Federal Register

Tuesday,
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Part V

Environmental Protection Agency

40 CFR Chapter I

Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act; Final Rule

Federal Register

Friday,
October 30, 2009

Part II

Environmental Protection Agency

40 CFR Parts 86, 87, 89 et al.
Mandatory Reporting of Greenhouse Gases; Final Rule

February 18, 2010.

Nancy Sutley,

Chair, Council on Environmental Quality.

[FR Doc. 2010–3531 Filed 2–22–10; 8:45 am]

BILLING CODE 3125–W0–P

COUNCIL ON ENVIRONMENTAL QUALITY

National Environmental Policy Act (NEPA) Draft Guidance, "Consideration of the Effects of Climate Change and Greenhouse Gas Emissions."

AGENCY: Council On Environmental Quality.

ACTION: Notice of Availability, Draft Guidance, "Consideration of the Effects of Climate Change and Greenhouse Gas Emissions."

SUMMARY: On February 18, 2010, the Council on Environmental Quality (CEQ) announced four steps to modernize, reinvigorate, and ease the use and increase the transparency of implementation of the National Environmental Policy Act (NEPA). Enacted in 1970, NEPA is a fundamental tool used to harmonize our economic, environmental, and social aspirations and is a cornerstone of our Nation's efforts to protect the environment. NEPA recognizes that many Federal activities affect the environment and mandates that Federal agencies consider the environmental impacts of their proposed actions before acting. Additionally, NEPA emphasizes public involvement in government actions affecting the environment by requiring that the benefits and the risks associated with proposed actions be assessed and publicly disclosed.

CEQ, which is charged with implementing NEPA, recognizes that it is a visionary and versatile law that can be used effectively to address new environmental challenges facing our nation and also to engage the public widely and effectively. Furthermore, CEQ wants to develop more effective and accessible tools for citizen involvement in government decision-making. These actions are designed to provide carefully-tailored new assessment and reporting requirements, facilitate agency compliance with NEPA, and enhance the quality of public involvement in governmental decisions relating to the environment.

DATES: Comments should be submitted on or before May 24, 2010.

ADDRESSES: The NEPA Draft Guidance documents are available at *http://www.nepa.gov.* Comments on the NEPA Draft Guidance "Consideration of the Effects of Climate Change and Greenhouse Gas Emissions" should be submitted electronically to GCC.guidance@ceq.eop.gov, or in writing to The Council on Environmental Quality, *Attn:* Ted Boling, 722 Jackson Place, NW., Washington, DC 20503.

FOR FURTHER INFORMATION CONTACT: Ted Boling, Senior Counsel, at (202) 395–5750.

SUPPLEMENTARY INFORMATION: CEQ is issuing draft guidance for public comment on when and how Federal agencies must consider the impacts of proposed Federal actions on global climate change, as well as the expected environmental effects from climate change that may be relevant to the design of the proposed Federal action. CEQ has been asked to provide guidance on this subject informally by Federal agencies and formally by a petition under the Administrative Procedure Act. The draft guidance explains how Federal agencies should analyze the environmental impacts of greenhouse gas emissions and climate change when they describe the environmental impacts of a proposed action under NEPA by (1) providing practical tools for agency reporting, including a presumptive threshold of 25,000 metric tons of carbon dioxide equivalent emissions from the proposed action to trigger consideration of a quantitative analysis, and (2) suggestions to agencies on how to assess the effects of climate change on the proposed action, and, in turn, on the design of agency actions. CEQ will seek public comment on this guidance for 90 days. Draft guidance documents are now available at the Council on Environmental Quality Web site at *http://www.nepa.gov.*

Public comments are requested on or before May 24, 2010.

February 18, 2010.

Nancy Sutley,

Chair, Council on Environmental Quality.

[FR Doc. 2010–3532 Filed 2–22–10; 8:45 am]

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COUNCIL ON ENVIRONMENTAL QUALITY

National Environmental Policy Act (NEPA) Draft Guidance, "NEPA Mitigation and Monitoring."

AGENCY: Council On Environmental Quality.

ACTION: Notice of Availability, Draft Guidance, "NEPA Mitigation and Monitoring."

SUMMARY: On February 18, 2010, the Council on Environmental Quality (CEQ) announced four steps to modernize, reinvigorate, and ease the use and increase the transparency of implementation of the National Environmental Policy Act (NEPA). Enacted in 1970, NEPA is a fundamental tool used to harmonize our economic, environmental, and social aspirations and is a cornerstone of our Nation's efforts to protect the environment. NEPA recognizes that many Federal activities affect the environment and mandates that Federal agencies consider the environmental impacts of their proposed actions before acting. Additionally, NEPA emphasizes public involvement in government actions affecting the environment by requiring that the benefits and the risks associated with proposed actions be assessed and publicly disclosed.

