Case No. S223603

IN THE SUPREME COURT OF THE STATE OF CALIFORNIA

Cleveland National Forest Foundation; Sierra Club; Center for Biological Diversity; CREED-21; Affordable Housing Coalition of San Diego; People of the State of California,

Petitioners and Cross-Appellants,

vs.

San Diego Association of Governments and San Diego Association of Governments Board of Directors,

Defendants and Appellants.

Court of Appeal of the State of California, Case No. D063288
Superior Court of the State of California, County of San Diego
The Honorable Timothy B. Taylor, Judge Presiding
Case No. 37-2011-00101593-CU-TT-CTL

RESPONDENTS' REQUEST FOR JUDICIAL NOTICE IN SUPPORT OF ANSWER TO AMICI'S BRIEFS

Cox, Castle & Nicholson LLP
*Michael H. Zischke (SBN 105053)
Andrew B. Sabey (SBN 160416)
Linda C. Klein (SBN 270016)
50 California Street, Suite 3200
San Francisco, CA 94111
Ph: 415.262.5100; Fax: 415.262.5199

The Sohagi Law Group, PLC
Margaret M. Sohagi (SBN 126336)
Philip A. Seymour (SBN 116606)
11999 San Vicente Boulevard
Suite 150
Los Angeles, CA 90049-5136
Ph: 310.475.5700; Fax: 310.475.5707

San Diego Association of Governments
Julie D. Wiley (SBN 185699)
401 B Street, Suite 800
San Diego, CA 92101
Ph: 619.699.1900; Fax: 619.699.1995

Attorneys for Defendants and Appellants San Diego Association of Governments and San Diego Association of Governments Board of Directors

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REQUEST FOR JUDICIAL NOTICE

Pursuant to California Evidence Code sections 451, 452 and 459, Defendants and Appellants San Diego Association of Governments and San Diego Association of Governments Board of Directors ("SANDAG") hereby requests that the Court take judicial notice of the exhibits identified below, offered in support of SANDAG's Answer to Amici Briefs, filed concurrently with this request. Authenticity of the exhibits is established through the declaration of Linda C. Klein, which follows this request.

Judicial notice may be taken of "[f]acts and propositions that are not reasonably subject to dispute and are capable of immediate and accurate determination by resort to sources of reasonably indisputable accuracy." Cal. Evid. Code § 452, subd. (h). This includes the existence of relevant published documents reporting scientific data such as the ones at issue in this request. (See *In re Jordan R.* (2012) 205 Cal.App.4th 111, 125 [court took judicial notice of scientific articles and abstracts concerning the effectiveness of polygraphs]; *People v. Smith* (2003) 107 Cal.App.4th 646, 671 [taking judicial notice of scientific articles relevant to the science at issue in a case that were published after the trial court hearing].)

SANDAG requests judicial notice of four documents to be able to fully respond to Amici's claims regarding science and the ability of SANDAG to determine (1) the impact on global climate change from the adoption of the 2011 Regional Transportation Plan/Sustainability Strategy (the "Plan") (see generally Amici Brief from Climate Scientists Dennis D. Baldocchi, Ph.D., et al. ("Climate Scientists")) , and (2) the analysis required to show an agency's role in meeting the state's goal to reduce greenhouse gas emissions eighty percent from 1990 levels by 2050 (see Amici Brief from League of Woman Voters, et al. ("LWV"), at pp. 14–20). Notably both of these arguments rely on extra-record evidence although Amici submitted no request to judicially notice that evidence. (See Climate Scientists at pp. 3–22, fns. 2–13, 15, 18–20, 22, 24–27, 30–39, 43, 44, 46–70, 72, 77–81, 83–85, 87–89, 91; LWV at pp. 17–18, fns. 4–8.) Normally litigation under the California Environmental Quality Act ("CEQA") concerns only the evidence presented to the agency whose decision is challenged. (See *Western States Petroleum Ass'n v. Superior Court* (1995) 9 Cal.4th 559, 575–78 [refusing to take judicial notice of scientific opinions not presented to the agency].) Courts generally do not admit extra-record evidence because the Legislature directed "that the existence of substantial evidence [to support a lead agency's decision] depends solely on the record before the administrative agency." (*Id.* at pp. 571, 575.) To the extent the court considers Amici's extra-record material, which was not before SANDAG when it adopted the Plan and much of which was published after SANDAG made its decision, SANDAG asks that the court also consider its extra-record evidence responding to Amici's extra-record evidence.

Accordingly, SANDAG requests judicial notice of the following documents:

Exhibit 1: Association of Environmental Professionals, *Beyond 2020: The Challenge of Greenhouse Gas Reduction Planning by Local Governments in California, Draft Whitepaper* (Mar. 16, 2015). This document is relevant to show that the there is no plan to achieve the statewide goal to reduce greenhouse gas emissions eighty percent from 1990 levels and the measures needed to achieve that reduction are largely outside SANDAG's control. This document is judicially noticeable under Evidence Code sections 452, subd. (h).

Exhibit 2: Ramboll Environ US Corporation, San Francisco and Irvine, California, *Achieving GHG Reductions Through California Legislation* (June 2015). This document is relevant to show that the measures needed to achieve the statewide goal to reduce greenhouse gas emissions eighty percent from 1990 levels by 2050 consist of technological and policy changes largely outside SANDAG's control. This document is judicially noticeable under Evidence Code sections 452, subd. (h).

Exhibit 3: Dr. Stephen Schneider, *Understanding and Solving the Climate Change Problem, Climate Policy*, available at http://stephenschneider.stanford.edu/Climate/Climate_Policy/Policy.html as of Nov. 9, 2015. This document is relevant to show that there is scientific uncertainty about the amount of greenhouse gas emissions needed to

produce any particular climate change affect. This document is judicially noticeable under Evidence Code sections 452, subd. (h).

Exhibit 4: Dr. Stephen Schneider, *Understanding and Solving the Climate Change Problem, Climate Science Introduction*, available at stephenschneider.stanford.edu/Climate/Climate_Science/Science.html as of Nov. 9, 2015. This document is relevant to show that there is scientific uncertainty about the exact role changes in land use and transportation patterns will have on global climate change. This document is judicially noticeable under Evidence Code sections 452, subd. (h).

Dated: November 13, 2015

Cox, Castle & Nicholson LLP

By: ______________________

Michael H. Zischke
Attorneys for Defendants and Appellants San Diego Association of Governments and San Diego Association of Governments Board of Directors

DECLARATION OF LINDA C. KLEIN IN SUPPORT OF REQUEST FOR JUDICIAL NOTICE

I, Linda C. Klein, declare,

1. I am an attorney with Cox Castle & Nicholson LLP, counsel of record for San Diego Association of Governments and San Diego Association of Governments Board of Directors ("SANDAG"). I submit this Declaration in Support of SANDAG's Request for Judicial Notice in Support of SANDAG's Answer to Amici Briefs. I have personal knowledge of the matters set forth in this declaration and, if called upon to testify, I could and would testify competently thereto.

   a. Attached as **Exhibit 1** to the RJN is a true and correct copy of a document titled *Beyond 2020: The Challenge of Greenhouse Gas Reduction Planning by Local Governments in California*, which is a draft whitepaper attributed to the Association of Environmental Professionals and dated March 16, 2015.

   b. Attached as **Exhibit 2** to the RJN is a true and correct copy of a document titled *Achieving GHG Reductions through California Legislation*, which is attributed to Ramboll Environ US Corporation and dated June 2015.

   c. Attached as **Exhibit 3** to the RJN is a true and correct copy of a document titled *Understanding and Solving the Climate*

Change Problem, Climate Policy, which is attributed to Dr. Stephen Schneider and was available at http://stephenschneider.stanford.edu/Climate/Climate_Policy/Policy.html as of November 9, 2015.

d. Attached as **<u>Exhibit 4</u>** to the RJN is a true and correct copy of a document titled *Understanding and Solving the Climate Change Problem, Climate Science Introduction*, which is attributed to Dr. Stephen Schneider and was available at stephenschneider.stanford.edu/Climate/Climate_Science/Science.html as of November 9, 2015.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Executed this 13th day of November, 2015 at San Francisco, California.

By: ______________________
Linda C. Klein

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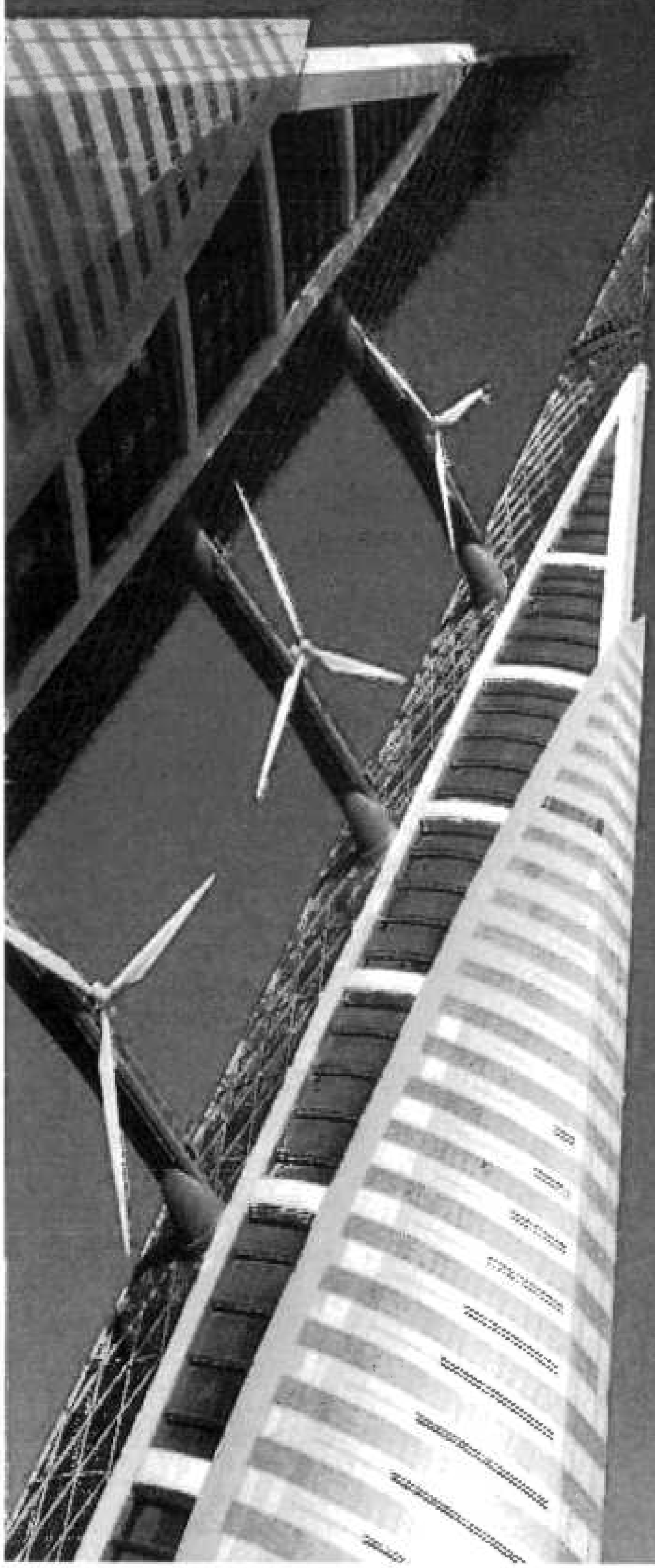
EXHIBIT '1'

EXHIBIT '1'



Association of Environmental Professionals (AEP)

Beyond 2020: The Challenge of Greenhouse Gas Reduction Planning by Local Governments in California
March 16, 2015

Comments on the Draft Whitepaper will be accepted through May 23, 2015. Comments can be email to: aepccc@googlegroups.com

AEP

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AEP White Paper
Beyond 2020: The Challenge for Greenhouse Gas Reduction Planning by Local Governments in California
(V7, 03/18/15)

Prepared by members of the AEP Climate Change Committee. The AEP Climate Change Committee consists of leaders of climate action planning practices from consulting firms that have lead many of the local greenhouse gas reduction planning efforts across California. The Committee focuses on advancing the professional practice of local climate action planning through periodic publication of white papers and conference presentations, as well as interaction with state, regional and local agencies.

AEP White Paper Management
Michael Hendrix, Project Director
Nicole Vermilion, Project Manager

Lead Author
Rich Walter (ICF International)

Contributing Authors
Nicole Vermilion (PlaceWorks)
Dave Mitchell (First Carbon Solutions)
Cheryl Laskowski, Ph.D. (Atkins)
Chris Grey (Fehr & Peers)

Technical Reviewer
Terry Rivasplata (ICF International)

Editor
Susan Scharf

AEP Climate Change Committee
Michael Hendrix, Chair
Chris Gray
Cheryl Laskowski, Ph.D.
Dave Mitchell
Tammy Seale
Nicole Vermilion
Rich Walter

AEP Executive Board
Gene Talmadge (President)
Devon Muto (Executive Vice President)
Christina Ryan (Administrative Vice President)
Lynn Calvert-Hayes (Financial Vice President and CFO)

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Executive Summary

Rich Walter, ICF International

The Post-2020 Challenge for Climate Action Planning in California

Local greenhouse gas (GHG) reduction planning by California's cities and counties has been primarily focused on adopting local measures that are supportive of reaching the GHG reduction target established in The Global Warming Solutions Act of 2006 (Assembly Bill (AB) 32), which calls for reducing emissions to 1990 levels by the year 2020. Similarly, GHG analysis and mitigation for discretionary projects reviewed under the California Environmental Quality Act (CEQA) has been conducted under the rubric of thresholds that are based on consistency with the AB 32 reduction target for 2020.

AB 32 is only a start for GHG reduction planning given that the long-term global imperative to limit the more extreme effects of global warming on climate change will require much more substantial reductions than required by AB 32. Some national governments have identified a long-term goal to reduce their 2050 emissions to a level 80 percent below 1990 levels. This goal is reflected in Governor Schwarzenegger's Executive Order (EO) S-03-05, although not through legislation to date. As 2020 approaches, California legislative attention is starting to turn to the post-2020 period. In addition, legal challenges brought under CEQA to the San Diego Association of Governments (SANDAG) Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS) and the San Diego County Climate Action Plan (CAP)[1] have successfully raised consistency with the EO S-03-05 2050 goal as an issue for CEQA review.

In 2008, the California Air Resources Board (ARB) adopted a Scoping Plan that detailed the main strategies California would use to achieve the AB 32 2020 target, and from which local jurisdictions could identify their role in emissions reduction through 2020. However, there are no true GHG reduction plans anywhere in the world that have adopted enforceable measures to meet the ambitious 2050 targets. Thus, if cities and counties in California intend to prepare GHG reduction plans and conduct CEQA analysis of projects with emissions that go beyond 2020 out to 2050, they will face substantial challenges with long-term emissions forecasting, regulatory uncertainty, reduction target determination, fair-share mitigation determination, and feasibility.

Based on research into pathways to deep GHG emissions reductions by 2050, the changes needed statewide are substantial and severe and would require fundamental changes in California's energy system, many of which are outside the jurisdiction of individual cities and counties. Scenario analysis and a case study presented in this paper highlight how achieving deep GHG emission reductions within California will require a coordinated effort across all sectors of the economy. In nearly all the deep reduction scenarios, the rate of transition—such as deployment of better vehicles, or renewable electricity—far exceeds the historical rate of change in California (State) to date. This adds a measure of uncertainty for local jurisdictions seeking to understand their role in GHG reductions within a context of shifting technologies, energy/technology prices, and regulations.

[1] "Climate Action Plan" or "CAP" is a term of art commonly used to refer to a local greenhouse gas reduction plan. Some CAPs also include a plan for adaptation to expected climate change. Some jurisdictions use "Greenhouse Gas Reduction Plan" instead. In this white paper the terms are used interchangeable in relation to greenhouse gas reductions.

Given these uncertainties—which increase as one proceeds from 2020 out to 2050—local GHG reduction planning will need to include a range of potential scenarios to help civic entities better understand the varying role of local GHG reductions compared to GHG reductions from State and federal policy.

The Role of CEQA

The CEQA Guidelines offer two paths to evaluating GHG emissions impacts in CEQA documents:

- Projects can tier off a "qualified" GHG Reduction Plan that establishes thresholds of significance (CEQA Guidelines Section 15183.5)
- Projects can determine significance by utilizing a model to calculate GHG emissions and assess their significance (CEQA Guidelines Section 15064.4)

The reduction target embodied in AB 32 for 2020 is the most common thread among the significance thresholds developed to date. AB 32 and ARB's 2008 AB 32 Scoping Plan provide a state-level plan for achieving the statewide GHG emissions target for 2020. The project-level CEQA significance threshold utilized by lead agencies will need to be updated to address post-2020 targets. The logical timing for updating thresholds will be when the State adopts its first post-2020 legislated reduction target, and when ARB has developed a statewide plan to achieve the adopted target.

This paper makes the following recommendations concerning CEQA:

- **Limit CEQA GHG Analysis to the State GHG Planning Horizon based on a State Legislatively Mandated Target.** This paper presents substantial evidence for the infeasibility for a local jurisdiction to meet the 80 percent below 1990 levels by 2050 in the near-to-medium term absent a real post-2020 State plan of action. Thus, requiring compliance with the 2050 goal in EO S-03-05 as a *de facto* significance threshold in CEQA documents is impractical. Nothing is served by establishing an impossible threshold or analyzing impacts so far in the future that they require substantial speculation. Instead, the limit of GHG analysis for CEQA documents should be the current State GHG planning horizon. At present, the only true State reduction plan is the AB 32 Scoping Plan, which only has a verified and quantified reduction plan to 2020. Once the State has a defined plan for 2030, then CEQA analysis and thresholds should shift from the current 2020 horizon to the 2030 horizon. When a post-2030 plan is in effect, the horizon should shift again.
- **Establish "Substantial Progress" as the CEQA significance criteria.** All the thresholds used in CEQA documents in California and all qualified GHG reduction plans used for CEQA tiering are based on meeting or exceeding the reduction targets in AB 32 requiring overall State reductions to 1990 levels by 2020. There are no local GHG reduction plans that have an actual plan to meet a 2050 target of 80 percent below 1990 levels. This paper recommends that Appendix G of the CEQA Guidelines be amended to provide the following new CEQA significance threshold for GHG emissions:
    - *"Does the project impede substantial progress in local, regional, and State GHG emissions reductions over time toward long-term GHG reduction targets adopted by the State Legislature?"*
- **Allow CEQA Tiering from GHG Reduction Plans that make "Substantial Progress" in Reducing GHG Emissions.** The recent (2014) San Diego court rulings have the potential to

deter local jurisdictions from preparing and implementing GHG reduction plans because, effectively, the rulings took away the "carrot" for CEQA streamlining, and created too much uncertainty. To promote CEQA streamlining and encourage local agencies to prepare GHG reduction plans for communitywide GHG emissions, legislation should require that CEQA Guidelines Section 15183.5 be amended to allow for tiering off GHG Reduction Plans that make "substantial progress" toward reducing GHG emissions on a path toward long-term reduction targets, without requiring such plans to meet a 2050 reduction target. This concept is not new and is similar to the language referring to tiering off infill developments using development standards that "substantially mitigate" impacts added to the CEQA Guidelines under Senate Bill 226 (SB 226).

- **Allow Partial CEQA Exemption for CAPs.** There is no exemption or streamlining for Climate Action Plans (CAPs) under CEQA. The analysis within the CEQA documents associated with CAPs is usually highly programmatic and non-location specific, meaning that those CAP elements which do result in potentially significant environmental impacts would still require a project-level CEQA document regardless of the programmatic level analysis. A better planning approach would be to provide a partial CEQA exemption for the CAP adoption. This should be a statutory exemption limiting the scope of CEQA compliance to addressing GHG emissions only, and would eliminate the need to analyze other environmental impacts at the programmatic level, while mandating CEQA evaluation on the project-level elements from the CAP that may have environmental effects of their own. This would retain the ability for CEQA tiering from a qualified GHG reduction plan, and would eliminate an impediment to local CAP development while still ensuring that project level secondary environmental impacts are fully disclosed and mitigated, as required by CEQA compliance.

How then to analyze GHG emissions in CEQA documents for the post-2020 world? Pragmatically, this can be broken down into several different eras. The suggested approaches would depend upon the State enacting enabling legislation along the following lines:

- **The Uncertain Interim: From San Diego rulings (2014) to "AB 32+1" to the "AB 32+1" Scoping Plan**
  - For general plans and multi-phase large projects with post-2020 phased development, CEQA analyses need to consider consistency with the 2020/AB 32 based framework, but also analyze the consequences of post-2020 GHG emissions in terms of their impacts on the reduction trajectory from 2020 toward 2050. A significance determination, as argued in this paper, should be based on consistency with "substantial progress" along a post-2020 trajectory, but should not be based on meeting the 2050 target.
  - CEQA analysis for most land use projects can continue to rely on the current thresholds and current CAPs with 2020 horizons for the immediate future, especially if there is action by the State legislature and ARB in the next few years. The closer we come to 2020 without legislative and ARB action on the post-2020 targets and planning, the more CEQA project analysis will need to analyze post-2020 emissions consistent with "substantial progress" along a post-2020 reduction trajectory toward meeting the 2050 target.
- **The Next Normal: With "AB 32+1" and an "AB 32+1" Scoping Plan**
  - When the Legislature adopts a post-2020 target and ARB develops a detailed, specific, and feasible scoping plan addressing the adopted target, a new framework will be established

for CEQA GHG analysis similar to that which exists in relation to AB 32 and the 2020 reduction target.

- CEQA GHG analyses will need to be completed using thresholds based on the new post-2020 target.
- CEQA tiering of GHG analysis will need to be conducted using CAPs that are consistent with the adopted post-2020 target.
- CEQA GHG analysis of general plans (and large multi-phased projects with long-term future horizons) will need to analyze horizons beyond the adopted target which are similar to the current conditions described above.

- **The Future: A 2050 Legislated Target and a 2050 Target Scoping Plan**
  - The Legislature could adopt a 2030 target in the near-term, but will also adopt a dedicated, long-range 2050 target at some point.
  - In the near-term, any ARB scoping plan for meeting a 2050 target will likely be a general phased approach that will not constitute a detailed, specific, and feasible plan of action like that which exists in the current AB 32 Scoping Plan. Lacking such a State action plan for 2050, CEQA GHG analyses should be based on evaluating project emissions out to the horizon year of state action planning (which may be sooner than 2050), and, as necessary, evaluation of "substantial progress" toward longer-term reduction targets.
  - In time, ARB will develop a feasible and specific plan of action for 2050, though it may be years in coming. At that point, CEQA GHG analysis will need to make adjustments in order to be based on fully evaluating project emissions for consistency with a 2050 plan of action.

The Role of General Plans

In the post-2020 period, there will be increasing pressure to include ambitious policies to reduce GHG emissions within general plans. Given past history, it is likely that pressure groups will continue to use CEQA lawsuits, GHG emissions, and the need for long-term reductions to gain leverage in an attempt to force local jurisdictions to modify general plans to reflect their desired outcomes. As we shift from 2020 targets to 2030 targets and beyond, many people will be looking to general plans to ensure that land use planning reflects the current State target(s) and milestones for GHG emission reductions.

This paper makes the following recommendations concerning general plans:

- **Coordinate General Plans and Climate Action Plans.** With ever-increasing GHG emissions reduction ambitions, general plans and CAPs must be brought into better and closer alignment in order for local GHG reduction measures to have sufficient rigor, support, enforcement, and monitoring to ensure that they are effectively implemented.
- **Limit Planning Horizons to 20 years for General Plan CEQA Analysis to Better Match Regional Planning Horizons**. Legislation should require the CEQA Guidelines to be amended specific to general plans, to allow for impacts to be analyzed over the same planning horizon required for other regional planning tools such as water supply/demand, and transportation planning.

The Role of Climate Action Plans

The local target setting process for CAPs for 2020 has provided important lessons that can be applied to setting targets in coming years. Most CAPs have included targets for 2020, and some discuss reductions to achieve a trajectory for 2050, but 2020 has been the primary focus on identifying reduction measures.

The 2014 AB 32 Scoping Plan Update states the following:

> *"Local government reduction targets should chart a reduction trajectory that is consistent with, or exceeds, the trajectory created by statewide goals. Improved accounting and centralized reporting of local efforts, including emissions inventories, policy programs, and achieved emission reductions, would allow California to further incorporate, and better recognize, local efforts in its climate planning and policies."*

Achieving a reduction trajectory that is consistent with or exceeds a statewide trajectory is not a straightforward process. The circumstances in each community vary tremendously due to differing growth rates, climate, existing built environment, economic health, and local community and political preferences.

Currently, it is extremely difficult for a lead agency or project to fully achieve a local post-2020 target in the absence of a statewide plan to achieve a post-2020 target. While there are GHG reduction plans that do include a post-2020 target, those emissions reductions are subject to uncertainty and speculation about the amount of reductions that can be attributed to State and federal reductions beyond 2020. In the absence of a post-2020 target passed by the Legislature, the question that will become increasingly important for local GHG reduction planning is whether showing progress to achieve post-2020 goals is sufficient, or whether the GHG reduction plan must actually achieve the 2050 target even in the absence of a State legislative target or plan for a particular milestone.

This white paper provides sector-by-sector considerations for local GHG emissions reduction measures in the post 2020 period. While not comprehensive, this review is intended to provide ideas for different strategies that can be applied in a post-2020 world.

This paper makes the following recommendations concerning Climate Action Plans:

- **Adopt Post-AB 32 Targets.** The California Legislature should take action to adopt 2030 (or 2035) and 2050 GHG reduction targets that have the force of law throughout the State. There is no State plan to achieve 80 percent below 1990 levels by 2050 (or an interim goal for 2030), and consequently there is no guidance on a framework by which a local jurisdiction can understand its fair share to be addressed through local GHG reduction planning.
- **Initiate ARB Planning for 2030 and 2050.** Concomitant with legislative action, ARB should prepare a plan to achieve the selected legislative target for 2030 with a detailed analysis by measure and sector of the GHG reductions achievable through State policy and initiative. This extended scoping plan can create the context within which local and regional governments can evaluate and identify their fair-share role.
- **Create 2030 to 2050 Scenarios/Calculators.** California should create a 2050 California calculator to inform Californians as they face the 2050 challenge in the coming years. Such a calculator should be prepared not only for the State as a whole, but should be extended to allow jurisdictions to examine their local emissions, as well applying different scenarios. Given

the need for interim target planning toward 2050, the models should also include interim year markers of 2030, 2040, and 2050.

"Walking to Run"

This paper argues that the prudent approach for local GHG reduction planning is to focus on realistic and achievable GHG reductions under the control and/or substantial influence of local governments themselves, and to do so in the current context of State (and in the future possibly federal) GHG reduction planning. Local GHG reduction planning will need to become increasingly more ambitious on a phased basis. CAPs should be updated and expanded periodically to reflect the emerging broader framework for deeper future reductions. The test for local CAPs and associated CEQA practices concerning GHG project analysis should be whether local action and project mitigation is resulting in reasonable local fair-share of GHG reductions over time, and which show "substantial progress" toward the long-term State reduction targets.

I. Introduction

Rich Walter, ICF International

Problem Definition

Local GHG reduction planning by cities and counties in California has been primarily focused on adopting local GHG reduction measures that are supportive of reaching the 2020 GHG target established in Assembly Bill (AB) 32 to limit emissions to 1990 State levels. Similarly, GHG analysis and mitigation for discretionary projects reviewed under CEQA has been conducted under the rubric of thresholds that are based on consistency with AB 32 reduction goals for 2020.

AB 32 is not the end but the beginning of GHG reduction planning, given that the long-term global imperative to limit the more extreme effects of global warming on climate change will require much more substantial reductions out to 2050. Those goals are most commonly defined as reducing developed world emissions to a level 80 percent below 1990 levels (as reflected in Executive Order S-03-05).

As 2020 approaches, legislative attention is starting to turn to the post-2020 period. In addition, legal challenges brought under CEQA to the San Diego Association of Governments (SANDAG) Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS), and the San Diego County Climate Action Plan (CAP)[2], have successfully raised consistency with 2050 reduction goals as an issue for CEQA review.

There are no true GHG reduction plans anywhere in the world that have adopted enforceable measures to meet the ambitious 2050 targets.

As local cities and counties in California prepare GHG reduction plans and conduct CEQA analysis of projects with emissions that go well beyond 2020 out to 2050, they will face substantial challenges which include, but are not limited to, the following:

- **Long-term Emissions Forecasting**. Forecasting for a point 35 years in the future is fraught with issues, uncertainties, and potentially large margins of error. One need only look at the pre-2008 forecasts for population, housing, and economic conditions (compared to actual conditions during and after the following recession) to understand how profoundly socioeconomic forecasts can change. Forecasting to 2050 requires numerous assumptions about the energy and transportation systems related to energy use and related GHG emissions. For example, how GHG-intensive will electricity be? What will energy prices be? What will the regional transportation network look like? Assumptions must also be made about technology: What types of vehicles will be in use? What kinds of transportation fuels will be readily available? What will be the feasibility of local-level renewable energy generation and storage technologies?
- **Regulatory Uncertainty**. With the passage of AB 32, a legally enforceable statewide goal for GHG emissions reductions was established. The AB 32 Scoping Plan defined how the State

[2] "Climate Action Plan" or "CAP" is a term of art commonly used to refer to a local greenhouse gas reduction plan. Some CAPs also include a plan for adaptation to expected climate change. Some jurisdictions use "Greenhouse Gas Reduction Plan" instead. In this white paper the terms are used interchangeable in relation to greenhouse gas reductions.

would meet that goal. A framework of analysis was then developed using the AB 32 target to make significance determinations under CEQA. The development of California's plan to achieve 2020 reduction targets provided a critical context for understanding how the GHG emissions of local projects and plans fit into the overall picture. No such clarity exists for post-2020 since there are no actual plans for achieving 2050 reduction targets, or any milestone between 2020 and 2050.[3] In other words, there is no comprehensive approach (like the AB 32 Scoping Plan) that establishes a framework for collaborative actions by State, local, and regional agencies to meet GHG reduction goals. A local or regional CEQA lead agency is therefore left on its own to ascertain what the State or federal government may (or may not) implement to achieve a post-2020 reduction goal.

- **Target Determination.** The "zero threshold" approach of considering any new GHG emission to result in a cumulatively considerably impact has been rejected by nearly all CEQA lead agencies and practitioners. Instead, current CEQA analyses are examining project GHG emissions in the context of their potential to adversely affect the State's ability to meet AB 32 for 2020. That approach is feasible given that lead agencies can evaluate the State's plan to implement AB 32 for 2020. Those lead agencies can also evaluate their jurisdiction's contributions to GHG emissions and identify the reductions needed on a local level that would meet the AB 32 goal, using the combined effect of State and local action. It would be speculative to predict the impacts of a State or federal action to 2050. Accordingly, one cannot readily complete such a gap analysis for 2050 without massive speculation, and such speculation would further hinder determination of an informed target to guide local actions for 2050.
- **Fair-Share Determination.** Setting aside the challenges with forecasting, regulatory uncertainty, and target determination described above, it is both speculative and problematic to determine what a local jurisdiction's "fair share" of GHG reductions should be for 2050 at this time. Constitutional limitations (*Nollan, Dolan*, etc.) mandate that mitigation must be proportional to a project's level of impact. As noted above, absent an actual State plan to reduce emissions for 2050, it is hard to see how a local or regional plan or project can be fairly assigned the majority of the mitigation burden and still be called "proportional." Local jurisdictions would be flying blind if they were to individually speculate what their fair-shares would be at this point, and would risk unduly burdening their citizens and businesses with disproportionate mitigation responsibilities if they imposed additional mitigation beyond that needed to meet AB 32.
- **Feasibility.** In addition to the fair-share burden issue is the question of feasibility. Technically, there are numerous ways to reduce GHG emissions for new development (see discussion later in this paper). But there are also severe technical challenges to fully achieving substantial emissions reduction. Furthermore, the feasibility of achieving substantial reductions on the order of 80 to 90 percent through local action only is questionable given limitations on local municipality authority. No city or county is completely autonomous in matters of energy and transportation systems. While a municipality can influence certain matters, many decisions about the electricity and transportation systems are under the control of the State and federal government, and/or are controlled by market determinations. To achieve a 2050 goal will require major shifts in how we obtain and use energy, transport ourselves and goods, and how

[3] Executive Order S-03-05 is an executive department goal and is neither a legally enforceable target for private development or local governments nor is it a plan.

we live and build. These transformations would require implementation across all levels of the economy, not just what local jurisdictions have authority over; placing the 2050 burden predominantly on local jurisdictions would thus be highly disproportional, costly, and potentially subject to litigation. Even if offsets are included to overcome potential local mitigation limitations, the purchase and use of offsets would be fraught with uncertainty in terms of how they should be applied and what the legal basis would be for imposing mitigation to be consistent with a 2050 target,

Progress vs. Perfection

"For every problem there is a solution that is simple, elegant, and wrong." - H. L. Mencken

The simplistic answer to the challenges described above is that GHG reduction plans and CEQA documents should use the 80 percent below 2050 target as the metric of evaluation, and should mandate compliance accordingly. This line of reasoning is the subtext of the two CEQA legal challenges in San Diego noted above.

While easy to understand, this point of view is wrong on many levels; notably regarding feasibility, jurisdictional control, economic efficiency, and common sense. As will be explained in detail later in this paper, in order to reach the 2050 reduction target, the California economy would have to undergo a radical transformation in energy usage and control of non-energy emissions. Such a transformation is not feasible in the short run. The reality is that California cities and counties have only limited regulatory tools by which to effect change, not the broader regulatory control over vehicle technology, fuels, and energy systems that is exerted by the State and the federal government. GHG reduction planning to date has shown that relative portfolios of reduction methods employed by local, State, federal governments vary widely. To require that most of the reductions come only from measures within the control of local governments—rather than seeking cost-effective measures over time from every level of control— would result in enormous economic costs. As shown in GHG reduction planning to meet the AB 32 target to date, the amount of expected reductions from State measures fundamentally influences the gap that local jurisdictions often seek to fill through local action. Finally, it makes no sense to insist on a solution to a global problem by pursuing remedies at the smallest levels of organization, i.e., the local jurisdiction for GHG reduction plans and the project by project under CEQA.

Instead, this paper argues that for the 2020 to 2050 period, the fundamental metric for local GHG reduction plans and for project analysis under CEQA should be *substantial progress toward the 2050 target*, rather than *achievement of the 2050 target*. A metric based on steady progress toward a 2050 target will be a better foundation for local support and commitment over time, and would be a key source of support for continued State GHG reduction efforts. Conversely, a metric requiring radical and highly disruptive change over a short period will be much more likely to engender substantial local resistance and organized opposition to local GHG reduction action, resulting in less local support for State GHG reduction plans in the long run.

Be Careful What You Wish For: The Limitations and Perils of CEQA

CEQA is primarily intended to provide disclosure to the public and to decision-makers about the environmental effects of new projects, and to create opportunities for consideration of public input on environmental impacts. CEQA is a poor planning tool for finding and implementing solutions to cumulative impacts that operate on a landscape level, as it is inherently bound to the individual project circumstances of each CEQA review. For example, CEQA review has not resulted in effective solutions to existing regional traffic solutions in congested parts of California, nor has it resulted in effective solutions to existing air quality challenges. The solutions to those problems will be found outside of CEQA.

One of the premises of the San Diego CEQA challenges noted above is that the solutions to regional GHG reductions can and will be found within the CEQA process, which is highly unlikely. Rather than obtaining the long-term results desired by those who brought forward the San Diego challenges, a more likely result is that CEQA processes, if faced with infeasible mitigation and/or alternative demands, will be forced to use larger documents (more EIRs), and make more statements of overriding circumstances. Further, if the opposition to additional GHG reduction mandates were to compel further action on a statewide political level, one could see legislative changes to CEQA to prevent such demands.

While CEQA can be a supporting tool for GHG reductions, it is the premise of this paper that local and regional GHG reduction planning, coordinated and in phase with State planning and action, focused on actions that are realistically under the control and influence of local government, is a preferred approach to ever-increasing and ultimately ineffective CEQA lawsuits.

Slow and Steady Wins the Race

Environmental policy (and most public policy) operates in a dynamic tension between radical change and incremental reform. While there is an unmistakable appeal to bold and rapid change when faced with a profound challenge, like that posed by climate change, that urgency needs to be tempered with the ability of society, the economy, and government entities to adapt to and embrace that change. In the experience of the authors of this paper—who lead GHG reduction planning practices at professional firms that conduct many of the GHG reduction plans, as well as CEQA analysis of GHG emissions in California—local governments will take action when there is 1) a clear context for planning, 2) a balanced and reasonable burden on local jurisdictions (compared to that taken on by the State and federal government), and 3) realistic expectations that have a favorable chance of success.

The CEQA lawsuits in San Diego are the equivalent of hitting a bee hive with a stick to remove the bees and obtain honey. Conversely, leveraging local support and action, with a steady and consistently coordinated approach with State and federal support, is equivalent to the more cautious approach of an experienced beekeeper who understands bee behavior, prepares carefully, and moves slowly and steadily to complete the tasks at hand.

