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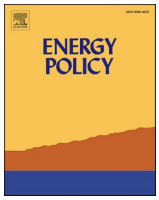

California's ambitious greenhouse gas policies: Are they ambitious enough?

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ABSTRACT

California's landmark AB 32 legislation, enacted in 2006, tasked the California Air Resources Board (CARB) with (1) ensuring that statewide greenhouse gas emissions in 2020 would not exceed the 1990 level, and (2) achieving the "maximum technologically feasible and cost-effective reductions in greenhouse gas emissions". CARB adopted a caps-and-standards framework for regulating emissions in energy sectors (electricity generation, industrial combustion, and transportation fuels). The regulations interpreted the statutory emissions limit in 2020 as a predetermined "target", thus rendering the maximum-reduction mandate ineffectual. CARB's November 2022 Scoping Plan extends the same framework to implement California's new legislative directive (AB 1279) requiring achievement of "net zero greenhouse gas emissions as soon as possible, but no later than 2045". The plan continues CARB's reliance on Cap-and-Trade, which establishes the minimum statutory requirement as a "target" and disincentivizes overcompliance by nullifying the environmental benefits of supplemental climate actions (the "waterbed effect"). To put California on track toward decarbonization at the scale and pace required for global climate stabilization, the legislature should institute a regulatory policy paradigm that accommodates and supports local and individual climate action, and which gives meaning and effect to the mandate requiring maximum technologically feasible and cost-effective emissions reductions.

1. Introduction

Building on California's landmark Global Warming Solutions Act, AB 32 (California Legislature, 2006), the state's more recent SB 32 legislation (California Legislature, 2016) requires CARB to adopt rules and regulations ensuring that statewide emissions are further reduced by at least 40% by 2030, and AB 1279 (California Legislature, 2022a) establishes a statewide goal of achieving carbon neutrality no later than 2045. In its Scoping Plan released in November 2022 (CARB, 2022a), CARB proposed a regulatory strategy for achieving these objectives, which the report characterizes as "ambitious and aggressive … comprehensive, far reaching, and transformative …". The report considered two plan alternatives that were even more ambitious, aiming for carbon neutrality by 2035, but these options were rejected as being too costly and uncertain. The plan did, however, adopt a more ambitious interim reduction target of 48% in 2030 – up from the 40% mandated by SB 32.

The Scoping Plan's level of ambition is quantified by its projected costs, which are estimated at $187 per household per year in 2035, declining to $76 in 2045. These costs represent an income loss of 0.08% in 2035 and 0.03% in 2045 – not relative to today's household income, but relative to a projected income rise from 2021 of 22% in 2035 and 45% in 2045 under CARB's no-new-policy "Reference Scenario".[1]

Weighing those exceedingly modest cost projections against the potential consequences of catastrophic and irreversible climate change, the question arises: Are California's greenhouse gas policies ambitious enough? More to the point, would the proposed plan achieve the "maximum technologically feasible and cost-effective greenhouse gas emissions reductions" required by California statutes? The Scoping Plan makes no assertion that it would.

The low projected costs indicate that more ambitious climate actions by individuals, corporations, and local municipalities could significantly accelerate the scale and pace of statewide decarbonization beyond state mandates. However, Cap-and-Trade not only fails to incentivize overcompliance, it actively impedes and disincentivizes additional emission-reduction actions by nullifying their environmental benefits. Any additional reductions in capped sectors merely free up surplus GHG

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[1] CARB (2022a), Appendix H: AB 32 GHG Inventory Sector Modeling. See Figure H-28 ("Impact by household …"). The number of households is 13.3 million in 2020, 14.6 million in 2035 and 15.0 million in 2045 (p. 109), interpolated to 13.38 million in 2021 (from link cited in footnote 141, spreadsheet P-4). Aggregate personal income is $2.7 trillion in 2021, $2.7 trillion in 2035, and $4.4 trillion in 2045 (p. 108). The data in Figure H-28 is actually from the May 10, 2022 Draft Scoping Plan, which was incorporated in the November 16, 2022 Final Scoping Plan without updating to the revised final plan.

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allowances, enabling greater emissions elsewhere. Cap-and-Trade operates to channel the benefits of local and individual climate actions toward reducing industry's compliance costs and not toward further reducing emissions, under the false premise that a guaranteed emission cap obviates the need for further emissions reduction. A state regulatory policy that operates to actively undermine and nullify efforts to accelerate decarbonization contravenes the AB-32 mandate (§38562(b)(1)) requiring CARB to "Design the regulations … in a manner that … encourages early action to reduce greenhouse gas emissions."

CARB's plan has been widely criticized (Cullenward D. , 2022; Lopez, 2022; Earthjustice et al., 2022; Food & Water Watch et al., 2022; Becker and Cart, 2022; California Legislative Analyst's Office, 2023) for its inadequacy and lack of ambition, but the criticisms have not been expressly grounded on statutory mandates and do not generally question the fundamental compatibility of CARB's caps-and-standards regulatory framework with the underlying legislative policy. The following critique analyzes CARB's regulatory strategy through the lens of legislative policy, it elucidates the consequences of CARB's prioritization of cost minimization over emissions minimization in contravention of the maximum-reduction and early-action mandates, and it identifies inconsistencies and contradictions in the state's greenhouse gas regulations and legislation that should be resolved to effectively address the imminent threat of climate change. The critique is focused on California but the core policy issues are also relevant to other regulatory jurisdictions (RGGI, EU-ETS, etc.).

This paper is not an academic treatise on the economic theory of regulatory climate policy, but it raises fundamental questions of purpose and policy rationale relating to the economic foundations of Cap-and-Trade. The questions at issue have their roots in the "Prices vs. Quantities" debate of environmental economics (Weitzman, 1974): Should regulatory policy operate to constrain emissions (quantities) and minimize costs (prices), or to constrain costs and minimize emissions? California's legislative and regulatory policy straddles the fence on this question, reflecting equivocation in the economic foundation of California's policies. The statutes impose a predetermined emission cap and authorize Cap-and-Trade as an implementation instrument, but they also require that emissions be minimized subject to a cost-effectiveness constraint (with "cost-effectiveness" being expressly defined in terms of a carbon price). The incongruity of these dual mandates is partially reconciled by CARB's implementation of Cap-and-Trade as a "hybrid" instrument, which is primarily quantity-constrained while also incorporating "price-containment" elements. This middle-of-the-road regulatory framework provides neither the emissions certainty of a pure quantity instrument nor the price stability of a carbon tax or fee.

To the extent that Cap-and-Trade operates as a quantity-constrained instrument, it nullifies efforts and actions to further reduce emissions in capped sectors because statewide emissions in capped sectors are predetermined by the cap. A fundamental question for the state legislature is whether regulatory climate policy in California should operate to encourage and support, or to undermine and neutralize, individual and local actions to accelerate decarbonization. Should California citizens, institutions, and local governments have the ability, and the right, to influence the scale and pace of statewide decarbonization by reducing their own carbon footprint?