CEQ, which is charged with implementing NEPA, recognizes that it is a visionary and versatile law that can be used effectively to address new environmental challenges facing our nation and also to engage the public widely and effectively. Furthermore, CEQ wants to develop more effective and accessible tools for citizen involvement in government decision-making. These actions are designed to provide carefully-tailored new assessment and reporting requirements, facilitate agency compliance with NEPA, and enhance the quality of public involvement in governmental decisions relating to the environment.

DATES: Comments should be submitted on or before May 24, 2010.

ADDRESSES: The NEPA Draft Guidance documents are available at *http://www.nepa.gov.*

Comments on the NEPA Draft Guidance "NEPA Mitigation and Monitoring" should be submitted electronically to *Mitigation.guidance@ceq.eop.gov,* or in writing to The Council on Environmental Quality, *Attn:* Ted Boling, 722 Jackson Place, NW., Washington, DC 20503.

FOR FURTHER INFORMATION CONTACT: Ted Boling, Senior Counsel, at (202) 395–5750.

SUPPLEMENTARY INFORMATION: Draft Guidance Clarifying (1) the Appropriateness of "Findings of No Significant Impact" and (2) Specifying the Need for Ongoing Monitoring of Environmental Mitigation Commitments: Many Federal actions receive an environmental review, known as an Environmental Assessment. In those instances, NEPA compliance is usually completed with a "Finding of No Significant Impact" (FONSI) on the environment and a more

February 18, 2010

MEMORANDUM FOR HEADS OF FEDERAL DEPARTMENTS AND AGENCIES

FROM: NANCY H. SUTLEY, Chair, Council on Environmental Quality

SUBJECT: DRAFT NEPA GUIDANCE ON CONSIDERATION OF THE EFFECTS OF CLIMATE CHANGE AND GREENHOUSE GAS EMISSIONS

I. INTRODUCTION

The Council on Environmental Quality (CEQ) provides this draft guidance memorandum for public consideration and comment on the ways in which Federal agencies can improve their consideration of the effects of greenhouse gas (GHG) emissions[1] and climate change in their evaluation of proposals for Federal actions under the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321 et seq. This draft guidance is intended to help explain how agencies of the Federal government should analyze the environmental effects of GHG emissions and climate change when they describe the environmental effects of a proposed agency action in accordance with Section 102 of NEPA and the CEQ Regulations for Implementing the Procedural Provisions of NEPA, 40 C.F.R. parts 1500-1508. This draft guidance affirms the requirements of the statute and regulations and their applicability to GHGs and climate change impacts. CEQ proposes to advise Federal agencies that they should consider opportunities to reduce GHG emissions caused by proposed Federal actions and adapt their actions to climate change impacts throughout the NEPA process and to address these issues in their agency NEPA procedures.

The environmental analysis and documents produced in the NEPA process should provide the decision maker with relevant and timely information about the environmental effects of his or her decision and reasonable alternatives to mitigate those impacts. In this context, climate change issues arise in relation to the consideration of:

(1) The GHG emissions effects of a proposed action and alternative actions; and
(2) The relationship of climate change effects to a proposed action or alternatives, including the relationship to proposal design, environmental impacts, mitigation and adaptation measures.

NEPA demands informed, realistic governmental decision making. CEQ proposes to advise Federal agencies to consider, in scoping their NEPA analyses, whether analysis of the direct and indirect GHG emissions from their proposed actions may provide meaningful information to decision makers and the public. Specifically, if a proposed action would be reasonably anticipated to cause direct emissions of 25,000 metric tons or more of CO_2-equivalent GHG emissions on an annual basis, agencies should consider this an indicator that a quantitative and qualitative assessment may be meaningful to decision makers and the public. For long-term actions that have annual direct emissions of less than 25,000

[1] For purposes of this guidance, CEQ defines "GHGs" in accordance with Section 19(i) of Executive Order 13514 (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

metric tons of CO_2-equivalent, CEQ encourages Federal agencies to consider whether the action's long-term emissions should receive similar analysis. CEQ does not propose this as an indicator of a threshold of significant effects, but rather as an indicator of a minimum level of GHG emissions that may warrant some description in the appropriate NEPA analysis for agency actions involving direct emissions of GHGs.

CEQ does not propose to make this guidance applicable to Federal land and resource management actions, but seeks public comment on the appropriate means of assessing the GHG emissions and sequestration that are affected by Federal land and resource management decisions.