II. Climate Science Background

Rich Walter, ICF International

Scientific studies have demonstrated a causative relation between increasing man-made GHG emissions and a long-term trend in increasing global average temperatures. This conclusion is the consensus of the vast majority of climate scientists who publish in the field. The effects of past increases in temperature on the climate and the earth's resources are well documented in the scientific literature, which is best summarized in the Intergovernmental Panel on Climate Change (IPCC)'s periodic reports, the latest of which is the Fifth Assessment Report, released in 2014 (http://www.ipcc.ch/report/ar5/).

Modeling of future climate change with continued increase in GHG emissions indicates that net substantial adverse effects to both the human environment and the physical environment will increase with the rise in temperatures. Many scientific bodies around the world have concluded that avoiding the most severe outcomes of projected climate change will require keeping global average warming to no more than 2°C (3.5°F), relative to pre-industrial levels (or ~1 °C (2°F) above present levels). While remaining below these levels does not guarantee avoidance of substantial adverse effects, if these levels are exceeded impacts are projected to become more severe, widespread, and irreversible. It should be noted that a global average rise of 2°C means that the center of large continents, including North America, will see temperature increases twice this rate, with even larger increases in the Polar Regions.

In order to have an even[4] chance at keeping global average temperatures to these levels, the concentrations of GHGs in the atmosphere would likely need to peak below 450 ppm carbon dioxide equivalent (CO2e) (IPCC 2014). In order to have an even chance to stabilize GHG concentration at this level, global emissions would have to decline by about 50 percent (compared to 2000 levels) by 2050. Given the more limited capability of developing countries to limit their emissions in this period of rapid economic growth and expansion, estimates are that greenhouse gas emissions in industrialized countries, including the United States, would have to decline by approximately 80 percent (compared to 2000 levels). For the U.S., this target would correspond to approximately 78 percent below 1990 levels (Union of Concerned Scientists 2007). Some estimates assert that industrialized countries may have to reduce emissions by 80 to 95 percent compared to 1990 levels to provide for stabilization at the 2°C increase threshold (IPCC 2007).

The policy shorthand for these estimates has most commonly been a target for industrial countries to reduce their emissions by 80 percent below 1990 levels. This is the level referenced in Executive Order S-03-05, for example, for 2050 (see discussion below). The more short-term GHG reduction targets, such as the AB 32 State reduction target of reaching 1990 levels by 2020, are intended as interim steps to reverse the trend of ever-increasing GHG emissions, and to make substantial progress on the decades-long effort to reach long-term reductions needed by 2050.

[4] "Even" as in a 50 percent chance. In general, a variety of scientific studies, as summarized in the IPCC 2014 Fifth Assessment Report conclude that there is a 50:50 chance of keeping temperature increases below the 2°C/3.5°F increase threshold with GHG concentrations of 450 ppm CO2e.

III. Regulatory Setting

Rich Walter, ICF International; Cheryl Laskowski, Atkins.

In setting expectations for local GHG reduction planning beyond 2020, it is important to review the existing regulatory setting and how it may affect local GHG reductions from 2020 to 2050.

Legislation, Regulation and Other Guidelines

Executive Order S-03-05 (2005)

EO S-03-05 established the following GHG emission reduction targets for California's State agencies:

- By 2010, reduce GHG emissions to 2000 levels.
- By 2020, reduce GHG emissions to 1990 levels.
- By 2050, reduce GHG emissions to 80 percent below 1990 levels.

Executive orders are binding only on State agencies and are not binding on local governments or the private sector. Accordingly, EO S-03-05 guides State agencies' efforts to control and regulate GHG emissions, but has no direct binding effect on local governmental or private actions. The Secretary of the California Environmental Protection Agency (CalEPA) is required to report to the Governor and State Legislature biannually on the impacts of global warming on California, on mitigation and adaptation plans, and on progress made toward reducing GHG emissions to meet the targets established in this executive order.

As described below in discussion of GHG litigation, EO S-03-05 has played a role in recent CEQA court cases in terms of determining the adequacy of GHG project analysis.

Assembly Bill 32-California Global Warming Solutions Act (2006)

AB 32 codified the State's GHG emissions target by requiring that California's global warming emissions be reduced to 1990 levels by 2020. Since its adoption, the ARB, CEC, CPUC, and the Building Standards Commission have all adopted regulations that will help meet the goals of AB 32.

The 2008 Scoping Plan for AB 32 identifies specific measures to reduce GHG emissions to 1990 levels by 2020, and requires ARB and other State agencies to develop and enforce regulations and other initiatives for reducing GHGs. Specifically, the Scoping Plan articulates a key role for local governments, recommending that they establish GHG reduction goals for both their municipal operations and their communities, consistent with those of the State.

The 2014 Update of the AB 32 Scoping Plan reviewed the status of progress toward meeting the AB 32 target for 2020, and it also presented priorities and recommendations for achieving longer-term emission reduction objectives. The 2014 Update includes discussion of a potential GHG reduction target for 2030 of 35 to 40 percent below 1990 levels, but does not specifically recommend a 2030 target, nor does it present an actual plan to achieve such reductions. The Update stipulates that emissions from 2020 to 2050 will have to decline several times faster than the rate needed to reach the 2020 emissions limit (from approximately 1 percent decline per year between 2010 and 2020 to over 5 percent per year between 2020 and 2050).

AB 32 also established the legislative intent that the statewide GHG emissions limit should endure, and should be used to maintain and continue reductions in GHG emissions beyond 2020. ARB is required to make recommendations to the Governor and the Legislature on how to continue reductions of GHG emissions beyond 2020; but it will take an act of the Legislature to legally establish binding statewide GHG emissions targets for the period beyond 2020.

Assembly Bill 1493: Pavley Rules (2002, Amendments 2009, 2012)

Known as "Pavley I," AB 1493 set the nation's first GHG standards for automobiles. AB 1493 required ARB to adopt vehicle standards that lowered GHG emissions from new light duty autos to the maximum extent feasible, beginning in 2009. Additional strengthening of the Pavley standards (previously referred to as "Pavley II," now commonly called the "Advanced Clean Cars" measure) has been adopted for vehicle model years 2017-2025. Together, the two standards are expected to increase average fuel economy to roughly 43 miles per gallon by 2020, and reduce GHG emissions from the transportation sector in California by approximately 14 percent. In June 2009, the EPA granted California's waiver request enabling the State to enforce its GHG emissions standards for new motor vehicles beginning with the current model year.

EPA and ARB worked together on a joint rulemaking effort to establish GHG emissions standards for model-year 2017-2025 passenger vehicles which would lead to a fleet average of 54.5 mpg in 2025.

There are currently no adopted standards for passenger vehicles for after 2025. However, the 2017 mid-term review for Advanced Clean Cars—where ARB, USEPA, and NHTSA will conduct a technical assessment of vehicle technology trends—will inform future light-duty vehicle standards targeted at continuing to achieve GHG emission reductions of about five percent per year through at least 2030.

Senate Bills 1078/107 and Senate Bill 2 (2011): Renewables Portfolio Standard

Senate Bills (SB) 1078 and 107, California's Renewables Portfolio Standard (RPS), obligates investor-owned utilities (IOUs), energy service providers (ESPs), and Community Choice Aggregations (CCAs) to procure an additional 1 percent of retail sales per year from eligible renewable sources until 20 percent is reached, no later than 2010. The California Public Utilities Commission (CPUC) and CEC are jointly responsible for implementing the program. Senate Bill 2 (2011) set forth a longer range target of procuring 33 percent of retail sales by 2020. There is no current RPS requirement for the period after 2020 and thus the 33 percent requirement would remain in place after 2020 pending additional legislation. The current policy affects only the proportion of energy derived from renewables and does not set absolute GHG emission reduction goals. If the other 67 percent of a provider's portfolio is derived from static sources, emissions should reduce over time, but there is no emissions reduction mandate from this standard.[5]

Executive Order S-01-07: Low Carbon Fuel Standard (2007)

EO S-01-07 mandates that (1) a statewide goal be established to reduce the carbon intensity of California's transportation fuels by at least 10 percent by 2020; and (2) a Low Carbon Fuel Standard (LCFS) for transportation fuels be established in California. There is no LCFS requirement for the period after 2020 and thus the 10 percent requirement would remain in place after 2020 pending

[5] Since nuclear and large hydroelectric power are not considered renewable, variations in procurement of these sources of energy relative to fossil fuel-based sources could affect the total emissions from energy, even while achieving the RPS.

additional legislation. However, ARB has identified a priority in the 2014 AB 32 Scoping Plan Update to propose more aggressive long-term targets, such as a 15 to 20 percent reduction in average carbon intensity of transportation fuels below 2010 levels by 2030.

Senate Bill 375: Sustainable Communities Strategy (2008)

SB 375 establishes a planning process that coordinates land use planning, regional transportation plans, and funding priorities that would help California meet the GHG reduction goals established in AB 32. SB 375 requires regional transportation plans developed by metropolitan planning organizations (MPOs) to incorporate a "sustainable communities strategy" (SCS) in their Regional Transportation Plans (RTPs). The goal of the SCS is to reduce regional vehicle miles traveled (VMT) through land use planning and consequent transportation patterns. The regional targets were released by ARB in September 2010. SB 375 also includes provisions for streamlined CEQA review for some infill projects, such as transit-oriented development.

The current goals for VMT-GHG reductions identified by ARB are for 2020 and 2035. However, SB 375 calls for adopting additional goals periodically through 2050, which provides a mechanism for requiring future RTP/SCSs to continue reducing VMT-related GHG emissions all the way out to 2050. The current goals identified for VMT-GHG reductions are focused on reducing per capita VMT-related GHG emissions compared to a nominal 2005 baseline, but they do not mandate an absolute reduction in GHG emissions.

California Energy Efficiency Standards for Residential and Non-Residential Buildings: Green Building Code (2011), Title 24 Update (2014)

California has adopted aggressive energy efficiency standards for new buildings and has continually updated them for many years. In 2008, the California Building Standards Commission adopted the nation's first green building standards, which include standards for many other built environment aspects besides energy efficiency. The California Green Building Standards Code (proposed Part 11, Title 24) was adopted as part of the California Building Standards Code (24 California Code of Regulations [CCR]). Part 11 established voluntary standards that became mandatory in the 2010 edition of the code, including planning and design for sustainable site development, energy efficiency (in excess of the California Energy Code requirements), water conservation, material conservation, and internal air contaminants. The voluntary standards took effect on January 1, 2011. The latest update of the Title 24 energy efficiency standards was adopted in 2012 and took effect on January 1, 2014. While there is no legal mandate that the energy efficiency standards be updated, given past practice, it is probable that Title 24 standards will be periodically updated up to and beyond 2020.

California Public Utilities Commission's Energy Efficiency Strategic Plan

The CPUC has adopted Zero Net Energy (ZNE) goals as part of its long-term energy efficiency strategic plan calling for ZNE for all new residential buildings by 2020, and ZNE for all new commercial buildings by 2030. While not a legal mandate, these goals will heavily influence the periodic updates of the California Building Standards under Title 24.

Greenhouse Gas Cap-and-Trade Program (2013)

On October 20, 2011, ARB adopted a cap-and-trade program for California, which has created a market-based system with an overall emissions limit for affected sectors. The program proposes to regulate more than 85 percent of California's emissions, and will stagger compliance requirements according to the following schedule: (1) electricity generation and large industrial sources (2013); (2) fuel combustion and transportation (2015). The first auction occurred in late 2012 with the first compliance year in 2013. The cap-and-trade program is implemented in support of AB 32. Beyond 2020, the cap-and-trade program is likely to continue to be implemented. Without additional legislation, the legal authority for the cap-and-trade program would be limited to maintain State GHG emissions levels at 1990 levels.

CEQA Guidelines (2010)

The CEQA Guidelines require lead agencies to describe, calculate, or estimate the amount of GHG emissions that result from discretionary projects in their CEQA document. Moreover, the CEQA Guidelines emphasize the need to determine potential climate change effects of a given project and propose mitigation as necessary. The CEQA Guidelines confirm the discretion of lead agencies to determine appropriate significance thresholds, but require the preparation of an environmental impact report (EIR) if "there is substantial evidence that the possible effects of a particular project are still cumulatively considerable notwithstanding compliance with adopted regulations or requirements" (Section 15064.4).

The guidelines were updated in 2010 to address GHG emissions. CEQA Guidelines Section 15126.4 includes considerations for lead agencies regarding feasible mitigation measures to reduce GHG emissions, which may include (1) measures in an existing plan or mitigation program for the reduction of emissions that are required as part of the lead agency's decision; (2)implementation of project features, project design, or other measures which are incorporated into a project to substantially reduce energy consumption or GHG emissions; (3) offsite measures, including offsets that are not otherwise required, to mitigate a project's emissions; (4) measures that sequester carbon or carbon-equivalent emissions, and/or (5) other possible measures.

CEQA GHG Thresholds

A number of air districts have adopted CEQA guidelines including GHG thresholds used for stationary source permitting. Some air districts have also adopted guidelines with recommended (but not binding) GHG thresholds for use in jurisdictions within the air district for land use projects. The County of San Diego has also developed GHG thresholds for use by the County for projects under its jurisdiction.

The methodologies for the different thresholds vary, and may include some or all of the following: (1) mass emissions "bright-line" thresholds; (2) percent reductions below a Business as Usual (BAU) level; (3) efficiency-based thresholds; (4) compliance with a qualified GHG reduction strategy; and (5) Best Management Practices (BMP). Some of the district thresholds include multiple options.

All of the adopted CEQA GHG thresholds are based on the reduction targets in AB 32. None of the adopted CEQA GHG thresholds address reductions targets beyond 2020 or out to 2050.

General Plan Guidelines

The existing California General Plan Guidelines were last comprehensively updated in 2003. A supplement on Community and Military Compatibility Planning was published in 2009 and updated in 2013, and a supplement on Complete Streets and the Circulation Element was published in 2010. The existing 2003 guidelines and military compatibility supplement are silent on the subject of GHG emissions and climate change. The complete streets and circulation element supplement does mention that reducing VMT is an important aspect of meeting the State's GHG reduction effort, but does not elaborate on or describe any specific GHG reduction efforts.

The Office of Planning and Research (OPR) is presently working on an update to the General Plan Guidelines. The update was planned for release in 2014 for public review, but as of March 2015 it has not yet been released. The update is expected to include an extensive overview of the required general plan elements including tips for compliance, best practices, and data resources. In addition to the currently required mandatory elements, the update will reportedly focus on four key areas: Economics, Equity, Climate Change, and Healthy Communities.

OPR-recommended policies in the update will reportedly focus on implementing the vision of the State's "California's Climate Future"—the Governor's Environmental Goals and Policy Report (EGPR)—for which a discussion draft was released 2013. The EGPR acknowledges the AB 32 target and the EO S-03-05 2050 target, and calls for a mid-term emissions reduction target. The EGPR asserts that comprehensive policy approaches are needed to achieve the State's climate change emission reduction and readiness goals, and it identifies five key elements that will make up the State's plan to meet the challenge of climate change.

- Decarbonize the State's energy and transportation systems;
- Preserve and steward the State's lands and natural resources;
- Build sustainable regions that support healthy, livable communities;
- Build climate resilience into all policies; and
- Improve coordination between agencies and improve data availability.

As the General Plan Guidelines update is intended to help implement the EGPR, one can expect additional policy recommendations for general plans in terms of each of these five areas. For example, the EGPR calls for alignment of local general plans with regional sustainable communities strategies (where they exist). The EGPR also calls for environmental metrics to be incorporated at the State, regional, and local level.

OPR also includes a web portal on a "Climate Change/Global Warming Element" that is identified as optional.[6] OPR describes that existing general plan law provides many opportunities for local governments to address climate change, and that many existing general plan policies already reduce GHG emissions and prepare for the impacts of climate change. These existing policies and programs can provide a starting point for communities as they develop comprehensive plans to reduce GHG emissions and consider adaptation strategies. OPR also describes that the general plan structure allows cities and counties to align GHG emission reduction efforts with other community goals, thereby strengthening the long-term sustainability and resiliency of the community and the State.

[6] http://www.climatechange.ca.gov/action/cclu/output2.php?gpElmt=climateChngGlbl

Another resource for city and county planners is the CAPCOA report on Model Policies for Greenhouse Gases in General Plans (CAPCOA 2009). It discusses general plan structure and options for including GHG policies in existing general plan elements, or for creating a separate GHG Element and/or GHG Reduction Plan. The Model Policies Report contains a menu of model language for inclusion in the general plan element(s). The report does not dictate policy decisions; rather, it provides cities and counties with an array of options to help them address GHGs in their general plans.

There have been rumors that the General Plan Guidelines will include much more ambitious recommendations for local jurisdictions in terms of integrating climate change concerns (both mitigation and adaptation), but the extent to which such efforts are required or merely optional within future general plans remains to be seen.

Recent San Diego CEQA Court Rulings

Two 2014 decisions by the California Fourth Appellate District underscore the uncertainty of analyzing GHG emissions under CEQA, and the need for additional guidance in the post-2020 period.

Cleveland National Forest Foundation et al. v. SANDAG

In October 2011, SANDAG adopted the 2050 Regional Transportation Plan and Sustainable Communities Plan (RTP/SCS). The RTP/SCS was the first Regional Transportation Plan that included a Sustainable Communities Strategy, and the first to include the regional per capita VMT-related GHG reduction targets for the passenger and light-duty vehicle sector required under Senate Bill 375 for 2020 and 2035. Subsequently, Cleveland National Forest and the Center for Biological Diversity filed a petition claiming that the SANDAG EIR certifying the RTP/SCS was inadequate.

The petitioners claimed that SANDAG failed to properly analyze (among other issues) GHG impacts. The EIR analyzed GHG emissions and concluded that the RTP/SCS would meet the per capita reduction goals identified by the SB 375 mandate. The EIR concluded that the RTP/SCS would result in a net reduction in VMT-related GHG emissions for 2020, and would not conflict with AB 32. The RTP/SCS included projects beyond 2020 and the EIR disclosed an increase in GHG emissions post-2020.[7] However, the EIR claimed that there were no adopted targets or plans beyond those in AB 32 and SB 375, and therefore concluded that the RTP/SCS did not conflict with any plans to reduce GHG emissions. In 2012, the trial court ruled that the EIR was "impermissibly dismissive of Executive Order S-03-05" in failing to analyze how the RTPs/SCS 2050 GHG emissions related to the 2050 goal of the Executive Order, and in failing to adequately consider transportation mitigation measures accordingly.

SANDAG appealed the lower court decision and in November 2014, a three-judge panel from the Fourth Appellate District issued a two-to-one finding upholding the lower court decision, concluding that the EIR violated CEQA. The majority opinion held that the EIR failed to analyze the impact of the RTP/SCS GHG emissions over time (including its increase over baseline emissions by 2050) on the ability of the State to meeting the 2050 GHG reduction target in EO S-3-05. Of particular interest, the

[7] The EIR indicated that transportation emissions were 14.33 million MT CO2e in 2010 (baseline) and would be 12.04 MMTCO2e in 2020, 12.94 MMTCO2e in 2035, and 14.74 MMTCO2e in 2050 with implementation of the RTP/SCS and State adopted transportation regulations (LCFS + Pavley). The EIR actually disclosed a significant and unavoidable impact for 2050 emissions but did not specifically make any findings relative to consistency with Executive Order S-3-05 which the court took issue with.

majority opinion stated that it did not intend to suggest that the RTP/SCS must achieve the EO's 2050 goal, or any other specific numeric goal, but rather that the EIR should have analyzed consistency with the 2050 goal, including consideration of mitigation. The minority opinion asserted that the EO S-3-05 does not, as argued by SANDAG, constitute a mandate or threshold of significance, as it was not passed by the Legislature. The minority opinion asserted that EO S-3-05 does not have an "identifiable foundation in the constitutional power of the Governor or in statutory law." The minority opinion also described the substantial difficulties in determining a regional fair-share of GHG emissions in the absence of a legislative GHG reduction target for 2050, or without a State plan to achieve any such target.

In December 2014, SANDAG voted to appeal the decision to the California Supreme Court and the Supreme Court decided in March 2015 that it would hear the appeal.

San Diego CAP Lawsuit

In 2011, the County of San Diego prepared and adopted a General Plan Update and Programmatic EIR (PEIR). In the PEIR, mitigation measure (MM) CC-1.2 stated that the County would prepare a CAP to reduce emissions to a less than significant finding. In June 2012, the County of San Diego Board of Supervisors adopted a CAP and GHG significance thresholds, and prepared an addendum to the PEIR as its environmental document. The Sierra Club sued, arguing that the CAP did not comply with MM CC-1.2; that it failed to meet the requirements for adopting thresholds of significance for GHGs; and that it should have been reviewed in a separate EIR document, not an addendum.

In 2013, the Superior Court (the same judge as presided in the trial court of the SANDAG case) ruled in favor of the petitioners, stating that a supplemental EIR was the appropriate environmental document and the CAP did not contain sufficient enforcement rigor for reducing GHG emissions. The County appealed the ruling and in 2014 the Fourth Appellate District affirmed the earlier finding, agreeing the CAP was inadequate by not complying with the requirements of MM CC-1.2. The decision notes that "[t]he County cannot rely on unfunded programs to support the required GHG emissions reduction by 2020;" the "CAP contained no detailed deadlines...acknowledg[ing] that it will not be effective unless it is updated;" and that "the County made an erroneous assumption that the CAP and Thresholds project was the same project as the general plan update." Further, the Court noted that the "County's failure to comply with Mitigation Measure CC-1.2 and Assembly Bill No. 32 and Executive Order No. S-3-05 supports the conclusion that the CAP and Thresholds project will have significant adverse environmental impacts that have not been previously considered, mitigated or avoided." This conclusion, in the Court's opinion, was based in part on the fact that the CAP, which was limited to meeting a 2020 reduction target, did not address the need to further reduce emissions after 2020 sufficiently to support meeting the 2050 target in EO S-3-05.

In December 2014, the County voted to appeal the decision to the California Supreme Court. The Supreme Court decided, in March 2015, to not hear the appeal. Thus the appellate court ruling can be cited as precedent in other CEQA cases. However, since the Supreme Court decided to hear the SANDAG appeal, the Supreme Court may rule on the issue surrounding EO S-3-05 and the 2050 target which could overrule the precedent in the appellate court ring in the San Diego CAP ruling.

Implications of the San Diego Court Rulings

The SANDAG decision marked the first time a California court held that a CEQA lead agency must analyze consistency with EO S-03-05 to have an adequate analysis of GHG emissions; however, this goal was reaffirmed in the San Diego County CAP case. The SANDAG ruling raises a number of questions, including:

- *How should plans analyze emissions beyond 2020?* The court decision did not explicitly state that the EO constituted a threshold, but suggested that the increase in emissions beyond 2020 would be inconsistent with the EO. There is ambiguity in whether maintaining emissions at 2020 levels, ongoing reductions post-2020, or strict compliance with a 2050 target would demonstrate consistency with the intent of State policy through 2050. In the opinion of the dissenting judge in the SANDAG case, this is a role for the Legislature, not the courts.
- *If a plan is consistent with AB 32 but cannot conclude consistency with the EO, can that plan conclude a significant impact?* For CAPs currently being developed, jurisdictions usually demonstrate compliance with AB 32. Some also show reductions beyond 2020, but none have a fully funded plan to achieve 2050 reductions consistent with the EO. If the plan is not consistent with the EO, can the CAP be considered a GHG reduction plan under CEQA Guidelines Section 15183.5? If not, jurisdictions may be dissuaded by the cost of preparing a CAP without the incentive of CEQA tiering from the CAP for individual projects.
- *What are the implications for long-term planning?* As noted by the court, SANDAG was not required to plan out to 2050 in its RTP/SCS. Should agencies avoid long-term planning to avoid the uncertainty in GHG emissions? Near-term GHG reduction goals are easier to attain, due to State and federal legislation to reduce emissions from energy and transportation sectors. Agencies preparing general plans, CAPs, RTPs, and other programmatic documents may opt for shorter planning horizons to feasibly analyze GHG impacts and identify reasonable mitigation measures. For certain documents this approach may work well; however, long-range planning has been used in California to identify goals and policies that guide the physical, economic, and social development of communities or agencies. Identifying major development goals and projects can be beneficial, even for long-term GHG reduction planning, and shortening a planning time could be detrimental. What horizon year would be appropriate is not clear.

The San Diego CAP decision reiterates these questions and also brings new questions to light:

- *What level of enforcement must be demonstrated for GHG reduction measures included in a CAP?* Many CAPs rely solely or primarily on voluntary actions to be taken in conjunction with education and outreach programs, financially incentivized programs, and coordination with agencies that affect emissions within a jurisdiction. Numerous studies demonstrate that reductions can be attained through non-mandatory participation; however, the decision suggests that these may not constitute sufficient evidence for assuring GHG reductions. In addition, suggesting that a CAP cannot rely on unfunded programs would likely eliminate many of the anticipated projects included in a CAP. Certainly this impedes conducting an analysis for reducing emissions over the long term, as most jurisdictions do not have funding identified over the span of several approaching decades.
- *What level of monitoring would be adequate to demonstrate enforceability?* The CAP recognized that some measures may fall short of their anticipated reductions, and therefore the CAP should be updated to account for shortfalls. The CAP also included an annual monitoring and reporting program. However, the CAP did not set a specific timeline for revision, should shortfalls be found. Many CAPs do include language to update the CAP "prior to 2020," but this may be open to scrutiny if the update is not completed adequately prior to 2020 to ensure a 2020 target can be met.

IV. The 2050 Reduction Challenge

Rich Walter, ICF International

Contributing Author: Chris Gray, Fehr & Peers

In order for a local jurisdiction to understand its role in reducing GHG reductions, it is fundamental to understand the potential economic, technological, and regulatory scenarios shaping GHG reductions in the post-2020 period. Academic, government agency, and other research on potential pathways for California to achieve 2050 reduction goals are summarized in this section.

2050 Scenarios

Potential 2050 scenarios from a variety of studies are summarized below. One study (Greenblatt and Long 2012) is reviewed in detail to illustrate some of the variables that drive future scenarios. A comparison of future scenarios overall is then provided based on a recent UC Davis study (Morrison et al. 2014). Subsequent scenarios are reviewed more briefly than the more detailed presentation of Greenblatt and Long (20120), but similar discussion of key drivers can be found in the source study documentation.

California's Energy Future: The View to 2050

Greenblatt and Long (2012) analyzed changes in California's energy systems that would be necessary to reduce emissions to 60 percent and 80 percent below 1990 levels by 2050.

The authors first analyzed what would be needed to achieve a level 60 percent below 1990 levels using energy systems technologies that are available or in demonstration today as summarized below.

- **Increase Efficiency.** All buildings would either have to be demolished, retrofitted, or built new to very high efficiency standards. Vehicles of all sorts would need to be made substantially more efficient. Industrial processes would need to advance beyond technology available today.
- **Require Electrification.** Widespread electrification wherever technically feasible would be required, through the use of hybrid or all-electric vehicle drivetrains, heat pumps for space and water heating, and specialized electric heating technology (microwave, electric arc, etc.) in industrial applications.
- **Use Low Carbon Electricity.** The demand for electricity generation would have to be met with combinations of nuclear energy, fossil fuels with carbon capture and sequestration (CCS), and renewable energy. Emissions from balancing supply and demand at all temporal and spatial scales would also need to be considered.
- **Use Low Carbon Fuels.** As much as possible, the demand for fuel would need to be met with low net lifecycle GHG biofuels.

The authors concluded that with these four strategies it would be technically possible to achieve reductions approximating 60 percent below 1990 levels. However, there are some substantial challenges to implementing these strategies, as explained below:

- **Electricity Supply**. At present, it is illegal to expand nuclear power in California unless a solution to the permanent storage of nuclear waste is resolved. CCS has not been successfully deployed at scale, and is best considered experimental at this time. Scenarios with high fractions of wind and solar energy create more severe challenges for load balancing (i.e., providing power when the wind isn't blowing or the sun isn't shining).
- **Electricity Load Balancing**. Load balancing becomes a more critical issue with increased electrification and increased use of intermittent renewable energy sources. At present, the most feasible load balancing source is natural gas. As a fossil fuel, increased use of natural gas will frustrate emission reduction goals in time. Zero emissions load balancing (ZELB) technologies include electricity storage, flexible demand management, and possibly other strategies. Greenblatt and Long did not analyze the likelihood of achieving any particular technology for accomplishing ZELB, and this issue was identified as clearly deserving of further study.
- **Biomass Fuel Supply**. For transportation and stationary uses that cannot be electrified, Greenblatt and Long state that a substantial increase of biomass-produced fuels will be needed. They estimate that perhaps 13 to 42 percent of the median supply needed could be met from California waste products, crop residues, and use of marginal lands with the remainder from out-of-state and out-of-country sources. The authors note there is substantial uncertainty as to the worldwide supply of biomass fuels and also in calculating GHG intensities for biofuels.

In analyzing what would be needed to achieve a level 80 percent below 1990 levels, Greenblatt and Long examined more radical measures beyond those discussed above in the 60 percent scenario. They list the following ten strategies that could reduce emissions by 80 percent:

- Develop the technology to make CCS 100 percent effective and economical.
- Eliminate fossil fuels with CCS from the electricity mix, and rely only on nuclear energy, renewable energy, or a combination of these sources for making electricity.
- Increase the amount of load balancing that is achieved without emissions from 50 percent to 100 percent.
- Produce biomass with net zero carbon emissions by eliminating net emissions from land use change.
- Reduce energy demand through ubiquitous behavior change.
- Produce hydrogen fuel (from coal with CCS) and use it to reduce fuel and electricity use.
- Burn all domestic biomass with CCS to make electricity with net negative GHG emissions, creating an offset for the required fossil fuel use.
- Increase the supply of sustainable biomass twofold, and use it to make low-carbon biofuels, using feedstocks that best fit efficient conversion to the needed energy mix.
- Gasify coal and biomass together with CCS, and use it to make low-carbon fuels plus some electricity.
- Using CCS, convert biomass to fuels (plus some electricity) with net negative GHG emissions, creating an offset for the required fossil fuel use.

Only the last three strategies are sufficient, on their own, to achieve the 80 percent reduction target (on top of the 60 percent measures). There are myriad theoretical combinations that could achieve the 80 percent reduction target. The authors stress that "the challenges are great for implementing even one of these strategies, let alone several." As an example of the magnitude of challenges, the authors note that, "It is possible to conceive of biomass-derived energy without disastrous impacts on food supply, if the biomass for energy production is limited to marginal lands, wastes and off-season cover crops, but this is not something to take for granted." Another example of challenges the authors describe is that "the widespread availability of CCS is not a foregone conclusion; much development work remains to be done."

As should be evident from this review above, the changes needed statewide are substantial and severe and would represent fundamental change in California's energy system—many of which are outside the jurisdiction of individual cities and counties.

Summary of Other 2050 Scenario Studies

Several other research groups have built integrated energy planning models for California that estimate the future trajectories of technologies, fuels, infrastructure, and/or economic impacts (ARB-VISION – ARB 2012; BEAR-Roland-Holst 2008; CCST – Greenblatt and Long 2012; PATHWAYS - Williams et al. 2012; CALGAPS - Greenblatt 2014; WWS - Jacobson et al. 2014; SWITCH - Nelson et al. 2014; LEAP - Wei et al. 2014; and CA-TIMES - Yang et al. 2014). Morrison et al. (2014) reviewed these studies in detail and the summary below draws directly from their work.

Across models, the BAU 2050 scenarios have a wide range of emissions. The models with the highest BAU GHG emission are those with the highest population and income assumptions. Higher BAU GHG emission means more effort would be necessary to reach the 2050 goals. In scenarios that achieve deep reductions in GHGs by 2050, the GHG emissions with policy interventions also vary widely. Achievable emissions for 2030 in these studies ranged from 8 to 49 percent below 1990 levels and 2050 emissions ranged from 59 to 84 percent below 1990 levels (Morrison et al. 2014).

There are various factors driving the differences between the scenario results. For example, forecasts for market adoption of technologies are based on a diversity of methods. The adoption rate is typically related to an underlying technology review of the literature or forecasts, but the method of application varies. Optimization models also have an additional set of factors that drive their GHG reductions, including the relative costs of mitigation, discount rate, the design of optimization algorithms, and other factors.

Power Sector

Between 2001 and 2013, electricity generation in California (including both in-state and net imports) increased from 267 Terrawatt-hours (TWh) to 296 TWh, and the corresponding renewable fraction of generated energy increased from 14 to 20 percent. Across BAU scenarios modeled in the various long-term scenario studies noted above, the total power generation from in-state and imported electricity ranges from 356 to 389 TWh by 2030, and 429 to 518 TWh by 2050 (Morrison et al. 2014). These results reflect both an increased demand for electricity as well as increased electrification of uses, such as an increased transportation use of electricity.

Renewables

A common result across the long-term reduction scenarios is that the electricity grid shifts towards renewable generation—particularly after 2030—and most end-uses are electrified by 2050. Because some sectors cannot be electrified or are difficult to decarbonize (such as aviation, marine, heavy duty road freight, etc.), GHG emissions from the electricity grid will likely need to be reduced beyond 80 percent to support an overall goal for all sectors of 80 percent below 1990 levels. Across different scenarios, the renewable portion of total generation ranges from 30 to 85 percent by 2030, and 38 to 100 percent by 2050, with the majority of new generation coming from wind and solar. In general, the lower values in these ranges reflect scenarios with greater nuclear and/or CCS use (Morrison et al. 2014).

Nuclear and CCS

California has only one operational nuclear power plant (Diablo Canyon) providing 2.1 GW of power to the State. The permit for the facility expires in 2024 but can be renewed. No new nuclear power plants are under construction or planned. Scenario models differ in their representation of future nuclear power. CCS also has diverse representation across models. All models have at least one scenario with natural gas CCS and some also have coal CCS (Morrison et al. 2014).

Growth Rate of Power Grid

Across scenarios, the implied buildout rate of in-state plus imported renewable electricity (mostly solar and wind) ranges between 0.2 to 4.2 GW per year from 2013 until 2030, with an average of 0.8 GW per year. The renewable build-out rate increases to between 1.5 to 10.4 GW per year from 2030 until 2050, with an average of 3.9 GW per year (Morrison et al. 2014). For perspective, from 2001 to 2013 the renewable capacity used by the State (in-state and imported electricity) expanded by 0.7 GW per year, while non-renewable capacity expanded by 1.6 GW per year (CEC 2014).

Electricity Imports

Models vary in their assumptions about imports, with some assuming California remains a net electricity importer, and others assuming electricity imports are phased out; still others make assumptions about the electricity mix out of State or are neutral regarding the locations of electric generation plants needed to meet California's demand (Morrison et al. 2014).

Passenger Transportation Sector

A standard practice among transportation energy models is to make assumptions about future energy service demand (e.g., statewide VMT) and then allow the model to estimate future fuel mix, vehicle/technology mix, and emissions. The models reviewed by Morrison (2014) all follow this practice. The lower the future demand assumptions, the less the need for low-GHG emitting fuels (Morrison et al. 2014).

For example, in the reduction scenarios cited above, statewide VMT for light-duty vehicles is assumed to change from 293 billion miles per year in 2010 to 226 to 600 billion miles per year in 2050. The range of the various VMT assumptions is a resultant wide variation in the projected energy mix (Morrison et al. 2014).

Total light-duty vehicle energy drops from 2010 to 2030 and again from 2030 to 2050 in deep reduction scenarios in most scenarios due to (1) underlying assumptions about energy service demand decreases in future years, and (2) the improved efficiency of light duty vehicle technology. Across the studied scenarios, petroleum consumption declines 39 to 59 percent by 2030 and 58 to 100 percent by 2050 as the light-duty-vehicle fleet moves primarily to battery electric, plug-in hybrid electric, and hydrogen fuel cell vehicles (although the composition and magnitude of change varies between scenarios). Regardless of the exact fleet composition, hydrogen and electricity with near-zero life-cycle GHGs (e.g., from wind, solar, biomass, natural gas with CCS) is needed to power virtually all of the light-duty vehicle fleet by 2050 (Morrison et al. 2014).

Local jurisdictions have a key role in influencing VMT outcomes given their control over local land use and their influence over placement of new development relative to transit systems.

Contribution from Bioenergy

Across most models reviewed by Morrison et al. (2014), between 4 to 15 billion gallons of gasoline equivalent (BGGE) are available in 2050, up from about 1.0 BGGE today. Most models make simple assumptions regarding the carbon content of bioenergy. Across the scenarios reviewed, bioenergy accounts for a maximum of about 40 percent of transportation energy in 2050. Not all long-term energy modeling assumes that large quantities of biofuels are needed in the transportation sector. The WWS model, for example, presents a vision of 2050 without bioenergy, relying instead on battery electricity and hydrogen for the transportation sector (Morrison et al. 2014).

Non-CO2 Emissions

The relative contribution of non-energy and High Global Warming Potential (HGWP) GHGs to overall emissions levels is likely to increase in the coming decades. Greenblatt (2014) and Wei et al. (2013) find that, absent further policy, these emissions could exceed the 2050 emission goal even if all other emissions are zero (Morrison et al. 2014).