To the extent that Cap-and-Trade operates as a price-constrained instrument, would the policy rationale for price containment not favor a straightforward price instrument over a hybrid instrument? Does the policy rationale for a price floor and ceiling in California's Cap-and-Trade system provide any basis for setting the price floor at a level lower than the price ceiling?

Bringing these questions to the forefront of policy discussions could engender a higher standard of logical rigor and clarity of purpose in regulatory climate policy.

Section 2 discusses the legal context of CARB's greenhouse gas regulations, with a focus on the 2009 AIR v. CARB lawsuit that brought the "Prices vs. Quantities" debate into the judicial arena. The appellate court in that case ruled, in effect, in favor of continued policy ambiguity. Section 3 discusses the practical consequences of CARB's reliance on Cap-and-Trade and its nonadherence to the maximum reduction mandate, which have motivated CARB to favor cost conservatism over ambition in its regulatory policies. Section 4 explains a little-understood consequence of Cap-and-Trade, the "waterbed effect", which nullifies the environmental benefits of all additional carbon-reduction actions in capped sectors. Section 5 enumerates fundamental deficiencies and logical inconsistencies in California's climate policies, which should be resolved to enable effective greenhouse gas regulation. Section 6 suggests alternative policy approaches that leverage the substantial investment potential of renewable energy to expedite decarbonization while also mitigating wealth inequality. Consumers' long-term interests can best be served by investing carbon pricing revenue in decarbonization and distributing "decarbonization dividends" to consumers in the form of affordable clean energy and equity returns on clean energy investments. Conclusions and policy implications are summarized in Section 7.

2. The legal context of CARB's greenhouse gas regulations

California's AB 32 legislation (Health and Safety Code, § 38500 et seq. (California Legislature, 2006)) established in Section 38562 that "the state board shall adopt greenhouse gas emission limits and emission reduction measures by regulation to achieve the maximum technologically feasible and cost-effective reductions in greenhouse gas emissions in furtherance of achieving the statewide greenhouse gas emissions limit".

The qualifier "maximum" in this context applies unambiguously to emissions reductions; it does not apply to feasibility or cost-effectiveness.

The "statewide greenhouse gas emissions limit" was defined to mean "the maximum allowable level of statewide greenhouse gas emissions in 2020". (§38505(n)) This was expressly a "maximum", not a "target", but CARB adopted the limit as a target in setting the cap for its Cap-and-Trade regulations. CARB's interpretation of the emissions "limit" as a "target" rendered the maximum-reduction mandate of Section 38562 meaningless and ineffectual because the reduction target was predetermined by statute, not by any maximization condition, and the emissions trading system operates to minimize compliance costs and not to minimize emissions.

CARB's interpretation of the statute was challenged in a lawsuit filed in 2009 by the Association of Irritated Residents et al. (AIR v CARB, 2012). The plaintiffs contended that CARB failed to achieve "the *maximum* technologically feasible and cost-effective reductions" in emissions by converting the "statewide greenhouse gas emissions limit" from a reduction minimum to a reduction ceiling (i.e., a "target"). An appellate court ruled against AIR in 2012, based on the following reasoning:

> "… Contrary to AIR's argument, the 1990 level which section 38550 requires to be reached by 2020 was not considered by the Legislature to be unrelated to the goal of achieving maximum reductions as required by section 38561. Section 38562, which requires the Board to adopt regulations implementing the measures described in the scoping plan, calls for regulations 'to achieve the maximum technologically feasible and cost-effective reductions in greenhouse gas emissions *in furtherance of achieving the statewide greenhouse gas emissions limit*.' …"

The ruling appears to argue that in the context of the "in furtherance …" clause the maximum-reduction mandate means something less, or something different, than what the plain language seems to state.

A fundamental role of courts is to interpret law, and a basic principle of statutory interpretation is that statutory language should not to be construed as "mere surplusage": "A statute should be construed so that effect is given to all its provisions, so that no part will be inoperative or

superfluous, void or insignificant." (Eig, 2011) The fundamental question before the appellate court in AIR v. CARB was what actionable meaning, if any, the qualifier "maximum" in Section 38562 had, and whether the legislature intended that the inclusion of the qualifier in the statute would have any effect on CARB's regulations and on the statewide emissions reductions achieved under AB 32. The court's ruling did not expressly resolve this question, but its Conclusion made the court's position clear:

> "The Governor and the Legislature have set ambitious goals for reducing the level of greenhouse gas emissions in California and to do so by means that are feasible and most cost-effective. …"

There is no mention of "maximum" reductions. By interjecting the qualifier "most" in "feasible and most cost-effective", the ruling effectively rewrites the statute, which does not require the "most cost-effective" emissions reductions. It only requires that emissions-reductions measures be "feasible and cost-effective", subject to which emissions reductions are to be maximized.

The court ascribed no actionable meaning to the qualifier "maximum" in Section 38562, leaving the intended meaning and effect of the maximum reduction mandate in a state of unresolved ambiguity and upholding CARB's policy framework, which gives no weight to the mandate. The 2022 Scoping Plan, for example, makes one mention of the maximum-reduction mandate, but only as a quoted, rote recital of the statutory language without interpretive context: "AB 32 includes a requirement that rules and regulations 'achieve the maximum technologically feasible and cost-effective' greenhouse gas emissions reductions" (CARB, 2022a, page 153). The report makes no assertion that CARB's plan achieves that objective, and it conspicuously avoids stating whether the rejected policy alternatives are "cost-effective". Under CARB's and the court's interpretation, the AB 32 maximum-reduction mandate amounts to "mere surplusage".

3. CARB's proposal adopts the least-cost, not the most ambitious, regulatory policy

To give meaning and effect to the full statute, CARB would need to make a determination, for each of the policy alternatives considered in the Scoping Plan, of whether the alternative would be technologically feasible and cost-effective. CARB would then need to select, from the alternatives that are deemed to be feasible and cost-effective, the option that achieves the maximum greenhouse gas emissions reductions.

The Scoping Plan considers four policy alternatives, with Alternative 1 exhibiting the greatest projected GHG emissions reductions while Alternative 3 represents CARB's preferred option. Alternative 1 would achieve statewide carbon neutrality by 2035, while Alternative 3 targets carbon neutrality by 2045. No intermediate options (e.g., net-zero by 2040) are considered in the Scoping Plan.

All four alternatives appear to be feasible; CARB makes no suggestion that they are not. The Scoping Plan discusses the alternatives' costs in depth. Alternative 1 is projected to reduce the gross state product (GSP) by 0.6% in 2045 (compared to 0.1% for Alternative 3). That is relative to a growing economy; even with that reduction the GSP is projected to increase from $3.2 trillion in 2021 to $5.07 trillion in 2045, only marginally less than the $5.1 trillion GSP expected under CARB's Reference Scenario.[2] (By comparison, climate change costs are projected to reach 1.5% of U.S. GDP by 2070, continuing to increase thereafter, even if global GHG emissions are eliminated by 2050 and global warming is limited to 1.5 °C (Philip et al., 2022).) The projected costs are clearly quantified, but CARB does not say whether Alternative 1 would be cost-effective according to the statutory requirement.

