionable.

- One plus for the modeling is that the Alternatives include a range of direct carbon capture options, including none.
- However, as formulated, the Alternatives for 2035 are extremely unrealistic.
 - Alternative 1 may be difficult politically. It is, as the IPCC has said, still doable technically in the narrow window of the next few years. But there are no indications now that it will be accomplished in California, let alone worldwide. In California under Governor Newsom, ambitious legislation is often killed and necessary modifications to cap and trade are stonewalled. Furthermore, the modifications of lifestyle (virtual elimination of meat and use of synthetic fertilizer, drastic reduction of VMT) don’t seem to be issues any politician wants to take on. ***The role of the Scoping Plan should be to make clear to politicians and consumers the difficult realities we face so that Alternative 1 is seen as the least that we can do.*** By casting it as “radical,” the authors of the draft document are contributing to denial of climate problems.
 - Alternative 2 is unrealistic technologically because the tough problems of decarbonization have not yet been solved (cement, steel, air travel). Most importantly, direct air capture (DAC) is extremely unlikely to be a significant factor in such a short time. A recent IEA report states:

There are currently 19 direct air capture (DAC) plants operating worldwide, capturing more than 0.01 Mt CO₂/year, and a 1Mt CO₂/year capture plant is in advanced development in the United States. The latest plant to come online, in September 2021, is capturing 4 kt CO₂/year for storage in basalt formations in Iceland. In the Net Zero Emissions by 2050 Scenario, DAC is scaled up to capture more than 85 Mt CO₂/year by 2030 and ~980 Mt CO₂/year by 2050. This level of deployment will require several more large-scale demonstrations to refine the technology and reduce capture costs.⁴

There is no credible assumption that this technology will be ready to annually remove several hundred million metric tons of CO₂ in California by 2035. DAC may be a way of taking us back to 350 parts per million sometime after 2050. But for now it is fantasy (as in a fairy tale) to assume it will have the effects portrayed in Alternative 2 in that short timeframe.
 - This leaves Alternatives C and D. D suffers from the same objections as does B, namely the low probability that engineered carbon removal will be sufficient to produce the assumed effects. Unproven technologies should not be considered in

⁴IEA (2021), Direct Air Capture, IEA, Paris <https://www.iea.org/reports/direct-air-capture>

the scoping plan, because overly optimistic assumptions could lull us onto a catastrophic path.

- So in reality, we are left with Alternative 3, which is phrased as essentially climate business as usual, nothing major outside of what was already planned years ago. A news report from April 28 reads: “The board’s staff last year released four options for discussion. At a workshop last week, air board officials said they will present the board with the option that has the least impact on the state’s economy rather than accelerating the pace of achieving carbon neutrality.”⁵ We wonder what audience the IPCC intends their reports and scenarios for? Clearly not California policymakers.
- As noted in earlier comments, the 2045 options are likely the only realistic ones to reach the levels of decarbonization required. However, there are different *speeds* at which we can arrive at net zero by 2045.
 - If we put far more effort into publicly approved and critically important decarbonization of the power sector within ten years, we would achieve much greater greenhouse gas reduction overall than following current plans. The IPCC’s list of the effectiveness and cost of 43 mitigation efforts (see Appendix 1) shows the rapid growth of wind and solar to be at the top of the list (and carbon capture at the bottom).
 - Similarly, under current federal and state law we may achieve a reduction of HFCs on the order of 85 percent by 2035, however, an all-out effort to virtually eliminate HFCs is very feasible and not that expensive (see Appendix 1 for this too). This could be accomplished well before 2035.
 - Thirdly, a major effort to stop fossil methane leaks is politically popular and will be, if it happens, highly effective. Much of the cost will be paid for by conserving the energy now lost to emissions.
 - Finally, we need to repair and update our electricity grid. As one author has written, “At this point in the US, grids are so poorly maintained and designed that they waste 65% of the energy put into them.”⁶ And as FERC has begun to recognize, we must create regional transmission entities to distribute renewable energy efficiently.⁷
- Although the earliest feasible date for carbon neutrality, using current technologies and Shared Socioeconomic Pathway (SSP)⁸ frameworks, is probably 2045, we can do much of the heavy lifting early if we focus on big impact, do-able interventions in the short term. Interim targets are recommended every other year. This is shown in the hypothetical pathways below, with rapid electrification and reduction of short-lived climate