Economic Impacts of Deep GHG Reductions

The economic impact of deep GHG reductions varies greatly across the studies reviewed both in terms of what is assumed and of what is estimated. For those studies that include an estimate of technology costs, the results vary due to assumptions regarding technology availability, costs, learning curves, discount rates, and policy actions. In general, while initial technology and energy infrastructure investment costs are expected to increase in some sectors, the statewide investment in energy efficiency is expected to provide financial savings that can be invested back into the State economy, providing overall economic benefits. Improving energy efficiency also reduces costs to the State by reducing the need to build new power plants or new refineries (Morrison et al 2014).

Estimates of average carbon mitigation cost in dollars per ton of CO2e ($/tCO2e), all converted to 2013 dollars) vary between models, across sectors, and over time. For example, in the CA-TIMES mitigation costs are estimated by technology and year, and range from -$75/tCO2e to +$124/tCO2e between 2010 and 2050. Williams et al. (2012) estimated an average mitigation cost across from 2010 to 2050 of $90/tCO2e (Morrison et al. 2014). For perspective, in California's cap-and-trade program, prices since inception of the program have ranged from $12 to $24/tCO2e.

Valuable co-benefits (e.g., improved air quality, health benefits, etc.) are not captured in many of these estimates. For models that include macro-economic feedback, calculate net savings, or include full accounting of social costs, savings have the potential to offset most or all of the increased technology costs (Morrison et al. 2014).

Case Study of Local 2050 "Gap Analysis:" Sonoma County

ICF International, working for the Sonoma County Regional Climate Protection Authority (RCPA), has completed GHG inventories, forecasts, and future scenario analysis for Sonoma County jurisdictions for potential county GHG emissions from 1990 out to 2050, as part of RCPA's Climate Action 2020 initiative.

1990 and 2010 emissions are based on GHG inventories for those years. 2020 BAU emissions are based on trends in GHG emissions local to the county including the local and regional GHG reduction measures already in place by 2010, as well as on the effect of adopted State emission reduction measures. Future 2040 and 2050 BAU GHG emissions projections are based on forecasted population, employment, and other socioeconomic factors beyond 2020 but exclude any additional State measures beyond those already adopted and any local and regional reduction measures.

ICF conducted a scenario analysis for 2040 and 2050 using two different reduction scenarios based on the work of Greenblatt (2013). The first scenario includes only committed State policies that have been adopted based on Greenblatt (2013) Scenario 1. The second scenario includes State policies that have been considered but are not yet adopted, as well as potential technology and market futures based on current proven technologies, based on Greenblatt (2013), Scenario 3. The second scenario does not rely on any unproven technologies or assumptions about markets or personal behavioral shifts that are thought to be infeasible.

As shown in Figure 1 below, in 2050, based on current committed State policies alone, Sonoma County would have emissions approximately 20 percent below 1990 levels, leaving an additional 60 percent reduction to reach the 80 percent below 1990 level target. As shown in Figure 2 below, in 2050, based on uncommitted State policies and assumptions about technology and market futures, Sonoma County jurisdictions would have emissions approximately 65 percent below 1990 levels, leaving an additional 15 percent reduction to reach the 2050 target.

Based on GHG reduction planning experience with local cities and Counties to date, the local gap beyond State policies to meet the AB 32 2020 target is usually somewhere between 25 and 33 percent, depending on the jurisdiction. What the Sonoma County scenario analysis shows is that the local gap for 2050 is highly dependent on future State (and/or federal) policy actions as well as technological development and market conditions, which will vary substantially from current conditions.

The RCPA and Sonoma County as a whole are examining a regional goal of 25 percent below 1990 for 2020 as part of the current Climate Action 2020 effort. In both Figure 1 and Figure 2 below, the "Sonoma County Path to 2050" shows the effect of the regional goal for 2020 and the substantial contributions that will need to be made by local measures to meet such a goal. Achieving such a goal would place the County in a better position on the path toward 2050 than would simple compliance with the AB 32 goal of 1990 emission levels by 2020.

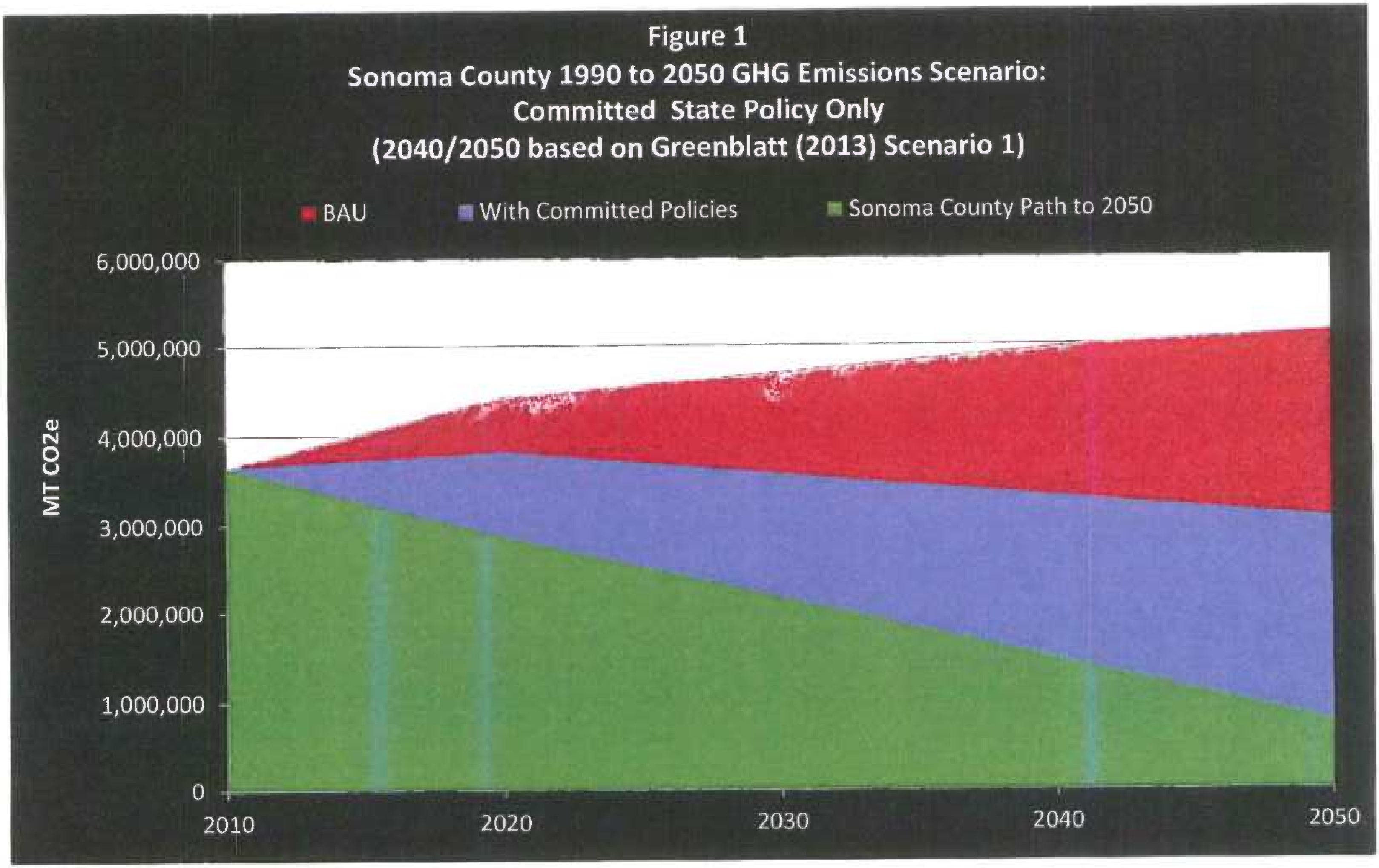
Figure 1
Sonoma County 1990 to 2050 GHG Emissions Scenario:
Committed State Policy Only
(2040/2050 based on Greenblatt (2013) Scenario 1)
BAU
With Committed Policies
Sonoma County Path to 2050
MT CO2e
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
2010
2020
2030
2040
2050

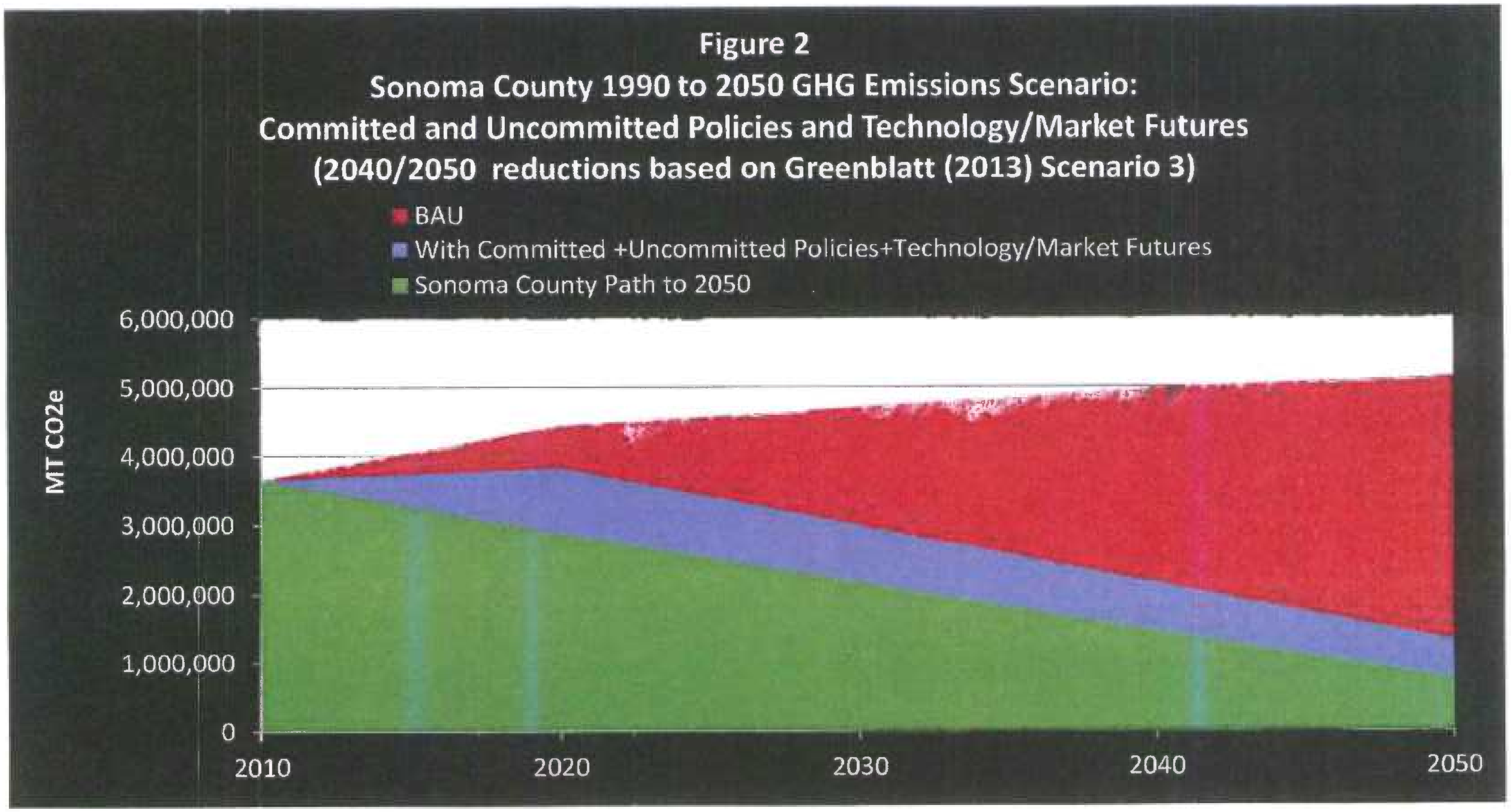
Figure 2
Sonoma County 1990 to 2050 GHG Emissions Scenario:
Committed and Uncommitted Policies and Technology/Market Futures
(2040/2050 reductions based on Greenblatt (2013) Scenario 3)
BAU
With Committed +Uncommitted Policies+Technology/Market Futures
Sonoma County Path to 2050
MT CO2e
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
2010
2020
2030
2040
2050

Post-2020 Transportation Considerations

Regional and local transportation agencies routinely engage in the analysis of post-2020 scenarios in conjunction with long-range planning efforts. Regional agencies such as Metropolitan Planning Organizations (MPOs) plan infrastructure 20 to 30 years in advance using a variety of analytical tools. These long-range infrastructure plans are reflected in the RTPs that guide long-term transportation investment. Local government agencies engage in similar forecasts at the city-level through activities such as the preparation of general plans.

Agencies preparing these long-range forecasts often face three challenges, which introduce a high-level of uncertainty in the process:

- Uncertainty in the preparation of long-term demographic forecasts, which are a key input into any long-range transportation forecasts. Population and employment forecasting, particularly at the citywide level, often require assumptions with a high potential for substantial error.
- Uncertainty regarding transportation costs, which is a key input for travel forecasting. As an example, one can simply look at the history of fuel costs over the past 10 years. In 2008, the national average gas price increased to over $4 per gallon, decreasing in the subsequent year to $1.50, and then increasing to almost $4 again in 2011, with late 2014/early 2015 decreases to close to $2, and a following steady increase in gas prices. Given these changes, it is challenging for any agency to forecast one of the major inputs towards transportation behavior.
- Uncertainty regarding technological innovation. For much of the past 100 years, transportation technology has been focused on automobiles that are manually driven. Within the last 5 years, there have been substantial innovations related to the use of technology for ride sharing through companies like Uber and Lyft. These riding sharing applications have the potential to affect decisions to own and operate automobiles. Another change with an even larger potential for disruption relates to the deployment and use of autonomous and connected vehicles. All of the current automobile manufacturers are currently testing autonomous vehicles for retail sale. The Victoria Transportation Policy Institute (VTPI) predicts that by 2050 nearly half of the total vehicle fleet will be autonomous vehicles. This change is important since autonomous vehicles have the potential to substantially change travel patterns and infrastructure performance. Autonomous vehicles have the potential to operate with substantially reduced headways and increased travel speeds, resulting in far greater roadway capacities.

The typical approach within a transportation study when faced with uncertainty is to develop well-reasoned and documented assumptions for all key input variables. These input variables are then evaluated using robust mathematical models to produce long-range demand forecasts. This same general approach has been applied for 50 years, but only recently have planners made a substantial effort to verify the accuracy of their forecasts. A study of nearly 100 forecasts for roadway, tunnel, and bridge projects commissioned by Standard & Poor (published in Traffic Technology International) determined that the travel forecasts were generally off by an average of 20 to 25 percent when compared to the post-construction traffic counts (Bain 2011). In some instances, the forecasts were less than 80 percent of the observed post-construction traffic volumes based on this same study (Bain 2011)

Because of the uncertainty noted above, it may be tempting to treat post-2020 transportation forecasts in a cursory manner. This approach could be justified by citing the challenges and difficulties in developing reasonable forecasts, but it would be an attempt to sidestep uncertainty rather than embrace it. An alternative approach would be to embrace uncertainty through the use of alternative scenarios that reflect possible changes in variables. Rather than generate a single future estimate of travel demand, a study would instead produce some variation of a low, medium, and high forecast. This approach would provide a range of results which would essentially bracket potential outcomes.

Implications of Post-2020 Scenario Analysis for Local Climate Action Planning

2050 scenario analysis, the Sonoma County case study, and review of transportation forecasting challenges summarized above highlights how achieving deep GHG emission reductions in the State will require a coordinated effort across all sectors of the economy. In nearly all the deep reduction scenarios, the rate of transition—such as deployment of better vehicles or renewable electricity—exceed the historical rates of change in the State.

Potential rates of progress overall (as well as by sector) vary widely in the studies completed to date. In addition, there are inherent uncertainties associated with long-term forecasting. This adds uncertainty for local jurisdictions seeking to understand their role in GHG reductions in a context of changing technologies, energy/technology prices, economic conditions, and regulations.

There is no uniformly accepted source for GHG forecast assumptions and methodology. Future regulations beyond those adopted to support the AB 32 target are uncertain, and thus local jurisdictions at this time can only guess at the actual regulations that may or may not be adopted.

Given this range of uncertainty, which increases as one proceeds further in the post-2020 period, local GHG reduction planning will need to include a range of potential scenarios in order to understand the varying role of local GHG reductions compared to those due to State and federal policy.

Local Climate Action Planning Examples beyond 2020

There are a number of jurisdictions that have already begun planning for GHG reductions beyond 2020. A few examples are presented below.

San Diego County Climate Action Plan

San Diego County adopted a CAP in 2012 that included an analysis and GHG reduction measures to reduce County emissions to 17 percent below 2005 levels by 2020 (San Diego County 2012). Although the CAP has been put on hold reflecting the court ruling in the CEQA lawsuit related to the CAP, the analysis in the CAP of emissions out to 2035 is illustrative.

The CAP included an analysis of GHG emissions and reductions out to 2035, as the CAP was intended to also address buildout of the County's general plan out to 2035. The County developed an emissions target for 2035 that would put the County on a path toward the 2050 goal of 80 percent below 1990 levels, which would be the equivalent for the County of 49 percent below 2005 levels by 2035. Similar to the 2020 analysis, the County developed a framework for reducing emissions by 2035 that worked within the context of the unincorporated County. The measures developed for the 2020 scenario were also used in the 2035 scenario but with increased rates of participation. The

CAP assumes that technology will improve and/or will lower in cost, making measures more feasible for a greater percentage of the population. For example, the residential building retrofit measure, which assumed a feasible participation rate of 15 percent by 2020, was increased to 90 percent participation rate by 2035.

Assuming aggressive but feasible goals, the local actions analyzed by the County showed that they could achieve emissions 14 percent below 2005 levels by 2035. While this does not achieve the 49 percent below 2005 levels reduction target, the assumptions for the 2035 scenario included only current technology and existing State and federal regulations. The CAP described that State and federal actions account for more than 55 percent of the reductions needed to achieve the 2020 goal, but since they are frozen to existing actions, they only account for 34 percent of the reductions needed to achieve the 2035 goal. The CAP identifies that meeting GHG reduction goals beyond 2020 will require even greater participation in existing measures, inclusion of additional measures, guidance from State and federal authorities, additional State and federal regulation, improved technology, and infrastructure changes. The CAP included an alternative 2035 scenario analysis (as an appendix) to demonstrate that the 49 percent reduction target could only be met with additional federal, State, and local measures. Additional measures included achieving 44 miles per gallon average fuel efficiency among *all* on-road vehicles (not just new model years), a 50 percent RPS, and retrofitting all pre-2005 residential units to achieve 35 percent greater energy efficiency. San Diego County intends to revisit the CAP periodically, and update and expand beyond the adopted measures for 2020 over time to support meeting the 2035 target.

San Bernardino Regional Greenhouse Gas Reduction Plan

Twenty-one partnership cities in San Bernardino County working through the San Bernardino Associated Governments (SANBAG) collaborated to create the San Bernardino Regional GHG Reduction Plan (SANBAG 2014) that included customized GHG reduction plans for each participating city to reach city-identified 2020 GHG reduction targets. Collectively, the individual city commitments would result in the region returning to 1990 emissions (approx. 11.5 MMT CO2e) or lower in 2020.

The Regional Plan also includes recommendations for post-2020 GHG reduction planning and action. Beginning in 2018, it is recommended that the partnership cities and SANBAG commence planning for the post-2020 period. At this point, the partnership cities would have implemented the first phases of their local CAPs, and would have a better understanding of the effectiveness and efficiency of different reduction strategies and approaches. The new post-2020 reduction plan should include a specific target for GHG reductions for at least 2030, and if supported by long-term planning at the State level, should also include preliminary planning for 2040 and 2050. The targets should be consistent with broader State and federal reduction targets and with the scientific understanding of the reductions needed by 2050. It is recommended that partnership cities adopt the post-2020 reduction plan by January 1, 2020, which would require cities to start a new inventory/assessment process by 2017 or 2018 at the latest.

The regional plan also included an analysis of emission trajectories for the participating cities out to 2030. To stay on course toward the 2050 target (2.3 MMT CO2e), the region's GHG emissions need to be reduced to approximately 8.4 MMTCO2e by 2030. This translates to an average reduction of 2.9 percent per year between 2020 and 2030, or an additional 3.3 MMTCO2e in reductions during the period 2020 to 2030. An additional challenge comes from the fact that the population in the region (sum of participating cities considered in this analysis) will continue to grow between 2020 and 2030 (estimated population growth in the study is from approximately 1.73 million in 2020 to 1.96 million in 2030). Taking into account population growth, per-capita emissions would need to decrease at an average rate of approximately 0.2 MTCO2e per person per year during the 2020 to 2030 period. The measures needed are logical expansions of the programs recommended in the AB 32 Scoping Plan at the State level, and the measures included in the Regional Plan at the local level. By building on planned State efforts during this period, and ramped up efforts in the local building energy and transportation (and other) sectors on the part of the local governments, the region can be on track to reach a 2050 goal through 2030.

Assumptions about State action were based on an ARB scenario analysis for 2030 included in the 2008 AB 32 Scoping Plan, as follows:

- Expand vehicle efficiency regulations to achieve a 40 percent fleet-wide passenger vehicle reduction by 2030 (approximately double the almost 20 percent expected in 2020).
- Increase California's use of renewable energy in electricity generation (beyond the 33 percent planned for 2020).
- Reduce the carbon intensity of transportation fuels by 25 percent (a further decrease from the 10 percent level set for 2020).
- Increase energy efficiency and green building efforts (so that the savings achieved in the 2020 to 2030 timeframe are approximately double those accomplished in 2020).
- Use a regional or national cap-and-trade system to further limit emissions from the 85 percent of GHG emissions in capped sectors (Transportation Fuels and other fuel use, Electricity, Residential/Commercial Natural Gas, and Industry).

Partnership cities in San Bernardino can do their part to be on track through 2030 to meet the 2050 goal by implementing the following:

- Increase energy efficiency and green building efforts (for city municipal buildings as well as private buildings in the region) so that the savings achieved in the 2020 to 2030 timeframe are approximately 81 percent those accomplished in 2020.
- Continue to implement land use and transportation measures to lower VMT and shift travel modes (assumed improvement of 8 percent compared to the unmitigated condition, which is within SCAG's assumed range of 8 to 12 percent of GHG reductions for 2035).
- Capture more methane from landfills receiving regional waste, move beyond 75 percent local waste diversion goal for 2020, and utilize landfill gas further as an energy source.
- Continue to improve local water efficiency and conservation.
- Continue to support and leverage incentive, rebate, and other financing programs for residential and commercial energy efficiency, and renewable energy installations to shorten payback period and costs and to develop programs that encourage increased use of small-scale renewable power as it becomes more economically feasible.

The conceptual effects of these strategies would represent an approximate doubling of effort for most cities from that planned at the State and city level for 2020. In total, the measures described above would produce reductions to bring the region's GHG emissions to an estimated 8.4 $MMTCO_2e$. While the potential mix of future GHG reduction measures presented in the Regional Plan scenario analysis is only a conceptual example, it serves to demonstrate that the current measures in the AB

32 Scoping Plan and the Regional Plan can not only move the region to its 2020 goal, but can also provide an expandable framework for much greater long-term GHG emissions reductions.

Examples from Outside California

NYC Pathways to Deep Carbon Reductions

New York City (NYC) has committed to reduce its GHG emissions by 30 percent below 2005 levels by 2030 ("30 by 30") as part of its long-term sustainability agenda, PlaNYC. As of 2013, emissions have been reduced by 19 percent and thus the city is approximately two-thirds of its way to the "30 by 30" goal.

NYC conducted a study of potential to achieve deep long-term carbon reductions that is feasible and mindful of economic impacts (NYC 2013). The goal of the study was to examine if it was possible to achieve a reduction to 80 percent below 2005 levels by 2050 ("80 by 50"), and if feasible to identify the lowest cost pathways and highest priority near-term actions needed to reach the 2050 goal. The analysis focused on existing and emergency technologies rather than future technologies. The study also assumed no meaningful price on carbon and a continued lack of comprehensive federal policy.

A summary of the study results are as follows:

- New York City could achieve "80 by 50" but it would be exceptionally difficult.
  - This would require change at an unprecedented and technologically-untested scale.
  - It would require large investments in energy efficiency, cleaner energy sources, wholesale transition to low-carbon transportation technologies, and the transformation of the solid waste sector.
  - Up to two-thirds of the investment could be cost effective, but the rest would yield little to no payback.
  - Market barriers would need to be overcome every step of the way.
- Action on all fronts would be needed.
  - Every section, market segment, and technology application would require action.
- Accelerating near-term action would increase the likelihood of achieving "80 by 50."
  - Meeting the 2050 target would require consistent progress year-in and year-out.
  - Meeting the "30 by 30" target 10 years earlier in 2020 would put the city on the trajectory to meet the 2050 target.
- Abatement potential from 2050 BAU emissions were split among measures as follows:
  - new building energy efficiency (5 percent);
  - existing building energy efficiency (33 percent);
  - building fuel switch from fossil fuels to renewable or low-carbon energy (10 percent);
  - clean power (12 percent);
  - distributed generation (5 percent);

- o transportation reductions through expanded transit and accelerated adoption of cleaner technologies for private and public vehicles (13 percent); and
- o solid waste reductions through source reduction diversion, recycling, and improved waste processing infrastructure (7 percent).

The study describes that although it is theoretically possible, the city could not realistically achieve "80 by 50" by acting alone. Federal and /or regional action would be needed to create a level playing field and send a price signal to the entire marketplace. Unilateral actions, in contrast, could create market distortions and inefficient outcomes. The study also notes that the "80 by 50" target may not be the right goal for New York City, as it is already far more energy efficient than most parts of the United States already.

United Kingdom Pathways to 2050

The 2008 Climate Change Act in the United Kingdom (UK) established a legally binding climate change target to reduce the UK's GHG emissions by at least 80 percent (from the 1990 baseline) by 2050.

The UK government is trying to achieve this reduction through action nationally and internationally. Moving to a more energy efficient, low-carbon economy will help them meet this target. It will also help the UK become less reliant on imported fossil fuels and less exposed to higher energy prices in the future.

To make sure that its government policies contribute effectively to our GHG reduction targets, the UK is[8]:

- setting carbon budgets to limit the amount of GHGs the UK is allowed to emit over a specified time;
- using statistics on GHG emissions and further evidence, analysis, and research to inform energy and climate change policy;
- using the European Union Emissions Trading Scheme (EU ETS) to deliver a substantial proportion of the UK's carbon emission reductions between 2013 and 2020;
- using a set of values for carbon to make sure project and policy appraisals account for their climate change impacts; and
- using the 2050 Calculator to let policy makers and the public explore the different options for meeting the 2050 emissions reduction targets.

The UK is also seeking to reduce the demand for energy by helping people and businesses to use energy more efficiently through the following means by:

- reducing demand for energy with smart meters and other energy-efficient measures for industry, businesses, and the public sector;
- reducing emissions by improving the energy efficiency of properties through the Green Deal[9];

[8] Summary from: https://www.gov.uk/government/policies/reducing-the-uk-s-greenhouse-gas-emissions-by-80-by-2050#background.

- providing incentives for public and private sector organizations to take up more energy-efficient technologies and practices through the CRC Energy Efficiency Scheme[10];
- reducing GHGs and other emissions from transport;
- reducing GHG emissions from agriculture; and
- investing in low-carbon technologies.

Low-carbon technologies will also make an important contribution to UK GHG reduction targets through the following actions:

- taking action to increase the use of low-carbon technologies and creating an industry for CCS;
- reducing emissions from the power sector and encouraging investment in low-carbon technologies by reforming the UK's electricity market;
- providing over £200 million of funding for innovation in low-carbon technologies from 2011 to 2015; and
- Publicly reporting carbon emissions from businesses and the public sector.

Public reporting of carbon emissions helps to encourage organizations to become more energy efficient, and enables us to assess the progress that's being made through:

- measuring and reporting environmental impacts;
- guidance for businesses; and
- asking English local authorities to measure and report their GHG emissions.

While the UK, along with Germany, is one of the international leaders in GHG reduction planning on a national level, even the UK does not have a definitive plan for how to achieve their 2050 target. As noted above, the Department of Energy and Climate Change (DECC) has created a key educational tool, the 2050 Calculator[11], to allow decision makers, the public, and stakeholders to conduct their own evaluation of potential pathways to 2050. The 2050 Pathways work presents a framework through which to consider some of the choices and trade-offs the UK will have to make over the next 40 years. It is system wide, covering all parts of the economy and all GHG emissions released in the UK. It is rooted in scientific and engineering realities, looking at what is thought to be physically and technically possible in each sector. It allows users of the Calculator to explore all the available options and some of their key implications.

It is a key recommendation of this paper that California needs to create a 2050 California Calculator to inform Californians as they face the coming 2050 challenge. Furthermore, this paper recommends

[9] The Green Deal is an ambitious and long term initiative designed to upgrade the energy efficiency of Britain's homes. It lets householders and businesses pay towards the cost of energy-saving improvements to their properties, over time, through savings on their energy bills, using suppliers they can trust

[10] The CRC Energy Efficiency Scheme (or CRC Scheme) is designed to incentivize energy efficiency and cut emissions in large energy users in the public and private sectors across the UK, together responsible for around 10 percent of the UK's greenhouse gas emissions. Participants include supermarkets, water companies, banks, local authorities and all central government departments

[11] The 2050 Calculator is available online here: https://www.gov.uk/2050-pathways-analysis

that such a calculator be prepared not only for the State as a whole, but that the model be extended to allow local jurisdictions to examine their local emissions as well using different scenarios.

V. CEQA, General Plans, and Climate Action Plans for the Post-2020 Horizon

Nicole Vermillion, Placeworks; Rich Walter, ICF International; Dave Mitchell, First Carbon

CEQA Project Analysis in a Post-2020 World

For the purpose of this section, a "project-level" analysis is considered an analysis for any CEQA project with the exception of a CEQA document prepared for a general plan. This white paper includes a separate section on GHG emissions analyses for general plan projects.[12]

The CEQA Guidelines offer two paths to evaluating GHG emissions impacts in CEQA documents.

- Projects can tier off a qualified GHG Reduction Plan (CEQA Guidelines Section 15183.5).
- Projects can determine significance utilizing a model to calculate GHG emissions and assess the significance (CEQA Guidelines Section 15064.4).

This section discusses potential changes in CEQA practice for the post-2020 world.

Tiering Off a Qualified GHG Reduction Plan

CEQA Guidelines Section 15183.5 identifies that programmatic documents such as general plans, long-range development plans, or separate plans (e.g., GHG reduction plans/CAPs) can be prepared by lead agencies to mitigate the GHG emissions impacts within a jurisdiction. If a jurisdiction has adopted a qualified GHG Reduction Plan, then individual CEQA projects that are consistent with the GHG Reduction Plan may have less than significant GHG emissions impacts.

Plans that meet the following criteria are defined as "qualified" GHG reduction plans, eligible to be the basis for CEQA streamlining, as follows:

- Quantify GHG emissions, both existing and projected, over a specified time period, resulting from activities within a defined geographic area;
- Establish a level, based on substantial evidence, below which the contribution to GHG emissions from activities covered by the plan would not be cumulatively considerable;
- Identify and analyze the GHG emissions resulting from specific actions or categories of actions anticipated within the geographic area;

[12] General plans are a long-range planning tool that typically goes beyond the target year for AB 32 of 2020. In addition, a lead agency may integrate the general plan with a GHG reduction plan. Therefore, while specific plans, area plans, and general plans are typically treated as "program" level CEQA documents under CEQA Guidelines Section 15168, CEQA significance thresholds have been developed for general plans separately under a "plan-level" approach.

- Specify measures or a group of measures, including performance standards, that substantial evidence demonstrates would collectively achieve the specified emissions level, if implemented on a project-by-project basis;
- Establish a mechanism to monitor the plan's progress toward achieving the target level, and to require amendment if the plan is not achieving specified levels; and
- Be adopted in a public process following environmental review.

Current CEQA Significance Thresholds Types

Methodology to evaluate GHG emissions impacts in CEQA documents have evolved considerably since GHG emissions became a mandatory component of environmental documents. Yet, there is no single statewide uniformly-applied significance metric used by CEQA practitioners for evaluating GHG emissions. Rather, individual air districts and other agencies, primarily in the larger metropolitan areas, have offered guidance on how to address GHG emissions impacts in CEQA documents.

Although there is no single metric used statewide, there are common themes utilized by air districts/agencies to substantiate the significant thresholds developed. In general, there are three significance metrics that have been developed to identify the threshold at which project-level GHG emissions impacts may be substantial, and therefore, significant:

- **Bright-Line Thresholds.** These are numeric thresholds that assess total GHG emissions generated by a project. The bright-line threshold is typically based on a "capture" rate and a gap analysis, which is tied back to AB 32 targets at a regional level. Projects that generate GHG emissions which exceed this bright-line threshold are typically considered to have a significant GHG emissions impact. Projects that fall under it (with or without mitigation) are less than significant. The bright-line threshold compares the net increase in project-related emissions with existing conditions. The bright-line threshold does not consider the potential efficiencies of large projects or the inefficiencies of small projects. As emissions decline with implementation of GHG regulations, the number of projects below the bright line will increase.
- **Performance Based Thresholds.** These are quantitative thresholds that are based on a percent reduction from a future, projected emissions inventory, without any GHG reduction measures compared to the future, projected emissions inventory with project-specific GHG reduction measures in place.[13] Because the BAU scenario is based on a "future" condition, the level of significance conclusions are not based on the increase in GHG emissions from existing conditions. However, the percent reduction from BAU considers the potential increase in efficiency integrated into a project's design and operation. The performance-based significance threshold stems from the GHG reduction targets of AB 32, and the inventory and/or targets identified in the AB 32 2008 Scoping Plan.
- **Efficiency Thresholds.** These are quantitative thresholds that are based on a per capita efficiency metric. Projects that attain the per capita efficiency target, with or without mitigation, would result in less than significant GHG emissions. The efficiency metric is typically defined as a "service population" (SP), which means people who live and work in the project site. The efficiency metric considers the GHG reduction measures integrated into a

[13] Performance-based thresholds vary on accounting for various federal and State policies that would result in project-level GHG reductions. Some include certain federal and State measures as "baseline".

project's design and operation, and is based on the net increase in emissions, but the significance conclusion is not based on the magnitude of the increase. Like the performance-based threshold, the efficiency-based significance threshold also stems from the GHG reduction targets of AB 32, and the inventory and/or targets identified in the AB 32 2008 Scoping Plan. Most individual projects are not mixed-use and hence often score poorly in terms of SP efficiency, even in mixed-use walkable neighborhoods, unless the analysis accounts for the benefits from neighboring existing and planned development.

As identified above, the target embodied in AB 32 for year 2020 is the most common thread among the significance thresholds developed. Consequently, while quantitative significance criteria differ among air districts/agencies in California, the significance metrics are derived using a similar methodology.

Post-2020 Considerations for CEQA Thresholds

Current California guidance and goals for reductions in GHG emissions are generally embodied in Executive Order S-03-05 and AB 32.

While EO S-03-05 provides a long-term goal for the State for 2020, unlike AB 32, EO S-03-05 is not a Legislative action. Therefore, the long-term goal for 2050 identified in EO S-03-05 has not, to date, carried the same weight in project-level CEQA analyses because the Legislature has not directed the State to provide a plan to reach the 2050 goal, or an interim goal. As noted above, this was a key issue in the SANDAG CEQA lawsuit, which found that the SANDAG EIR should have assessed the project's impact on meeting the EO S-03-05 2050 goal.

CEQA significance criteria for GHG emissions for both projects that identify significance based on consistency with a GHG reduction plan, and projects that utilize the bright-line, performance, or efficiency significance thresholds, are mainly derived from the GHG reduction target embodied in AB 32. However, AB 32 and the AB 32 Scoping Plan only provide a statewide plan for achieving the statewide GHG emissions target for 2020. While AB 32 is the only State legislated reduction target, the GHG thresholds that utilize the AB 32 targets are likely to remain defensible under CEQA, unless the reasoning in the SANDAG ruling becomes widespread practice.

In order to develop post-2020 GHG significance thresholds, the Legislature would need to direct the State to identify an interim goal, and draft and implement a plan to achieve it. This post-2020 plan would be a critical tool in the development of post-2020 GHG reduction targets.[14] Without this tool, it would be difficult for lead agencies to substantiate post-2020 GHG significance criteria. Regardless, at some point the project-level CEQA significance threshold utilized by lead agencies will need to be updated to address post-2020 targets because the current significance thresholds for GHG emissions impacts and GHG reduction plans are primarily based on 2020 targets. The logical timing for updating thresholds will be when the State adopts its first post-2020 legislated reduction target.

[14] Senate Bill 32 (Pavley), Assembly Bill (AB) 33 (Quirk), and AB 21 (Perea) will be considered in the 2015-2016 legislative session. As introduced, these bills propose to require ARB to approve a statewide GHG emission limit that is equivalent to 80 percent below the 1990 level to be achieved by 2050 and authorize ARB to adopt interim GHG emissions level targets to be achieved by 2030 and 2040.

CEQA GHG Analysis Should Change in Concert with State GHG Reduction Planning

In order to identify how to best analyze GHG emissions going forward from 2015, it is useful to review how CEQA GHG analysis has developed since 2006.