CARB is apparently reticent to pursuing a more ambitious climate action agenda because the most ambitious plan would also be the most uncertain and most at risk of exceeding limitations of feasibility and cost-effectiveness under a traditional caps-and-standards regulatory system. A primary limitation of Alternative 1 cited by CARB is its "High degree of uncertainty due to highest pace of clean energy and technology deployment and adoption" (CARB, 2022b). Add to that the unforeseen impacts of events such as recessions, pandemics, foreign wars, etc., and it becomes near impossible to predict limits of feasibility and cost-effectiveness based on the kind of economic modeling and forecasting that the Scoping Plan relies on. To mitigate the risk, CARB selected the most cost-conservative rather than the most ambitious plan alternative.

This cost conservatism underscores a fundamental weakness of the caps-and-standards (quantity-based) regulatory approach employed by CARB. While caps and standards can guarantee attainment of a predetermined emissions target, the target itself must be sufficiently weak to ensure feasibility and cost-effectiveness under worst-case predictive assumptions, and the regulations provide no incentive for over-compliance. By contrast, if the target is feasible and cost-effective then more flexible and ambitious policies that are constructed to incentivize the *maximum* feasible and cost-effective emissions reductions would at least achieve, and likely surpass, the target.

The consequence of CARB's cost conservatism can be illustrated by the transportation industry. California's target of 100% ZEV (zero-emission vehicle) sales by 2035 (CARB, 2022c) could be outpaced by current market trends. The data underlying the 2022 Scoping Plan forecasts 110,290 light-duty electric vehicle sales in California in 2021 and 152,099 in 2022 ,[3] but the actual reported sales were 183,933 in 2021 and 292,496 in 2022 (California Energy Commission, 2023). At the current market growth rate, ZEV's would reach 100% of new vehicle sales in California within about five years, well in advance of the 2035 target. (The ZEV market share was 7.8% in 2020, 12.4% in 2021, and 18.8% in 2022.) And as EV technology matures and costs decline it could become possible, perhaps with regulatory incentives, to accelerate the phase-out of the existing stock of internal combustion vehicles via EV conversion kits (Jacobs, 2021; Cenizo, 2022; Kuhudzai, 2022). This could facilitate early decarbonization of the state and global vehicle fleets without requiring early retirement of passenger vehicles, which have typical lifespans of two decades or more (Held et al., 2021).

These types of unforeseen opportunities in transportation and other sectors could make it possible to expedite decarbonization of California's economy – and the world. But CARB's statewide emissions target is uninfluenced by such opportunities because the target is predetermined by statute and regulation.

4. Cap-and-trade and the "waterbed effect"

One of the least-understood characteristics of Cap-and-Trade is that it operates to nullify the environmental benefit of all additional carbon-reduction actions in capped sectors. To the extent that emissions in capped sectors are controlled by a predetermined cap, they are not influenced by supplemental actions. Several examples of this effect are discussed below.

4.1. The Greenhouse Gas Reduction Fund

CARB's Greenhouse Gas Reduction Fund (GGRF), the repository of

[2] CARB (2022a), Appendix H, under "Gross State Product" (pages 113–114). Note: The alternatives comparison data are based on the analysis underlying CARB's May 10, 2022 Draft Scoping Plan, which was replicated in the November 16, 2022 Final Scoping Plan but was not updated to reflect the final plan. The "Proposed Scenario" in the draft plan and the "Scoping Plan Scenario" in the final plan are variants of Alternative 3.

[3] CARB (2022a), AB 32 GHG Inventory Sectors Modeling Data Spreadsheet, LDV Sales https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp-PATHWAYS-data-E3.xlsx.

Cap-and-Trade auction revenue, is reported to have achieved 78.6 million MTCO2e (metric tons of CO2-equivalent greenhouse gasses) cumulative carbon emissions reductions between 2015 and mid-2022 (CARB, 2022d). This characterization of the GGRF's environmental benefits is inaccurate and misleading.

Two questions were recently posed to CARB staff [4] about the GGRF; similar questions apply to any policy affecting emissions in capped sectors: (1) Do GGRF investments ("California Climate Investments") influence the supply of emission allowances under California's Cap-and-Trade system? The response was "No". (2) Do GGRF investments influence statewide emissions in capped sectors? Staff did not answer this question, although it should be apparent that statewide emissions in capped sectors are determined by the supply of allowances. (Each allowance authorizes emission of one MTCO2e.) This was explained in a 2016 report from the California Legislative Analyst's Office on the topic of Cap-and-Trade revenue expenditures, which stated the following:

> "Spending on Capped Sources Likely Has No Net Effect on Overall Emissions. … As long as the cap is limiting emissions, subsidizing an emission reduction from one capped source will simply free–up allowances for other emitters to use. The end result is a change in the sources of emissions, but no change in the overall level of emissions." (California Legislative Analyst's Office, 2016)

GGRF expenditures can provide real reductions in statewide emissions from sectors outside of Cap-and-Trade jurisdiction and can be used to support a variety of policy goals. But within capped sectors (which cover approximately 80% of statewide emissions (CARB, 2023a)) the GGRF provides no demonstrable environmental benefit as long as the market supply of GHG allowances is predetermined by regulation.

4.2. Voluntary renewable electricity

CARB's Cap-and-Trade regulations generally disallow individuals from influencing statewide emissions in regulated sectors. Individual actions such as installing energy-efficient appliances or residential solar panels, driving an electric vehicle, etc. do not normally influence either the supply of allowances or aggregate emissions in capped sectors; such actions merely free up surplus allowances that allow increased emissions elsewhere.

However, there is one state regulatory policy that is expressly designed to ensure the environmental benefits of individual climate action. Electricity utilities in California have Green Power programs, which enable ratepayers to purchase up to 100% of their power from renewable sources. These programs are regulated by the California Public Utilities Commission (CPUC) under its Green Tariff Shared Renewals (GTSR) program (California Public Utilities Commission, 2021b), which was legislatively mandated in 2014 for the purpose of "expanding access to all eligible renewable energy resources to all ratepayers who are currently unable to access the benefits of onsite generation" (California Legislature, 2013). But program participants do not generally share in the economic benefits of renewable energy. Whereas residential solar power ("onsite generation") can provide long-term cost savings in the form of lower utility bills, Green Power sales do not give buyers an equity share in the expanded renewable generation capacity that their rate premiums help subsidize. The GTSR program operates primarily to provide participating customers the environmental benefit of a reduced carbon footprint.