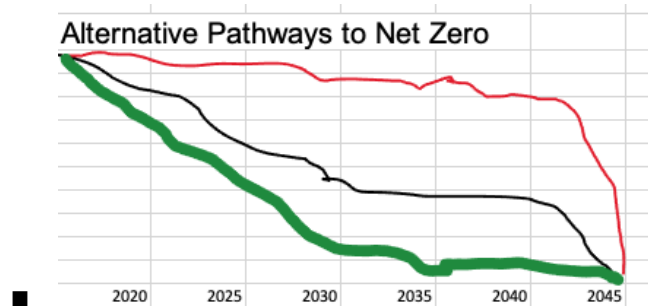
⁵ Lopez, Nadia. "Lower cost, slower gains: California prepares controversial new climate strategy," CalMatters April 29, 2022: <https://calmatters.org/environment/2022/04/california-climate-change-strategy/>

⁶ Kaufman, Cynthia. *The Sea is Rising and So are We: A Climate Justice Handbook*. PM Press, 2021. Chapter 4, p. 64.

⁷ Jeff St. John, “The US needs to build a bigger, stronger grid. FERC has a plan for that,” Canary Media, April 30, 2022: <https://www.canarymedia.com/articles/policy-regulation/the-us-needs-to-build-a-bigger-stronger-grid-ferc-has-a-plan-for-that>

⁸ O’Neill, Brian C., Timothy R. Carter, Kristie Ebi, Paula A. Harrison, Eric Kemp-Benedict, Kasper Kok, Elmar Kriegler et al. "Achievements and needs for the climate change scenario framework." *Nature climate change* 10, no. 12 (2020): 1074-1084.

pollutants being the green line, Alternative 3 the black line and Alternative 4 the (unrealistic) red line:



This front-loading approach is, notably, the one staff are recommending *against*.

- A further argument against the staff-recommended approach is that the lifetime of carbon dioxide in the atmosphere is hundreds of years. Every year we wait to reduce emissions increases the catastrophic effects of global warming. The obverse is also true: CO₂ *not* released between now and 2050 permanently reduces warming.

3. The Social Cost of Direct Air Capture

- Above we question a) the reliance on direct air capture (DAC), b) the sanguine nature of economic projections, c) the lack of a 2045 model with very rapid electrification of power, and d) the lack of incorporating IPCC projections into your models. Here we would like to expand on the implications of the most recent IPCC report for the assumptions used by CARB, the Department of Finance, E3, and Rhodium. Other research is also cited.
 - Direct air capture uses very large amounts of energy, which could come from either natural gas or wind/solar. CARB assumes the latter. But CARB also anticipates the scaling of DAC contemporaneously with the reduction of fossil fuels. There would be enormous demand for renewables if these two occur at the same time.
 - A 2019 study modeled DAC powered both by natural gas and DAC powered by renewables and compared them with rapid adoption of renewable technology. The conclusion:

In sum, spending on capture rather than wind replacing fossil or bioenergy always increases social cost. No improvement in [carbon capture] equipment can change this conclusion while fossil emissions exist.⁹
 - Reliance on, or anticipation of DAC diverts attention from the societal changes that must occur. Currently, talk of DAC is mostly greenwashing. In a few years' time that may not be true, as large-scale pilots demonstrate (or fail to demonstrate) feasibility.¹⁰ But planning in the near term must focus on rapid electrification of the grid and other emissions reduction measures—which we know will work.

⁹ Jacobson, Mark Z. "The health and climate impacts of carbon capture and direct air capture." *Energy & Environmental Science* 12, no. 12 (2019): 3567-3574.

¹⁰ Gertner, Jon. "The Dream of Carbon Air Capture Edges Toward Reality." *Yale Environment360*. <https://e360.yale.edu/features/the-dream-of-co2-air-capture-edges-toward-reality>

- Most of the scenarios modeled by the IPCC include enormous amounts of DAC,¹¹ and most project the need to utilize approximately one third of all power simply for this purpose. A third of our power would be diverted from developing non-polluting, decarbonized living styles. That would be a tremendous drain on any economy, including California's. Yet that vast societal and economic effect appears not to be incorporated into the macro-economic projections.
- What alternative does the IPCC AR6 provide to this Sorcerer's Apprentice scenario where we use a third of our resources to mop up the seemingly unstoppable emission of greenhouse gases? It is a massive reduction in per capita consumption and demand. For example, instead of having 2.2 billion cars on the road in the world in 2050, we cut the current number (1.7 billion) in half and have 850 million. DAC would still be required but in much lower amounts. It is these minimal-DAC alternatives, considered by the IPCC, that should form the basis for CARB's Alternative 1.¹² The IPCC's alternatives require a faster reduction of greater quantities of emissions than projected in the Scoping Plan. **Anything other than a much-expanded Alternative 1, according to the IPCC, will not get us where we need to go.**