- **A Chaotic Beginning: From AB 32 (2006) to the AB 32 Scoping Plan (2008)**
  - With the passage of AB 32 in 2006, CEQA analyses increasingly began to consider GHG emissions, but the method of analysis was somewhat haphazard, inconsistent, and often without any framework for determining significance or developing mitigation.
  - Some early GHG reduction plan developers, including San Francisco (2004) and Marin County (2006), pioneered climate action planning but outside of a context of connecting CAPs to CEQA.
  - Practitioners started to evaluate options for CEQA practice through the AEP White Paper (2007), the CAPCOA White Paper (early 2008), conference presentations, and other methods.
- **Creating the New Normal: From the AB 32 Scoping Plan (2008) to SB 97 (2010)**
  - The adoption of the AB 32 Scoping Plan in 2008, with a specifically articulated role for local jurisdictions in GHG emissions reductions and a framework of State reductions, solidified a foundation for both CEQA analysis and local climate action plans.
  - Using the prior development of methods in the AEP and CAPCOA white papers, CEQA GHG analysis became much more widespread, and more and more CAPs were developed and began to be seen as an alternative path to CEQA compliance.
  - Key lawsuits were filed calling for GHG analysis, including the San Bernardino (2008) and Stockton (2008) general plans.
- **Solidifying the Practice: From SB 97 (2010) to "AB 32+1"**
  - The adoption of SB 97 resolved any lingering doubts as to whether GHG analysis was required under CEQA, and appellate court rulings confirmed this conclusion.
  - Thresholds were further developed and adopted by many air districts, including BAAQMD (2010), SJVAPCD (2010) and others.
  - CAPs were developed in many jurisdictions throughout California. The use of thresholds was upheld in court rulings. GHG analysis became universal for CEQA documents and CAPs became increasingly used for CEQA tiering.

How then to analyze GHG emissions in CEQA documents for the post-2020 world? Pragmatically, this can be broken down into several different eras, as follows:

- **The Uncertain Interim: From San Diego Rulings (2014) to "AB 32+1" to the "AB 32+1" Scoping Plan**
  - CEQA GHG analysis practice is now entering another period of change. The San Diego rulings have introduced the question of post-2020 analysis. The Legislature is considering the next set of State GHG reduction targets.

- For general plans and multi-phase large projects with post-2020 phased development, CEQA analyses need to take into account consistency with 2020/AB 32 based frameworks, but they must also analyze the consequences of post-2020 GHG emissions in terms of their impacts on the reduction trajectory from 2020 toward 2050. A significance determination, as argued in this paper, should be based on consistency with "substantial progress" along a post-2020 trajectory, but should not be based on meeting the 2050 target.
- CEQA analysis for most land use projects can continue to rely on the current thresholds and current CAPs with 2020 horizons for the immediate future, especially if there is action by the State Legislature and ARB in the next few years. The closer we come to 2020 without legislative and ARB action on the post-2020 targets and planning, the more CEQA project analysis will need to analyze post-2020 emissions consistent with "substantial progress" along a post-2020 reduction trajectory toward meeting the 2050 target.

- **The Next Normal: With "AB 32+1" and a "AB 32+1" Scoping Plan**
  - When the Legislature adopts a post-2020 target and ARB develops a detailed, specific, and feasible scoping plan addressing the adopted target, a new framework will be established for CEQA GHG analysis that is similar to what exists in relation to AB 32 and the 2020 reduction target.
  - CEQA GHG analyses will need to be completed using thresholds based on the new post-2020 target.
  - CEQA tiering of GHG analysis will need to come from CAPs that are consistent with the adopted post-2020 target.
  - CEQA GHG analysis of general plans (and large multi-phased projects with long-term future horizons) will need to analyze horizons beyond the adopted target.
- **The Future: A 2050 Legislated Target and a 2050 Target Scoping Plan**
  - The Legislature may adopt a 2030 target in the near term, but will also likely adopt a 2050 target, at some point.
  - In the near-term, any ARB scoping plan for meeting a 2050 target will likely be a general phased approach that will not constitute a detailed, specific and feasible plan of action such as that in the current AB 32 Scoping Plan. Lacking such a State plan of action for 2050, CEQA GHG analyses should be based on evaluating project emissions in light of the horizon of State action planning (which may be less than 2050), and, as necessary, based on evaluation of "substantial progress" toward longer-term reduction targets.
  - In time, ARB will develop a feasible and specific plan of action for 2050, though it may be years in coming. At that point, CEQA GHG analysis will need to change again in order to be based on fully evaluating project emissions for consistency with a 2050 plan of action.

General Plans in a Post-2020 World

General plans often have roughly 20 year planning horizons; so contemplating the need for policy actions two decades in the future is not new to California planners. Some general plans already include post-2020 actions to reduce GHG emissions within their local jurisdiction. Many recently adopted general plans, for example, include substantial land use policy frameworks designed to reduce VMT by promoting infill development, TOD, transit, and alternatives to vehicle travel such as bicycle and pedestrian linkages. Land use approaches to reducing VMT are by their nature long-term efforts that will, in most cases, deliver only small absolute reductions in the short run (e.g., by 2020), but can deliver much more substantial VMT reductions in the longer term (e.g., by 2035). The general plan is absolutely essential to GHG reduction strategies that involve land use form and spatial planning, and long-term transportation planning. Some recent general plans have included the adoption of a CAP as part of an update, and others have included a GHG reduction target and have called for adoption of a CAP to meet the locally adopted reduction target by a date certain. Conversely, some CAPs call for revisions to local general plans in order to implement CAP-related GHG emission reduction strategies.

While there hasn't been a mandatory requirement to consider climate change in general plans from the State's General Plan Guidelines to date (although this may change soon), CEQA challenges to general plan EIRs have created pressure to include consideration of GHG emissions through both policy measures and target setting in general plans, and/or via requirements to do the same through development of a CAP.

In the post-2020 period, there will be increasing pressure to include ambitious policies to reduce GHG emissions within general plans, with the greater reduction effort necessary to achieve long-term reduction targets beyond AB 32. Given past history, it is likely that pressure groups will continue to use CEQA lawsuits, GHG emissions, and the need for long-term reductions to gain leverage in an attempt to force local jurisdictions to modify general plans.. As we shift from 2020 targets to 2030 targets and beyond, many different stakeholders will be looking to general plans to ensure that land use planning reflects contemporary State target milestones for GHG emissions.

Optimal planning happens in a social and community context in which the public, planners, stakeholders, and decision-makers can address issues of broad concern in a balanced way. CEQA lawsuits can effectively distort that delicate balancing process by interveners attempting to gain a broader, often political, outcome that are outside of the scope and capacity of the planning process. This paper takes the position that planning is best done free of such pressure. In order to keep general plans focused on doing the hard work of planning for the future, the recommendations below seek to reasonably limit the horizon of GHG analysis under CEQA. If this proposed change were put into effect, it would enable general plans to focus on realistic and achievable reduction timeframes and targets, rather than spending unproductive time engaged in speculative exercises about the distant future.

Climate Action Plans in a Post-2020 World

CAP Target Setting

The local target setting process for 2020 has provided important lessons that can be applied to setting future targets. Most CAPs have included targets for 2020, and some discuss reductions to achieve a trajectory toward 2050; but the primary focus on identifying reduction measures has been on 2020. Early targets adopted prior to the AB 32 Scoping Plan completion in 2008 were generally overly optimistic about the amount of reductions that would be achieved by those jurisdictions. Changes to CEQA adopted by OPR in 2010 provide guidance for using CAPs for CEQA streamlining and for addressing GHG emissions in CEQA documents. Legal challenges and decisions on general plan and project-level CEQA documents have provided some guidance, but with sometimes contradictory results. The following discussion attempts to bring some clarity to how to move beyond 2020.

The 2014 AB 32 Scoping Plan Update states the following:

> *"Local government reduction targets should chart a reduction trajectory that is consistent with, or exceeds, the trajectory created by statewide goals. Improved accounting and centralized reporting of local efforts, including emissions inventories, policy programs, and achieved emission reductions, would allow California to further incorporate, and better recognize, local efforts in its climate planning and policies."*

Achieving a reduction trajectory that is consistent with or exceeds a statewide trajectory is not a straightforward process. The circumstances in each community can vary due to differing growth rates, climate, existing built environment, economic health, and local politics. The SB 375 Regional Targets process took local circumstances into account and resulted in a wide range of targets for areas around the State.

Currently, it is extremely difficult for a lead agency or project to achieve a local post-2020 target in the absence of a statewide plan to achieve a post-2020 target. While there are GHG reduction plans that do include a post-2020 target, those emissions reductions are subject to uncertainty and speculation about the amount of reductions that can be attributed to State and federal reductions beyond 2020. In the absence of a post-2020 target passed by the Legislature, the question that will become increasingly important for GHG reduction planning is whether showing progress to achieve post-2020 goals is sufficient, or whether the GHG reduction plan must actually achieve the post-2020 target even in absence of a State legislative target or plan for a particular milestone. The logical steps in setting post-2020 Targets for CAPs are to:

- Prepare a baseline inventory.
- Forecast GHG emissions for future milestone years based on growth forecasts for the community.
- Identify reductions from existing regulations such as Title 24, the RPS, Pavley I/Advanced Clean Cars, and the LCFS that apply to prepare an adjusted forecast with State measures. Include federal actions (such as CAFE fleet vehicle standards) where appropriate.
- Determine potential reductions from current scoping plan measures with a definitive schedule for adoption in the near-term future. Scoping plan programs without a reasonable certainty for implementation by a date certain should not be included.
- Determine the difference in emissions between the current legislated State target(s)[15] and the adopted and planned State regulations. This number is the amount of reductions needed from either additional unplanned State regulations or local measures.
- Identify the feasible strategies and measures available to close the gap, after considering the benefits of regulations on the future year emission inventory. Note that more distant milestone years are likely to produce a larger gap because the effect of current regulations may be offset partially or entirely by the emissions resulting from cumulative economic and population growth over time.

[15] The current legislated State target is for 2020 from AB 32. The next likely legislated State target will be for 2030. The Executive Order S-03-05 includes a target for 2050 that should also be considered but it is an argument of this white paper that CAPs do not necessarily need to achieve a 2050 target to qualify for tiering under CEQA Guidelines Section 15183.5 or to support a less-than significant finding under CEQA. Instead, this paper argues that "substantial progress" toward post-2020 GHG reductions should be the threshold for both tiering and less than significant findings.

- The reduction from feasible strategies and measures may or may not exceed the amount required to close the gap with the legislated State target(s).

Different CAP Target approaches are reviewed below in light of post-2020 considerations.

- **Percent below 1990 Approach.** At present, the most clearly consistent target with AB 32 is 1990 emissions by 2020. In the post-2020 period, consistency with State target(s) will depend on how the State decides to articulate post-2020 targets. If the State adopts a "percent below 1990" basis (such as 30 or 40 percent below 1990 by 2030), then local jurisdictions could identify the same percentage below their own 1990 jurisdictional emissions as their CAP target.
- **Percent below Alternative Baseline Approach.** Many jurisdictions do not have 1990 inventories and have been using "proxy" inventory years as a baseline, with an alternative reduction target to provide the functional equivalent of reducing to 1990 emissions levels. For example, the original 2008 AB 32 Scoping Plan identified a goal for local jurisdictions to reduce emissions by 15 percent below "current" (usually defined as 2005 – 2008 emissions) levels to support the AB 32 goal of reaching 1990 emissions by 2020. Thus, jurisdictions that have used a non-1990 baseline inventory will need to calculate the additional reductions needed to reach a post-2020 reduction target. For example, if a city's 2005 inventory was 500,000 metric tons of CO_2e, and their current CAP target was 15 percent below 2005 levels, then the "proxy" 1990 emissions level would be 425,000 MT CO_2e. Assuming a new statewide reduction target is 30 percent below 1990 levels, then the example city's 2030 target could be 297,500 MT CO_2e (40.5 percent below the city's 2005 emissions).
- **Percent below 2020 Approach.** As noted above, many jurisdictions don't have a 1990 inventory but have adopted a reduction target for 2020 in their current CAP that is considered functionally equivalent to 1990 emissions. If that rationale is sufficiently grounded, then a post-2020 reduction target could be used in future CAP updates. Using our example city from above, with 2005 emissions of 500,000 MTCO_2e and a 2020 reduction target of 425,000 MTCO_2e that is presumed equivalent to 1990 emissions, then a 2030 target could be 30 percent below the 2020 target, or 297,500 MT CO_2e.
- **Percent below Future Business as Usual (BAU) Approach.**
    - There has been confusion regarding the concept of BAU emission forecasts (and targets based on reductions from BAU) among agencies and opposition groups involved with general plans and CAPs. BAU forecasts are used by ARB in developing criteria pollutant emission inventories for Air Quality Attainment Plans. BAU represents emissions forecasts for projected growth without the reductions expected from the implementation of regulations. ARB applied this concept in the AB 32 Scoping Plan.
    - The benefit of a BAU analysis is that it clearly shows the impact of growth, and the amount of reductions required, to offset growth and reach the emission target level. The percentage reduction from BAU required to achieve AB 32 targets has been used in many CAPs to demonstrate consistency with AB 32. CAPs that show emission reductions from BAU at least as great as what is required by the State are considered consistent with AB 32.
    - Using a BAU approach beyond 2020 will require a new Scoping Plan with State targets that will be determined in coming years. State Legislation is currently being introduced[16] that

[16] SB 32 (Pavley), AB 33 (Quirk), and AB 21 (Perea).

would set targets for 2030, 2040, and 2050, and would require ARB to update the Scoping Plan to identify a strategy to achieve the new targets. A new statewide BAU forecast would be developed and the percent reduction from BAU necessary to meet a new State target could then be determined. This new percentage reduction could be applied to local GHG forecasts to develop new post-2020 CAP targets.

- One problem with the BAU approach can be characterized as "target shift." As time passes and new regulations are implemented, the amount of reduction required to achieve the original percentage reduction from BAU is reduced. For example, in 2020, a 40 percent reduction from 2030 BAU may be required, but in 2025 new regulations and the retirement of higher emitting equipment may achieve a 20 percent reduction from 2030 BAU. Therefore in 2025, a local plan would need to deliver only the reduction of 20 percent from 2030 BAU. To keep a stable target, one must maintain the same starting year until new targets are adopted by the State. Otherwise, new targets would need to be determined every year based on progress in implementing regulations in effect up to that point. As long as the calculations used to determine progress are transparent, a fixed past year baseline is the simplest approach. However, a periodic CAP update based on progress reported in State Scoping Plan updates is preferable to more accurately define and account for the amount of reduction that remains to be achieved.

Climate Action Plan GHG Reduction Measures for a Post-2020 World

Below we review some considerations for local GHG emissions reduction measures in the post-2020 period. This is not a comprehensive review of potential reduction measures, but is rather intended to give an idea of several different strategies that can be applied in a post-2020 world.

Building Energy Sector

The building energy sector is normally the second largest emission sector after motor vehicles in city GHG emission inventories. Reductions from the building energy sector are obtained through increased energy efficiency and through transition to energy sources with lower GHG emission intensities.

Energy Efficiency

Programs to Exceed State Energy Efficiency Standards for New Development

One of the primary measures encouraged by the State for local government implementation is to require new development to exceed State energy efficiency standards. While this measure is commendable, cities adopting it must be prepared for nearly continuous updates to match the State's update schedule, or to consider it only a temporary measure pending the next State standards update.

Factors for local governments to consider in adopting regulations that go beyond State regulations include:

- **Will builders be able to meet the efficiency levels set by the local government policy or regulation?** CEC is tightening energy efficiency regulations every three years, so it is difficult to get ahead of the regulations for any length of time. CEC conducts an extensive feasibility assessment when it adopts new regulations and works closely with industry to ensure that changes to standards can be implemented without undue burden and disruptions.

- **Adoption of ZNE will eventually limit local opportunities for additional reductions.** The CPUC and CEC are working toward requirements for new residential buildings achieving ZNE consumption starting in 2020. Once ZNE is achieved, there will be limited opportunities for local governments to require residential development to go beyond State standards. The CPUC and CEC are working toward ZNE for commercial buildings by 2030, thus from 2020 to 2030 there may be more local opportunities for reductions in the commercial sector.
- **Does the city have resources to train staff on complying with its own standards that are different from those of Title 24?** Will compliance software developed for Title 24 be transferrable to the local program? With Title 24 being updated about every three years, is the city willing to update its standards on the same schedule, or will exceeding Title 24 be a temporary measure pending the next State update?
- **Communities must consider whether they are placing themselves at a competitive disadvantage for attracting high GHG producing development.** The Uniform Building Code helps provide a level playing field for building standards including those that relate to energy efficiency. Communities with hot real estate markets may be able to push the envelope towards efficiency because it is easier for developers to absorb capital costs in an escalating market. Conversely, energy efficiency will provide value to whoever is paying the utility bills, so the extent to which energy efficiency is reflected in property values is an important factor. If all nearby communities are pushing the envelope beyond current Title 24 minimums as part of their CAPs, then they could avoid artificial distortions in their regional building market.
- **One size doesn't fit all communities.** California coastal communities have milder climates requiring relatively low amounts of energy for heating and cooling. Inland areas of California have hotter summers and colder winters and commensurately higher energy consumption for cooling and heating. Locations with high energy use have faster paybacks on energy conservation investments compared to places with milder climates.

Building energy technology is changing quickly. The State is pursuing technology-forcing regulations that are anticipated to speed implementation of new technologies. Although industry consistently complains that higher standards will be impossible to meet, when it comes time for implementation the technology is nearly always ready for the market at a lower cost than was estimated when the regulation was adopted.

The bottom line is that striving to achieve greater energy efficiency is part of any GHG post-2020 reduction strategy, but given the relatively rapid shift toward ZNE requirements for new buildings, this is a strategy that will have diminishing net returns as 2030 approaches.

Energy Efficiency Retrofit Programs for Existing Development

The existing built environment currently provides a large potential source of emission reductions in California cities. Existing homes and businesses have opportunities to improve energy efficiency by incorporating new technologies when remodeling or when replacing aging equipment. In some cases, energy savings can justify energy efficiency upgrades while current systems are still functional.

There have been substantial retrofit efforts across California through programs like California Energy Upgrade and other local, regional, and State efforts. While these programs have resulted in implementation of several "low-hanging fruit" strategies such as lighting replacements, there remains a substantial portfolio of potential retrofits still to be used.

Continued efforts to incorporate the cost of GHG emissions into the price of energy (electricity, natural gas) through the California cap-and-trade system will help individual consumers to better account for the total social costs of GHG emissions, which have not been adequately included in energy prices in the past. Thus, there will likely be cost-effective retrofits in the post-2020 world that may not exist today.

A further consideration for the post-2020 building sector is that with the highly ambitious ZNE strategies for new development, there could be a widening divergence between new development and existing development, in terms of building user energy costs. This could add market pressure on existing development that would support demand for more energy-efficiency retrofits.

Renewable Energy

The second part of any building energy emissions reduction strategy is the supply side of energy. Local governments can consider measures that support switching to lower GHG intensity fuels or renewable energy for electricity to help meet post-2020 targets.

Fuel Switching for Building Heat

According the 2014 AB 32 Scoping Plan Update, meeting a long-term 2050 goal will require eventual transformation of the energy sources for heating used by nearly all homes and businesses in California. Natural gas is currently the preferred fuel for heating most structures in California due to its relatively low cost and high efficiency. Over 80 percent of the energy used in natural gas heaters is converted to usable heat during combustion in central heating applications.

The emissions associated with electric heaters, although considered 100 percent efficient in generating heat, are impacted by the efficiency (or inefficiencies) of the power plant (and its associated emissions), as well as by transmission and distribution losses. Electricity for space heating has not achieved substantial market share because it has been more costly to operate than natural gas. According to the US DOE Heating Fuel Comparison Calculator, the fuel price of electricity averages $35.14 per million Btu, while natural gas costs $10.02 per million Btu. This is a major constraint to potential fuel switching to electric heating.

For climates with moderate heating and cooling needs, heat pumps offer an energy-efficient alternative to furnaces and air conditioners. Like a refrigerator, heat pumps use electricity to move heat from a cool space to a warm space, making cool spaces cooler and warm spaces warmer. Heating and cooling seasons alternate between moving air from the inside to the outside of homes, or vice-versa, as needed. Because they move heat rather than generate heat, heat pumps can provide equivalent space conditioning at as little as one quarter of the cost of conventional heating or cooling appliances. As a result, this may be a strategy that is increasingly used for emissions reduction.

Furthermore, as the grid contains more and more renewable fractions, and as cap-and-trade increasingly internalizes GHG emission costs, the price differential between electrical heating and natural gas heating is likely to get smaller. At present, with the relatively large disparity in cost, large-scale fuel switching does not appear to be a feasible short-term strategy and is not included in most CAP documents. However with approaching ZNE requirements in the 2020 to 2030 period, changing energy prices, and an ever-decreasing GHG intensity in California electricity, fuel switching could be a viable strategy in the post-2020 period.

Utility-Scale and Distributed Renewable Energy

The State has a primary role in increasing the renewable portfolio in the major electrical utility power generation mix. Governor Brown has called for increasing the current 33 percent RPS standard to a 50 percent standard for 2030, and legislation is being developed in 2015 to implement such a standard. Thus, the State is expected to contribute substantially to increased reductions in building energy emissions.

Some jurisdictions, such as cities in Marin County and Sonoma County, have decided to and implement community choice aggregation (CCA), which gives local jurisdictions control over their electricity supply choice. Where CCA is determined to be viable, those jurisdictions can benefit from a potential lower GHG intensity than what might be otherwise provided by their utility company under the State-mandated RPS. However, CCAs need to pay careful attention not only to their qualified renewable fraction (as defined by CEC regulation), but also to their overall GHG intensity, as the non-renewable fraction is critical to determining the CCAs overall relative GHG reduction benefits.

Self-generation and distributed generation of renewable electricity via solar or wind, and having a low GHG emitting utility scale electricity system that provides power at a reasonable cost, comprise critical elements in any strategy to efficiently achieve net zero energy new buildings between 2020 and 2030. In addition, distributed renewable generation can be utilized for existing buildings to increase the net renewable energy beyond what might be achieved by a local utility, or even a CCA.

As increasing amounts of variable renewable energy (such as solar and wind) come to fruition, there will be new challenges faced by utilities in balancing their electrical loads. If electricity storage solutions and demand management solutions (such as advanced smart grids) are not sufficiently developed, then load balancing may need to be achieved by natural gas generation, at least in the short run, which can reduce the GHG reduction effects of adding more renewable generation. This will become a larger concern in the post-2020 period, depending on the load balancing and energy storage solutions that prove to be viable and cost-effective. Local jurisdictions will need to be cognizant of these issues to ensure that the GHG reduction effectiveness of local measures supporting renewable energy are not being overestimated, especially if there are "debits" to account for in load balancing. Local jurisdictions can also be supportive in this regard by promoting and piloting smart grids along with utility companies, including deployment of smart meters and similar technologies.

Transportation

GHG reduction strategies in the transportation sector are threefold: (1) changing fuels to lower GHG-intensity alternatives; (2) increasing transportation vehicle efficiency; and (3) reducing vehicle miles traveled.

Governor Brown has called for a 50 percent reduction of petroleum consumption by 2030.

Fuel Strategies

The State has led the effort to promote alternative fuels for transportation primarily through the LCFS. The LCFS will nominally reduce the GHG intensity of transportation fuels by 10 percent by 2020. An expansion of the current LCFS target for 2030 is included in the 2014 AB 32 Scoping Plan Update, and is considered likely. The State also seeks to promote zero emissions vehicles (ZEVs) such as electrical vehicles (EVs) through a number of programs. The State also incentivizes purchase of alternative vehicles through measures such as allowing certain vehicles to use HOV lanes with only a single occupant.

Many local jurisdictions currently support alternative fuel vehicles for their municipal fleets. Some local jurisdictions also promote alternative fuel vehicles through programs such as local installations of EV charging stations at public facilities, preferential parking for alternative fuel vehicles, and other measures. Some local jurisdictions promote replacement of landscaping equipment with electrical equipment where feasible. However, some of these measures have been suboptimal to date; for example, the business model for private EV charging stations has met only limited success at current market electricity and charging prices.

Looking at the post-2020 period, local jurisdictions can continue to replace municipal vehicles, promote alternatively fueled off-road equipment, and support infrastructure for electric and other alternatively fueled vehicles. Local measures in the post-2020 world will likely have greater cost-effectiveness and feasibility than in the pre-2020 era due to changing energy prices and State incentives.

Vehicle Strategies

Federal and state governments have been the primary actors in promoting greater efficiency for fossil-fueled transportation vehicles, through the CAFÉ standards at the federal level and through the Pavely 1/Advanced Clean Car programs at the state level. Current programs include a goal of an average efficiency of 54.5 miles per gallon for light duty vehicles by 2025. Thus, local jurisdictions will be able to count on continuing GHG reductions in the transportation sector from 2020 to 2025. It is also likely that the State will expand vehicle efficiency beyond 2025 at some point in the future.

Local government actions in regard to vehicle efficiency have primarily been focused on municipal purchasing policies requiring greater efficiency as a major consideration in fleet replacement planning. While these types of programs can and should continue in the post-2020 period, given State and federal regulation of vehicle technology, the State will remain the primary actor for vehicle efficiency in the foreseeable future.

VMT Reduction Strategies

From the 1960s to the beginning of this century, VMT and VMT per adult in the U.S. have increased at approximately the same rate as Gross Domestic Project (GDP). However since 2007 vehicle miles traveled per adult nationwide has declined, while California witnessed a similar decline beginning in 2005. The cause of this change has been debated. Commonly cited explanations include changing economic conditions (the recent recession); changing fuel prices; aging of the baby boomer generation; reductions in teen driving; changing lifestyle preferences (e.g., urban living, public transit); increased smartphone use; a rise in telecommuting; and other factors. While many of these explanations are plausible, other than a focus on fuel prices there is little research to support alternative explanations. California's long-run trend in VMT per adult has mirrored that of the country as a whole. In recent years, however, the trend lines have diverged: Californians drive fewer miles annually than the average American. California's high fuel prices, high automobile insurance rates, and severe traffic congestion are thought to explain most of the divergence (Hymel 2014). The current economic recovery, if sustained, may have a substantial effect on VMT trends in the near-term. It is uncertain whether the recent drop in fuel prices will be sustained. A sustained drop in fuel prices could also have an effect, if it were to occur.

One lesson learned from CAPs, project-level CEQA reviews, and SB 375 implementation is that changes in VMT will not be easy to achieve on a large scale in the near-term. Built out communities have few opportunities to substantially change their land use. Some urban areas are pursuing higher density uses that are supported by transit as a VMT-reduction strategy. This push for higher density has met substantial opposition in some parts of the Bay Area and San Diego. Fast growing localities often have large greenfield areas that allow more suburban low-density development with limited prospects to reduce VMT. Some fast growing areas have committed to infill and higher density to achieve objectives such as reduced farmland conversion, lower service costs, and support for alternative transportation. It remains to be seen whether these initiatives will achieve their desired results in the long term.

Local jurisdictions, through general plans and CAPs, have often included support for infill, transit-oriented development, mixed use development, expansion of transit, and expansion of pedestrian and bicycle facilities as local strategies to reduce VMT. Local jurisdictions are also coordinating with transportation agencies through SB 375 Regional Transportation Plan/Sustainable Communities Strategies, which are prioritizing transportation funding toward infrastructure that can support long-term reductions in VMT.

In the post-2020 period, local jurisdictions can continue to expand their support for lower-VMT land uses through continued efforts using the strategies noted above, many of which will only show their actual VMT reduction potential on a decadal scale.

As vehicle efficiency continues to increase and transportation fuels with lower GHG intensities come into wider use, the effectiveness of lowering VMT as a GHG reduction strategy will decrease. For example, the fleet average mpg of 2013 cars is approximately 24 mpg. With CAFÉ standards requiring a fleet average for new cars of 54 mpg in 2025, the GHG effectiveness of VMT reduction on a per-mile basis will be lowered by 56 percent. While VMT reduction strategies will continue to be important for congestion management and access, local jurisdictions will see smaller reductions from VMT strategies as vehicle efficiencies and fuel GHG intensities change over time.

A further challenge in the post-2020 period is that increasing vehicle efficiency could lower the cost of driving, depending on what happens with transportation fuel prices. As a general rule, reduced driving costs can incentivize increases in VMT. Reduced driving costs could result in a renewed demand for housing in more outlying areas, which if authorized, could undermine VMT reduction efforts.

Solid Waste

Waste reduction strategies by local jurisdictions focus on reducing the amount of waste placed in landfills, and reducing the amount of methane released to the atmosphere from landfills.

Waste Reduction

Nearly all CAPs include waste reduction as a standard GHG reduction strategy, particularly since waste reduction has been a long-standing policy for most California jurisdictions. Source reduction, reuse, and recycling programs all fit under the rubric of waste reduction. A common goal in many CAPs has been to divert approximately 75 percent of local waste from the landfill, and many CAPs include food waste, composting and other supporting measures to help in this effort. Some municipalities have adopted near-future targets of zero waste to landfills (= 100 percent diversion).

In the post-2020 period, it is expected that common waste diversion targets will exceed 75 percent, with more communities adopting zero waste goals along with expansion of programs for construction and demolition waste, food waste composting, reuse requirements, and other measures.

Methane Capture

Current State law (AB 449) requires larger landfills to capture at least 75 percent of the methane generated. Some waste authorities, such as San Bernardino County, have adopted measures in their GHG reduction plan to exceed 75 percent methane recovery at some of their key landfills. Waste to energy technology has been improving over time but community concerns about emissions have hindered implementation of some proposed plants. If those concerns can adequately be addressed, local jurisdictions that own landfills may seek to expand waste to energy facilities. Methane digesters for high organic waste (such as food waste) have also been implemented by some waste management authorities. In the post-2020 period, local jurisdictions that control landfill facilities may be looking to accelerate many of these strategies as part of local GHG reduction planning.

Other Sectors

While building energy, transportation, and solid waste usually constitute the dominant sources of emissions under the control of a local jurisdiction, most CAPs address other sectors as well. Potential post-2020 considerations for these other sectors are noted below.

Water

Many local jurisdictions in California have had a long-standing policy role concerning water conservation due to (1) the inadequacy of local water supplies to water demands in many parts of the State, (2) the costs in transporting water over long distances, and (3) the susceptibility to drought. Most studies of the effects of climate change in California indicate that the water supply in many parts of California will be adversely affected. Thus, separate from concern over GHG emissions, there are important societal goals achieved by water conservation.

In the post-2020 period, water supply will continue to be a critical issue, and it is expected that most local jurisdictions will examine and implement tougher water conservation measures. SB X7 7 requires urban retailers to reduce urban water conservation by 20 percent per capita below nominal 2005 levels by 2020. It is likely that the State or local entities will go further than these requirements in the post-2020 period. The range of measures to reduce water use is well known to local jurisdictions (including landscape efficiency, conservation of local sources, efficient appliances, water pricing, use of grey water, etc.), but their application is expected to increase. Several water supply technologies, such as recycled water and desalination, are expected to come into wider use , and are associated with increased energy demands that could offset some of the energy reductions from water conservation measures.

Wastewater

Local jurisdictions that own and operate wastewater facilities often include improvements in plant equipment efficiency in their CAPs, with some jurisdictions considering methane capture and/or waste-to-energy schemes. In the post-2020 period, these measures may become more common throughout the State.

Industrial Point Sources

Most local jurisdictions do not include industrial point sources in their local GHG reduction planning, although many will disclose point source emissions in local inventories. Given State and federal regulation of large industrial point sources, it is unlikely that local jurisdictions will want to add local GHG reduction regulation to avoid duplicating or interfering with State or federal regulations. State and federal regulation—under California's cap-and-trade system and/or federal source permitting under the Clean Air Act—will continue, and is highly likely to become more stringent over time. Since most local jurisdictions exclude such large industrial sources from their local GHG reduction planning, this is not a likely source of additional reductions for local GHG reduction planning in the post-2020 era.

Some jurisdictions operate utility point sources of GHG emissions and include such emissions in municipal CAPs. These facilities are usually subject to State and federal regulation, and utilities are subject to RPS requirements as well. For these jurisdictions, some may find it cost effective to exceed regulatory mandated minimums and achieve additional GHG reductions, but this is a case- by-case determination and will depend on how deep reductions are mandated by the State and federal government.

Agriculture

Most cities have limited agricultural sector emissions, but non-urban counties such as Central Valley counties, some central coast counties, and Monterey County, Napa County, Sonoma County, and Imperial County have substantial agricultural sector emissions. To date, most local CAPs have been limited in their approach to agricultural emissions, especially in light of limited attention on the agricultural sector in the 2008 AB 32 Scoping Plan. In the 2014 Scoping Plan Update, ARB indicated its intention to focus more on agricultural emissions in the next round of State level GHG reduction planning, including establishing agricultural sector GHG reduction targets for both the mid-terms and 2050. As such, it is expected that counties with substantial agricultural sector emissions will also have a greater focus on developing agricultural GHG reduction measures for post-2020 targets. Most agriculture is allowed by right, with the exception of confined animal facilities, so there is limited local governmental ability to apply conditions. Given that regulation of the agricultural sector is very different from other land use sectors, such as housing and commercial, it is expected that counties will approach agricultural sector reductions with increased reliance on voluntary partnerships with the agricultural industry, more so than with specific regulatory approaches for other land use sectors. Sequestration in agricultural landscapes is addressed separately below.

Carbon Sequestration

To date, there has been limited focus on carbon sequestration in local CAPs other than urban forestry measures focused on tree planning. However, there is a substantial potential for GHG reductions through increasing soil carbon in agricultural landscapes (both in cropped fields as well as rangelands). Some local efforts, such as the Marin Carbon Project[17], are demonstrating methods and developing protocols to support increased soil carbon in working landscapes, and to identify the potential to scale up practices to cover larger areas within the State. With State planning focusing more attention on agriculture in the next few years, it is expected that carbon sequestration will become a larger component of agricultural county GHG reduction planning in the post-2020 era.

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[17] See: http://www.marincarbonproject.org/

Outside of urban forestry, carbon sequestration in working forests and natural landscapes has been included in local GHG reduction planning on only a limited basis to date. Some CAPs call for restoration of riparian corridors and other priority areas for habitat conservation purposes as well as GHG reductions. The 2014 AB 32 Scoping Plan Update called for development of a "Forest Carbon Plan" by 2016 which will include quantitative targets to increase net forest carbon storage. Thus, for counties with substantial forested areas, there may be increasing pressure and opportunities for local GHG reduction planning to support State efforts to increase forest carbon sequestration.

VI. Recommendations

Rich Walter, ICF International; Nicole Vermillion, Placeworks

The Role of CEQA in a Post-2020 World

The following recommendations are made in light of maintaining and enhancing the role of CEQA in supporting, not hindering, post-2020 GHG reduction efforts.

Limit CEQA GHG Analysis to the State GHG Planning Horizon based on a State Legislatively Mandated Target

This paper points to the infeasibility of requiring compliance with the goals in EO S-03-05 as a *de facto* significance threshold in CEQA documents. Nothing is served by establishing an impossible threshold, or by analyzing impacts so far in the future that they require speculation. Instead, the limit of GHG analysis for CEQA document should be the current State GHG planning horizon. At present, the only true State reduction plan is the AB 32 Scoping Plan, which has a verified and quantified reduction strategy only to 2020.

ARB is presently considering feasible GHG reduction strategies for 2030 and beyond, but lacks the legislative authority to mandate such reductions for the private sector or local governments absent further legislative action to mandate reductions beyond 2020. The next likely step for the Legislature and for ARB is adoption of a 2030 target and the creation of a new Scoping Plan laying out the State's plan for achieving the 2030 target. As we have seen with AB 32 implementation, local action is an important part of achieving the State's target and this will likely continue to be true in the post-2020 world. Thus, only when the State has a plan for 2030, should CEQA analysis and thresholds then shift from the current 2020 horizon to the 2030 horizon. When a post-2030 plan is in effect, the horizon should shift again.

Set "Substantial Progress" as the Significance Threshold

Current practice for evaluation of GHG emissions in project-level documents is to use a comparison to a threshold, or to evaluate consistency with the "qualified" GHG reduction plan. All the thresholds used in CEQA documents in California, and all "qualified" GHG reduction plans in use for CEQA tiering, are based on meeting (or exceeding) the AB 32 reduction targets, but there are no local GHG reduction plans that have an actual plan to meet a 2050 target of 80 percent below 1990 levels.

Given the collective impact of (1) the scientific imperative for reducing GHG emissions globally, (2) the existence of the 2050 goal in EO S-03-05, (3) the SANDAG CEQA Appellate Court ruling, and (4) possible State legislative action to adopt a 2050 goal, there were be substantial pressure to change the framework for CEQA analysis of GHG emissions to account for the need to move beyond the 2020 AB 32 goals.

As argued in this paper, currently, local jurisdictions cannot on their own develop feasible plans to deliver jurisdiction-level emission reduction all the way to the 2050 goal because the effort to change the economic activity and technology in use will require the action of the federal and State governments, as well as the financial ability (through market means or government funding) to implement the necessary changes. While local jurisdictions can and should contribute to and support this long term effort, on their own they will be limited in their ability to deliver the full amount of reductions needed. Furthermore, solving a large cumulative problem like GHG emissions entirely at the smallest levels of government is very likely to result in inefficient, cost-ineffective, piecemeal, and/or inconsistent solutions that will tax the financial and political will of local communities.