To ensure the environmental integrity of utilities' Green Power offerings, the CPUC requires that they be "Green-e certified" by the Center for Resource Solutions (CRS), the "trusted global leader in clean energy certification". (Center for Resource Solutions, 2023a; California Public Utilities Commission, 2015; Center for Resource Solutions, 2023b; Center for Resource Solutions, 2023c) Green-e participant guidelines require that GHG emission allowances under California's Cap-and-Trade system be retired on behalf of purchasers of Green-e certified renewable energy. (Center for Resource Solutions, 2018) Allowance retirement is also a specific requirement of the GTSR legislation (California Public Utilities Commission, 2021c; California Legislature, 2022b), which further requires that the allowances be retired from a special Voluntary Renewable Electricity (VRE) allowance reserve that CARB established as part of its Cap-and-Trade program (CARB, 2023b). (Similar allowance retirement policies have been proposed or enacted in other Cap-and-Trade jurisdictions (Bird et al., 2007; Twomey et al., 2012).)

The policy rationale for the VRE reserve was clearly articulated in CARB's 2010 Cap-and-Trade rulemaking record: "… Without an allowance set-aside for VRE purchase, once the cap-and-trade program is in place, the voluntary use of electricity generated from renewable resources and delivered to California would no longer contribute additional greenhouse gas emission reductions because the level of allowable emissions is determined by the cap. …" (CARB, 2010) However, under CARB's implementation of the VRE Program, the voluntary use of renewable electricity still "would no longer contribute additional greenhouse gas emission reductions" because the "retired" allowances were already retired, in effect, when they were put into the VRE reserve and taken out of circulation. The number of allowances allocated to the reserve was not connected in any way to actual VRE purchases; consequently, a customer's VRE purchase has no effect on the number of allowances actually in circulation and available for compliance, and it thus has no effect on statewide emissions.

The set-aside allocation was fixed in advance at 0.5% of CARB's annual allowance budget in 2013–2014, and at 0.25% in 2015–2020. No set-aside was authorized beyond 2020, and the remaining balance of allowances in the reserve is expected to be depleted in 2023. (Center for Resource Solutions, 2022) In principle, the GTSR program should be able to continue by requiring that utilities retire allowances from their own accounts. Assuming that VRE purchases are really delivering the GHG reductions that customers are paying for, the allowance retirement would not impose any additional cost on utilities because they would accrue the surplus allowances resulting from VRE sales. The retirement of allowances from utility accounts in response to VRE demand would establish a clear causal connection between VRE purchases and reduced statewide emissions.

However, the GTSR legislation (SB 43) specifically requires that the allowances be retired from CARB's VRE reserve. On the other hand, there is no statutory requirement for the VRE reserve itself and CARB has expressed no intent or interest in reviving the VRE program. CARB's policy position on VRE was articulated in its 2011 Statement of Reasons for its final Cap-and-Trade ruling (CARB, 2011a), in which staff rejected stakeholder arguments that there should be no predetermined quantity or time limits on the VRE allowance set-aside. CARB characterized the VRE program is a short-term "transitional strategy", which should not continue past 2020:

> "We believe that allowing voluntary renewable electricity to retire allowances is a transitional strategy. … We make a temporary exception for voluntary renewable electricity so that during the early years of the cap-and-trade program, the voluntary market can continue to sell its product as something that reduces GHG emissions. … As allowance prices rise, and assuming that the cost of renewable electricity will continue to fall, electricity end-users will have increasing economic incentives to purchase electricity that is not subject to a carbon price, including voluntary renewables. …"

This reasoning fails to recognize that ratepayers might not be motivated by "economic incentives" to reduce their carbon footprint. Moreover, the economic incentives of rising allowance prices would only motivate use of renewable electricity sufficient to achieve CARB's statewide emissions cap; there is no incentive for overcompliance.

[4] Author's communication with CARB staff, May 4, 2022: Jessica Gordon, Senior Attorney; Mario Cruz, Chief of CARB's Climate Investments Branch; Mark Sippola, Manager – Allowance Allocation and Emissions Leakage.

CARB's policy statement implicitly rejects the right of individuals to eliminate their carbon footprint (at their own expense) or to reduce their carbon footprint beyond minimal statutory requirements.

The CPUC currently has no apparent strategy for continuing the GTSR program without the VRE reserve (Johnson K. C., 2022), and the future of the program is uncertain. But the sunsetting of CARB's VRE program presents an opportunity to establish a more firmly grounded policy framework for VRE certification, which will ensure that VRE purchases materially affect statewide emissions. VRE programs could perhaps include allowance retirement (or allowance value crediting) for residential solar power, which has become less economical with the adoption of California's new Net Metering 3.0 rules (Cart, 2022).

4.3. Local Climate Action Plans

Cap-and-Trade has broad implications for municipal and regional climate initiatives such as San Diego City's recently enacted Climate Action Plan (CAP) targeting net-zero by 2035 (City of San Diego, 2022). CARB's Scoping Plan says "California encourages local jurisdictions to take ambitious, coordinated climate action at the community scale; action that is consistent with, and supportive of, the state's climate goals" (CARB, 2022a, page 268). But in the context of Cap-and-Trade, such actions would have no impact on statewide emissions in capped sectors unless they somehow influence the number of emission allowances in circulation. This was explained in a publication co-authored by Dallas Burtraw, the Chair of the Independent Emissions Market Advisory Committee (IEMAC, 2023a), which advises CARB and the California legislature on climate policy. This explanation pertains to the Regional Greenhouse Gas Initiative (RGGI, 2023) but is equally applicable to California:

> "Additional actions may be taken by cities, states, companies, or individuals to reduce emissions associated with electricity consumption based not on the price of CO2 emissions but for other environmental reasons. These additional efforts lead to an economic benefit for all RGGI states in the form of lower allowance prices, but they do not yield additional emissions reduction benefits. We refer to this as the 'waterbed effect.' Reducing emissions in one place simply makes available allowances to emit CO2 in another place. … The waterbed effect undermines the incentive for environmentally motivated cities, states, companies, and individuals to take actions to reduce emissions associated with electricity consumption as any such actions may yield no climate benefit." (Burtraw et al., 2017)

Additional climate actions under Cap-and-Trade lead to an "economic benefit … in the form of lower allowance prices" only to the extent that they fail to yield an environmental benefit in the form of lower aggregate emissions, contrary to the expectations and intent of entities who take such actions.

The "waterbed effect" is well-known in economics literature, particularly in connection with the EU-ETS (Edenhofer et al., 2017; Perino, 2018; Rosendahl, 2019; Perino, 2019; Eichner and Pethig, 2019; Schmidt, 2020; Perino et al., 2022; Flachsland et al., 2020) and the interaction of federal Cap-and-Trade programs with state and local climate policies (Goulder and Stavins, 2011; Shobe and Burtraw, 2009). But a 2016 study of CAPs in California found that CAP administrators are generally oblivious to the waterbed effect (which is referred to as "handcuffing" in the paper) (St-Louis and Millard-Ball, 2016). The study found that "… the limitation of cap-and-trade on the city's ability to reduce aggregate emissions is not addressed in any of the 72 Californian [climate action] plans reviewed" and it further found that "cities are not dramatically changing their behavior in response to handcuffing". That behavior probably manifests a misinformed and erroneous expectation that local climate action will result in reductions in statewide and global emissions additional to state mandates. CARB's Scoping Plan does nothing to dispel that misconception, and the waterbed effect is given scant attention in IEMAC reports to the Legislature and CARB. (The 2022 report briefly discusses the waterbed effect in relation to interactions between California's Cap-and-Trade program and the federal Inflation Reduction Act of 2022 (IEMAC, 2023b).)