4. CARB's documentation lacks a schedule for reducing fossil emissions.

The most glaring omission in the macro-economic scoping plan is the lack of a timeline for when and how fossil fuel emissions shall be reduced (or perhaps four timelines corresponding with the alternatives). Developing such a timeline is clearly a challenge, but a plan that does not include this timetable can't be called a plan, only a wish list. *Some* reduction of fossil fuels is implied. For instance, If we have an all renewable electric grid it will be using zero or minimal natural gas.

But much that should be explicit is not. ***In particular, we need to know when we must ban gas from buildings.*** CARB doesn't have the power to do what is necessary, but it can model the effects of such a ban at different times, as well as the consequences of not banning gas rapidly.

COMMENTS PART II: AIR POLLUTION AND HEALTH SAVINGS

"99% of Humans Breathe Unhealthy Air:"¹³

Comparison of results on health savings with a recent peer reviewed study shows:

- Because CARB's air quality and health benefits/costs modeling is not designed to be comprehensive, neither cumulative avoided health risks (including early deaths) or cost

¹¹ "In modeled pathways that reach global net zero CO2 emissions, at the point they reach net zero, 5-16 GtCO2 of emissions from some sectors are compensated for by net negative CO2 emissions in other sectors."

https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf

¹² Meyer, Robinson. "There's No Scenario in Which 2050 Is 'Normal.'" The Atlantic, April 27, 2022. Based on an interview with lead IPCC researcher Zeke Hausfather. <https://www.theatlantic.com/science/archive/2022/04/ipcc-report-climate-change-2050/629691/>

¹³ Roxane, O. "99% of Humans Breathe Unhealthy Air, Latest WHO Data Shows," EcoWatch, April 5, 2022.

<https://www.ecowatch.com/air-pollution-us-public-health.html>

savings can be inferred from Scoping Plan data. In the table “Air pollution improvements reduce incidence of harmful health outcomes”¹⁴ we see only data from one year in one month. What is the justification for such a limited perspective?

- Peer-reviewed research *does* include the information we need to assess the costs and benefits of rapidly and completely reducing sources of air pollution.

We find that approximately 14,000 premature deaths can be avoided in California in 2050 and that these health co-benefits are disproportionately higher in disadvantaged communities (that is, 35% of avoided deaths will come from 25% of the state’s population). The annualized monetary benefits (US\$215 billion) exceed the GHG abatement cost (US\$106 billion) by US\$109 billion.¹⁵

- The IPCC also affirms that savings from eliminating pollution exceed mitigation costs globally.¹⁶

COMMENTS PART III: NATURAL AND WORKING LANDS, FIRE

Relationship to the 30 x 30 plan

- The Alternatives presented in the April 20 workshop are too general and vague for any conclusions to be drawn. We have used the more detailed document released for the February 28, 2022 Natural and Working Lands discussion.¹⁷ The inadequacy of the Scoping Plan “Alternatives” is nowhere more apparent than in the natural and working lands sections. In order to indicate the direction we think California should go, we select aspects of the alternatives and compare them with the proposals in [Natural and Working Lands Climate Smart Strategy](#), released April 22, 2022 and containing a plan for achieving our climate goals. A companion report, [Pathways to 30x30: Accelerating Conservation of California’s Nature](#), focuses on achieving our goal of conserving 30 percent of both land and ocean resources in the face of climate change.
- Alternative 1 is described as maximizing short term carbon sequestration. The important part of that for forests is to end clear cuts (please see *Finding the Mother Tree* by Suzanne Simard¹⁸) and maximize large tree growth in order to maximize carbon sequestration. This strategy, though, fits perfectly well with Alternative 3, which is essentially the 30 x 30 strategy. It does *not* fit with maximizing fire suppression, also listed as part of Alternative 1. Managing fire is an integral part of climate-smart forestry.

¹⁴ MacKinnon, M., Zhu, S., and Samuelsen, S., “Air Quality and Public Health Benefits of the DRAFT Scoping Plan Scenarios,” slide deck presented in the Draft Scoping Plan Air Quality Workshop, April 20, 2022, p. 13/17. <https://ww2.arb.ca.gov/sites/default/files/2022-04/SP22-Initial-AQ-Health-Econ-Results-ws-UCL.pdf>

¹⁵ Wang, T., Jiang, Z., Zhao, B. *et al.* Health co-benefits of achieving sustainable net-zero greenhouse gas emissions in California. *Nat Sustain* 3, 597–605 (2020). <https://doi.org/10.1038/s41893-020-0520-y>.