Even if some municipalities were to agree to a demanding future threshold based on the 2050 goal, as some advocates desire, given the difficulties in achieving such substantial reductions on a project-level basis, the end result is likely to be increasing numbers of EIRs with more statements of overriding considerations, which (1) would not result in additional GHG reductions, (2) would consume more local government time, effort, and cost, and (3) would not inspire motivation for local governments to engage in holistic local GHG reduction efforts.

Instead, this paper recommends that a new CEQA significance threshold for GHG emissions should be the following:

> *"Does the project impede substantial progress in local, regional, and State GHG emissions reductions over time toward long-term GHG reduction targets adopted by the State Legislature?"*

Allow CEQA Tiering from GHG Reduction Plans that Make "Substantial Progress" Toward Reducing GHG Emission Impacts

The recent San Diego cases detailed earlier in this paper have the potential to deter local jurisdictions from seeking to prepare and implement a GHG reduction plan because, essentially, they remove the "carrot" for CEQA streamlining and create too much uncertainty.

While CEQA Guidelines allow lead agencies to prepare GHG reduction plans for the purpose of CEQA streamlining of GHG emissions impacts, the recent San Diego rulings, taken at face value, could be interpreted to mean that no GHG reduction plan as currently written would meet the criteria set forth in CEQA Guidelines Section 15183.5.

To promote CEQA streamlining and encourage local agencies to prepare GHG reduction plans for communitywide GHG emissions, the Legislature should require a change to the CEQA Guidelines that will allow for tiering when a jurisdiction shows "substantial progress" toward meeting State legislatively-adopted GHG reduction goals.

This concept is not new and is similar to the language added to the CEQA Guidelines under Senate Bill 226 (SB 226) for infill development. SB 226 (2011) amended the CEQA Guidelines to provide a streamlined review process for infill projects. As stated in CEQA Guidelines Section 15183.3, the purpose of this section is to streamline review where the effects of an infill project have been addressed in a planning decision or by uniformly applicable development policies. This is directly comparable to the purpose and intent of GHG reduction plans, and is similarly written in CEQA Guidelines Section 15183.5. It is clear that GHG emissions reductions are best handled at a citywide, regional, or statewide level in order to attain the applicable GHG reduction goals, rather than on a project-by-project basis. Thus it is most beneficial for a jurisdiction to prepare a GHG reduction plan that addresses emissions on a communitywide level, rather than on a project-by-project basis. The purpose of a GHG reduction plan directly aligns with the intent of the Legislature when adopting SB 226.

Because the intent of the CEQA streamlining offered under SB 226 is so closely aligned with the purpose of the GHG reductions plans and CEQA Guidelines Section 15183.5, it important to note that

SB 226 allows lead agencies to tier off development standards that would "substantially mitigate" the environmental effects(CEQA Guidelines Section 15183.3 (b)(c)). If CEQA Guidelines Section 15183.5 was afforded the same flexibility by allowing tiering off a GHG reduction plan that made "substantial progress" toward reducing GHG emissions over time, it would provide lead agencies with additional flexibility, as well as provide more incentive for utilizing this kind of planning and implementation tool.

The CEQA Guidelines already allow for CEQA streamlining of impacts when there are programs, plans, and regulations that substantially mitigate impacts for infill projects. Therefore, it would make sense that a similar application should be applied for GHG Reduction Plans under CEQA Guidelines Section 15183.5.

Allow Partial CEQA Exemption for CAPs

One of the more absurd applications of CEQA is to require CEQA documents on CAPs. Many of the actions included in CAPs, such as energy-efficient retrofits or energy efficiency for new development, are unlikely to result in significant environmental impacts. However, some of the actions included in local CAPs can certainly have impacts on the environment, such as utility-scale solar energy facilities that might be proposed within sensitive habitat areas. On the other hand, project specific impacts from siting solar or similar facilities such as habitat impacts would be speculative unless specific locations were proposed in a CAP and would be subject to their own CEQA review. There is no exemption or streamlining for CAPs under CEQA. The analysis within the CEQA documents associated with CAPs is usually highly programmatic and non-location specific, meaning that those CAP elements that do result in potentially significant environmental impacts would require a project-level CEQA document regardless of the programmatic level analysis. As a result, the CEQA documents for CAPs by and large do not provide useful disclosure or consequential environmental mitigation.

A more productive approach would be to establish a partial CEQA exemption for the CAP adoption. The exemption would limit the scope of CEQA compliance to addressing GHG emissions only, and would eliminate the need to analyze other environmental impacts at the programmatic level, while mandating CEQA evaluation on the project-level elements from the CAP that may have environmental effects of their own. This approach would retain the ability for CEQA tiering from a qualified GHG reduction plan, and would eliminate an impediment to local CAP development, while still ensuring that project -level secondary environmental impacts are fully disclosed and mitigated as required by CEQA.

The Role of General Plans in a Post-2020 World

The following recommendations are made in light of maintaining and enhancing the role of local general plans in supporting post-2020 GHG reduction efforts.

Improve General Plan/CAP Coordination

There has been debate in the planning world about whether or not CAPs should be integrated into general plans. This is best decided on a case-by-case basis in order to respect the particular preferences, style, and local considerations that go into each general plan. Given that jurisdictions are limited in how many general plan amendments can be made in a year, and the amount of effort associated with such amendments and updates, some communities see advantages in having a separate CAP process and CAP document; arguing that it can be more responsive to fast-changing conditions while maintaining the general plan as a more broad policy "charter" for the community. Other communities prefer a full integration of the general plan with the CAP to ensure that GHG reduction measures permeate all necessary aspects of local planning.

The post-2020 GHG reduction challenge should not dictate a local jurisdiction's choice unless the State mandates that climate change becomes a required general plan element. Such legislation would be reflected in future General Plan Guideline updates.

In any case, general plans and CAPs must still be brought into closer and better alignment for GHG reduction measures under the control of a local jurisdiction to be effective. However, the manner in which that alignment is conducted should be left to local discretion, provided that there is sufficient rigor, support, enforcement (where necessary), and monitoring to ensure that local GHG initiatives can be and are effectively implemented.

Establish 20-year Planning Horizons for General Plan CEQA Analysis to Better Match Regional Planning Horizons

As identified in this paper, GHG reduction plans are often prepared concurrently with general plan updates. GHG reduction plans seek to identify measures that would be implemented by a jurisdiction over in the near- and long-term to achieve GHG reduction goals. Therefore, a GHG reduction plan is tied to a clear timeline with a defined horizon year.

General plans typically have long-term timeframes, and many do not link general plan development to any timetable at all. This is because general plans guide growth and development based on development standards set forth in the land use plan, and on goals and policies identified in the general plan elements. Although the land use plan guides growth and development within a jurisdiction, actual growth is based on market conditions and demographic changes over time. While some GHG reduction plans go beyond 2020, most GHG reduction plans prepared since the arrival of AB 32 were drafted to achieve the 2020 target. As a result, the timeline identified in a GHG reduction plan may not have always been consistent with the general plan timeline.

The time horizon for environmental impact analysis for a general plan is another important sticking point, because under CEQA one must analyze the "whole of an action," per CEQA Guidelines Section 15378(a). For a general plan, this means the analysis must consider the reasonably foreseeable direct and indirect physical changes associated with the underlying land use plan, including reasonable buildout of all the parcels based on the land use designations. Many jurisdictions are unlikely to be built out by 2100, much less by the year 2050.

Furthermore, not all regional governments and transportation agencies have forecasted out to year 2050. This presents difficulties when drafting general plan CEQA analyses and can add to the confusion over "buildout" versus "horizon year." For example, long-range transportation plans, including the RTPs prepared by MPOs and congestion management plans (CMPs) prepared by local congestion management agencies, only forecast out to a 20-year planning horizon. Transportation modeling for a general plan usually depends on the circulation network and the cumulative traffic growth assumptions outside the jurisdiction, based on these regional transportation tools. Consequently, the horizon year for the traffic analysis in a general plan is typically capped based on the latest forecast year available from the regional/sub-regional transportation agencies. Other regional planning tools, such as urban water management plans (UWMPs), are also forecasted out to only a 20 year planning horizon, and are becoming increasingly more important in light of the increasing drought concerns throughout the State.

General plans rely heavily on these various types of regional planning tools, most of which are forecasted out to a 20-year planning horizon. Yet, there is no cut-off date or mandate that the general plan impact analysis be required to consider growth and associated physical environmental impacts for only a 20-year planning horizon. As a result, there is a disconnect between how we analyze impacts for CEQA, and the regional planning objectives/forecasting data available.

To bridge this gap in how we plan for growth and how lead agencies must analyze impacts under CEQA, legislation should require that the CEQA Guidelines be amended to recommend that general plans analyze impacts over the same planning horizon required for other regional planning tools, such as water supply/demand, and transportation planning. If the CEQA Guidelines specifically redefined the planning horizon for a general plan as being on a 20-year basis, then it would link growth analyzed in the EIR to a clear and consistent planning horizon. Furthermore, nothing would preclude a jurisdiction from extending the planning horizon to a longer timeframe. Linking the analysis of the general plan EIR to a clear planning horizon would also provide benefits for GHG reduction planning by allowing the horizon analyzed in the general plan to be the same as the horizon analyzed for measures to achieve GHG reduction goals for the jurisdiction.

The Role of Climate Action Plans in a Post-2020 World

The following recommendations are made in light of maintaining and enhancing the role of local CAPs in supporting post-2020 GHG reduction efforts.

The Need for Legislative Action on Post-AB 32 Targets

The California Legislature needs to take action to adopt 2030 and 2050 GHG reduction targets that have the force of law throughout the State. A 2030 target is needed to inform State policy efforts for the RPS, vehicle standards, transportation fuel policy, the cap-and-trade program, and other regulations. In addition, a 2030 target would inform the next generation of local GHG reduction plans and would support CEQA thresholds and evaluation. The 2030 target should represent an ambitious target to keep the State on track for 2050 reductions, but should also be an achievable target based on available technologies and a realistic rate of social and economic change. A 2050 target from the Legislature is also needed to replace the limited legal applicability of the 2050 target in EO S-03-05.

As identified earlier in this paper, a critical issue facing planners and CEQA practitioners is that there no mandate that the State, as a whole, must achieve the long-term GHG reduction goals established in Executive Order S-03-05. As a result, there is no plan to achieve 80 percent below 1990 levels by 2050 (or an interim goal for 2030), and there is no guidance available on how local jurisdictions can address post-2020 GHG reduction goals. Yet, there is case law and substantial pressure from advocacy groups to go beyond 2020 when establishing GHG reduction programs. Without a mandate for post-2020 reductions for State agencies, local jurisdictions in California would have an insurmountable task in meeting the criteria outlined in CEQA Guidelines Section 15183.5. As a result, there would be little incentive for preparing local GHG reduction plans to achieve post-2020 GHG reduction goals.

In light of the rulings in *Sierra Club v. the City of San Diego* (2014) and *Cleveland v. SANDAG* (2014), it is clear that at some point the Legislature will need to consider interim targets to align the long-term goals of Executive Order S-03-05 with the statewide plans and programs being considered. At the time of this white paper (March 2015), there were three separate proposals in front of the Legislature that would provide an interim target between 2020 and 2050, and that would ensure that State agencies begin to plan for policies, programs, and regulations to achieve the interim target.

- **Senate Bill 32 (SB 32)** was introduced by Senator Pavley and would require that (1) ARB approve a GHG emissions limit that is equivalent to 80 percent below 1990 levels by 2050, (2) an interim GHG reduction target be achieved by 2030 and 2040, and (3) State agencies adopt policies that ensure long-term emissions reductions in advance of the criteria for 2030, 2040, and 2050.
- **Assembly Bill 33 (AB 33)** was introduced by Assembly Member Quirk and would require that ARB—on or before January 1, 2017—submit an Update to the Scoping Plan that includes a GHG reduction goal for 2030, 2040, and 2050. This bill would require that ARB include quantified statewide goals and strategies to achieve the 2030 target.
- **Assembly Bill 21 (AB 21)** was introduced by Assembly Member Perea and would require that ARB—on or before January 1, 2018—recommend to the Governor or Legislature a specific target of statewide emissions reductions for 2030.

ARB Needs an Actual Plan for 2030 (and a Later One for 2050)

If the Legislature moves forward with any of these proposals and establishes a GHG reduction target for 2030, 2040, and/or 2050, then ARB should be required to draft a plan to achieve the new interim/long-range target(s), and State agencies should be required to adopt programs and regulations to support the statewide target(s). Adoption of a post-2020 target by the Legislature would go a long way toward supporting jurisdictions in their GHG reduction efforts, because local actions alone are insubstantial compared to the top-down reductions that could occur if GHG reduction mandates are implemented at the State level. This would create the context within which local and regional governments could evaluate and identify the fair-share role of local governments to help the State meet its overall targets.

ARB should also conduct ever-more detailed scenario analysis for pathways to meet the selected legislative target for 2050. This will help the public and decision makers to understand how near-term policy and regulation to support the 2030 target will relate to the further effort necessary to meet the identified 2050 target.

Create 2030, 2040 and 2050 Scenarios/Calculators

Building on the groundbreaking work in the UK for their 2050 Calculator, the State needs to create a 2050 California Calculator to inform Californians as they face the coming 2050 challenges. ARB would be the logical author of the statewide calculator. Furthermore, a calculator should be prepared not only for the State as a whole, but should be extended to allow jurisdictions to examine their local emissions as well to apply different scenarios. Given the need for interim target planning in the lead-up to 2050, the models should also include interim years of 2030, 2040 and 2050.

In order to develop statewide and local-use calculators, there will be a need to create a rough consensus about acceptable assumptions for modeling population and economic growth, BAU conditions, and reduction strategy effectiveness.

Ideally, such calculator efforts would be coupled with economic and cost-effectiveness modeling, in order to best inform the public and decision makers as to the economic implications of different pathways to 2050.

"Walking to Run"

As demonstrated throughout this paper, without either a State legislative reduction target and a realistic State plan for reducing GHG emission beyond 2020, it will not be feasible in the foreseeable future for local jurisdictions on their own to adopt enforceable GHG reduction strategies to meet a 2050 reduction target consistent with EO S-03-05 2050 goals, or to achieve progress toward the 2050 goal for interim years.

Instead, the prudent approach is for local GHG reduction planning to focus on the realistic and achievable GHG reductions that are under the control or substantial influence of local governments themselves. Local GHG reduction planning will need to become increasingly more ambitious on a phased basis. CAPs should be updated and expanded periodically to reflect the emerging State (and possibly federal) framework for deeper future reductions.

The test for local CAPs and associated CEQA practices concerning GHG project analysis should be whether local action and project mitigation results in reasonable local fair-share of GHG reductions over time, showing substantial progress toward the long-term State reduction targets.

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EXHIBIT '2'

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Achieving GHG Reductions Through California Legislation

Prepared by:
Ramboll Environ US Corporation
San Francisco and Irvine, California

Date:
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RAMBOLL ENVIRON

1 Achieving GHG Reductions Through California Legislation

To have a good chance of avoiding significant global temperature increases, atmospheric concentrations of carbon dioxide equivalent (CO_2e) would need to peak below about 400 to 450 ppm and stabilize in the long-term at around today's levels. There is not one precise atmospheric CO_2e value because the sensitivity of the climate system to greenhouse gases (GHGs) is not known precisely; different models show slightly different outcomes within this range. Consistent with an Intergovernmental Panel on Climate Change (IPCC) emissions trajectory that would stabilize atmospheric GHG concentrations at 450 parts per million CO_2e and reduce the likelihood of dangerous anthropogenic interference with climate, climate experts have estimated that global emissions of GHGs would need to be reduced by 80% over 1990 emissions by 2050[1]. It is in this context that California is considering its future climate leadership policies.

1.1 Current Regulatory Environment

The passage of AB 32, the California Global Warming Solutions Act of 2006, began California's leadership for addressing climate change in the United States and the world. AB 32 requires California to reduce its total GHG emissions to 1990 levels by 2020 — a reduction of approximately 30 percent below emissions expected under a "business as usual" scenario of continued population and economic growth through 2020. The law required a substantial reduction of GHG emissions in California and set the stage for California's transition to a sustainable, low-carbon future. AB 32 was the first program in the country to take a comprehensive, long-term approach to addressing climate change, and was the first law in the world to require a capped mass emission limit on greenhouse gases, rather than simply setting a long-term aspirational goal[2].

Under AB 32, the California Air Resources Board (ARB) was required to adopt regulations to achieve the maximum technologically feasible and cost-effective GHG emission reductions throughout California in order to achieve the required mass reductions in GHG to change the "business as usual" course the state was on before AB 32 was enacted. The implementation of AB 32 has put California in a leadership position regarding waste reduction, low carbon technologies, energy efficiency, and the development and use of renewable energy resources. California also implemented a cap-and-trade program to reduce industrial emissions of GHGs. While this program is projected to result in the collection of hundreds of millions of dollars of new state revenues annually, the efficacy of this program in reducing GHG emissions is currently unclear.

The Sustainable Communities and Climate Protection Act of 2008 (SB 375) was the next landmark climate legislation adopted in California, and was intended to achieve GHG reductions consistent with the AB 2020 goals and also new 2035 goals through coordinated regional and local transportation and land use planning, including increasing transit utilization and densities in California's cities, collocating jobs and housing, and encouraging telecommuting, biking, walking and carpooling. Under SB 375, ARB set regional targets for GHG emissions reductions from

1 https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf
2 http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf

passenger vehicle use using Vehicle Miles Traveled (VMT) per capita as a proxy measure. Accordingly, rather than mandating mass reductions of emissions on a capped basis, SB 375 sets efficiency targets[3]. California's regions collaborated and adopted the plans required by SB 375, and are implementing land use and transportation policies to reduce GHG emissions and achieve the efficacy targets prescribed for 2020 and 2035. ARB is required to periodically review and update the targets, and has stated an interest in extending these targets beyond 2035 to 2050.

There are a number of other important pieces of California legislation aimed at reducing GHG emissions, including a wide range of bills intended to: set a Renewable Portfolio Standard (RPS) to substantially increase the amount of electricity produced from renewable sources like solar and wind rather than fossil fuels like natural gas; restrict incandescent lightbulbs; increase appliance efficiency levels; reduce fossil fuel use in cars and light duty trucks with fleet efficiency targets; incentivize zero- and low- emission vehicle purchases; and regulate tire inflation to improve fuel efficiency.

1.2 Pending Regulatory Environment

There are several pending pieces of legislation that are seeking to extend GHG reduction goals beyond 2020. These include proposed SB 350 and proposed SB 32.

1.3 Senate Bill 350: 2030 GHG Reductions

SB 350, also known as the 50-50-50 rule, is seeking to implement an RPS requiring 50% of the state's electricity to be generated from renewable energy by 2030, reduce petroleum usage from vehicles in the state by 50% by 2030, and to double the efficiency of existing buildings by 2030[4].

Renewable energy, in the form of solar, wind, and geothermal energy, has become far more cost effective over the past few years, partially in response to substantial government investment in the sector. According to the International Renewable Energy Agency, renewable power generation costs in 2014 were either as cheap or cheaper than coal, oil, and gas-fired power plants—despite drops in oil prices. Solar-powered energy has had the largest cost decline, with solar photovoltaic panels (for utility- scale and rooftop installations) being about 75% less expensive than they were in 2009.

Fifteen years ago, California enacted the nation's first law requiring energy companies to buy 20% of their power from renewable sources. Prior to this mandate, renewable energy comprised less than 8% of the overall electrical mix in the state. Within 5 years of implementation, most energy companies were close to, or had purchased under contract, enough power to meet or exceed the 20% renewable energy production target. In 2011, Governor Brown signed legislation to increase the RPS to 33% by the year 2020. Currently, most energy utilities have bought or have built enough energy resources to meet the 33% RPS before the target year. According to studies, California's RPS standard has created hundreds of thousands of new jobs, millions of new investment and tax dollars, and significant clean air and climate benefits. SB 350 increases the RPS to 50% by the year 2030.

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3 http://www.leginfo.ca.gov/pub/07-08/bill/sen/sb_0351-0400/sb_375_bill_20080930_chaptered.pdf

4 http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350

Reducing petroleum use in vehicles by 50% by the year 2030 is likely to be much more challenging. In a CARB analysis, one pathway towards this goal could include reducing growth in VMT to 4%; increasing the on-road fuel efficiency of cars to 35 mpg and heavy-duty trucks to 7 mpg; and at least doubling the use of alternative fuels such as biofuels, electricity, hydrogen, and renewable natural gas. Increasing fuel efficiency in vehicles has been refractory to price signals, and mandated fleet efficiencies has required approvals from the federal government (e.g., for cars and light duty trucks, an administrative waiver would be needed from the United States Environmental Protection Agency, but for heavy duty trucks as recently confirmed by the United States Supreme Court, Congressional legislation would be required to allow California to set its own emission standards).

Since 1978, the state's building energy efficiency standards have saved Californians $66 billion in electricity and natural gas costs – as well as substantially reduced the amount of energy (and related GHG) used for heating and cooling. However, these energy efficiency standards only apply to new and modified buildings. SB 350 seeks to increase energy efficiency in all buildings by 50% by 2030, through a building retrofit program, and gives California's energy agencies the authority to review and revise our state's energy efficiency programs to marshal the funds and regulatory actions necessary to reach this target. Unlike transportation fuel reduction goals that are dependent in part on federal government action, building retrofits are generally within the jurisdiction of state and local government agencies.

Retrofits will require very substantial new funding sources, but no information has been presented on the total estimated funding or potential sources of that funding.

1.4 Senate Bill 32

Proposed SB 32 is a short piece of legislation that amends Section 38550 of the Health and Safety Code, which codifies AB 32. The legislation would add a new mandatory 2050 GHG emissions cap for the state that is equivalent to 80% below 1990 levels. AB 32 required a reduction of 169 $MMTCO_2e$ below "business as usual" emissions that were projected to occur based on continued economic and population growth in 2020. SB 32 sets an absolute mass emission limit that is equivalent to additional reduction of 342 $MMTCO_2e$ beyond the 169 $MMTCO_2e$ required by 2020. Under SB 32, California would be required to reduce its GHG mass emissions to 85 $MMTCO_2e$, or 80% lower than the GHG emissions produced by California's 1990 population and economy. The bill would also authorize the ARB to adopt interim greenhouse gas emissions level targets to be achieved by 2030 and 2040[5].

Similar to AB 32, SB 32 does not provide a methodology to achieve the required 80% mass reduction metric, but directs the ARB to achieve this outcome by 2050 based on the best available scientific, technological, and economic assessments. In a change to AB 32, SB 32 explicitly includes the regulation of short-lived climate pollutants, which adds black carbon and fluorinated gases to the list of previously regulated GHGs. Black carbon is produced from the incomplete combustion of fossil fuels and biomass burning, particularly from older diesel engines and forest fires. Fluorinated gases were first used as a substitute for ozone depleting chemicals.

[5] http://www.leginfo.ca.gov/pub/15-16/bill/sen/sb_0001-0050/sb_32_bill_20150601_amended_sen_v96.pdf

1.5 Overview of Studies for Attaining More Substantial GHG Reductions in California

There are several studies that have been completed, or which are in process, which discuss methods for achieving the very deep cuts in California's GHG emissions level that would be mandated by SB 32, and the cuts that would be needed by the United States to achieve a reduction of 80% below 1990 emissions by 2050. These studies include those provided by E3[6] and summarized in a presentation provided by E3 under a study conducted for the ARB regarding modeled scenarios to achieve deep emissions cuts in the United States,[7] a report by the California Center for Science and Technology (CCST) on emission reductions in California,[8] a CalTrans report that studies solely GHG emission reductions from the transportation sector in California, and a study published in *Science*[9] that analyzes the technologies required by 2050 for an 80% reduction in emissions in California. In general, these studies have similar conclusions. Deep cuts in GHG emissions can only be reached with substantial changes in electricity production, transportation fuels, and industrial processes. Meeting the 2050 goals would require:

- Electricity production that relies on much more renewable energy, plus nuclear energy and carbon capture and sequestration (CCS) for electricity that continues to be produced from fossil fuels or biomass. This is referred to as a "decarbonized" electricity supply, or an electricity supply that does not rely on fossil fuels (coal, oil or natural gas) without carbon capture.
- The electrification of transportation to reduce the mass amount of GHG emissions with increased energy efficiency that comes from electric motors and reduced fossil fuel use due to the decarbonized electricity supply.
- The electrification of industrial process heating that is currently provided by fossil fuels.

The studies state that the electrification of transportation and industry will in turn result in a substantial net increase in the demand for electricity.

Both the *Science* and CCST studies also acknowledge that meeting the 2050 goals will require technologies that have not yet been proven.

The lead author of the *Science* study, which was published in 2012, is James Williams of E3. He is also the lead author of the study funded by ARB on achieving the 2050 goals across the United States. The *Science* study is, at this point, three years old, and some of the conclusions may be outdated. However, it states that "technically feasible levels of energy efficiency and decarbonized energy supply alone are not sufficient; widespread electrification of transportation and other sectors is required to meet 2050 goals. Decarbonized electricity would become the dominant form of energy supply, posing challenges and opportunities for economic growth and climate policy. This transformation demands technologies that are not yet commercialized, as well as coordination of investment, technology development, and infrastructure deployment."

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6 https://ethree.com/public_projects/energy_principals_study.php
7 http://www.arb.ca.gov/research/lectures/speakers/williams/williams.pdf.
8 http://www.ccst.us/publications/2012/2012ghg.pdf
9 *Science* 335, 53 (2012); James H. Williams, et al. The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity. http://www.sciencemag.org/content/335/6064/53.full

Consistent with other studies, the *Science* study showed that the electricity supply had to be nearly decarbonized, and most existing direct fuel uses had to be electrified, with electricity constituting 55% of end-use energy in 2050 versus 15% today (in 2012). The study showed that of the emissions reductions relative to 2050 baseline emissions, 28% came from energy efficiency, 27% from decarbonization of electricity generation, 14% from a combination of energy, conservation and alternative energy measures [including "smart growth" urban planning, biofuels, and rooftop solar photovoltaics (PV)], 15% from measures to reduce non-energy CO_2 and non-CO_2 GHGs, and 16% from electrification of existing direct fuel uses in transportation, buildings, and industrial processes. The study showed that nearly the entire light duty vehicle fleet would have to be electrified by 2050, along with nearly all of the space heating (cooking was not addressed). According to the study, this would lead to a doubling of the required electricity generation capacity.

The *Science* study found a maximum of 74% renewable energy in California's electrical system despite California's substantial renewable resources "even assuming perfect renewable generation forecasting, breakthroughs in storage technology, replacement of steam generation with fast-response gas generation, and a major shift in load curves by smart charging of vehicles." The balance of electricity would need to be supplied through a combination of nuclear power, and coal-fired energy using carbon capture and storage (CCS), with a small bit of natural gas to supply peak loads when needed. The study also noted that the fraction of renewable energy may be higher if there was lower population growth or less economic growth. "Smart growth" urban planning to reduce driving requirements was responsible for 5% of total emission reductions in 2050. It was not clear from the study how much reduction in overall VMT was assumed in this scenario.

The *Science* study noted that there are currently few options for the long-term emissions reductions for several sources of emissions, such as process-related CO_2 emissions (e.g., cement manufacturing and sulfur oxide control); methane and nitrous oxide from agriculture and waste treatment; and greenhouse gases used as refrigerants. The Science study also showed that if those emissions were not reduced, the statewide 2050 target could not be met. Although technologies for emissions reductions in these areas were generally poorly understood, the *Science* study assumed that reductions of those types of emissions would need to be made at the same level as the emissions reductions in other sectors to meet California's 80% GHG reduction requirement under 2050.

The *Science* study also found that achieving the changes required to reduce emissions 80% below 1990 levels by 2050 would require major improvements in a "wide array of technologies and infrastructure systems, including but not limited to cellulosic and algal biofuels, CCS, on-grid energy storage, electric vehicle batteries, smart charging, building shells and appliances, cement manufacturing, electric industrial boilers, agriculture and forestry practices, and source reduction/capture of high-GWP emissions from industry." It also found that the inherent energy efficiencies of electrical engines in transportation would result in lower fuel costs for transportation, while the costs of electricity for uses that have traditionally used electricity (e.g., household and other consumer uses) would increase.

The study by the CCST from 2012 was conducted to analyze the potential for future energy systems to meet California's 2050 GHG reduction targets. Similar to the study published in Science, this study is three years old, and technology may have improved since the study was published. Emissions from agriculture and waste disposal were not evaluated in this study. The CCST study was somewhat inconsistent in its description of methods to show a 60% reduction in emissions from 1990 levels. In one section of the report, it stated that it was able to show that emissions could be cut by about 60% from the 1990 levels using only technology that was either commercially available, or in demonstration at costs that were estimated to be "reasonable." Later in the report, it stated that "industrial processes would need to advance beyond technology available today" to achieve reductions of 60% below 1990 levels. Again, similar to the study published in *Science*, CCST concluded that meeting 2050 goals required eliminating petroleum as a transportation fuel, an approximate doubling of electrical generation capacity and a mix of electricity generating techniques, including renewable energy, nuclear energy, fossil-fired energy with carbon sequestration, and transition of nearly all natural gas uses to electricity.

The CCST study also evaluated biomass in far more detail than did the *Science* study, and evaluated the potential for using biomass combustion with CCS to allow for more flexibility of the use of fossil fuels elsewhere in the economy. Of greatest note, this study described the types of decisions that must be made on an economy-wide scale regarding the appropriate usage of biomass in the low carbon economy, as biomass supply was likely to be limited. Since biomass can be used, through a variety of pathways to make liquid and gaseous biofuels, this study noted that limited biomass would need to be directed to its best, highest usage, rather than for electricity production with CCS. This would limit the amount of biomass coupled with CCS that would be available to allow for other GHG emissions.

Early this year, the California Department of Transportation published[10] the California Transportation Plan 2040 (CTP 2040). This document describes California's transportation system and explores major trends that will likely influence travel behavior and transportation decisions over the next 25 years. It outlines goals, policies, strategies, performance measures, and recommendations to achieve that vision.

While the CTP 2040 is largely a policy document, it includes estimates of the impacts of policies on VMT reductions. In particular, it showed that VMT is difficult to reduce, even with significant pricing strategies. In particular, it indicates that a 75% increase in operating costs on a per mile basis only results in a 17% reduction in VMT. The sum total of transportation alternatives, including mode shift by improving public transit, increasing telecommuting, expanding biking, walking and carpooling only results in reductions of slightly over 12%.

Finally, the most recent study published by E3, who also produced the *Science* paper described earlier, addressed the potential for meeting the 2050 GHG reductions goals of 80% below 1990 levels in the United States. While there is no paper published to accompany the presentation provided by the ARB,[11] the charts that are incorporated state that in order to meet the 2050 goals, the focus must be on meeting the 2050 80% GHG reduction mandate rather than on

[10] http://www.dot.ca.gov/hq/tpp/californiatransportationplan2040/Documents/index_docs/CTP_ReportPublicDraft_03022015.pdf

[11] http://www.arb.ca.gov/research/lectures/speakers/williams/williams.pdf

meeting any interim reduction goals – and concludes that if policymakers choose to focus on meeting interim targets then the 2050 mandate cannot be met. For example, E3's presentation concludes that energy infrastructure, which has a long lifetime, must be changing now to meet the 2050 target, and should not be focused on meeting interim goals.

The public information from E3 about the assumptions, methodologies, allocation of GHG reduction obligations, and the costs (and cost allocations) for achieving the 2050 goal of 80% below 1990 levels for the United States is difficult to access and interpret. For example, although E3's earlier study on California stated that the entire light duty vehicle fleet (all passenger cars) would have to be electrified to meet 2050 goals, the presentation provided on May 13, 2015 on the United States appears to state that the light duty fleet need be only 50% electrified by 2050 (although it would have much higher energy efficiency than current fleets), while other charts indicate that the light-duty fleet would be wholly comprised of electric vehicles and Plug-in Hybrid Electric Vehicles (PHEVs). As with other studies, this E3 focus is on transportation, buildings, and energy sources. There appears to be no evaluation of industrial processes that generate CO_2 (i.e., cement), agriculture, or waste generation and disposal. In fact, the presentation appears to leave some significant sectors that ARB's SB 32 scoping plan had targeted for GHG reductions – such as methane emissions from agriculture - untouched through 2050.

The 2015 E3 study does include automobile turnover rates required to achieve compliance with 2050 goals in the United States, although, as noted above, there is some uncertainty as to whether the Plug-In Hybrid Electric Vehicles (PHEV) will be sufficient to meet the 2050 goals. It appears as if the operating assumption may be that the battery range on the PHEV vehicles is sufficient to meet nearly all driving.

In any case, the E3 scenario presumes that by 2020, less than 10% of the vehicles sold in the United States are PHEV or electric, but by 2030, over 80% of the vehicles sold are PHEV or electric. The mechanism for encouraging this substantially higher fraction of EVs and PHEVs is not clear. If it were to involve changing vehicular emissions standards, then federal approval would be required. There are approximately 13 million registered vehicles in California as of January 2015[12]. While volumes of new car sales vary annually, just over 1.8 million new cars were sold in California in 2014,[13] approximately 3.2% of which were electric or PHEV.[14] To meet the passenger car component of the 80% GHG reduction standard, both the existing fleet and all new cars would need to be powered by electricity by 2050.

1.6 CARB Scoping Plan Approach

In order to implement AB 32, ARB prepared a Scoping Plan that divided statewide emission into sectors, and evaluated options for GHG emissions reduction in each sector[15]. The initial Scoping Plan was approved in 2008, and as required by AB 32 was updated in 2011. The Scoping Plan was further revised in 2014, to evaluate further reductions beyond 2020.

[12] http://www.statista.com/statistics/196024/number-of-registered-automobiles-in-california/
[13] http://www.cncda.org/CMS/Slides/CNCDA%20EIR2015_FINAL.pdf
[14] http://www.electric-vehiclenews.com/2014/11/electric-vehicles-account-for-almost-10.html
[15] http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm

The initial Scoping Plan contained a mix of recommended strategies that combined direct regulations, market-based approaches, voluntary measures, policies, and other emission reduction programs calculated to meet the 2020 statewide GHG emission limit and prepare for the State's long-range climate objectives. The passage of AB 32, and its ongoing implementation, has reduced GHG emissions by adopting and implementing regulations and other programs to reduce emissions from cars, trucks, electricity production, fuels, and other sources. Importantly, as it relates to emissions from light duty vehicles (automobiles and light duty trucks), the GHG reduction measures required (and California received) approval from the United States Environmental Protection Agency.

ARB's 2014 Scoping Plan revised the division of the emission sources into six sectors: Energy, Transportation, Waste Management, Agriculture, Water, and Natural and Working Lands. Energy usage associated with buildings and manufacturing are subsumed into the energy sector.

According to the most recent scoping plan, over the last decade, the total statewide GHG emissions decreased annually from 466 MMTCO2e in 2000 to 459 MMTCO2e in 2012 - a decrease of 1.7 percent. The emissions in 2012 increased for the first time in the five-year period since 2007. According to the most recent Scoping Plan, this increase was due to the closure of the San Onofre Nuclear Generating Station (SONGS) as well as the drought, causing a drop in the in-state hydropower generation. While California's population grew by 11.3 percent between 2000 and 2012, California's per capita GHG emissions have decreased by 11.6 percent. The 2020 target is 431 MMTCO2e, or a decrease of 6% over the 2012 emissions. The required per capita decrease is greater, assuming predicted population and economic growth in the State.

1.7 Achieving 80% Reduction of GHG Emissions in 2050

As noted earlier, achieving an 80% reduction of GHG emissions over 1990 levels requires two major substantial changes in California's economy: both transportation and electricity generation must be nearly entirely decarbonized. In addition, California's manufacturing and industrial sectors must electrify their process heating, and reduce other process-related GHG emissions.

Decarbonization of the transportation fuels supply would require that electric and PHEV light duty vehicles comprise all or nearly all of automobiles. In order to drive such wholesale fleet transformation, federal approvals would be required. Similarly, energy efficiency in trucks would have to increase, which would likewise require federal approval. Finally, liquid biofuels would be required for aviation, and some long distance trucking. The entire freight management system could also be changed, to allow for increased optimization of freight movement. Federal approvals would likewise be required for freight-based transportation fuels. In the absence of federal approvals, SB 32 would still require the same mass GHG emission reductions, which would presumably be met through other means.

As described in both the *Science* study and the CCST study, decarbonizing the transportation fuel supply and industrial process heating would require an approximate doubling of electricity generation capacity in the California, along with a decarbonized electricity supply. Most projections call for a major renewable component, nuclear power, and an electricity supply that includes fossil or biomass-fired power with CCS. In addition, distributed generation and storage plays a substantial role in the 2050 electricity grid. In order to accommodate the large fraction of renewable power that would be required to meet 2050 goals, breakthroughs in storage technology, replacement of steam generation with fast- response gas generation, and a major shift in load curves by smart charging of vehicles would be required. This would entail a substantial redesign of California's energy generation system.

In order to reduce energy usage to meet 2050 goals, new buildings would be required to be "zero energy" by 2030. This would include increases in energy efficiency for buildings and distributed energy production in new buildings. The CCST study states that existing buildings would have to be replaced or substantially modified or retrofit to meet even a 60% reduction goal, whereas the *Science* study did not reach this conclusion.