The waterbed effect is not inadvertent or unintended; it is a deliberate consequence of the policy premises and rationale underlying Cap-and-Trade. As a generic policy instrument, Cap-and-Trade is not intended and does not operate to incentivize the "maximum technologically feasible and cost-effective greenhouse gas emissions reductions"; neither does it operate "in a manner that … encourages early action to reduce greenhouse gas emissions." Its priority objective is to achieve a predetermined emissions target at minimum cost. The benefits of unanticipated market opportunities, whether from economic conditions, technology advances, or local and individual climate actions, are channeled toward reducing compliance costs, not toward further reducing emissions.

The implicit economic rationale for favoring cost reductions over emissions reductions is that no further reduction in emissions is needed. The cap supposedly guarantees attainment of a defined environmental objective, so supplemental local and individual climate actions are pointless and superfluous. This conceptualization of Cap-and-Trade is an academic idealization of cartoonish simplicity, which is not grounded in reality. The California legislature's and CARB's climate policies do not prioritize environmental certainty over cost acceptability; their policies provide no guaranteed assurance of attaining global climate stability or any specific sustainability goal; and additional climate actions by individuals, corporations, and local municipalities are undertaken to help achieve what the state government is unable to do on its own. A state regulatory policy that operates to actively undermine and nullify such actions is fundamentally flawed and irrational, and it contravenes the AB-32 maximum-reduction and early-action mandates.

5. Economic and legislative policy coherence

5.1. Prices vs. quantities

The economic policy foundation of CARB's regulations lacks internal coherence and consistency, largely because it tries to use a quantity-constrained regulatory tool – Cap-and-Trade – to implement price-constrained policy objectives.

A variety of adaptive design features – a price floor and ceiling, price containment points, reserve accounts – have been added to California's Cap-and-Trade system to incorporate price constraints and partially overcome its shortcomings. A price floor, for example, could mitigate the waterbed effect: If CARB is unable to find buyers for all of its offered allowances at the auction floor price, then the surplus allowances resulting from additional climate actions will probably also remain unsold. (Or if they are sold at a lower price, then even fewer allowances would need to be bought from CARB.) Similarly, if allowances are selling at the ceiling price, then surplus allowances will likely remain unsold (or would result in fewer sales by CARB) because industry could obtain an unlimited number of allowances at the ceiling price.

In the case that allowances are selling at either the floor or ceiling prices, the auction reverts to a fixed-price sale of allowances, i.e., a carbon tax, and any policy rationale in favor of a price floor or ceiling might equally favor a straightforward carbon tax. The supply of allowances under a fixed-price sale would not be predetermined by CARB; it would be market-determined and could be influenced by independent and complementary climate actions. (The EU ETS has instituted reforms that replace the predetermined emissions cap with a variable cap that is responsive to market demand, like a carbon tax, and the policy objectives of these reforms might be better achieved by using a price floor (Perino et al., 2022; Flachsland et al., 2020), or alternatively, a carbon tax in lieu of Cap-and-Trade.)

Price constraints ameliorate the defects of Cap-and-Trade, but without resolving fundamental deficiencies and logical inconsistencies in California's climate policies, as outlined below.

5.2. The statutory emissions limit is either superfluous or ineffectual

If the statutory statewide emission limit (either the 2020 limit under AB 32, the 2030 limit under SB 32, or the 2045 limit under AB 1279) is feasible and cost-effective, then the requirement is superfluous because it would be superseded by any policy directed toward achieving the required *maximum* technologically feasible and cost-effective greenhouse gas reductions. On the other hand, if the limit is not feasible and cost-effective then the statute is inconsistent. In this case Cap-and-Trade allowance prices would rise to unaffordable levels, but CARB has eliminated this possibility by establishing an allowance price ceiling above which the supply of allowances would be unlimited. (The ceiling was authorized by AB 398 in 2017. It was set at $65 per allowance in 2021, rising by 5% per annum plus inflation, and is $81.50 in 2023 (California Legislature, 2019a; CARB, 2023c). This is comparable to current EU-ETS trading prices (Trading Economics, 2023).) In the event that the price ceiling is imposed, the statutory emissions limit would be ineffectual.

5.3. The cap is neither guaranteed nor sufficient

The primary benefit of Cap-and-Trade, a guaranteed emissions cap, is forfeited by the price ceiling. Even if it were guaranteed, the cap would be of limited value unless it is environmentally sufficient, in which case there would be no need for a price floor. A price floor has been established in recognition of the cap's insufficiency. (The floor was set at $10 per allowance in 2012, rising by 5% plus inflation annually, and is $22.21 in 2023 (California Legislature, 2019b; CARB, 2023d).)

5.4. The price floor level has no clear basis in legislative policy

If the price ceiling is within limits of feasibility and cost-effectiveness then any price floor less than the ceiling will fail to incentivize the maximum feasible and cost-effective emissions reductions. The logic of the AB 32 maximum-reduction mandate implies a price floor equal to the ceiling, in which case Cap-and-Trade would devolve into a carbon tax.

CARB considered a carbon tax (or "fee") alternative in its original Scoping Plan (2011 Supplement (CARB, 2011b)), but many of the policy considerations were not germane to the intrinsic relative merits of Cap-and-Trade and taxes. An apples-to-apples comparison of the policy alternatives would consider a tax or fee equivalent to Cap-and-Trade in all respects except that the price floor is equal to the price ceiling. Issues such as allocation, scope of coverage, point of regulation, etc. can be considered independently of whether Cap-and-Trade or a carbon tax is used.

5.5. The cost-minimization function of cap-and-trade amounts to a policy of procrastination

Allowance trading, cross-jurisdiction linkage, and emission offsets enable industry to minimize marginal compliance costs by using the cheapest available emissions-reduction measures, which favor incremental emissions reductions over foundational technology and energy infrastructure investments. Minimizing near-term costs does not necessarily avoid higher-cost reductions; it just "kicks the can down the road", deferring the more difficult and costly emission reductions to the future. The long-term costs include opportunity costs of deferred technology investment returns and delayed health and safety benefits of renewable energy.

A more proactive regulatory strategy would not seek a homogenized, economy-wide carbon price, but would rather establish separate emission caps or carbon prices for different economic or industry sectors based on limits of feasibility and cost-effectiveness for each individual sector. California's standards-based regulations (e.g., ZEV mandates, Renewable Portfolio Standard, Low Carbon Fuel Standard) take this approach, but they lack incentives for additional emissions reductions beyond minimal statutory requirements.