¹⁶ “The economic benefits on human health from air quality improvement arising from mitigation action can be of the same order of magnitude as mitigation costs, and potentially even larger (*medium confidence*). {3.6.3}” IPCC op cit.

¹⁷ <https://ww2.arb.ca.gov/sites/default/files/2022-02/Revised-NWL-2022SP-Scenario-Assumptions-28Feb.pdf>

¹⁸ Simard, Suzanne. *Finding the mother tree: uncovering the wisdom and intelligence of the forest*. Penguin UK, 2021.

Our conclusion is that the Scoping Plan Alternatives are an unrealistic combination of incompatible elements.

IN CONCLUSION

We are disheartened to read in the press, while preparing these comments, that CARB staff are recommending “the option that has the least impact on the state’s economy rather than accelerating the pace of achieving carbon neutrality.”¹⁹ In our view, this is a complete abdication of CARB’s, and indeed California’s vaunted global leadership in climate policy.

As a thought experiment we typed “Climate Crisis” into Google News. Appendix 2 shows a partial list of the headlines that came up for *just three days* last week. The press warns of a projected loss of 30 percent of all animal life in the oceans; a four percent contraction in world GDP by 2050 (so much for discount rates); huge risk of disease spillover from animals to humans; and a warning from the IPCC that we have only eight years to “turn the ship.” Can you imagine what a similar search would turn up in 2035 or 2045? ***As Californians and humans living and raising children and grandchildren on this planet, can you in good conscience propose plans for the next 23 years that don’t drastically accelerate the pace of decarbonization?***

As António Guterres, Secretary General of the United Nations, says: “We are sleepwalking to climate catastrophe.”²⁰

Thank you for considering these comments.

Sincerely,



Daniel Chandler
Legislative Committee Chair
350 Humboldt



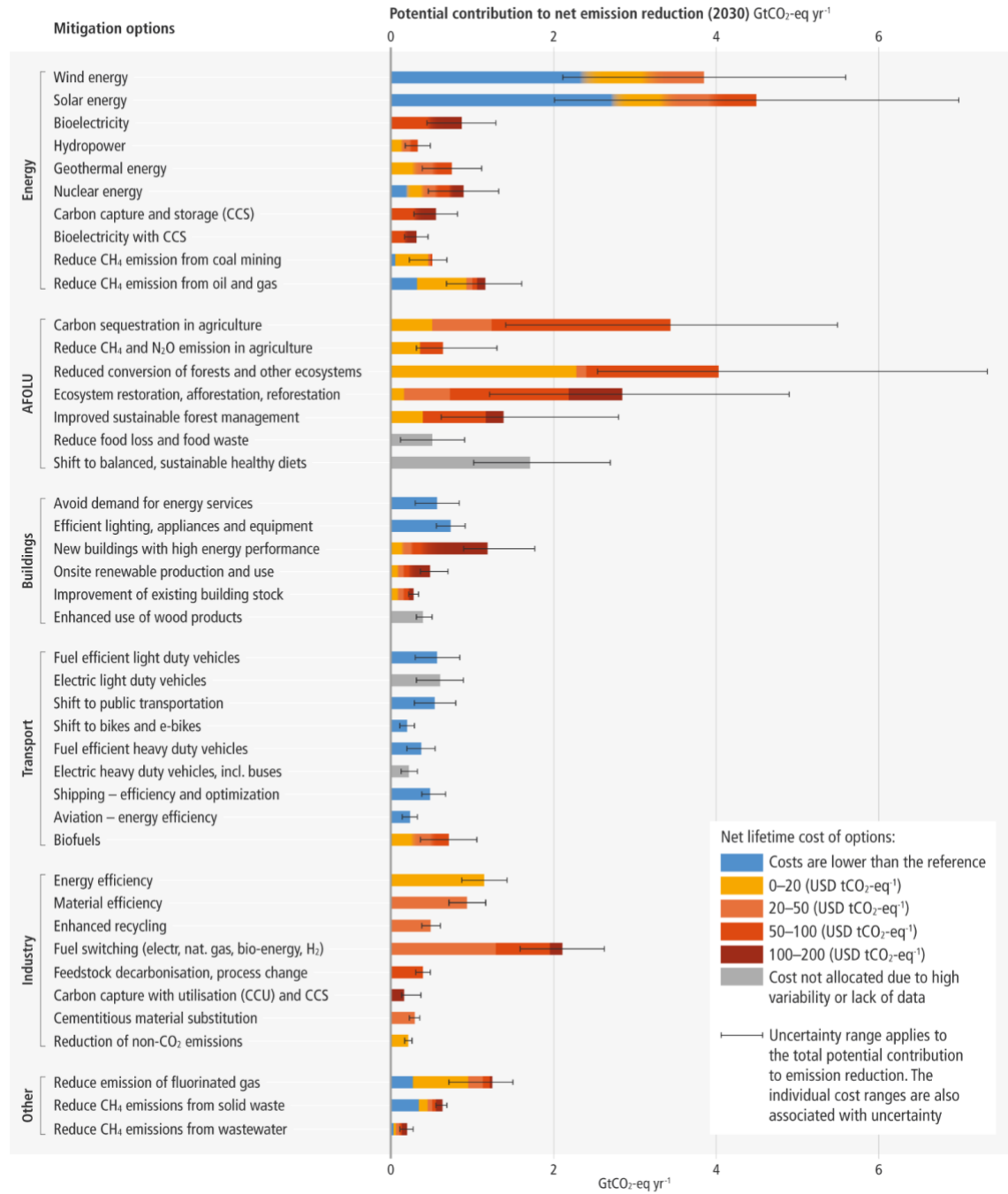
Janet Cox
Legislation/Policy Director
Interim President
350 Silicon Valley