The Scoping Plan also calls for the incorporation of manufacturing facilities in the Cap and Trade program. The Cap and Trade program allows industry to determine whether it is more cost-effective to reduce emissions, buy emissions allowances, or close or curtail their operations and sell their allowances to others. Manufacturing and industrial operations that can rely on electricity usage, such as automobile assembly, can more readily use a decarbonized electricity supply. The reduction of GHG emissions from manufacturing operations that rely on process fuel combustion or larger-scale and more intensive energy consumption, such as glass manufacturing, is more difficult; large-scale electrification of these types of facilities has not been demonstrated. In addition, GHG emissions are caused by California's stringent air pollution control standards (e.g., requiring the destruction of volatile organic compounds results in GHG emissions). Implementing deep decarbonization in California that does not allow the emissions of GHGs from certain types of manufacturing operations has the potential to reduce manufacturing in California. This could be counterproductive to the goal of reducing worldwide GHG emissions, as manufacturing outside of California would be less GHG efficient.

As noted earlier, none of the studies explicitly addressed methods to effect a reduction of emissions from the agricultural sector, although the *Science* study simply assumed that emissions reductions from agriculture could be achieved consistent with emissions reductions in other sectors. The most recent version of the Scoping Plan did address agricultural emissions, as agricultural emissions have increased in California, due to the increasing numbers of cattle in California. In particular, the Scoping Plan called for improving methane capture from dairies, potentially through regulation, and reducing fertilizer usage through work practice requirements. To the extent agricultural emissions are required to be substantially reduced in California without subsidies, Californian agricultural products may be more expensive than those purchased out of state. Careful consideration of subsidy provisions to California farms will be required. Similar to the issue with manufacturing, displacement of agriculture production will result in greater GHG emissions if they take place outside of California in a higher GHG environment.

1.8 Summary

Several studies have been produced over the past few years that show pathways to deep reductions in GHG emissions in California. They all call for decarbonized transportation fuels and electricity, and electrification of process heat for industry. This would require rapid adoption of electric cars in the state, new technologies to electrify trucks and reduce emissions from freight transport, and a doubling of electricity generation in the state. In addition, it would involve using a mixed portfolio of electricity generating technologies, including a strong component of renewable fuels, plus nuclear power and fossil fuel combustion coupled with CCS. The pathways to reducing emissions from the manufacturing and agricultural sectors are less apparent, and would require additional research and investment. The new technologies that must be developed for all sectors could allow California to lead in the development of low-carbon technologies, but alternatives to the mass reduction metric included in SB 32 – such as the efficiency and sector-specific metrics included in SB 350 – may prove more effective in creating the incentives needed to develop, manufacture and deploy this technology in California, and thereby demonstrate that deep decarbonization can be achieved in a successful economy with a diverse and growing population.

EXHIBIT '3'

EXHIBIT '3'

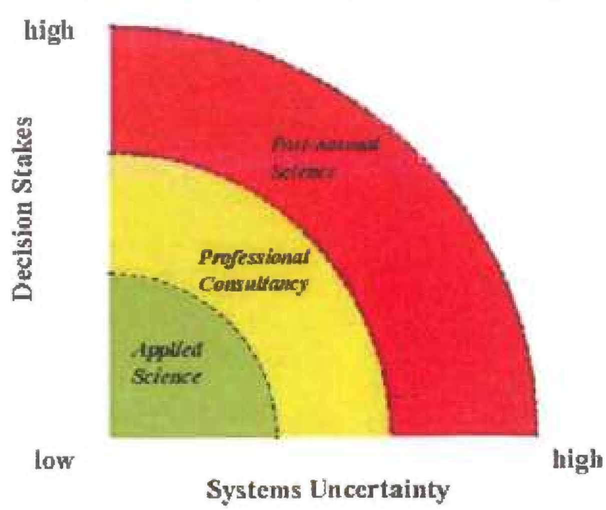
Climate Policy

Previous: Climate Impacts

Post-Normal Science

We must think of climate change in terms of risk, not certainty.

As should be abundantly clear by now, when assessing climate science, impacts and now policy issues, we are rarely talking about certainties, but rather about risks. The climate problem, like the ozone problem (see, e.g., the **EPA ozone website** or the **NOAA ozone website**) and, in fact, almost all interesting socio-technical problems, is filled with "deep uncertainties," uncertainties in both probabilities and consequences that are not resolved today and may not be resolved to a high degree of confidence before we have to make decisions regarding how to deal with their implications. They often involve very strong and opposite stakeholder interests and high stakes. In fact, sociologists Funtowicz and Ravetz (see, for example: **Funtowicz and Ravetz, 1993**) have called such problems examples of "post-normal science." In Kuhn's "normal science" (**Kuhn, 1962**), we scientists go to our labs and we do our usual measurements, calculate our usual statistics, build our usual models, and we proceed on a particular well-established paradigm. Post-normal science, on the other hand, acknowledges that while we're doing our normal science, some groups want or need to know the answers well before normal science has resolved the deep inherent uncertainties surrounding the problem at hand. Such groups have a stake in the outcome and want some way of dealing with the vast array of uncertainties, which, by the way, are not all equal in the degree of confidence they carry. Compared to applied science and professional consultancy, post-normal science carries both higher decision stakes and higher systems uncertainty, as depicted in the graphic below, which accompanies **Jerry Ravetz's website's discussion of post-normal science**.



The climate change debate — particularly its policy components — falls clearly into the post-normal science characterization and will likely remain there for decades, which is the minimum amount of time it will take to resolve some of the larger remaining uncertainties surrounding it, like climate sensitivity levels and the likelihood of abrupt nonlinear events, including a possible shutoff of the Gulf Stream in the high North Atlantic (see **What is the Probability of "Dangerous" Climate**

Change?).

And the climate problem emerges not simply as a post-normal science research issue, but as a risk management policy debate as well. Risk is classically defined as probability times consequences. One needs both. The descriptive science — what we like to call our "objective" purview — entails using empirical and theoretical methods to come up with the two factors that go into risk assessment: **a)** what can happen? and **b)** what are the odds? And both are essential. However, it's not as simple as it sounds, as we can't possibly obtain empirical data about future climate change before the fact. Our empirical data is only about the present and the past, and therefore, the best way we can simulate the future is by constructing a systems theory — built, of course, by aggregating empirically derived sub-models. However, the full integrated systems model is not directly verifiable before the fact (i.e. until the future rolls around and proves it right or wrong — or, more likely, a mixture of both), and thus only subjective methods are available. The degree of confidence we may assign to any assessed risk is always subjective, since probabilities about future events necessarily carry some subjectivity. That doesn't mean it is not an expert-driven assessment, but it is still subjective. So, the big question we're left with is: **what probabilities should we use and from whom do we obtain them**?

There are also normative judgments, or value judgments, that must be made when considering climate change policy: what is safe and what is dangerous? The 1992 **UNFCCC**, which was signed by President Bush Senior (and ratified by Congress) and the leaders of about 170 other countries, essentially stated that it is the job of the Framework Convention to prevent (and this is a direct quote) "dangerous anthropogenic interference with the climate system" — although nobody knows what that means! "Dangerous" is a *value judgment* that depends upon the assessment of the probabilities and consequences just discussed. We scientists can provide a range of scenarios and even assign subjective likelihoods and confidence levels to them, but it's up to policymakers to decide what risks are acceptable, and which are dangerous and should be avoided — and what course of action should be taken or not taken either way.

The other major question in the climate change debate is: **what is fair?** If a cost-benefit analysis is performed to find the least expensive way to achieve maximum climate abatement, it may be that in the "one dollar, one vote" world that cost-benefit methods typically imply, some action — passive adaptation, for example — might appear to be the most cost-effective. But here's the dilemma: a rich country that has historically produced large emissions of greenhouse gases could well find it cheaper to adapt by building seawalls, for example, than to mitigate through an action such as retiring a few coal-burning power plants. On the other hand, a poorer country in the hotter equatorial area with fewer resources (and thus less adaptive capacity) might be both more harmed by climate change and less able to pay for or otherwise deal with the damages it causes because the country lacks the same degree of adaptive capacity as the richer country. Thus, adaptation might seem cheaper in a cost-benefit analysis that aggregates all costs and benefits into equivalent dollars since the rich country, with a much larger share of world GDP, will be able to adapt more easily. But, that policy may not be fair in its distribution across rich and poor countries, which is the concept behind distributive justice/equity. Efficiency versus equity dilemmas, as just outlined, can lead to alternative political views of what should be done, and are also connected to the question of who should pay to abate risks. These equity/efficiency trade-offs are inherent in the ozone problem as well; they're just multiplied by a much larger factor in dealing with climate change.

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Uncertainties in Climate Change Projections and Impacts

(See also **Climate Science** and **Climate Impacts**)

It is almost tautological to note that unexpected global changes, such as the development of the hole in the ozone layer, are inherently difficult to predict. It is perhaps equally non-informative to suggest that other climate "surprises" can arise in the future. But despite the difficulty prevalent in forecasting climate change and its consequences, it is imperative that we address the uncertainties underlying our understanding of climate change and its effects. Global change science and policymaking will have to deal with uncertainty and surprise for the foreseeable future. Thus, more systematic analyses of surprise issues and more formal and consistent methods of incorporation of uncertainty into global change assessments will become increasingly necessary, as exemplified in the Climate Science and Climate Impacts sections of this website (see especially **What is the Probability of "Dangerous" Climate Change?**).

Significant uncertainties plague projections of climate change and its consequences, but one thing is known for certain: the extent to which humans have influenced the environment since the Victorian Industrial Revolution is unprecedented. Human-induced climate change is projected to occur at a very rapid rate; natural habitats will become more fragmented as land is cleared for agriculture, settlements, and other development activities; "exotic" species are and will continue to be imported across natural biogeographic barriers; and we will persist in assaulting our environment with a host of chemical agents. For these reasons, it is essential to understand not only how much climate change is likely to occur, but also how to estimate climate damages (see **Climate Impacts**). Speculation on how the biosphere will respond to human-induced climate change is fraught with deep uncertainty (see **Root and Schneider, 2002**), but as research continues we will continue to narrow our range of plausible projections.

The combination of increasing global population and increasing energy consumption per capita is expected to contribute to increasing CO_2 and sulfate emissions over the next century. However, projections of the extent and effect of the increases are, as you might have guessed by now, very uncertain. Midrange estimates of emissions suggest a doubling of current equivalent CO_2 concentrations in the atmosphere by the middle of the 21st century, leading to projected warming ranging from more than one degree Celsius all the way up to six degrees Celsius by the end of the twenty-first century (see ***Earth's surface temperature***). Warming at the upper end of this range is even more likely if CO_2 concentrations reach triple or more their current levels, which could occur during the 22nd century in about half the SRES scenarios (see ***CO2 concentrations***). While warming at the low end of this range could still have significant implications for species adaptation, warming of five degrees or more could have catastrophic effects on natural and human ecosystems, including serious coastal flooding, collapse of thermohaline circulation (THC) in the Atlantic Ocean, and nonlinear ecosystem responses (see ***Reasons for climate impact concerns***). The overall cost of these impacts on "market sectors" of the economy could easily run from tens of billions of dollars annually in the near term up to perhaps as much as trillions of dollars by the late 21st century (see ***Probability distributions (f(x)) of climate damages***), and non-market impacts (i.e., loss of human lives, loss of biodiversity — see the *Five Numeraires*) could be even greater.

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Decision-Making Under Uncertainty

Debate about the level of certainty required to reach a "firm" conclusion and make a decision is a perennial issue in science and policymaking. The difficulties of explaining uncertainty have become increasingly salient as politicians seek scientific advice and societies seek political advice on dealing with global environmental change. Policymakers struggle with the need to make decisions that will have far-reaching and often irreversible effects on both environment and society — against a backdrop of sparse and imprecise information. Not surprisingly, uncertainty often enters the decision-making process through catch-phrases like "the precautionary principle," "adaptive environmental management," "the preventative paradigm," or "principles of stewardship." While a preventive approach is preferable, in my view, it entails a step that many governments have been unwilling to make thus far. But in **The Climate Change Challenge**, Grubb, 2004 reminds us: "No business or government expects to take decisions knowing everything for certain, and climate change embodies the same dilemmas on a global and long term scale. Policymaking nearly always requires judgment in the fact of uncertainty and climate change is no different. Taking no action is itself a decision." Any shift towards prevention in environmental policy "implies an acceptance of the inherent limitations of the anticipatory knowledge on which decisions about environmental [problems] are based" (**Wynne, 1992**). In order for such a shift to occur, we must ask two major questions. First, how can scientists improve their characterization of uncertainties so that areas of slight disagreement do not become equated with major scientific disputes, which occurs all too often in media and political debates? (See **"Mediarology"**.) Second, how can policymakers synthesize this information and formulate policy based on it?

In dealing with uncertainty in the science and policy arenas, two options are typically available: **1)** bound the uncertainty, or **2)** reduce the effects of uncertainty. The first option involves reducing the uncertainty through data collection, research, modeling, simulation techniques, and so forth, which is characteristic of normal scientific study. However, the daunting magnitude of the uncertainty surrounding global environmental change, as well as the need to make decisions before the uncertainty is resolved, make the first option a goal that is rarely achieved. That leaves policymakers with the second alternative: to manage uncertainty rather than master it. This typically consists of integrating uncertainty directly into the policymaking process. The emphasis on managing uncertainty rather than mastering it can be traced to work on resilience in ecology, most notably by **Holling (1973, 1986)**. Resilience refers to the ability of a system to recover from a disturbance, without compromising its overall health.

The fields of mathematics, statistics, and, more recently, physics, have all independently and concurrently developed methods to deal with uncertainty. Collectively, these methods offer many powerful means and techniques climatologists can use to conceptualize, quantify, and manage uncertainty, including frequentist probability distributions, subjective probability, and Bayesian statistical analysis, and even a method for quantifying ignorance. In addition, fuzzy set logic offers an alternative to classical set theory for situations in which the definitions of set membership are vague, ambiguous, or non-exclusive. More recently, researchers have proposed chaos theory and complexification theory in attempts to create models and theories that expect the unexpected (see the discussion and references in **Schneider, Turner and Morehouse Gariga, 1998**, from which much of this section has been derived). More work must be done to assure that these methods, especially subjective probability and Bayesian statistical analysis, are widely accepted and used in climate change modeling.

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Scaling in Integrated Assessment Models (IAMs) of Climate Change

Strictly speaking, a surprise is an unanticipated outcome. Potential climate change, and more broadly, global environmental change, is replete with this kind of truly unexpected surprise because of the enormous complexities of the processes and interrelationships involved (such as coupled ocean, atmosphere and terrestrial systems) and our insufficient understanding of them (see, for example, **Climate Surprises and a Wavering Gulf Stream?**). In the IPCC SAR (**IPCC 1996a**), "surprises" are defined as rapid, nonlinear responses of the climatic system to anthropogenic forcing, such as the collapse of the "conveyor belt" circulation in the North Atlantic Ocean (**Rahmstorf, 2000**) or rapid deglaciation of polar ice sheets. Unfortunately, most climate change assessments rarely consider low-probability, high-consequence extreme events. Instead, they consider several scenarios thought to "bracket the uncertainty" rather than to explicitly integrate unlikely surprise events from the tails of the distribution associated with the assessment. Structural changes in political or economic systems and regime shifts, such as a change in public consciousness regarding environmental issues, are not even considered in most scenarios.

Integrated assessments of global change disturbances involve "end-to-end" analyses of relationships and data from the physical, biological and social sciences (e.g., see the reviews and references in **Weyant et al. (1996)**, **Morgan and Dowlatabadi (1996)**, **Rotmans and van Asselt (1996)**, **Parson (1996)**, **Rothman and Robinson (1997)**, and **Schneider (1997b)**. Often, data or processes are collected or simulated across vastly different scales — for example, consumption at national scales and consumer preferences at family scales, or species competition at a field plot the size of a tennis court and species range boundaries at a scale of half a continent, or thunderstorms in ten-kilometer squares and grid cells of a global climate model in squares hundreds of kilometers in length, or the response of a plant in a meter-square chamber to increased concentrations of CO_2 and the response of an ecosystem to CO_2 at biome scales of thousands of kilometers. Not only must individual disciplines concerned with the impacts of global change disturbances — like altered atmospheric composition or land use and land cover changes — often deal with orders of magnitude of difference in spatial scales, but integrated studies must bridge scale gaps across disciplinary boundaries as well (see, e.g., **Root and Schneider, 2003**, from which much of this discussion is adapted). For instance, how can a conservation biologist interested in the impacts of climate change on a mountaintop-restricted species scale down climate change projections from a climate model whose smallest resolved element is a grid square that is 250 kilometers on a side? Or, how can a climate modeler scale up knowledge of evapotranspiration through the sub-millimeter-sized stomata of forest leaves into the hydrological cycle of the climate model, which is resolved at hundreds of kilometers? The former problem is known as downscaling (see, e.g. **Easterling et al., 2001**), and the latter, up-scaling (see, e.g. **Harvey, 2000b**). This cross-disciplinary aspect can be particularly daunting when different scales are inherent in different sub-disciplines. Scaling problems are particularly likely when the boundary between natural and social science is crossed. Only a greater understanding of the methods and traditions of each of these sub-disciplines by practitioners in the others will help to facilitate boundary-bridging across very different disciplines operating at very different scales.

Scaling in Natural Science Forecast Models. First, let us consider natural scientific scale bridging. For a forecasting model to be credible, it must analytically solve a validated, process-based set of equations accounting for the interacting phenomena of interest. The classical reductionist philosophy in science is a belief that laws (i.e., the laws of physics) apply to phenomena at all scales. If such laws can be found (usually at small scales), then the solution of the equations that represent such laws will provide reliable forecasts at all scales. This assumes, of course, that those laws are applicable to all of the phenomena incorporated into the model.

The philosophy behind most climatic models is that solutions to the energy, momentum, and mass conservation equations should, in principle, provide credible forecasting tools. Of course, as all climate modelers have readily admitted for decades (e.g. **SMIC, 1972**, and **IPCC 1996a**), this "first principles," bottom-up approach suffers from a fundamental practical limitation: the coupled nonlinear equations that describe the physics of the air, seas, and ice are far too complex to be solved by any known (or foreseeable) analytic (i.e., exact) technique. Therefore, methods of approximation are applied in which the continuous differential equations (i.e., the laws upon which small-scale physical theory comfortably rest) are replaced with discrete, numerical, finite difference equations. The smallest resolved spatial element of these discrete models is known as a grid cell. Because the grid cells are larger than some important small-scale phenomena, such as the condensation of water vapor into clouds or the influence of a tall mountain on wind flow or the evapotranspiration from a patch of forest, "sub-grid scale" phenomena cannot be explicitly included in the model. In order to *implicitly* incorporate the effects of an important sub-grid scale phenomenon into a model, top-down techniques are used, in which a mix of empiricism and fine-resolution, scale-up sub-models are applied. From this, we can create a parametric representation, or "parameterization," of the influence of sub-grid scale processes at larger scales. Determining whether it is even possible in principle to find valid parameterizations has occupied climate modelers for decades (see **Climate Modeling**).

In order to estimate the ecological consequences of hypothesized climate change at small scales, a researcher must first translate his/her large-scale climate change forecast to a smaller scale. For an idea of the enormity (literally!) of this task, it could involve translating climate information at a 200x200 kilometer grid scale to, perhaps, a 20x20 meter field plot — a ten-thousand-fold interpolation! Therefore, how can climatologists possibly map grid-scale projections to landscapes or even smaller areas?

At the outset, one might ask why the atmospheric component of such detailed climate models, known as general circulation models (GCMs), use such coarse horizontal resolution. This is easy to understand given the practical limitations of modern, and even foreseeable, computer hardware resources (see, e.g., **Trenberth, 1992**).

A 50 x 50 kilometer scale in a model falls into the range known as "the mesoscale" in meteorology. If such a resolution were applied over the entire earth, then the amount of time required for one of today's "super computers" to run a year's worth of weather data for it would be on the order of many days. (For example, to run the NCAR CCM3 at 50 km (T239) for a year, using an IBM SP3 and 64 processors, takes 20 wall-clock days. This is not running it with a full ocean model, but with fixed Sea Surface Temperature (SST) data sets. Such tests are run, e.g., at Lawrence Livermore National Laboratory; see **Scientists Create Highest Resolution Global Climate Simulations**, and **Simulating the Earth's Climate**.) 50 kilometers is still roughly a hundred times greater than the size of a typical cloud, a thousand times greater than the typical scale of an ecological study plot, and even greater orders of magnitude larger than a dust particle on which raindrops condense. Therefore, in the foreseeable future, it is inevitable that climate change information will not be produced directly from the grid cells of climate models at the same scale that most ecological information is gathered, nor will climate models be able to accurately account for some sub-grid-scale phenomena, such as cloudiness or evapotranspiration from individual plants — let alone leaves! However, the usual scale mismatch between climate and ecological models has caused some ecologists to attempt to produce large-scale ecological studies and some climatologists to shrink the grid sizes of their climate models. **Root and Schneider, 1993**, have argued that *both* are required, as are accurate techniques for bridging the scale gaps, which, unfortunately, will exist for at least several more decades.

In order for action to be taken to avoid or correct potential risks to environment or society, it is often necessary to establish that a trend has been detected in some variable of importance - the first arrival of a spring migrant or the latitudinal extent of the sea ice boundary, for example - and that that trend can be attributed to some causal mechanism like a warming of the globe from anthropogenic greenhouse gas increases. Pure association of trends are not, by themselves, sufficient to attribute any detectable change above background noise levels to any particular cause; explanatory mechanistic models are needed in order to obtain a high confidence level about whether a particular impact can be pinned on the suspected causal agent. **Root and Schneider, 1995** argued that conventional scaling paradigms — top-down associations among variables believed to be cause-and-effect and bottom-up mechanistic models run to predict associations but for which there is no large-scale data time series to confirm — are not by themselves sufficient to provide high confidence in cause-and-effect relationships embedded in integrated assessments. Rather, a cycling between top-down associations and bottom-up mechanistic models is needed. Moreover, we cannot assign high confidence to cause-and-effect claims until repeated cycles of testing in which mechanistic models predict and large-scale data "verifies" that a claim is correct. There should also be a degree of convergence in the cycling (**Root and Schneider, 2003**).

Modellers continue to attempt to model more regional climate change, despite the difficulties. The European Union has provided $4.2 million in funding to a project called Prudence, which is working with various models to assess climate change in Europe (see **Schiermeier, 2004b** and a clarification of Schiermeier's disussion of the role of the US National Assessment of the Potential Consequences of Climate Variability and Change (USNA) by **MacCracken et al., 2004**). Modellers in America and Canada are now seeking funding of their own to establish a similar organization. Such regional modelling is still in its early stages of development but is definitely a step in the right direction.

Strategic Cyclical Scaling. Root and Schneider, 1995 called this iterative cycling process "strategic cyclical scaling" (SCS). The motivation behind development of the SCS paradigm stemmed from the need for: (1) better explanatory capabilities for multi-scale, multi-component interlinked environmental models (e.g., climate-ecosystem interactions or behavior of adaptive agents in responding to the advent or prospect of climatic changes); (2) more reliable impact assessments and problem-solving capabilities - predictive capacity - as has been requested by the policy community; and (3) the insufficiency of both bottom-up and top-down modeling approaches by themselves.

In SCS (see **Root and Schneider, 2003**), from which much of this section is derived), both macro (top-down) and micro (bottom-up) approaches are applied to address a practical problem — in our original context, the ecological consequences of global climatic change. Large-scale associations are used to focus small-scale investigations so that the valid causal mechanisms generating the large-scale relationships will be found and applied. The large-scale relationships become the systems-scale "laws" that allow climatologists or ecologists to make more credible forecasts of the consequences of global change disturbances. "Although it is well understood that correlations are no substitute for mechanistic understanding of relationships," **Levin, 1993** observed, "correlations can play an invaluable role in suggesting candidate mechanisms for (small-scale) investigation." SCS, however, is not only intended as a two-step process, but rather a continuous cycling between large- and small-scaled studies, with each successive investigation building on previous insights from all scales. This paradigm is designed to enhance the credibility of the overall assessment process, including policy analyses, which is why it is also called "strategic." I believe that SCS is a more scientifically viable and cost-effective means of improving the credibility of integrated assessment compared to isolated pursuit of either the scale-up or scale-down methods.

Though SCS seems to be a more well-rounded approach, it is by no means simple. The difficulty in applying SCS is knowing when the process has converged, for that requires extensive testing against some applicable data that describes important aspects of the system being modeled. When the model is asked to project the future state of the socio-environmental system, only analogies from past data can be used for testing since there is no empirical data,. Therefore, assessing "convergence" will require judgments as well as empirical determinations, as discussed below.

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Climate Damages and the Discount Rate

Rate of forcing matters. Even the most comprehensive coupled-system models are likely to have unanticipated results when forced to change very rapidly by external disturbances like CO_2 and aerosols. Indeed, some of the transient coupled atmosphere-ocean models which are run for hundreds of years into the future exhibit dramatic change to the basic climate state (see **Climate Surprises and a Wavering Gulf Stream?**).

Estimating Climate Damages. A critical issue in climate change policy is costing climatic impacts, particularly when the possibility for nonlinearities, surprises, and irreversible events is allowed. The assumptions made when carrying out such estimations largely explain why different authors obtain different policy conclusions (see **Dangerous Climate Impacts and the Five Numeraires**).

One way to assess the costs of climate change is to evaluate the historic losses from extreme climatic events, such as floods, droughts, and hurricanes (**Alexander et al., 1997**). Humanity remains vulnerable to extreme weather events. Catastrophic floods and droughts are cautiously projected to increase in both frequency and intensity with a warmer climate and the influence of human activities such as urbanization, deforestation, depletion of aquifers, contamination of ground water, and poor irrigation practices (see IPCC: **1996a**, **2001b**, and the table ***Projected effects of global warming***). The financial services sector has taken particular note of the potential losses from climate change. Losses from weather-related disasters in the 1990s were eight times higher than in the 1960s. Although there is no clear evidence that hurricane frequency has changed over the past few decades (or will change in the next few decades), there is overwhelming data that damages from such storms has increased astronomically (see figure below). Attribution of this trend to changes in socioeconomic factors (e.g., economic growth, population growth and other demographic changes, or increased penetration of insurance coverage) or to an increase in the occurrence or intensity of extreme weather events, as a result of global climate change, is uncertain and controversial. (Compare **Vellinga et al.**, which acknowledges both influences and recognizes the difficulty in attribution, to **Pielke Jr. and Landsea, 1998**, which, in the context of hurricane damage, dismisses any effects of climate change and says increased damages result solely from richer people moving into harm's way. However, **Pielke and Downton, 2000**, do suggest that for non-coastal casualty losses, climate is a partial factor — see "**Population and wealth...**".)

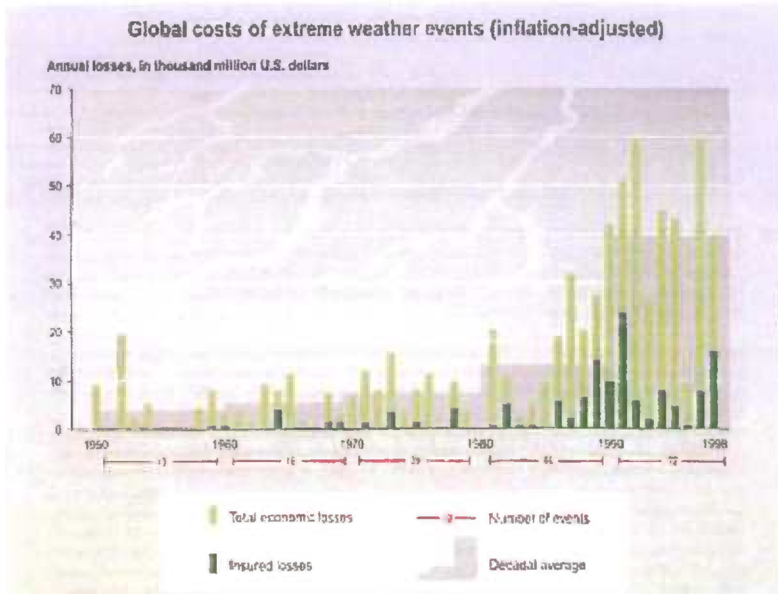

Figure — *The economic losses from catastrophic weather events have risen globally 10-fold (inflation-adjusted) from the 1950s to the 1990s, much faster than can be accounted for with simple inflation. The insured portion of these losses rose from a negligible level to about 23% in the 1990s. The total losses from small, non-catastrophic weather-related events (not included here) are similar. Part of this observed upward trend in weather-related disaster losses over the past 50 years is linked to socio-economic factors (e.g., population growth, increased wealth, urbanization in vulnerable areas), and part is linked to regional climatic factors (e.g., changes in precipitation, flooding events). (Source:* IPCC TAR Synthesis Report, figure 2-7.*)*

Many projections have been made regarding the extent of future climate-related damages. For example, **Nicholls et al., 1999** project that if fossil fuel usage continues to grow at the current rate and climate changes as they expect, by 2080, the number of additional people affected by flooding in delta areas like the Nile, the Mekong, and Bangladesh and in coastline cities and villages in India, Japan, and the Philippines would be in the hundreds of millions (assuming no adaptation measures are implemented). Using four different emissions scenarios, researchers at the UK's **Office of Science and Technology** (OSTP) concluded that by 2080, the combination of sea level rise and increased stormy weather will likely cause storm surges to hit areas farther inland and could have the potential to increase flood risk to as much as 30 times present levels. In the worst-case scenario, serious storms that now occur only about once per century would become recurring events, coming every three years. Under this scenario, British inhabitants at risk of serious flooding would more than double to 3.5 million, and weather-related damages would skyrocket (see the UK's OSTP **Foresight website**, which is home to the Flood and Coastal Defense project).

An assumption in cost-benefit calculations within the standard assessment paradigm is that "nature" is either constant or irrelevant. Since "nature" falls out of the purview of the market, cost-benefit analyses typically ignore its non-market value. For example, ecological services such as pest control and waste recycling are omitted from most assessment calculations (**Vellinga et al., 2001**). Implicitly, this assumes that the economic value of ecological services is negligible or will remain unchanged with human disturbances. However, many authors have acknowledged that natural systems are likely to be more affected than social ones (see **Root et al., 2003** and **IPCC, 2001b**). Recent assessments of the value of ecosystem services (e.g., **Daily and Ellison, 2002**) acknowledge the tremendous public good (i.e., free) provided, not to mention the recreational and aesthetic value. For example, a cost-assessment study done in New York discovered that paying residents and farmers in the Catskills to reduce toxic discharges and other environmental disruptions would provide a natural water purification service, producing savings to New York City on the order of billions of dollars relative to building new water treatment plants. Furthermore, it is highly likely that communities of species will be disrupted, especially if climate change occurs in the middle to upper range projected (**Root and Schneider, 2002**). These costs are rarely included in most cost-benefit calculations.

Cost-benefit analyses can be flawed in other ways, too. Phillip E. Graves, an economist at the University of Colorado at Boulder, also believes that the public-good nature of environmental goods causes difficulties in valuing them and thus in finding solutions for environmental problems. He argues that if people could pay for public goods like environmental protection in the same way that they pay for private goods -- i.e., from income -- then they would divert some of their spending from private to public goods, by making a different balance between income and leisure then they are now able to make. But since people know they can't buy public goods in the market, they don't, in this kind of CBA, devote income toward them; such miscalculation causes most economists to come up with artificially low "optimal" levels of public goods (see **Graves, 2003**).

The discount rate. Discounting plays a crucial role in the economics of climate change, yet it is a highly uncertain techniquer. Discounting is a method to aggregate costs and benefits over a long time horizon by summing net costs (or benefits), which have been subjected to a discount rate typically greater than zero, across future time periods. If the discount rate equals zero, then each time period is valued equally (case of infinite patience). If the discount rate is infinite, then only the current period is valued (case of extreme myopia). The discount rate chosen in assessment models is critical, since abatement costs will be typically incurred in the relatively near term, but the brunt of climate damages will be realized primarily in the long term. Thus, if the future is sufficiently discounted, present abatement costs, by construction, will outweigh discounted future climate damages. The reason is, of course, that discount rates will eventually reduce future damage costs to negligible present values.

Consider a climate impact that would cost 1 billion dollars 200 years from now. A discount rate of 5% per year would make the present value of that future cost equal to $58,000. At a discount rate of 10% per year, the present value would only be $5. Using a higher discount rate will result in more damaging effects than a lower rate. As **Perrings, 2003** notes, "The effect of discounting is both to increase the potential for unexpected future costs, and to eliminate those costs from consideration." Changes in the discount rate largely explain why some authors (**Nordhaus, 1994b**; **Nordhaus and Yang, 1996**; **Manne and Richels, 1997**; and **Nordhaus and Boyer, 2000**) using large discount rates conclude that massive CO_2 emission increases are socially beneficial — i.e., more economically efficient than cuts — whereas others (**Cline, 1992**; **Azar and Sterner, 1996**; **Hasselmann et al., 1997**; **Schultz and Kasting, 1997**; **Mastrandrea and Schneider, 2001**; **Lind, 1982**) using low or zero discount rates justify substantial emission reductions, even when using similar damage functions (**Portney and Weyant, 1999**) **Note 1**.

It would seem that the appropriate discount rate would be a matter of empirical determination, but in reality, choosing a discount rate involves a serious normative debate about how to value the welfare of future generations relative to current ones. Moreover, it requires that this generation estimate what kinds of goods and services future generations will value — e.g., how they will want to make trade-offs between material wealth and environmental services.

There are two basic methods for deciding on a discount rate. The *descriptive* approach chooses a discount rate based on observed market interest rates in order to ensure that investments are made in the most profitable projects. Supporters of this approach often argue that using a market-based discount rate is the most efficient way to allocate scarce resources used for competing priorities, one of which is mitigating the effects of climate change.

The *prescriptive* approach emphasizes that the choice of discount rate entails a judgment about how the future should be valued. Proponents of intergenerational equity often argue that it is difficult to find an argument supporting the discounting of the welfare of future generations. Why should future people count less just because they don't exist today?

Although these two approaches are the most commonly used to pick discount rates for use in IAMs of climate change, alternative discount methods have been proposed (see **Schneider and Kuntz-Duriseti, 2002**, from which much of this section has been derived — further references can be obtained from that chapter). There is empirical evidence to suggest that individuals exhibit "hyperbolic discounting", where discount rates decline over time, with higher-than-market discount rates in the short run and lower-than-market discount rates over the long term (**Ainslie, 1991**).

This behavior is consistent with a common finding that "human response to a change in a stimulus is inversely proportional to the preexisting stimulus" (**Heal, 1997**). Hyperbolic discounting can be derived from both the descriptive and the prescriptive approach and is obtained when discount rates fall over time. This can be modeled in IAMs with a logarithmic discount factor or by assuming that per capita income grows logistically (i.e., diminishes over time) over the next century; since the discount rate is proportional to growth rates, declining discount rates are obtained. (See the strong case made for declining discount rates in **Weitzman, 2001**.)

Furthermore, if climate change is extremely severe, such that future income falls rather than grows (the latter is assumed in almost all IAMs), then the discount rate could be negative, provided that the rate of time preference is sufficiently low (**Azar and Johansson, 1996**). In this case, future welfare should be valued *more* than the present. (For a definition of rate of time preference, see the latter part of the discussion on **Climate Surprises** in **What is the Probability of "Dangerous" Climate Change?**.)

Agency. The predominant approach to the discounting problem is based on an infinitely-lived representative agent (ILA) who maximizes utility from a future welfare stream subject to economic and environmental conditions, usually assumed to be known. The representative agent framework imposes strong assumptions regarding intergenerational fairness (**Solow, 1974a**; and **Solow, 1974b**). An alternative modeling paradigm, the overlapping generations (OLG) model, differentiates between individual time preference and intergenerational equity (whereas this distinction is suppressed in the ILA model) and endogenizes the choice of the discount rate (**Howarth 2000**; **Gerlagh and van der Zwaan, 2001**). A distinctive characteristic of OLG models, unlike infinitely-lived agent models in most IAMS, is that the OLG framework explicitly models the existence of generations, who work and save when young and consume savings, or "dissave," when old. Thus, the two modeling frameworks represent quite different conceptions of intergenerational equity. The policy recommendations derived from the OGM differ fundamentally from ILA model, including, but not limited to, higher carbon emission abatement today. (However, **Manne and Stephan, 1999** show that under certain specific restrictions, the results from the ILA and the OGM models concur.)

Much discussion has taken place in recent years on the subject of adaptation to climate change (see the **"Adaptation Day at COP9" report**). The overwhelming consensus opinion seems to be that adaptation has its dangers/downfalls but also has potential, but it should be proposed as a complement to mitigation, not a substitute for it.