5.6. Allowance banking contravenes the statutory annual emissions limit

The statutory authorization of allowance banking is inconsistent with the statutory emissions limit, which applies to statewide emissions in a specific year (2020, 2030, or 2045) relative to a specific base year (1990), not long-term average emissions. Cap-and-Trade with banking does not guarantee any specific annual emissions target even if the allowance price ceiling is not limiting.

California achieved its 2020 emissions goal four years ahead of schedule in 2016, in large part due to economic contraction after the 2008–2009 recession (Cullenward et al., 2019; Mastrandrea et al., 2020). The ease with which the target was achieved allowed industry to accumulate a large number of banked allowances (310 million in 2020, according to the Scoping Plan), a clear indication that the regulations had not achieved the "maximum technologically feasible and cost-effective greenhouse gas emissions reductions" in any meaningful sense. Those surplus allowances are not needed for cost containment in future years, given that there is a ceiling on allowance prices.

5.7. The statutory "cost-effectiveness" standard is ill-defined and does not clearly convey the legislative intent

The legislature could unambiguously assert its intent by affirming maximum feasible and cost-effective emissions reductions as the priority legislative policy goal, eliminating the confusion and conflict created by a predetermined emissions limit and by Cap-and-Trade authorization. However, AB 32 provides little guidance on the statutory meaning of "cost-effective", which is defined in the statute as "the cost per unit of reduced emissions of greenhouse gases adjusted for its global warming potential". The definition is ill-formed; it defines an adjective as a noun. What it does make clear is that cost-effectiveness is to be quantified in terms of an emissions price (dollars per MTCO2e). However, the regulatory cost of an emissions-pricing policy (either a tax or Cap-and-Trade) is not simply determined by the emissions price; it is more a function of allocation.

For example, Cap-and-Trade systems typically employ output-based allowance allocation to minimize regulatory costs and impacts on industry competitiveness. A similar allocation method can be applied to an emissions tax (e.g., as in the case of Sweden's NOx emissions charge in the 1990s (Ågren, 2000; Sterner and Isaksson, 2006)). With output-based allocation, the regulatory disincentive (tax) for carbon emissions is partly exchanged for a high decarbonization incentive (subsidy), which makes a higher carbon price feasible. (Regulated entities with lower-than-average emissions could profit from a high carbon price, and consumers would be minimally affected by regulatory costs.) Price stability would also enhance political viability relative to Cap-and-Trade with a comparable but volatile carbon price. Such policies would be politically and economically practicable if only legislators, their economic advisors, and policy advocates could think beyond Cap-and-Trade.

6. An ambitious climate policy paradigm

6.1. $450 per tonne

In developing its strategy for achieving carbon neutrality, California can take inspiration from prior policies that have been most impactful in propelling clean energy development and deployment. One such exemplary policy is Germany's feed-in tariff (FIT) program (Wikipedia, 2022; Appunn, 2022), which played a pivotal role in catalyzing rapid capacity expansion and cost reductions in renewable energy to the point where unsubsidized wind and PV are now the least costly utility power sources (Lazard, 2021). Germany's FIT program demonstrates how technology-forcing price incentives far exceeding California's carbon

trading prices can be practicable if carbon pricing revenue is used to finance decarbonization.

At its outset in the early 2000's, the FIT program subsidized renewable energy at a rate of 45¢/kWh. To translate this into the AB 32 "cost-effectiveness" metric, the subsidy rate would need to be converted into a price per MTCO2e. Assuming that the subsidized renewable power displaced coal power with an emissions intensity of about 1 MTCO2e/MWh (Belozerov, 2021) (and neglecting the relatively small lifecycle emissions of PV power), the 45¢/kWh subsidy corresponded to an emissions price of about $450/MTCO2e, i.e., the marginal regulatory incentive to reduce emissions via substitution of renewables for coal was equivalent to a $450/MTCO2e carbon tax. By comparison, carbon trading prices in California's Cap-and-Trade market have been trending around $30/MTCO2 or lower in 2022 (CARB, 2023d – Summary of Auction Settlement Prices and Results). Would an FIT incentive of $450/MTCO2e have been "cost-effective" according to AB 32?

The emissions price metric provides a good basis for comparing marginal incentives of regulatory alternatives, but what is more relevant to cost-effectiveness is the FIT's financing costs. The FIT was financed by a surcharge on consumer electricity bills initially amounting to 0.56¢/kWh (about 3% of household electricity costs). If the surcharge had been implemented as a carbon tax imposed on ratepayers' consumption of coal power it would have been roughly equivalent to a $5.60/MTCO2e carbon price, much lower than California's carbon floor price. The initially low regulatory cost was possible because renewables comprised only a small fraction of Germany's energy market, the financing costs were distributed over a large ratepayer base, and the surcharge revenue was allocated solely toward financing renewable energy in a specific industry sector (electricity). As renewables gained market share the surcharge increased, even as renewables' energy price plummeted and subsidy rates were reduced, to the point where it was trending between 6 and 7¢/kWh (comparable to a $60–70/MTCO2e carbon price) between 2014 and 2021. (Germany's residential retail electricity rates are much higher than U.S. rates, but the FIT surcharge amounted to only about one fifth of Germany's rates (Appunn, 2022; Mormann et al., 2016).) The surcharge was terminated as of July 1, 2022 to eliminate the disincentive for electrification of Germany's economy (and also to alleviate high energy prices resulting from Russia's invasion of Ukraine). The subsidy continues to be financed from other sources, although the rate has been progressively reduced and was only 5.9¢/kWh as of 2022.

A similar, more recent policy is the U.S. Clean Energy Tax Credit (part of the Inflation Reduction Act of 2022), which subsidizes green hydrogen at a rate of $3 per kg-H2. (U.S. Legislature, 2022; Collins, 2022) "Gray" hydrogen, produced by steam methane reforming, exhibits a production carbon intensity of about 7 kg-CO2 per kg-H2 (Soltani et al., 2014), implying that the subsidy's marginal incentive for substituting green for gray hydrogen is about $430/MTCO2. (If history is any guide, that incentive level will need to be reduced over time to keep the available funding in balance with a burgeoning green-hydrogen market.)

From a practical perspective, the "cost-effectiveness" standard guiding these and other climate-change regulations can perhaps be best defined as "politically and economically practicable". Similar cost-effective price incentive policies could be applied to accelerate nascent low-carbon technologies such as green cement, green steel, sustainable aviation fuel, long-term energy storage, EV conversion kits, etc., which are now at the stage where renewable energy was ten or twenty years ago, and which could similarly see exponential growth catalyzed by effective regulatory incentives. Whether they are structured as feed-in tariffs, feebates, refunded emission payments, government subsidies, etc., the essence of such policies is that they combine the resources of a large ratepayer or taxpayer base to provide initially high (e.g., over $400/MTCO2e) price incentives for emerging decarbonization technologies, declining over time as the technologies gain market share and economies of scale and become less dependent on subsidization.