¹⁹ Lopez, op cit.

²⁰ NYTimes, March 21, 2022: <https://www.nytimes.com/2022/03/21/climate/united-nations-fossil-fuels-climate-crisis.html> |

APPENDIX 1: IPCC MITIGATION INTERVENTIONS BEFORE 2030: COST AND EFFECTIVENESS²¹

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.



²¹ <https://www.ipcc.ch/report/ar6/wg3/figures/summary-for-policymakers>

Figure Legend SPM.7:

Costs shown are net lifetime costs of avoided greenhouse gas emissions. Costs are calculated relative to a reference technology. The assessments per sector were carried out using a common methodology, including definition of potentials, target year, reference scenarios, and cost definitions. The mitigation potential (shown in the horizontal axis) is the quantity of net greenhouse gas emission reductions that can be achieved by a given mitigation option relative to a specified emission baseline. Net greenhouse gas emission reductions are the sum of reduced emissions and/or enhanced sinks. The baseline used consists of current policy (~ 2019) reference scenarios from the AR6 scenarios database (25/75 percentile values). The assessment relies on approximately 175 underlying sources that together give a fair representation of emission reduction potentials across all regions. The mitigation potentials are assessed independently for each option and are not necessarily additive. {12.2.1, 12.2.2}

The length of the solid bars represents the mitigation potential of an option. The error bars display the full ranges of the estimates for the total mitigation potentials. Sources of uncertainty for the cost estimates include assumptions on the rate of technological advancement, regional differences, and economies of scale, among others. Those uncertainties are not displayed in the figure.

Potentials are broken down into cost categories, indicated by different colors (see legend). Only discounted lifetime monetary costs are considered. Where a gradual color transition is shown, the breakdown of the potential into cost categories is not well known or depends heavily on factors such as geographical location, resource availability, and regional circumstances, and the colours indicate the range of estimates. Costs were taken directly from the underlying studies (mostly in the period 2015-2020) or recent datasets. No correction for inflation was applied, given the wide cost ranges used. The cost of the reference technologies were also taken from the underlying studies and recent datasets. Cost reductions through technological learning are taken into account (FOOTNOTE 70).

When interpreting this figure, the following should be taken into account:

- The mitigation potential is uncertain, as it will depend on the reference technology (and emissions) being displaced, the rate of new technology adoption, and several other factors.
- Cost and mitigation potential estimates were extrapolated from available sectoral studies. Actual costs and potentials would vary by place, context and time.
- Beyond 2030, the relative importance of the assessed mitigation options is expected to change, in particular while pursuing long-term mitigation goals, recognising also that the emphasis for particular options will vary across regions (for specific mitigation options see sections C4.1, C5.2, C7.3, C8.3 and C9.1).
- Different options have different feasibilities beyond the cost aspects, which are not reflected in the figure (cf. section E.1).
- The potentials in the cost range 100 to 200 USD tCO₂-eq-1 may be underestimated for some options.