One danger is that **natural variability masks climate trends and delays adaptation.** One of the major differences in estimates of climatic impacts is due to the way in which each impact assessment model treats adaptation to climate change. Adaptation is a local response to a global-scale change. When assessing adaptation, it has often been assumed that agriculture is the most vulnerable economic market sector to climate change. For decades, agronomists have calculated potential changes to crop yields from various climate change scenarios, suggesting some regions that are already too hot would sustain heavy losses from warming whereas others, now too cold, could gain (**Rosenzweig and Parry, 1994**) **Note 2**. Norman Rosenberg (e.g., **Rosenberg and Scott, 1994**) has long argued that such agricultural impact studies implicitly invoke the "dumb farmer assumption; that is, they neglect the fact that farmers *do* adapt to changing market, technological, and climatic conditions. Some agricultural economists argue that such adaptations will dramatically reduce the climate impact costs to other market sectors as well, including transportation, coastal protection, and energy. Ecologists and some social scientists, however, often dispute this optimism. Michael Hanemann (**Hanemann, 2000**) notes that **Mendelsohn et al., 1994** confound the normative statement that public policy *should* encourage efficient adaptation with the positive statement that adaptation *will be* efficient: "it is a large leap to go from the observation that there will be *some* adaptation to the inference that there will be *perfectly efficient* adaptation" (p. 575). **Schlenker et al., 2003**, go beyond this and show empirically that the failure to disaggregate cross-sectional data into irrigated and non-irrigated farmland can actually reverse the Mendelsohn results and produce only losses, not gains. Furthermore, I have objected that the statistical analysis **Mendelsohn et al.** used ignores time-evolving or transient changes in temperature and other variables, not to mention surprises (see the "ergodic economics" section of **Schneider, 1997b**). Assuming a high level of adaptation neglects such real world problems as people's resistance to trying unfamiliar practices, problems with new technologies, unexpected pest outbreaks, and the high degree of natural variability of weather that masks slowly-evolving, anthropogenically-induced trends.

In reality, adaptations to slowly-evolving trends embedded in a noisy background of inherent variability are likely to be delayed by decades (**Kaiser et al., 1993**; **Schneider, 1996c**; **Morgan and Dowlatabadi, 1996**; **Kolstad et al., 1999**, and **Schneider, Easterling and Mearns, 2000**) Note 3. Moreover, were agents to mistake background variability for trend or vice versa, the possibility of adapting to the wrong set of climatic cues arises. In particular, agents might be more influenced by regional anomalies of the recent past when projecting future trends and deciding on adaptation measures. They may be unaware that a very recent weather/climate experience in one region may well be anomalous and largely uncorrelated with long-term, global-scale trends or may be part of a transient response that will reverse later on. This could lead to mal-adaptation, which only increases damages, especially in high-vulnerability regions that already have low adaptive capacity.

Passive versus anticipatory adaptation. In an early intercomparison of climate change, ozone depletion and acid rain problems, Starley Thompson and I (**Schneider and Thompson, 1985**) differentiated passive adaptation (e.g., buying more water rights to offset impacts of a drying climate) from "anticipatory" adaptation. We suggested a hedging strategy that consisted of investing in a vigorous research and development program for low-carbon energy systems *in anticipation* of the possibility that they would need to be used to reduce CO_2 emissions in the decades ahead. The idea is that it would be cheaper to switch to systems that were better developed as a result of such anticipatory investments. Proactive adaptation (e.g., building a dam a few meters higher in anticipation of an altered future climate) has been prominent in most formal assessments of anthropogenic climate change since then (**NAS, 1991**) Note 4.

Nearly all modern integrated assessments either explicitly (**Rosenberg, 1993**) Note 5 or implicitly (**Schneider, 1996c**) attempt to incorporate adaptation, albeit mostly passive Note 6. While these studies should be applauded for attempting to recognize and quantitatively evaluate the implications of adaptive responses on the impact costs of different climate change scenarios, serious problems with data, theory, and method remain (**Schlenker et al., 2003**). It is imperative that analyses incorporate a wide range of assumptions (**Carter et al., 1994**) Note 7 and that both the costs and benefits of climate change scenarios be presented as statistical distributions based on a wide range of subjective probability estimates (**Yohe, 1991**) Note 8. Groups' or regions' varying abilities to adapt must also be considered, and policies should aim to protect or assist the groups most at risk (**Miller and Brown, 2000**). **Perrings, 2003** suggests achieving an ideal climate policy involves balancing the marginal costs of adaptation and mitigation. Because adaptation produces more local results relative to mitigation, private individuals/firms have more incentive to implement such actions, as they will benefit from them and need not be concerned by the "free rider problem" (because adaptation mostly happens at a local scale).

However, it is important that adaptation be treated not as a replacement for, but as a complement to abatement. As discussed in **Consequences of global warming: Regional Impacts**, if a nation with high emissions chooses only to adapt, the extra climate change those emissions cause will likely hurt lower-emitting, poorer countries disproportionately. In addition, adaptation cannot *prevent* climate change; it can only help to reduce the effects on humans, and in cases of serious climate change-induced events, it may not even be able to do that.

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Uncertainty and Multiple Equilibria

Low-probability and catastrophic events, as well as evidence of multiple equilibria in the climate system, are of key concern in the climate debate. So, too, are threats to unique and valuable systems and the inequitable impacts of unabated climate changes. (See the figure ***climate change impacts*** in Climate Impacts, taken from **IPCC WG II, SPM** (**IPCC, 2001b**).) There are great uncertainties on the impacts side as well as the climate system projections side, which means there is probably some risk of dangerous events even for seemingly low CO_2 stabilization targets (**Azar**

and Rodhe, 1994; **Mastrandrea and Schneider, 2004**).

As complicated as each subsystem is by itself, the coupling of the atmosphere, ocean, ice, land, biota, and society systems that comprise the full coupled human-natural system can lead to interactions that create behaviors (often known in complexity theory as "emergent properties") not evident when studying only one or two of the subsystems in isolation.

Many climatologists have asserted that the effects of climate change on one such interaction could lead to a collapse of the Atlantic thermohaline circulation (see "**Climate Surprises and a Wavering Gulf Stream?**" and the Figure ***Atlantic thermohaline circulation***). The rate at which the warming forcing is applied to the coupled system could determine which of these opposing feedbacks dominates, and subsequently whether a THC collapse occurs (e.g., see the "simple climate demonstrator" (SCD) model of **Schneider and Thompson, 2000**, their **figure 10**).

While this and other possible consequences of climate change on coupled systems would be extremely severe, the bulk of integrated assessment models used to-date for climate policy analysis do not include any such abrupt nonlinear processes and will not be able to alert the policymaking community to the importance of abrupt nonlinear behaviors. A few models have looked at very nonlinear damages and these are described in the next section, **Guidance on Uncertainties**. At the very least, the ranges of estimates of future climate damages should be expanded beyond that suggested in conventional analytic tools to account for such nonlinear behaviors (e.g., **Moss and Schneider, 2000**).

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Guidance on Uncertainties

Attempts to achieve more consistency in assessing and reporting on uncertainties are just beginning to receive increasing attention. However, the scientific complexity of the climate change issue and the need for information that is useful for policy formulation present a large challenge to researchers and policymakers alike: it requires both groups to work together to improve communication regarding uncertainties. The research community must also bear in mind that when scientists do not specify probability distributions in their work on climate change, policymakers and other readers of their work will often have to guess what those probabilities are. **Moss and Schneider** have argued that it is by far more beneficial for experts to provide their best estimates of climate change probability distributions and highlight possible outlier situations than to leave novice users to make their own determinations. That guidance paper on uncertainties, included in the IPCC Third Assessment Report, recommends that scientists develop probability distribution estimates based on the ranges and distributions available in recent climate change literature, including information on the key causes of uncertainty. An assessment should include a measure of the median of the distribution (if appropriate), as well as a delineation of the end points of the range of outcomes, possible outliers, and the likelihood of outcomes *beyond* the end points of the range. Truncating the estimated probability distribution should be avoided, since this may narrow the range of outcomes too much and ignore outliers that may include "surprises." In short, a truncated probability distribution does not convey to potential users the full range of uncertainty associated with the estimate. Furthermore, it can be inappropriate to combine two or more different distributions into one summary distribution if the two distributions have very different shapes.

As shown in the figure below, uncertainty can be decomposed into three ranges. The smallest range represents "well-calibrated" uncertainty, which is based on conventional modeling literature. The middle range represents "judged" uncertainty, which is based on expert judgments -- including factors not well-represented in models. However, the judged range (e.g.) may not encompass the "full" and largest range of uncertainty, which takes into account the possibility of cognitive biases such as overconfidence (see ***M1 to M4***). New information, particularly reliable and comprehensive empirical data, may eventually narrow the range of uncertainty by falsifying certain outlier values.

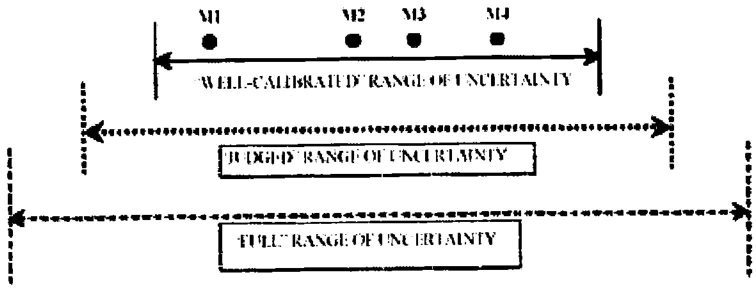

Figure — ***Schematic depiction of the relationship between "well-calibrated" scenarios, the wider range of "judged" uncertainty that might be elicited through decision analytic techniques, and the "full" range of uncertainty, which is wider to represent overconfidence in human judgments.*** M1 to M4 ***represent scenarios produced by four models (e.g., globally averaged temperature increases from an equilibrium response to doubled CO_2 concentrations). This lies within a "full" range of uncertainty that is not fully identified, much less directly quantified by existing theoretical or empirical evidence (modified from*** **Jones, 2000**, ***Figure 2.2 by*** **Schneider and Kuntz-Duriseti, 2002*****)***

Aggregation and the Cascade of Uncertainty. A single aggregated damage function or a "best guess" climate sensitivity estimate is simply a truncation of the wide range of beliefs on climate sensitivity or impacts available in the literature and among the lead authors of IPCC reports. The aggregate distribution based on that climate sensitivity estimate might have very different characteristics than the various distributions comprising the links of the chain of causality. Thus, if the projected ranges used in impact assessment are poorly managed, they may inadvertently propagate additional uncertainty. The process whereby uncertainty accumulates throughout the process of climate change prediction and impact assessment has been described as a "cascade of uncertainties," or the "uncertainty explosion." The cascade of uncertainty resulting from coupling the separate probability distributions for emissions, biogeochemical cycles (used to arrive at concentrations needed to calculate radiative forcing), climate sensitivity, climate impacts, and the valuation of such impacts into climate damage functions has yet to be thoroughly dissected in the literature (but see **Webster et al., 2003**, for an early attempt). If an assessment goes on to project economic and social outcomes, even *larger* ranges of uncertainty may accumulate (see ***Cascade of uncertainties*** and **Climate Impacts**). On the other hand, governance can arrest the growing cascade: policies to mitigage risks coulc be implemented, thereby shrinking the cascade.

Hedging. In essence, the "bottom line" of estimating climatic impacts is that both the "end of the world" and the "it is good for business" scenarios carry the lowest probabilities, and that the vast bulk of knowledgeable scientists and economists consider there to be a significant chance of climatic damage to both natural and social systems (see, for example, the figures ***Probability distributions (f(x)) of climate damages***, ***Cascade of uncertainties*** and ***Three climate sensitivities***). Under conditions of persistent uncertainty, it is not surprising that most formal climatic impact assessments have called for cautious but positive steps both to slow down the rate at which humans modify the climatic system and to make natural and social systems more resilient to whatever changes do eventually materialize (**NAS, 1991**) [Note 3]. Unsurprisingly, such assessments also call for more research to narrow uncertainties—and who could disagree, unless "more research" is used as an excuse to avoid positive steps to reduce risk (see a November 2002 **Revkin** story in the N.Y. Times on the Bush administration's plans). **Holdren, 2004** has argued that even if there is only a 50% chance (and the figure is likely higher) that mainstream climatologists' projections are right, it would justify more stringent abatement and other risk-reduction efforts than are currently being employed.

In many sectors, including business, health and security, policymakers prefer to hedge against low-probability but high-consequence outcomes. When it comes to climate change, many businesspeople, including insurance industry leaders and institutional investors (see **Feder, 2003** and **John Holdren's 2003 presentation at the Institutional Investors' Summit on Climate Risk**), are sounding alarms and encouraging a hedging strategy, but still, it seems that many governments have not heeded their warnings. This is especiallly true in the U.S. (see an article in the Washington Post by former EPA employee Jeremy Symons, **"How Bush and Co. Obscure the Science"**), which seems particularly ironic given Bush's insistence that the US work toward energy supply security (see an **AESR Briefing Paper**). When it comes to energy, Senator Robert Byrd (D - WV) believes "the Bush White House is stuck in short-sighted high-risk initiatives which seem largely guided by big dollar campaign contributors...[and] appears to see energy policy as a way to reward its friends while sidestepping the serious, lingering challenges that face this country and, in fact, the world." (See **Senator Byrd's May 2004 speech** from which this quote was taken.) In fact, the Bush Administration has taken a step backward by not only relaxing environmental standards, but by censoring some climate information altogether (see **Contrarians**). I think US senior climate change negotiator Harlan Watson was, sadly, correct when, in referring to President Bush's 2004 campaign against John Kerry, he said: "'Environment is really not a point. In the end, it is the economics and the Middle East in particular that is the focus of the American public." (See **"US Says Misunderstood on Climate Change Policy"**.)

Actions have, however, been taken at smaller scales (see **"The Warming Is Global but the Legislating, in the U.S., Is All Local"**; also **Kousky and Schneider, 2003**). In the absence of federal-level regulation on climate change, in the past three years, state legislatures have passed at least twenty-nine bills of their own, the most notable being California's law setting strict limits on new vehicle CO_2 emissions. In April 2004, California governor Arnold Schwarzenegger and New Mexico governor Bill Richardson co-signed a statement pushing for improved energy efficiency and greater use of renewable energy. The statement calls for the 18 western states to generate 30,000 megawatts of electricity, or about 15% of the region's present demand, from renewable energy by 2015 and to increase electrical efficiency by 20% by 2020 (see **"New Allies in the Energy Wars"**). The statement will likely be followed by a more detailed strategy in coming months. Oregon has instituted a law encouraging insurers to offer a pay-as-you-drive, or PAYD, car insurance plan that rewards vehicle-owners for driving less by charging on a per-mile basis rather than offering a fixed rate. Massachusetts has formulated a climate change plan which calls for about 70 regulatory changes, legislative proposals, and incentive programs, some of which are voluntary, with the goal of reducing CO_2 emissions. Surprisingly, Massachusetts governor Mitt Romney is not entirely convinced climate change is occurring, but he rationalized his climate policy actions by saying: "If we learn decades from now that climate change isn't happening, these actions will still help our economy, our quality of life, and the quality of our environment." In addition, fifteen different states are forcing their electric utilities to use energy sources other than coal and oil. Results have been mixed, with some promising and some less positive outcomes (see **"Region struggles on greenhouse emissions goals"** for information on the difficulties in New England).

Counties and cities, too, have joined the global warming battle. In San Francisco, for example, residents approved a $100 million bond issue in 2001 to pay for the purchase and installation of solar panels for public buildings. The city of San Jose, California, partnered with Silicon Valley firms Hewlett-Packard, Oracle, Calpine, Lockheed, ALZA, Life Scan, and PG&E, as well as the NASA Ames Research Center and the Santa Clara Valley Water District, has set a goal for Santa Clara County of reducing CO_2 emissions 20% below 1990 levels by 2010 (as discussed in **"Valley firms to fight global warming"**). In August 2002, Sonoma County (in Northern California) became the first US county to have 100% of the county's local governments agree to reduce their greenhouse gas emissions and calculate baselines for municipal operations. The county's goal is to reduce municipal operations' emissions by 20% below 2000 levels by 2010 (see **Sonoma County's climate website**). Sonoma County acknowledges that their goal falls short of the targets set by Kyoto and is nowhere near the 60% reduction from 1990 levels that many scientists recommend by mid-century, but it is nonetheless a start. **Kousky and Schneider, 2003** believe that these county- and city-level decisions are made mainly on the basis of the potential for cost savings and other possible benefits rather than pressure from environmentalist citizens.

Some state and local policies on climate are already being attacked by the federal government, which has allied itself to powerful special interest groups like the oil and auto industries (see **"State Officials Feel the Heat On Global-Warming Steps"** and **"Fed Up - Northeast Efforts to Reduce Greenhouse Gases Thwarted by Feds"**). They complain that if strict policies are enacted at state and local levels, the US will end up with a hodgepodge of confusing environmental laws that will be difficult to implement, especially where shared resources and interstate activities are concerned. As a result, states are enacting softer bills than they'd otherwise hoped for. California weakened its vehicle emissions bill after the auto industry protested, and Maine was forced to make a greenhouse gas emissions law less stringent. Nonetheless, action at more local levels demonstrates people want action, and could be the first step in pressuring for coordinated national-level policies, especially if the White House remains unwilling to enact a nationwide abatement policy (see **"White House Attacked for Letting States Lead on Climate"**). I recently attended a lecture at which I heard from an oil company official a realistic complaint about the costs of coping with a dozen different state rules on emissions. "Then join with us in lobbying Washington to have a coherent national policy," I rejoined, "and call off your anti-climate policy attack dog lobbyists!" He agreed -- in private.

In this environment, if scientists increase their use of probabilistic information, even if subjective, they will provide a much more representative picture of the broad views of experts and a fairer representation of costs, which in turn allow better potential policy insights that could facilitate future hedging. Regardless of how risk-prone or risk-averse the individual decision maker is, he or she must know the characterization and range of uncertainties of the information provided by decision analysis tools (see **Climate Impacts**: **What is the Probability of "Dangerous" Climate Change?**). Any climate policy analysis that represents best guess point values or limited (i.e., "truncated") ranges of outcomes restricts the ability of policymakers to make strategic hedges against such risky outlier events. The end result of any set of integrated assessment modeling exercises will be, as always, the subjective choice of a decision-maker, but a more comprehensive analysis with uncertainties in all major components explicitly categorized and displayed will hopefully lead to a better-informed choice (see **Titus et al., 1996**; and **Morgan and Dowlatabadi, 1996**).

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Modern-Day Policy Applications: Using Scenarios to Develop a Plausible Range of Outcomes

In 1996, the IPCC commissioned a Special Report on Emission Scenarios both to broaden assessments to include a range of outcomes and to focus analysis on a coherent set of outcomes (scenarios) to facilitate comparison. The resulting scenarios of the report, which was completed in 2000, concentrate on assumptions regarding economic growth, technological developments, and population growth, which are arguably the three most critical variables affecting the uncertainty over future climate change and policy options. To the extent possible, the TAR authors have used the SRES to inform and guide their assessments. (**Box 1** described the baseline SRES scenarios and ***climate change impacts*** demonstrates how the SRES has been used to evaluate projected temperature changes and potential reasons for concern.)

Around that same time, in the mid-1990s, many governments, academics and environmental organizations were calling for more stringent international climate policies. These calls resulted in the **Berlin Mandate**, which required that climate change targets and timetables be negotiated and set before the end of 1997, i.e., at the third meeting of the conference of the parties (**COP3**) in Kyoto.

Abatement now—or later? However, Wigley, Richels and Edmonds (**WRE, 1996**) presented data on various stabilization targets for atmospheric CO_2 ranging from 350-750 ppm and argued that no significant abatement was seen as desirable over the next couple of decades. They contended that it would not only be possible, but also more cost-effective, to defer emission abatement. They argued, using three economic points and one physical one, that it would be more cost-effective to continue on current emission trajectories, which would arrive at the same long-term stabilization concentrations as cutting emissions earlier on would.

This challenged the *raison d'être* of the Berlin Mandate and the upcoming negotiations in Kyoto. Although elimination of short-term targets for abatement was never seriously discussed during the climate negotiations, the WRE paper influenced many economists' and US policymakers' views on climate change and sparked an interest into research on more flexibility in international agreements on climate change (see e.g., **Toman et al., 1999**; and **Weyant, 1999**).

Christian Azar and I **(Schneider and Azar)** challenged the view that "dangerous anthropogenic climatic changes" can safely be avoided without serious consideration of substantial amounts of near-term abatement, showing that early abatement may not be at all inconsistent with economic efficiency arguments. Moreover, we attempted to show that substantial near-term abatement would not necessarily be prohibitively costly, despite some well-publicized claims to the contrary. Essentially, the arguments we used are as follows:

- There is still considerable uncertainty about the trajectory of the climate system, and as a result, substantial concern remains about low-probability, catastrophic impacts, especially if the climate is forced rapidly and strongly (**IPCC, 1996a**, p. 7). We do not dismiss the possibility of the converse — that substantial climate changes may not necessarily turn out to be "dangerous"—but the climate uncertainties also imply that in the near future, the possibility of dangerous changes, even at atmospheric stabilization targets some might consider to be relatively low, cannot be ruled out with high confidence.
- The WRE emission trajectories also suggest that low stabilization targets could be met cost-effectively without significant near-term abatement, but the WRE trajectories were never cost-optimized. In parallel modeling efforts, it was shown that for stabilization targets of about 450ppm or lower, early abatement is cost-efficient! Using the MERGE and the ERB-models, **Richels and Edmonds, 1995** find that "limiting concentrations at 400ppm will require an early and rapid departure from business-as-usual." These emission trajectories are not cost-minimized, but the authors state that they have "attempted to identify an emissions path close to the least-cost solution." More subsequent runs by **Manne & Richels (1997)**, however, confirm that "a more aggressive departure from the emissions baseline will be required" for targets in the range 450-550ppm. For stabilization targets above, say, 600ppm, very little near-term abatement is cost-effective in their modeling efforts. Similar results are also reported in **IPCC Third Assessment Report (TAR) working group (WG) III, chapter 2** (**IPCC 2001c**, p 153), where it is argued that "achievement of stabilization at 450ppm will require emissions reductions in Annex 1 countries by 2020 that go significantly beyond their Kyoto commitments for 2008-2012." **Schneider and Azar** did not at this point attempt to justify investments in such policies, only to point out that studies have been done for very low abatement targets.
- The larger the probability of abrupt nonlinear or catastrophic climate changes and the more "unique and valuable" systems that are threatened by climate changes of "only" a degree or two of warming (e.g., See **IPCC 2001b, chapter 19** and **climate change impacts**), the lower one can argue the stabilization target for efficient policies should be — depending on the characterization of "dangerous changes." Under such circumstances, more early abatement may well be demonstrated to be economically efficient.
- There is not only uncertainty about what the stabilization target should be and what the benefits of early stabilization are, but also about the abatement costs themselves. In particular, there is a vigorous debate over how the energy system would respond to incentives to reduce CO_2 emissions. By initiating abatement policies sooner, firms and governments will learn more about how the energy system responds to such policies. This information will be useful when designing future abatement policies.
- Furthermore, learning by doing (LBD) and induced technological change (ITC) resulting from early abatement could substantially reduce the costs of abatement policies over time relative to current calculations that neglect prospects for technological development.

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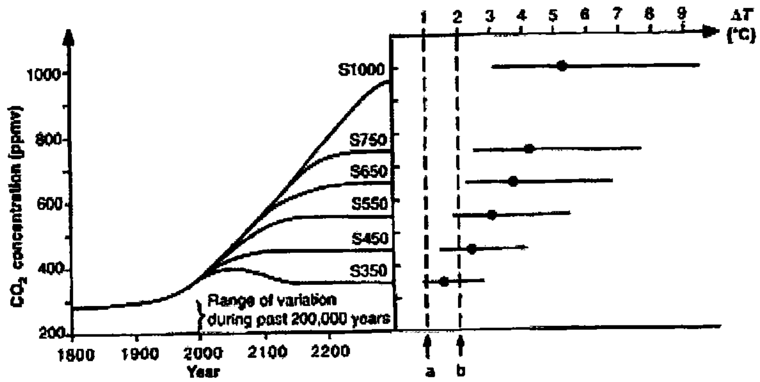
Uncertainty and Future Climate Policy

At present, it is not possible to uniquely relate greenhouse gas concentrations and temperature. The 2001 consensus among climate modelers was that a doubling of CO_2-equivalent concentrations would increase annual average global surface temperatures by 1.5-4.5°C (**IPCC, 2001a**), though we noted in the section on climate sensitivity that this is an oversimplification and likely underestimates the range (see **Climate Sensitivity**).

Figure — Left: IPCC stabilization scenarios for atmospheric CO_2. Right: Corresponding equilibrium changes in global mean temperature since pre-industrial times (central values plus uncertainty ranges from IPCC (1996a). (Source: Azar & Rodhe, 1997.)



From this **Figure**, it can be seen that the global temperature increase for an atmospheric CO_2 concentration of 550ppm will only stay below 2°C if the climate sensitivity is on the very low end of the IPCC's estimates.

Azar and Rodhe (1997) conclude that if climate sensitivity turns out to be in the upper range of the IPCC's estimates, then a CO_2 concentration of 550ppm will be sufficient to yield a global average temperature change of a magnitude approaching that which occurs over the thousands of years it takes to transition from an ice age to an interglacial period (roughly 5-7°C). It appears that in order to have a very high probability of keeping the global temperature changes within the range of natural fluctuations that have occurred during the past few millennia (roughly 1°C), the climate sensitivity has to be low or the atmospheric CO_2 concentration has to be stabilized at around 350ppm (i.e., below current levels).

The policy challenge that can be extracted from this is to ask whether 1) the burden of proof lies on those who argue that uncertainties which preclude confident prediction of the likelihood of exceeding any specific warming threshold — 2°C for the ***IPCC stabilization scenarios*** — should lead to a "wait and see" policy approach, or, 2) if, rather, the burden of proof lies on those who, citing precautionary principles, believe it is not "safe" or acceptable to risk such potentially dangerous changes in the global climate system. However — and this is a primary message here — *until* it has been widely accepted with much higher confidence that a temperature increase above 2°C is "safe" or that the climate sensitivity is lower than the central estimate, the projections shown in the ***IPCC stabilization scenarios*** suggest that the global climate policy community should not dismiss policies that lead to eventual stabilization in the range of 350-400 ppm.

When attempting to manage risk, a government should look at policy options that involve both adaptation *and* mitigation (Jones, 2003), though as stated by **Perrings, 2003** and discussed earlier in this web site, many future climate risks, especially abrupt events, favor mitigation over adaptation. It is not suggested that governments adopt specific targets that should be strictly adhered to over the next hundred years. On the contrary, the UNFCCC recognizes that steps to understand and address climate change will be most effective "if they are continually reevaluated in the light of new findings in these areas" (**UNFCCC, 1992**). In IPCC language, "The challenge now is not to find the best policy today for the next hundred years, but to select a prudent strategy and to adjust it over time in the light of new information" (**IPCC, 1996a**). Christian Azar and I (**Schneider and Azar, 2001**) made a similar comment:

> In our view, it is wise to keep many doors — analytically and from the policy perspective — open. This includes acting now so as to keep the possibility of meeting low stabilization targets open. As more is learned of costs and benefits in various numeraires and political preferences become well developed and expressed, interim targets and policies can always be revisited. But exactly how much near term abatement or other technology policies that are required to keep the option of low stabilization within reach is, of course, very difficult to answer, in particular because the inertia of the energy system, let al.one the political system, has proven difficult to model.

This revising of policy as new information becomes available is often referred to as *Bayesian updating*. Advocating the use of Bayesian updating in climate change policy has also been done by **Perrings, 2003**:

> A crucial element of any precautionary approach is the mechanism by which the decision maker learns about the probability distribution of outcomes. Since uncertainty implies that there is scope for learning (although learning does not necessarily reduce uncertainty), every problem that is a candidate for a precautionary approach is also a candidate for learning. Precautionary action implies a mechanism for learning, or for updating the information on which decisions are taken since expectations about the payoff to different outcomes are conditional on the state of knowledge, and are therefore revised as the state of knowledge changes.

Governments will be better able to deal with this uncertainty if they promote research on all sides of the issue through research grants and endowments and encourage the foundation of climate-specific organizations like the **California Climate Action Registry**, which teaches companies to monitor their CO_2 emissions levels in an attempt to establish emissions baselines against which any future greenhouse gas reduction requirements may be applied; and the **Green House Network**, whose goal is to educate people everywhere about the need to stabilize the climate.

Research on sequential decision-making under uncertainty includes, e.g., **Manne & Richels (1992)**, **Kolstad (1994, 1996a, 1996b)**, **Yohe and Wallace (1996)**, **Lempert and Schlesinger (2000)**, **Ha-Duong et al. (1997)**, **Narain and Fisher (2003)**, **Fisher (2001)**. The results of these studies are addressed in subsequent sections.

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Next: Implications of Uncertainty

EXHIBIT '4'

EXHIBIT '4'

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Contrarians

- Contrarians

Projections

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Climate Science Introduction

There is a great deal of confusion among policy makers and the public (see **"Mediarology"**) about many aspects of the science of climate change some of which, it should be said, carry large degrees of uncertainty. However, numerous other aspects are actually scientifically well-established. This combination of high certainty and deep uncertainty is the backdrop against which we must codify our understanding into models of the climate system which include as many relevant components of the Earth atmosphere system as possible, comprising the atmosphere, oceans, snow-ice fields, and soils-ecosystems subsystems. These subsystems are represented by sub-models, which are linked into an Earth systems model, which can be used to project the possible effects and impacts of human activities on future climate — the problem confronting decision makers at all scales, from the individual level to countrywide or international scales.

The **Intergovernmental Panel on Climate Change** (IPCC) has decomposed the overall climate change issue into three main categories, each of which is studied by an IPCC Working Group: climate science (**Working Group I**), climate impacts (**Working Group II**), and climate mitigation policy (**Working Group III**). In addition, a separate group — the **Special Report on Emission Scenarios** (**SRES**), which is really an offshoot of **Working Group III** — put together a team to produce a host of plausible scenarios of future population, economic growth, and technology in order to estimate the range of possible future emissions from human activities that may cause climate change. Analyzing the overall climate issue via scenarios, climate effects projections, climate impacts estimation, and costs of climate policy is a useful decomposition, as it makes the consequences of various levels of human-induced emissions or mitigation/adaptation responses very clear. I will follow that same decomposition in this website, briefly summarizing the main points from the IPCC Working Group reports and other sources from which more details and references can be obtained, including a chapter from a climate policy survey I co-authored with Richard Wolfson of Middlebury College (see **Chapter 1 of *Climate Change Policy: a Survey***). I can only briefly touch on main points in the various sections of this website, but I will provide many links to other works of mine and other authors for those wishing more detailed explanations and alternative viewpoints on these complex, interconnected issues.

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Uncertainty is prevalent in the climate change debate

Unlike this one, the 'crystal balls' scientists use are partly cloudy

The term "uncertainty" implies anything from confidence just short of certainty to informed guesses or speculation. Lack of information obviously results in uncertainty, but often, disagreement about what is known or even knowable is a source of uncertainty. Some categories of uncertainty are amenable to quantification, while others cannot be expressed sensibly in terms of probabilities. Uncertainties arise from such factors as linguistic imprecision, statistical variation, measurement error, variability, approximation, subjective judgment, and disagreement over the structure of the climate system, among others. These problems are compounded by the global scale of climate change, but many other factors add to it, including varying impacts at local scales, long time lags between forcing and its corresponding responses, very long-term (i.e., low frequency) climate variability that exceeds the length of most instrumental records, and the impossibility of before-the-fact experimental controls or empirical observations. Moreover, because climate change and other complex socio-technical issues are not just scientific topics but also matters of public and political debate, it is important to recognize that even good data and thoughtful analysis may be insufficient to dispel some aspects of uncertainty associated with the different standards of evidence and degrees of risk aversion/acceptance that individuals participating in this debate may hold. I will attempt to define some of the more important components of uncertainty and relate it to scientific assessment and the policy debate in the next several sections.

Box — Examples of *Sources of Uncertainty* (from **Moss and Schneider, 2000**).

Problems with data

- Missing components or errors in the data
- "Noise" in the data associated with biased or incomplete observations
- Random sampling error and biases (non-representativeness) in a sample

Problems with models

- Known processes but unknown functional relationships or errors in the structure of the model
- Known structure but unknown or erroneous values of some important parameters
- Known historical data and model structure, but reasons to believe parameters or model structure will change over time
- Uncertainty regarding the predictability (e.g., chaotic or stochastic behavior) of the system or effect
- Uncertainties introduced by approximation techniques used to solve a set of equations that characterize the model.

Other sources of uncertainty

- Ambiguously defined concepts and terminology
- Inappropriate spatial/temporal units
- Inappropriateness of/lack of confidence in underlying assumptions
- Uncertainty due to projections of human behavior (e.g., future consumption patterns, or technological change), which is distinct from uncertainty due to "natural" sources (e.g., climate sensitivity, chaos)

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The Greenhouse effect is scientifically well-established

Despite a multitude of uncertainties, some elements of the climate change debate are well-established, including the science behind the greenhouse effect. The gases that comprise Earth's atmosphere are largely transparent to visible light. That's obvious because we can see the sun, moon, and stars from the ground despite the gases circulating above. This explains why much incident sunlight penetrates the atmosphere and reaches the Earth's surface. There, the surface absorbs it, heats up, and then re-emits the energy as infrared radiation. But the atmosphere is not as transparent to infrared radiation. Certain naturally-occurring gases and particles — particularly clouds — absorb infrared radiation and hinder its ability to escape from Earth. The infrared energy that is trapped in the atmosphere by greenhouse gases and clouds is re-emitted, both up to space and back down towards the surface — the latter primarily adding heat to the lower layers. As a result, Earth's surface warms further, emitting infrared radiation at a still greater rate, until the emitted radiation is in balance with the incident sunlight and the other forms of energy coming and going from the surface (e.g., evaporative losses — see the figure ***Details of Earth's energy balance*** below). Because of infrared-absorbing gases and clouds in the atmosphere, the resulting surface temperature is higher than it would be otherwise. That is what accounts for the 33 °C (60 °F) difference between the Earth's actual surface air temperature and that which would prevail if there were no greenhouse constituents in the atmosphere.

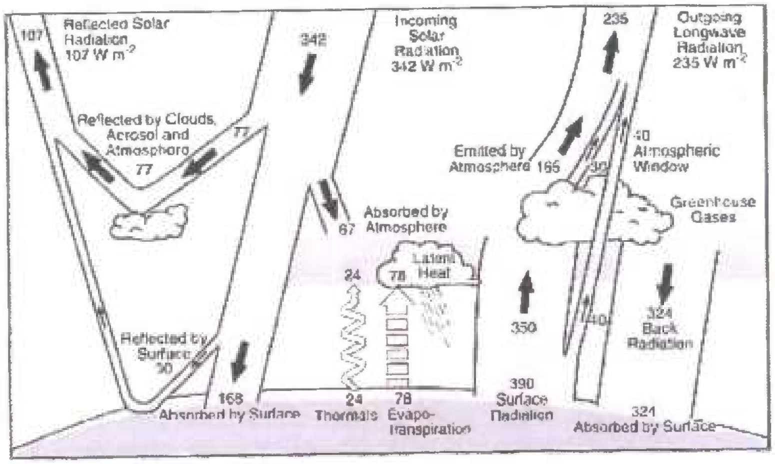

Figure — Details of Earth's energy balance (source: Kiehl and Trenberth, 1997). Numbers are in watts per square meter of Earth's surface, and some have a range of uncertainty of as much as +/-20%. The greenhouse effect is associated with the absorption and re-radiation of energy by atmospheric greenhouse gases and particles, which results in a downward flux of infrared radiation from the atmosphere to the surface (back radiation) and therefore, a higher surface temperature. Note that the total rate at which energy leaves Earth (107 W/m^2 of reflected sunlight plus 235 W/m^2 of infrared [long-wave] radiation) is equal to the 342 W/m^2 of incident sunlight. Thus, Earth is in approximate energy balance in this analysis.

Because the atmosphere functions, in a crude sense, like the heat-trapping glass of a greenhouse, this heating has earned the nickname "greenhouse effect," and the gases responsible are called greenhouse gases. The most important natural greenhouse gas is water vapor, followed by carbon dioxide, and, to a lesser extent, methane. (Actually, the greenhouse analogy is not such a good one; a greenhouse traps heat primarily by preventing the wholesale escape of heated air, with the blockage of infrared radiation playing only a minor role).

The 33 °C of warming due to natural greenhouse gases is known as the natural greenhouse effect, and it's a good thing it occurs because it makes our planet much more habitable than it would be otherwise. What we're concerned about now is the *anthropogenic greenhouse effect arising from additional non-natural greenhouse gases emitted as a result of human activities. Such emissions add to the "blanket" of heat-trapping gases in the atmosphere, further increasing surface temperatures.*

It's important to understand that the basic greenhouse phenomenon is well-understood and solidly grounded in basic science. More controversial is the extent to which humans have already caused climate change and by how much we will enhance future disturbance.