This contrasts with traditional carbon pricing approaches, which apply an initially low carbon price incentive that gradually increases over time (e.g., by 5% per annum in the case of CARB's allowance price floor and ceiling). A policy-of-procrastination might be rationalized by economists' discounting calculus, which assumes that emissions abatement will be expensive. But the investment potential of clean energy inverts this logic, making early action more valuable than deferred action. Mature clean-energy technologies such as solar PV and wind power, electric vehicles, and energy-efficient appliances can provide lifecycle cost savings without subsidies, and emerging technologies such as clean hydrogen could provide similar benefits with effective early-stage regulatory support. Earlier investment in clean energy will provide earlier and greater long-term compounded dividends, as well as accelerating decarbonization. As clean-energy technologies become price-competitive with fossil fuels, subsidization can be phased out and other obstacles such as financing, regulatory burdens, grid infrastructure, supply chains, labor shortages, consumer education, etc. will need to be overcome to unlock their market potential.

6.2. *The greatest investment opportunity of our lifetime*

A rapid transition of the global economy to green energy will require substantial up-front investment but would have an expected payoff of order $10 trillion (or around $100 trillion if climate benefits are taken into account) (Way et al., 2022). Whoever makes the investment will own the new economy. By default, that would be high-net-worth investors who already own a disproportionate share of society's wealth, but effective public policy could enable people of ordinary means to get in on the "greatest investment opportunity of our lifetime". (Fink, 2022).

A truly transformative climate policy, one that would be replicable on a national and global scale, would be framed as a statewide business plan to leverage the substantial investment potential of clean energy. State and local governments could offer individuals and businesses investment opportunities that would enable citizens to collectively control the scale and pace of state and federal decarbonization efforts (beyond minimal statutory requirements) through their investments. For example, bond auctions could provide microfinancing for home electrification or community solar; utility Green Power tariffs might be structured as equity investments (e.g., in offshore wind power, grid storage, etc.); regulatory fees and surcharges could be structured as investment mandates (e.g., for sustainable aviation (Johnson K. C., 2020)); etc. With such policies, first-movers in climate action could accrue long-term, monetary "decarbonization dividends" far exceeding any "carbon dividends" that could be extracted from moribund fossil-fuel industries.

Engaging consumers as investors would increase the supply of capital for global decarbonization while mitigating wealth concentration and inequality. Government-brokered investment opportunities would enable municipal governments to recycle dividends back into local economies via locally-financed community investments, while reduced reliance on government subsidization could free up resources for supporting economically disadvantaged communities. On the national level, the limitations of consensus politics and partisan polarization could be circumvented by the collective actions of individuals advancing national decarbonization goals through their own investments and personal actions.

Elon Musk has astutely observed that "the government is inherently not a good steward of capital." (Ball et al., 2021) There is some truth to this: If the U.S. Department of Energy had taken equity for the half-billion dollars it loaned Tesla in 2010, its shares would now be worth around $100 billion. Under an investment-based regulatory paradigm, governments acting as fiduciaries or brokers on behalf of citizens would serve the public good by expanding the investment pool for clean energy and facilitating an equitable distribution of wealth.

6.3. Share the wealth

The average household income in California in 2021 was approximately $200,000, but this statistic is biased by high net-worth households. Only 15% of households have incomes over $200,000; 50% are below the median income level of $85,000. Under the no-new-policy Reference Scenario in CARB's Scoping Plan, average incomes are projected to be $247,000 in 2035 and $293,000 in 2045 (in 2021 dollars). The projected distribution of the gain over income classes is not reported by CARB, but if the percentage gains are uniform across income levels, then the projected income change under CARB's Scoping Plan Scenario (Alternative 3) relative to the Reference Scenario has the distribution shown in Table 1.[5]

The income impacts are regressive and would probably be more so under Alternative 1, although the Scoping Plan does not provide projections for alternatives other than Alternative 3. The allocation of Cap-and-Trade auction revenue is intended to mitigate regressive economic impacts ,[6] but the revenue allocation is not accounted for in the household income projections. (Aside from these omissions, there are also inconsistencies in the Scoping Plan projections; e.g., Figures H-21 and H-27 show conflicting projections for Alternative 3. Figure H-21 is based on the "Scoping Plan Scenario" as reported in the November 16, 2022 Final Scoping Plan, whereas Figure H-27 is based on the "Proposed Scenario" as reported in the May 10, 2022 Draft Scoping Plan and carried over into the Final Scoping Plan without revision. CARB cautions that their analysis "may not represent the real world".[7]).

A possible explanation for why high-income households would profit from the regulations while lower-income households incur a loss is that the economic benefits of renewable energy accrue disproportionately to those who can best afford the up-front investment costs. For example, over 90% of vehicle-owning U.S. households could see reductions in their transportation costs by purchasing an EV – if they can afford a new or relatively new car (Vega-Perkins et al., 2023). Also, high-net-worth investors could accrue significant income gains from investments in clean energy.

The regressive impacts of carbon pricing could be mitigated by "cap-and-dividend" or "fee-and-dividend" allocation schemes, which disburse revenue to consumers as an equitable per-capita distribution, but the tradeoff to this form of wealth transfer is increased consumption resulting in higher emissions per capita (Rojas-Vallejos and Lastuka, 2020). Moreover, "carbon dividends" are inherently reliant on continued carbon emissions. The Energy Innovation and Carbon Dividend Act of 2021, a fee-and-dividend initiative introduced in the U.S. Congress (U.S. Legislature, 2021), would have imposed carbon fees starting at $15/MTCO2e in 2021 and rising by $10/MTCO2e each year thereafter under the premise that an ever-rising carbon price is required to counterbalance the high cost of decarbonization. But the carbon dividends that are intended to protect lower-income consumers from such high costs would disappear if the policy actually succeeded in eliminating carbon emissions. Carbon fee-and-dividend proposals (Barnes, 2004; Schultz and Halstead, 2018) are paradoxically modeled after the Alaska Permanent Fund, which keeps the state's citizenry permanently vested in and economically dependent upon fossil fuel extraction by disbursing the state's oil sales royalties as free per-capita dividends (Wikipedia, 2023).

Table 1
Income impacts in California by household income group under alternative 3.

Household annual income in 2020	Percentage of households	Change in household income (2021 dollars)	
		in 2035	in 2045
Less than $50,000	30%	-$662	-$867
$50,000 to $100,000	27%	-$304	-$346
$100,000 to $200,000	28%	+$612	+$952
More than $200,000	15%	+$457	+$578
Average	100%	-$41	0

However, regressive impacts of climate policies can be limited, without stimulating increased per-capita emissions or perpetuating economic dependence on fossil fuels, by applying carbon pricing revenue to subsidize renewable energy. A policy approach similar to Sweden's NOx charge in the 1990s (Ågren, 2000; Sterner and Isaksson, 2006), for example, could create pricing incentives for nascent clean-energy technologies far exceeding any existing or contemplated carbon tax, but declining over time as technology innovation and economies of scale bring down the cost of renewable energy. Consumers would accrue decarbonization dividends in the form of affordable clean energy, which would persist long after fossil fuel use has ceased.