- Costs for accommodating the integration of variable renewable energy sources in electricity systems are expected to be modest until 2030, and are not included because of complexities in attributing such costs to individual technology options.
- Cost range categories are ordered from low to high. This order does not imply any sequence of implementation.
- Externalities are not taken into account.

APPENDIX 2: Urgency of the Climate Crisis in Headlines from Three Days, April 27-29, 2022

April 27, 2022, CBS News:

"Eight years left to turn the ship: Scientists share how climate change could change daily life"

Earlier this month, [more than 300 people](#) in South Africa were killed as record rainfall washed away buildings and infrastructure in the Kwa-Zulu Natal province. A day earlier, dozens were killed in the Philippines after [tropical storm Megi](#) spurred landslides and floods. The world is rapidly shifting — and the impact of human-caused [climate change](#) is increasingly evident....Blumstein, Brosnan and Hall all agreed that the future is going to look vastly different than what we know today. Large-scale and urgent action is the only way to make the harshest of that future reality more manageable. Blumstein said we have the technology and knowledge to do it. One of the biggest issues in this storm is not holding governments or companies accountable for their negative contributions or inaction in fighting the climate crisis, they said.

April 27, 2022, The Guardian:

"UN says up to 40% of world's land now degraded"

Rising damage, caused mostly by food production, puts ability to feed planet's growing population at risk

April 27, 2022, BBC News:

"Climate change: Record tree losses in 2021 in northern regions"

Tree cover losses in northern regions of the world were the highest on record in 2021, according to new analysis from Global Forest Watch. Figures for these boreal forests were up 30% on 2020, with wildfires causing massive losses in Russia. Elsewhere, around ten football pitches per minute of tropical primary forest were lost across the year.

April 28, 2022, Washington Post:

"Ocean animals face a mass extinction from climate change, study finds"

If humanity's greenhouse gas emissions continue to increase, according to a [study released Thursday](#), roughly a third of all marine animals could vanish within 300 years.

April 28, 2022, Science News:

"Model pinpoints glaciers at risk of collapse due to climate change"

Meltwater seeping beneath Arctic glaciers puts thickest and fastest at risk of sudden collapse. As climate change warms the planet, glaciers are melting faster, and scientists fear that many will collapse by the end of the century, drastically raising sea level and inundating coastal cities and island nations.

April 28, 2022, Yale Environment 360:

"For Gen Z, Climate Change Is a Heavy Emotional Burden"

Among those studying this phenomenon is Britt Wray, 35, a postdoctoral fellow at Stanford University's [Center for Innovation in Global Health](#). Wray recently coauthored the largest-ever survey of climate anxiety in teenagers and young adults, a [10-nation study](#) published in *The Lancet*, which found that climate change is having a profound impact on young people.

April 28, 2022, Reuters:

“Climate change putting 4% of global GDP at risk, new study estimates”

Climate change could see 4% of global annual economic output lost by 2050 and hit many poorer parts of the world disproportionately hard, a new study of 135 countries has estimated. Ratings firm S&P Global, which gives countries credit scores based on the health of their economies, published a report on Tuesday looking at the likely impact of rising sea levels, and more regular heat waves, droughts and storms.

April 29, 2022, New York Times:

“Deforestation Remains High, Despite International Pledges”

Brazil had the largest share of tree loss last year, followed by the Democratic Republic of Congo and Bolivia. Indonesia showed improvement.

April 29, 2022, Washington Post:

“How Americans' love of beef is helping destroy the Amazon rainforest”

Cattle ranching is responsible for the great majority of deforestation in the Amazon, a vital carbon sink that scientists say must be preserved to avert catastrophic warming

April 29, 2022, The Guardian:

“‘Potentially devastating’: Climate crisis may fuel future pandemics”

‘Zoonotic spillovers’ expected to rise with at least 15,000 instances of viruses leaping between species over next 50 years

April 29, 2022, Washington Post:

“Heat wave breaks monthly records in India and continues to build”

The heat is increasing fire risks and threatening crops, and could lead to flooding from melting glaciers. Temperatures have already soared to dangerously high levels. They topped 110 degrees in the Indian capital of Delhi on Thursday and Friday, where [pavement melted amid the heat](#), while several cities broke April records.

April 29, 2022, CalMatters:

“Lower cost, slower gains: California prepares controversial new climate strategy”

A climate change roadmap to be proposed in May aims to minimize costs while reaching carbon neutrality by 2045. Environmentalists say it's too slow and reliant on carbon markets and capture technologies.