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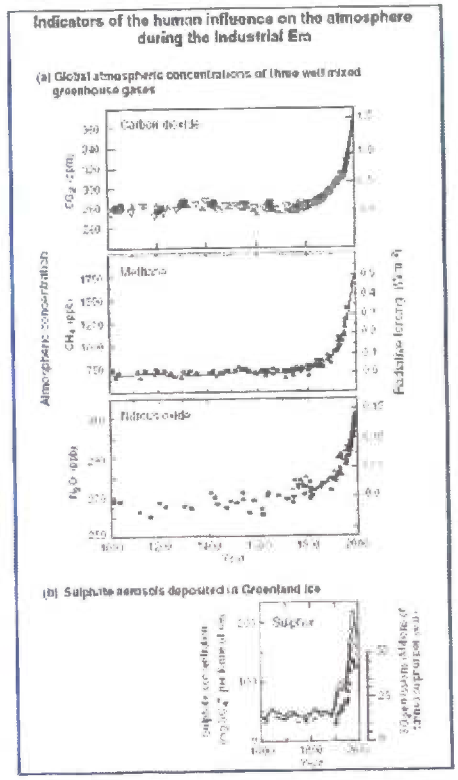
It is well-established that human activities have caused increases in radiative forcing

Figure — Indicators of human influence on the atmosphere since 1000 A.D. (source: IPCC, Working Group I, Summary for Policy Makers, figure 2).



In the past few centuries, as the figure **Indicators of human influence** shows, atmospheric carbon dioxide has increased by more than 30 percent. According to **King, 2004**, the annual atmospheric concentration of carbon dioxide is currently about 372 parts per million (ppm), higher than at any other time over the last 420,000 years. The reality of this increase is undeniable, and virtually all climatologists agree that the cause is human activity, predominantly the burning of fossil fuels, which themselves were created through a very wasteful process (see "**Buried losses**"); to a lesser extent, deforestation and other land-use changes, along with industrial activities like cement production, also contribute to climate change. Although water vapor is the dominant greenhouse gas, its concentration, for the most part, is affected only indirectly by human-induced warming via enhanced evapotranspiration when the Earth's surface is warmed. Carbon dioxide is the most important anthropogenic greenhouse gas that results directly in global warming, although there are some other significant heat-trapping gases and particles that can both cool and warm (see the figure **Global mean radiative forcing** below).

Figure — Global mean radiative forcing of the climate system for the year 2000 ***(source: IPCC, Working Group I, Summary for Policy Makers, figure 3).***

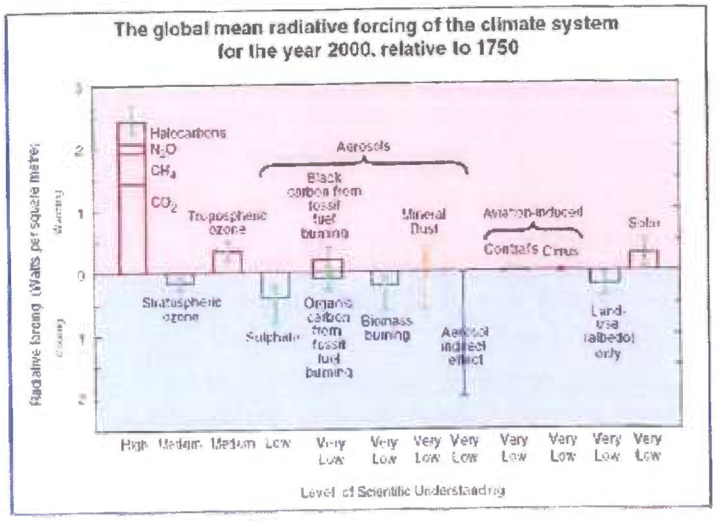


Figure Many external factors force climate change.

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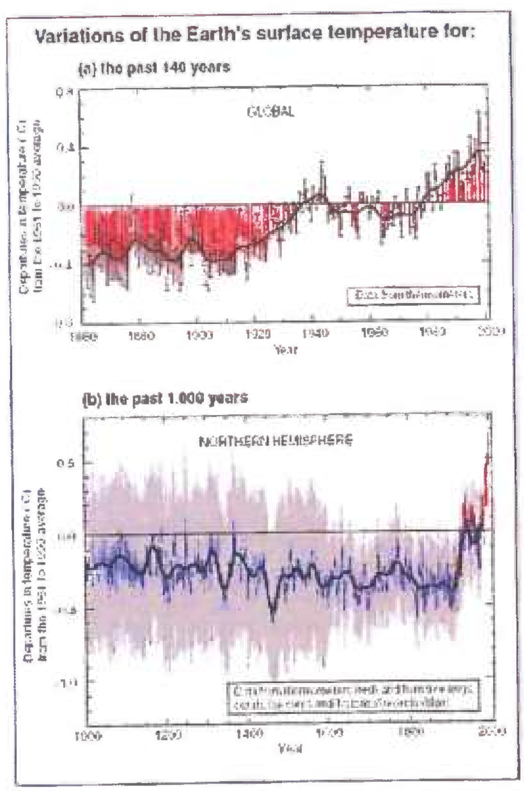
It is well-established that the Earth's surface air temperature has warmed significantly

Figure (a&b) — Variations of the Earth's surface temperature (source: IPCC, Working Group I, figure 1).



The figure ***Variations of the Earth's surface temperature (a)*** shows that Earth's temperature is highly variable, with year-to-year changes often masking the overall rise of approximately 0.6 °C that has occurred since 1860. Nevertheless, the twentieth century upward trend is obvious. Especially noticeable is the rapid rise at the end of the twentieth century. Indeed, the period from the 1980s onwards has been the warmest period in the last 2,000 years (see **Mann and Jones, 2003** and **Jones and Mann, 2004**). 19 of the 20 warmest years on record have occurred since 1980, the 12 warmest all since 1990. 1998 marked the all-time record high year, with 2002 and 2003 in second and third places, respectively. There is good reason to believe that the 1990s would have been even hotter, had not the eruption of Mt. Pinatubo in the Philippines put enough dust into the high atmosphere to block some incident sunlight and cause global cooling of a few tenths of a degree for several years — an event captured by current climate models (see, e.g., **Hansen**). Looking beyond the top ten years, ***Variations of the Earth's surface temperature (a)*** shows that the twenty warmest years on record include the entire decade of the '90s and all but three years from the 1980s as well. Clearly, substantial warming has taken place in the recent past. **Bertrand et al. (2002)** have noted that only highly improbable increases in volcanic activity and decreases in solar radiation could counteract the global warming that is expected to occur in this century.

Could the warming of the last 140 years (as shown in ***Variations of the Earth's surface temperature (a)***) be a natural occurrence? Might Earth's climate undergo natural fluctuations that could result in the temperature records documented? Increasingly, the answer to that question is "no." We would be in a better position to decide if the temperature rise of the past century has been natural if we could extend the record further back in time. Unfortunately, direct temperature measurements of sufficient accuracy or geographic coverage simply didn't exist before the mid-1800s. But by carefully considering other quantities that do depend on temperature, paleo-climatologists can reconstruct approximate temperature records that stretch back hundreds, thousands, and even millions of years.

The figure *Variations of the Earth's surface temperature (b)* shows the results of a remarkable study (see **Mann, Bradley, and Hughes, 1998** and **Mann, Bradley, and Hughes, 1999**), that attempts to push the Northern Hemisphere temperature record back a full 1,000 years. To produce this, climatologist **Michael Mann** and his colleagues performed a complex statistical analysis involving some 112 separate indicators related to temperature. These included such diverse factors as tree rings, the extent of mountain glaciers, changes in coral reefs, sunspot activity, volcanism, and many others. The resulting temperature record of ***Variations of the Earth's surface temperature (b)*** represents a "reconstruction" of what one might expect if thermometer-based measurements had been available. Although there is considerable uncertainty in each year of the millennial temperature reconstruction, as shown by the error band in ***Variations of the Earth's surface temperature (b)***, the overall trend shows a gradual temperature decrease over the first 900 years, followed by a sharp upturn in the twentieth century. That upturn is, of course, a compressed representation of the "real" (thermometer-based) temperature record shown in ***Variations of the Earth's surface temperature (a)***. Among other things, ***Variations of the Earth's surface temperature (b)*** suggests that the decade of the 1990s was not only the warmest of the century, but of the entire millennium. Taken in the context of ***Variations of the Earth's surface temperature (b)***, the temperature rise of the last century is clearly an anomaly. These results have been verified, re-verified, and fine-tuned in subsequent papers by Mann and his colleagues, including **Mann (2000)**, **Mann (2001)**, **Mann (2002)**, **Mann (2004)**, and **Jones and Mann (2004)** -- discussed again below. Many other scientists have come to similar conclusions, using similar and varying methods, including **Jones, Osborn, and Briffa (2001)**, **Duffy et al. (2001)**, and **Bradley (2003)**. The figure below, ***Various reconstructions of temperature over the last 1000-2000 years***, shows Bradley's aggregation of temperature data compiled by a multitude of scientists in different studies. It shows what not only Mann, but many others, have repeatedly shown: that a twentieth century temperature increase is detectable.

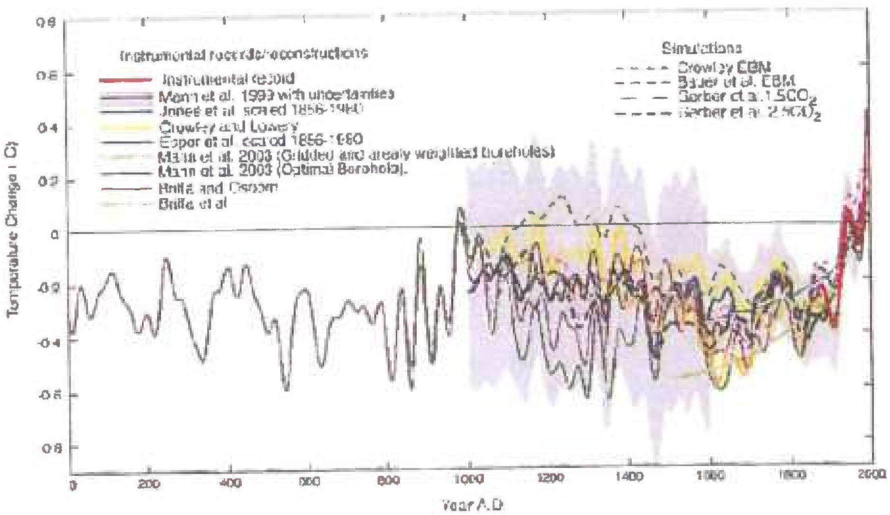


Figure — *Various reconstructions of temperature over the last 1000-2000 years*, relative to the reference period 1961-90. All reconstructions have been scaled to the annual, full Northern Hemisphere mean, over an overlapping period (1856-1980), using the NH instrumental record [**Jones et al, 1999**] for comparison, and have been smoothed on time scales of >40 years to highlight the long-term variations. The smoothed instrumental record (1856-2000) is also shown (from **Mann et al., 2003**). (**Source: Bradley, 2003**)

A few "contrarian" scientists have challenged this conclusion (i.e., the "hockey stick"), as discussed below in **Contrarians**.

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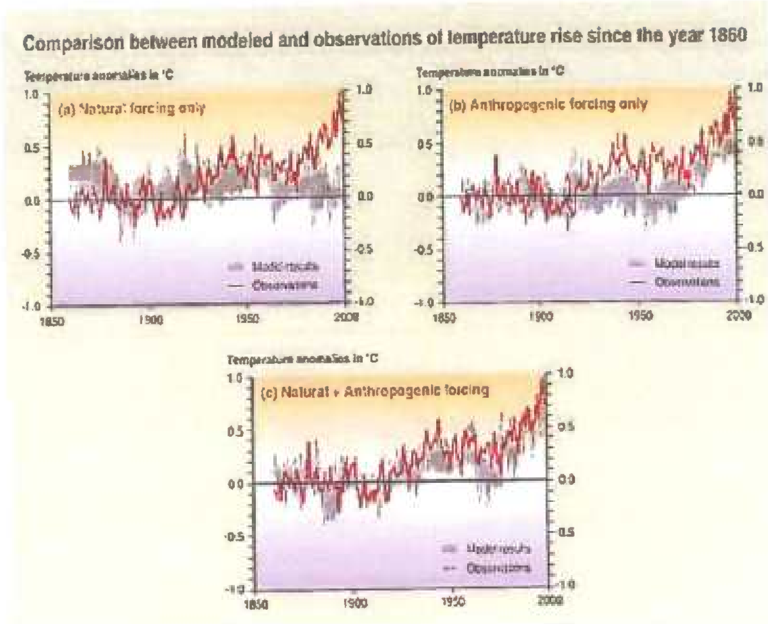
It is likely that human activities have caused a discernible impact on observed warming trends

The figure ***Global mean radiative forcing*** summarizes our best understanding up to 2001 of radiative forcings due to greenhouse gases, aerosols, land-use changes, solar variability, and other effects since the start of the industrial era. Even if the negative forcings (cooling) from some of these anthropogenic changes reach the high ends of their proposed ranges (see figure, ***Global mean radiative forcing***), they might be insufficient to offset much of the warming due to anthropogenic greenhouse gases after a few more decades. This is because the effects of cooling aerosols are short-lived and geographically localized relative to the long-term, global effects of the well-mixed greenhouse gases, and these health-damaging aerosols are likely to be controlled. The most advanced climate models are driven by a range of plausible assumptions for future emissions of all types, and make it clear that the overall effect of human activity on the atmosphere is almost certainly a net positive forcing — anthropogenic warming (see the figure ***Models of Earth's temperature*** below). However, very recently, data on black carbon aerosols has added more uncertainty (see **Jacobson, 2002**; **Jacobson, 2004**; **Novakov et al., 2003**; and **Hansen and Nazarenko, 2004**).

Figure — Models of Earth's temperature since 1860 ***(source: IPCC, Working Group I, Summary for Policy Makers, figure SPM-2).***



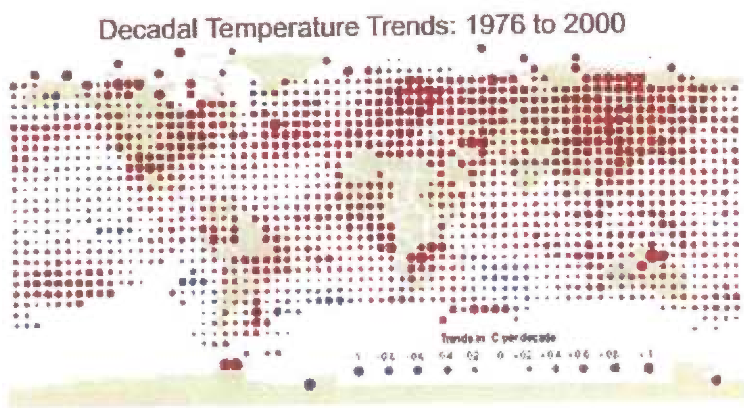
Taken together, the figures ***Indicators of human influence*** and ***Variations of the Earth's surface temperature*** show a high correlation between increases in global temperature and increases in carbon dioxide and other greenhouse gas concentrations during the era, from 1860 to present, of rapid industrialization and population growth. But, as the cliché phrase goes, correlation is not necessarily causation. So, are anthropogenic CO_2 emissions a direct cause of recent warming? As the data summarized in ***Models of Earth's temperature since 1860*** suggests, it looks increasingly like the answer is "yes." But the connection between the past 140 years' warming and the coincident rise in CO_2 is not so straightforward. For example, global temperature actually *declined* in the period after World War II, a time of rapid industrialization (and, therefore, increasing CO_2 concentrations). On the other hand, the temperature rise should lag CO_2 increases by some decades, so we shouldn't expect to find that recent temperature and CO_2 are instantly correlated. Moreover, there are other factors that can influence climate fluctuations or trends, and all of these are confounded in the record we observe in ***Indicators of human influence*** and ***Variations of the Earth's surface temperature***.

Separating the anthropogenic "signal" of climate change from the "noise" of natural fluctuations can be a tricky process, especially since that noise involves an unpredictable component of internal oscillations called "stochastic noise" and a component that may be forced by natural causes such as changes in the output of the sun or volcanic dust veils — called "natural forcings". ***Models of Earth's temperature since 1860*** shows the model-generated projections with and without several of these elements, and suggests, as noted, that the best results are obtained from a combination of natural and anthropogenic forcings. Although substantial, this is still circumstantial evidence.

The methods used to attribute some observed warming trends to humans are often called "fingerprint analysis." The most well-known use of this type of analysis is usually attributed to **Ben Santer**, a physicist and atmospheric scientists at the Program for Climate Model Diagnosis and Intercomparison at the Lawrence Livermore National Laboratories in Berkeley, California (see, for example, **Santer et al., 1993** and **Santer et al., 2003**). Although each "fingerprint" may be a circumstantial piece of evidence of human-induced climate changes (as is ***Models of Earth's temperature since 1860***), taken together, several such lines of evidence led the IPCC (2001) to conclude that there is even stronger evidence of a human signal in data collected in the past five years than there was in 1995, when the IPCC concluded that a human fingerprint was already discernible ("There is new and stronger evidence that most of the warming observed over the last fifty years is attributable to human activities."; see **Working Group I Summary for Policy Makers**, P. 10). One sign of a human fingerprint is the fact that the Earth's stratosphere has cooled while the surface has warmed — a sign of greenhouse gas forcing and ozone depletion rather than a naturally-occurring increase in the heat output of the sun, which would warm all layers of the atmosphere. The latter natural forcing is often claimed by so-called "contrarian" scientists to be responsible for the bulk of the observed warming, as discussed in **Contrarians**, below.

Other human fingerprints include the probabilities from models that higher latitudes will warm more than lower latitudes and land will warm more than oceans: all these *model-based* projections have been reflected in observed trends. The figures ***Decadal Temperature Trends*** and ***Variations of the Earth's surface temperature*** below support this.

***Figure — Decadal Temperature Trends**: 1976 to 2000 (source: Intergovernmental Panel on Climate Change, Synthesis Report, figure 2-6b).*



A consistent, large-scale warming of both the land and ocean surface occurred over the last quarter of the 20th century, with largest temperature increases over the mid- and high latitudes of North America, Europe, and Asia. Large regions of cooling occurred only in parts of the Pacific and Southern Oceans and Antarctica. The warming of land faster than ocean surface is consistent both with the observed changes in natural climate variations such as the North Atlantic and Arctic Oscillations and with the modeled pattern of greenhouse-gas warming. As described in the text, warming in some regions is linked with observed changes in biological systems on all continents.

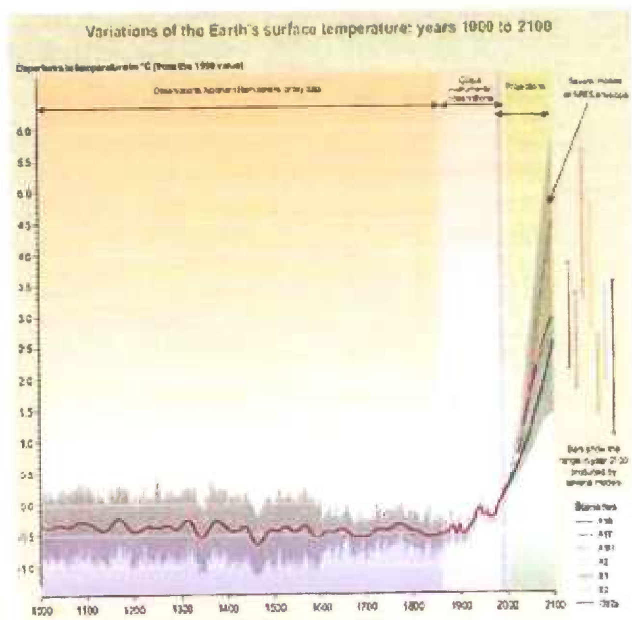


*Figure — **Variations of the Earth's surface temperature**: years 1000 to 2100 **(source: IPCC, Synthesis Report, figure SPM-10b).***

Another technique, known as "optimal fingerprinting," has been studied extensively and reported in the scientific literature (see the **Hadley Center — "Is humankind already changing global climate?"**, **"Causes of twentieth-century temperature change near the Earth's surface"**, and **Forest et al., 2001**). Such studies cautiously declare that a human fingerprint is, indeed, discernible in observations. This careful and thorough peer-reviewed science is in stark contrast to the shrill claims that humans have not caused the recent warming; claims that can be found in many opinion pieces written by nonclimatologists (see, e.g., **Robinson and Robinson** in a 1997 Wall Street Journal editorial; also see **"Mediarology"** and **"Contrarians"**). One of the most in-depth analyses of temperature changes over the last few millennia, the anomalous warming of the past few decades, and the human contributions to it was performed by **Jones and Mann (2004)**. In addition to reaffirming their earlier conclusions that warming of the late 20th Century is indeed anomalous and unprecedented, they reiterate and build upon past findings that indicate that whereas 19th Century temperature trends can be explained well by natural factors, the warming of the late 20th Century can only be well-explained when anthropogenic forcing is taken into account.

It is imperative that better quantitative estimates of what both human and natural radiative forcings have been over the past 50 years are obtained so that we increase our quantitative capacity in order to estimate precisely how much human activities have influenced climate and improve our confidence in projections of how much more warming the Earth is likely to experience. Although some uncertainty remains, it does not detract from the large body of scientific evidence that shows a clear, discernible influence of human activities on recent climate records and expects substantially greater amounts of climate change if human emissions continue at rates typically projected.

A very unique attribution study has been conducted by **Ruddiman, 2003**. Ruddiman's report, titled "The Anthropogenic Greenhouse Era Began Thousands of Years Ago," was quite revolutionary in its thinking. As the title implies, Ruddiman believes that atmospheric concentrations of CO_2 and CH_4 were first altered by humans -- yep, you guessed it -- thousands of year ago, resulting from the discovery of agriculture and subsequent technological innovations in farming. While Ruddiman admits that this is still no more than a hypothesis, it is based on three strong pieces of evidence (much of which is quoted as written in Ruddiman's abstract):

- Cyclic variations in CO_2 and CH_4 driven by Earth-orbital changes during the last 350,000 years predict decreases throughout the Holocene, but the CO_2 trend began an anomalous increase 8,000 years ago, and the CH_4 trend did so 5,000 years ago. If the declines had continued, there likely would have been another Ice Age 4,000 to 5,000 years ago, but the reversal prevented that from occurring.
- Published explanations for these mid- to late-Holocene gas increases based on natural forcing can be rejected based on paleoclimatic evidence.
- A wide array of archaeological, cultural, historical, and geologic evidence points to viable explanations tied to anthropogenic changes resulting from early agriculture in Eurasia, including the start of forest clearance by 8,000 years ago (beginning in Europe, China, and India to clear room for croplands and pastures) and of rice irrigation by 5,000 years ago (mainly in Southeast Asia).

Ruddiman analyzed the Pleistocene CO_2 record (something with which he is very familiar from past studies) by looking at the Vostok ice core and came to the conclusion that the interglacial life cycle of CO_2 in the present interglacial has varied from the other three interglacials occurring in the last 400,000 years. In typical interglacials, CO_2 peaks early and then stabilizes or decreases, but in the Holocene interglacials, CO_2 levels fell early on and then began to recover. Ruddiman believes the main difference between this abnormal interglacial and the others is the presence of land clearing and agriculture. He point to two ways in which land clearing typically increases CO_2 concentrations: burning and decomposition of downed vegetation and increased weathering of soil carbon in a system that has been disturbed (i.e., tilled). These forces, Ruddiman believes, warmed the Earth by a global mean of about 0.8°C in recent millennia (2°C at higher latitudes) and have contributed to an uncharacteristically stable 10,000 years. In addition, Ruddiman believes CO_2 changes during the last millennium cannot be explained by external factors but rather by forest regrowth following episodes of bubonic plague (when less agriculture was done), which, among other similar factors, were responsible for the Little Ice Age (1300-1900 AD). (For a brief summary of the paper, see a New York Times article, **"Scientist Links Man to Climate Over the Ages"**.)

Two editorial comments appeared alongside Ruddiman's paper in the December 2003 issue of *Climatic Change* (see **Crowley, 2003** and **Crutzen and Steffen, 2003**). Crowley believes that Ruddiman may be on to something clever, but that his estimate of 0.8°C of warming caused by greenhouse perturbation due mainly to agriculture may be high. It is on the upper end of climate sensitivity estimates, and a "best guess" would likely be closer to 0.3 to 0.4°C, according to Crowley. Crowley also believes that solar variability and volcanism cannot be written off, as they are thought to influence temperature and are thought to be responsible for much of the warming that occurred up to the time of the Industrial Revolution. Crutzen and Steffen also agree that there could have been an anthropogenic component to warming thousands of years ago, and they suggest that perhaps the period Ruddiman identifies is the first phase of the "Anthropocene" out of four phases (the fourth is expected to develop this century). They, too, warn that there are many unresolved uncertainties in Ruddiman's work (i.e., they point out that much of his argument is based on the correctness of the historical CH_4 concentration curve, which may or may not be correct). Clearly this issue is ripe for additional research.

Is land use change contributing to the observed climate trends, as Ruddiman suggests? It has been known for decades that a number of forcings, both natural and anthropogenic, can cause climate change (e.g., see the **table** from my 1984 book, **The Co-Evolution of Climate and Life**). Two decades ago, in the table just mentioned, I had an entry "Patterns of land use", which listed the climatic effects as "Changes surface albedo and evapotranspiration and causes aerosols", in which the scale and importance of the effect was described as "Largely regional: net global climatic importance still speculative". I think that is pretty close to what I would still say today, but at least in the past several years, there have been both modeling (see **Pielke Sr. et al., 2002**) and observational (see **Kalnay and Cai, 2003**, critiques by **Trenberth, 2004** and **Vose et al., 2004**, and a subsequent **response**, mainly directed at Vose et al., by Cai and Kalnay) studies suggesting that land use may have played a major role over the long term (to say nothing of the Ruddiman hypothesis). For example, it is well known that clearing land raises albedo but lowers evapotranspiration. The first process cools the Earth's surface, and the second warms it, but together they still cool the planet unless feedbacks negate that. This is why the role of land use change is still largely speculative — there are many interactions and feedbacks to be considered. Also, the dramatic rise in temperatures in the past thirty years would be much harder to explain using a land use change explanation than the overall rise over the past hundred years would be, since land use has not changed dramatically over the last few decades compared to century-long trends. Moreover, land covers only thirty percent of the planet, and it is questionable as to whether it has as much influence in the grand scheme of things relative to truly global forcings like greenhouse gases (unless it forces changes in greenhouse gases as Ruddiman projects). But as I said twenty years ago about aerosols (see the **Coevolution table**), their climatic effects are "largely regional, since aerosols have an average lifetime of only a few days, but similar regional effects in different parts of the world could have nonnegligible net global effects." That is also true for land use, unless it makes big changes in greenhouse gases. In addition, land use change can have major impacts on plants and animals, and the synergism of climate change and forced migration of wildlife through disturbed landscapes could be a prescription for many extinctions (see **Climate Impacts**).

I reproduce this 20-year-old table to show that we do make progress, albeit halting, with research. Today, I would put more emphasis on aerosols' role in cooling rather than in warming, although the soot issue is challenging that revision (see **Hansen and Nazarenko, 2004**; **Hansen et al., 2000**; **Hansen and Sato, 2000**; **Jacobson, 2002**; **Jacobson, 2004**; **Novakov et al., 2003**; and **Black Carbon Contributes To Droughts And Floods In China**). We also know that the decline in stratospheric ozone levels has a weak cooling effect at the Earth's surface. But, amazingly, most of what we knew twenty years ago is still in line with today's assessments.

Table — Summary of Principal Human Activities That Can Influence Climate Change (presented as a background document against which to compare modern conditions) (Source: Schneider and Londer, 1984)

Activity	Climatic effect	Scale and importance of the effect
Release of carbon dioxide by burning fossil fuels	Increases the atmospheric absorption and emission of terrestrial infrared radiation (greenhouse effect), resulting in warming of lower atmosphere and cooling of the stratosphere.	Global: potentially a major influence on climate and biological activity.

Release of chlorofluoromethanes, nitrous oxide, carbon tetrachloride, carbon disulfide	Similar climatic effect as that of carbon dioxide since these, too, are infrared-absorbing and fairly chemically stable trace gases.	Global: potentially significant influence on climate.
Release of particles (aerosols) from industrial and agricultural practices	These sunlight scattering and absorbing particles probably decrease albedo over land, causing a warming and could increase albedo over water, causing a cooling; they also change stability of lower atmosphere; net climatic effects still speculative.	Largely regional, since aerosols have an average lifetime of only a few days, but similar regional effects in different parts of the world could have nonnegligible net global effects; stability increase may suppress convective rainfall, but particles could affect cloud properties with more far-reaching effects.
Release of aerosols that act as condensation and freezing nuclei	Influences growth of cloud droplets and ice crystals; may affect amount of precipitation or albedo of clouds in either direction.	Local (at most) regional influences on quantity and quality of precipitation, but unknown and potentially important change to earth's heat balance if cloud albedo is altered.
Release of heat (thermal pollution)	Warms the lower atmosphere directly.	Locally important now; could become significant regionally; could modify large-scale circulation.
Upward transport of chlorofluoromethanes and nitrous oxide into the stratosphere	Photochemical reaction of their dissociation products probably reduces stratospheric ozone.	Global but uncertain influence on climate: less total stratospheric ozone probably allows more solar radiation to reach the surface but compensates by reducing greenhouse effect as well; however, if ozone concentration decreases at high altitudes, but increases comparably at lower altitudes, this would lead to potentially very large surface warming; could cause significant biological effects from increased exposure to ultraviolet radiation if total column amount of ozone decreases.
Release of trace gases (e.g., nitrogen oxides, carbon monoxide, or methane) that increase tropospheric ozone by photochemical reactions	Large atmospheric heating occurs from tropospheric ozone, which enhances both solar and greenhouse heating of lower atmosphere.	Local to regional at present, but could become a significant global climatic warming if large-scale fossil fuel use leads to combustion products that significantly increase tropospheric ozone levels; contact with ozone also harms some plants and people.
Patterns of land use, e.g., urbanization, agriculture, overgrazing,	Changes surface albedo and evapotranspiration and causes aerosols.	Largely regional: net global climatic importance still speculative.

deforestation, etc.		
Release of radioactive Krypton-85 from nuclear reactors and fuel reprocessing plants	Increases conductivity of lower atmosphere, with possible implications for earth's electric field and precipitation from convective clouds.	Global: importance of influence is highly speculative.
Large-scale nuclear war.	Could lead to very large injections of soot and dust causing transient cooling lasting from weeks to months, depending on the nature of the exchange and on how many fires were started.	Could be global, but initially in mid-latitudes of Northern Hemisphere. Darkness from dust and smoke could wipe out photosynthesis for weeks with severe effects on both natural and agricultural ecosystems of both combatant and noncombatant nations. Transient freezing outbreaks could eliminate most warm season crops in mid-latitudes or be devastating to any vegetation in tropics or subtropics.

It is likely that human emissions of greenhouse gases will continue to increase substantially

Most climatologists agree that humans' contributions to global warming will rise in the future, regardless of the resolution of the new aerosol debate. In order to project future global warming, it is first necessary to construct scenarios detailing human disturbances to radiative forcing, considering such factors as increased greenhouse gas emissions, aerosol injections, or land use changes. These then drive climate models to project future changes, which in turn are used by the climate impacts community (see **Climate Impacts**) to estimate and emphasize the benefits of mitigating such anthropogenic climate changes. As noted earlier, the **SRES** produced a range of plausible, alternative future worlds from which emission scenarios are derived and used in climate models to project alternative future climates (see ***Using scenarios to develop a plausible range of outcomes)***.

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Next: Contrarians

CERTIFICATE OF SERVICE
DECLARATION OF SERVICE BY MAIL

CASE NAME:	**Cleveland National Forest Foundation v. San Diego Association of Governments**
CASE NO:	**California Supreme Court No. S223603 Court of Appeal, 4th District, Div. 1 No. D063288 San Diego County Superior No. 37-2011-00101593-CU-TT-CTL**

I am employed in the County of San Francisco, State of California. I am over the age of 18 and not a party to the within action; my business address is 50 California Street, Suite 3200, San Francisco, California 94111.

On **November 13, 2015**, I served the foregoing documents described as:

1) **SAN DIEGO ASSOCIATION OF GOVERNMENTS' CONSOLIDATED ANSWER TO AMICI'S BRIEFS**
2) **RESPONDENTS' REQUEST FOR JUDICIAL NOTICE IN SUPPORT OF ANSWER TO AMICI'S BRIEFS**

in this action by placing a true copy thereof enclosed in a sealed envelope addressed as follows:

SEE ATTACHED SERVICE LIST

On the above date:

☒	BY U.S. MAIL: The sealed envelope with postage thereon fully prepaid was placed for collection and mailing following ordinary business practices. I am aware that on motion of the party served, service is presumed invalid if the postage cancellation date or postage meter date on the envelope is more than one day after the date of deposit for mailing set forth in this declaration. I am readily familiar with Cox, Castle & Nicholson LLP's practice for collection and processing of documents for mailing with the United States Postal Service and that documents are deposited with the United States Postal Service the same day as the day of collection in the ordinary course of business.
☐	BY ELECTRONIC MAIL DELIVERY: By causing a true copy of the within documents to be mailed electronically to the offices of the addressees set forth below, on the date set forth above.

I hereby certify that the above document was printed on recycled paper.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on **November 13, 2015**, at San Francisco, California.

Peggy Sanchez

SERVICE LIST

CASE NAME: **Cleveland National Forest Foundation v. San Diego Assn. of Governments**
CASE NUMBER: **California Supreme Court No. S223603**

Court of Appeal **<u>Fourth Appellate District, Division 1</u>** 750 B Street, Suite 300 San Diego, CA 92101 *(Case No. D063288* *(via mail only)*	**<u>Superior Court – San Diego County</u>** The Honorable Timothy B. Taylor 330 West Broadway San Diego, CA 92101 *(Case No. 37-2011-00101593-CU-TT-CTL* *(via mail only)*
Attorneys for Plaintiffs and Respondents Cleveland National Forest Foundation; <u>Sierra Club</u> Rachel B. Hooper Shute, Mihaly & Weinberger 396 Hayes Street San Francisco, CA 94102 *E-mail:* hooper@smwlaw.com	**Attorneys for Plaintiffs and Respondents Cleveland National Forest Foundation; <u>Sierra Club</u>** Daniel Patrick Selmi 919 S. Albany Street Los Angeles, CA 90015 *E-mail:* dselmi@aol.com
Attorneys for Plaintiffs and Respondents Cleveland National Forest Foundation; <u>Sierra Club</u> Marco Gonzalez Coast Law Group LLP 1140 South Coast Highway 101 Encinitas, CA 92024 *E-mail*: marco@coastlawgroup.com	**Attorneys for Plaintiff and Respondent <u>Center for Biological Diversity</u>** Kevin Patrick Bundy Center for Biological Diversity 1212 Broadway, Suite 800 Oakland, CA 94612 *E-mail:* kbundy@biologicaldiversity.org
Attorneys for Plaintiffs and Respondents Creed-21; Affordable Housing Coalition <u>of San Diego County</u> Cory Jay Briggs / Mekaela M. Gladden Briggs Law Corp. 99 East 'C' Street, Suite 111 Upland, CA 91786 *E-mail:* cory@briggslawcorp.com *E-mail:* mekaela@briggslawcorp.com	**Attorneys for Intervener and Respondent <u>People of the State of California</u>** Timothy Raymond Patterson, Supervising Deputy Attorney General Office of the Attorney General P.O Box 85266 San Diego, CA 92186 *E-mail:* timpatterson@doj.ca.gov
Attorneys for Intervener and Respondent <u>People of the State of California</u> Janill Loreen Richards Office of the Attorney General 1515 Clay Street, 20th Floor Oakland, CA 94612 *E-mail:* janill.richards@doj.ca.gov	**Attoneys for Amicus Curiae California Infill Builders Federation and <u>San Diego Housing Commission</u>** Tina Thomas Thomas Law Group 455 Capitol Mall, Suite 801 Sacramento, CA 95814

Attorneys for Amicus Curiae – League of <u>Women Voters of California, et al.</u> Michelle Wilde Anderson / Deborah Sivas Stanford Law School 559 Nathan Abbott Way Stanford, CA 94305 *E-mail:* manderson@law.stanford.edu *E-mail:* dsivas@stanford.edu	**Attorneys for Amicus Curiae** **<u>Dennis D. Baldocchi, Ph.D., et al.</u>** Cara Ann Horowitz UCLA School of Law 405 Hilgard Avenue Los Angeles, CA 90095
Attorneys for Amicus Curiae **<u>Backcountry Against the Dump, Inc.</u>** Stephan C. Volker / Alexis E. Krieg Law Offices of Stephan C. Volker 436 Fourteenth Street, Suite 1300 Oakland, CA 94612	**Attorneys for Amicus Curiae - Building <u>Industry Legal Defense Foundation, et al.</u>** Nancy C. Miller / Jennifer V. Gore Miller & Owen 428 J Street, Suite 400 Sacramento, CA 95814 *E-mail:* miller@motlaw.com
Attoneys for Amicus Curiae - California <u>Association of Councils of Governments</u> Whitman F. Manley Remy Moose & Manley, LLP 555 Capitol Mall, Suite 800 Sacramento, CA 95814 *E-mail:* cstiles@rmmenvirolaw.com	**Attoneys for Amicus Curiae** **Council of Infill Builders and** **<u>Planning and Conservation League</u>** Richard M. Frank UC Davis School of Law 400 Mrak Hall Drive Davis, CA 95612 *E-mail:* rmfrank@ucdavis.edu
Attoneys for Amicus Curiae **<u>Pacific Legal Foundation</u>** Jonathan C. Wood Pacific Legal Foundation 930 G Street Sacramento, CA 95814 *E-mail:* cstiles@rmmenvirolaw.com	