The goals of social equity and climate sustainability are not incompatible; wealth equalization can facilitate decarbonization by making clean energy affordable to those who can least afford it. For example, EVs would take decades to fully displace internal combustion engines even after they have gained 100% share of the new vehicle market (Held et al., 2021), but regulatory incentives for EV conversions could greatly accelerate the pace of decarbonization by making EV technology affordable to low-income vehicle owners who cannot afford a new car. (Ford and GM sell EV crate motors, and the company Transition One in France performs EV conversions at a cost of about $6000 (Jacobs, 2021; Cenizo, 2022; Kuhudzai, 2022; Transition One, 2023).)

EV conversions would likely be more impactful and cost-effective than California's "Clean Cars 4 All" program (CARB, 2023e), which provides grants of up to $9500 for vehicle scrappage and replacement. (This is one of the "California Climate Investments" financed by Cap-and-Trade revenue.) Since 2015 the program has subsidized approximately 15,000 vehicle replacements (CARB, 2023f) (1% of the state's 1.3 million potentially eligible replacement vehicles (CARB, 2023g)), and has reportedly reduced GHG emissions by 85,000 MTCO2e (0.06% of annual statewide transportation emissions (CARB, 2022e)) at a cost of $1090/MTCO2e (CARB, 2022d). Without a guiding standard of cost-effectiveness, policies such as "Clean Cars 4 All" can only provide benefits for very few.

The most cost-effective and impactful climate actions are those that provide a positive return on investment. Middle- and lower-class households could benefit from investments in clean energy brokered by or made on their behalf by state and local governments, for example, by evolving the CPUC's Green Tariff program into an investment fund. In 2020 Green-e certified Voluntary Renewable Electricity sales in California were less than 4 GWh [8] (compared to over 10,000 GWh annual generation from residential solar (EIA, 2023)), but in 2021 VRE demand suddenly spiked and the two major California utilities (Pacific Gas and Electric and Southern California Edison) had to put their Green Power programs on hold while they scrambled to find new generation sources to meet the demand. The CPUC-approved rate formulas that the utilities use to calculate the Green Power tariff had started putting out negative

[5] The data in the first paragraph of Section 6.3 and Table 1 is based on the 2022 Scoping Plan, Appendix H (CARB, 2022a), pages 108–110 and spreadsheet P-4 in the footnote 141 link.

[6] 2022 Scoping Plan, Appendix H (CARB, 2022a), footnote 142 on page 110.

[7] Author's communication with CARB staff, January 19, 2023: Dave Clegern, Public Information Officer, Climate Change Programs Staff stated that "It will be important to note the limitation of the data in the [Scoping Plan] for the analysis you are doing. Otherwise the use of numbers from this Plan without appropriate caveats/limitations will lead readers to believe the analysis is detailed and comprehensive-which it is not."

[8] Author communications, Sept. 30, 2022: Michael Leschke, Certification Programs Director, Center for Resource Solutions (Center for Resource Solutions, 2023c).

numbers because "premium" 100% renewable energy had become cheaper than the utilities' standard energy mix (California Public Utilities Commission, 2021aa).

If VRE premiums again become positive the market demand for VRE could plummet, but if "Green Tariffs" were reformulated as "Green Investments" then demand would likely remain high and stable and utilities could continue to enroll new participants well in advance of new source procurement. Such a program would enable ratepayers to reduce their carbon footprint by acquiring equity shares in the lucrative market for utility-scale wind and PV power, which are about five times less expensive than residential rooftop solar and half the cost of community solar on a Levelized Cost of Energy (LCOE) basis – without subsidies (Lazard, 2021, page 2). (The downscaling of residential solar subsidies under California's new Net Metering 3.0 rules increases the relative investment value of utility-scale renewables for homeowners as well as renters.)

Local governments and Climate Action Plans could achieve environmental and social equity objectives by procuring ownership or equity holdings in renewable energy generation capacity serving their communities. The benefit of local ownership is illustrated, for example, by Silicon Valley Power, a nonprofit utility owned by Santa Clara City, which is able to sell electricity at a retail residential rate of $0.144/kWh while Pacific Gas and Electric, California's largest investor-owned utility, charges $0.338/kWh (Silicon Valley Power, 2023).

7. Conclusion and policy implications

CARB's Scoping Plan summarizes the situation that we now face (CARB, 2022a, page 3):

> "The recent Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) … finds that atmospheric concentrations of CO2 have increased by 50 percent since the industrial revolution and continue to increase at a rate of two parts per million each year. By the 2030s, and no later than 2040, the world will exceed 1.5 °C warming unless there is drastic action. …"

How does the Scoping Plan measure up to the challenge? The last sentence of Appendix H sums it up:

> "Achieving carbon neutrality in 2045 under Alternative 3 will cost California households an average of $6 a month in income [in] 2045."

That's the cost equivalent of two lattes per month. Is this what CARB means by "drastic action"?

Clearly, a fundamental change in mindset is required for California to realistically and rationally respond to the imminent threat of global climate change. First and foremost, California's legislators and their advisers and policy advocates should rise to the challenge by ascribing actionable meaning to the statutory mandate requiring the "maximum technologically feasible and cost-effective greenhouse gas emissions reductions". The reductions cannot be maximized if the emissions target is predetermined by statute.

The limits of feasibility and cost-effectiveness are a moving target; they cannot be predicted in advance with any certainty. A policy paradigm that targets maximum emissions reductions should not be bound by predetermined, incremental and inflexible emission targets (even an interim "net-zero" target); it should be sufficiently adaptable to respond to and take advantage of unforeseen technology advances and market conditions.

Rapid decarbonization of California's economy will require substantial investments, but has the potential to generate much greater long-term investment returns. Carbon prices (or "decarbonization prices" in the form of subsidies) can help to jump-start commercialization of new clean-energy technologies and maintain their economic competitiveness, but regulatory policies should, to the extent possible, leverage the inherent investment potential of renewable energy to sustain renewables' high-volume, long-term growth. Distributional equity should be pursued as a core strategy in a statewide business plan for decarbonization, but "carbon dividends" will only impede the clean-energy transition by keeping beneficiaries vested in and economically dependent upon continued carbon emissions.

A statewide decarbonization project on the scale and scope required for climate stabilization may be too big a job for CARB or the California government to take on without an all-hands-on-deck effort from local municipalities, the business community, and citizens acting on their own initiative. Regulatory policy should accommodate, facilitate, and help coordinate complementary and independent climate actions in support of the state's climate goals; it should not undermine and discourage such actions by nullifying their environmental benefits. A core objective of state policy should be to empower individuals, businesses, communities, and municipalities to influence the scale and pace of decarbonization through their collective actions and investment choices, and to reap the economic dividends accruing from their choices.

The expedient decarbonization of California's economy would only directly impact about 1% of global emissions, but the state's early action in reducing statewide emissions, its support of transferrable clean energy technologies, and its policy leadership could be pivotal in achieving global climate goals.

CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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