Because climate change is a global problem that results from global GHG emissions, there are more sources and actions emitting GHGs (in terms of both absolute numbers and types) than are typically encountered when evaluating the emissions of other pollutants. From a quantitative perspective, there are no dominating sources and fewer sources that would even be close to dominating total GHG emissions. The global climate change problem is much more the result of numerous and varied sources, each of which might seem to make a relatively small addition to global atmospheric GHG concentrations. CEQ proposes to recommend that environmental documents reflect this global context and be realistic in focusing on ensuring that useful information is provided to decision makers for those actions that the agency finds are a significant source of GHGs.

With regards to the effects of climate change on the design of a proposed action and alternatives, Federal agencies must ensure the scientific and professional integrity of their assessment of the ways in which climate change is affecting or could affect environmental effects of the proposed action. 40 CFR 1502.24. Under this proposed guidance, agencies should use the scoping process to set reasonable spatial and temporal boundaries for this assessment and focus on aspects of climate change that may lead to changes in the impacts, sustainability, vulnerability and design of the proposed action and alternative courses of action. At the same time, agencies should recognize the scientific limits of their ability to accurately predict climate change effects, especially of a short-term nature, and not devote effort to analyzing wholly speculative effects. Agencies can use the NEPA process to reduce vulnerability to climate change impacts, adapt to changes in our environment, and mitigate the impacts of Federal agency actions that are exacerbated by climate change.

Finally, CEQ seeks public comment on several issues not directly addressed by this draft guidance, including the assessment of climate change effects of land management activities, and means by which agencies can tailor the amount of the documentation prepared for NEPA analysis so that it is proportional to the importance of climate change to the decision-making process.

II. CONSIDERATION OF THE EFFECTS OF A PROPOSED AGENCY ACTION ON GHG EMISSIONS: WHEN TO EVALUATE GHG EMISSIONS

By statutes, Executive Orders, and agency policies, the Federal government is committed to the goals of energy conservation, reducing energy use, eliminating or reducing GHG emissions, and promoting the deployment of renewable energy technologies that are cleaner and more efficient. Where a proposal for Federal agency action implicates these goals, information on GHG emissions (qualitative or quantitative) that is useful and relevant to the decision should be used when deciding among alternatives.

Many projects and programs proposed by the Federal government have the potential to emit GHGs. Accordingly, where a proposed Federal action that is analyzed in an EA or EIS would be anticipated to emit GHGs to the atmosphere in quantities that the agency finds may be meaningful, it is appropriate for the agency to quantify and disclose its estimate of the expected annual direct and indirect GHG emissions in the environmental documentation for the proposed action. Where the proposed

activity is subject to GHG emissions accounting requirements, such as Clean Air Act reporting requirements that apply to stationary sources that directly emit 25,000 metric tons or more of CO_2-equivalent GHG on an annual basis,[2] the agency should include this information in the NEPA documentation for consideration by decision makers and the public. CEQ does not propose this reference point for use as a measure of indirect effects, the analysis of which must be must be bounded by limits of feasibility in evaluating upstream and downstream effects of Federal agency actions. In the agency's analysis of direct effects, it would be appropriate to: (1) quantify cumulative emissions over the life of the project; (2) discuss measures to reduce GHG emissions, including consideration of reasonable alternatives; and (3) qualitatively discuss the link between such GHG emissions and climate change. However, it is not currently useful for the NEPA analysis to attempt to link specific climatological changes, or the environmental impacts thereof, to the particular project or emissions, as such direct linkage is difficult to isolate and to understand. The estimated level of GHG emissions can serve as a reasonable proxy for assessing potential climate change impacts, and provide decision makers and the public with useful information for a reasoned choice among alternatives.

The reference point of 25,000 metric tons of direct CO_2-equivalent GHG emissions may provide agencies with a useful indicator – rather than an absolute standard of insignificant effects -- for agencies' action-specific evaluation of GHG emissions and disclosure of that analysis in their NEPA documents. CEQ does not propose this reference point as an indicator of a level of GHG emissions that may significantly affect the quality of the human environment, as that term is used by NEPA, but notes that it serves as a minimum standard for reporting emissions under the Clean Air Act. Evaluation of significance under NEPA is done by the action agency based on the categorization of actions in agency NEPA procedures and action-specific analysis of the context and intensity of the environmental impacts. 40 CFR 1501.4, 1508.27. Examples of proposals for Federal agency action that may warrant a discussion of the GHG impacts of various alternatives, as well as possible measures to mitigate climate change impacts, include: approval of a large solid waste landfill; approval of energy facilities such as a coal-fired power plant; or authorization of a methane venting coal mine. Other Federal policies, programs, or plans that cover multiple actions subject to NEPA – such as actions tiered from programmatic NEPA documents – may more appropriately address GHG emissions at the level of individual projects. In many cases, the GHG emissions of the proposed action may be so small as to be a negligible consideration. Agency NEPA procedures may identify actions for which GHG emissions and other environmental effects are neither individually or cumulatively significant. 40 CFR 1507.3.

Many agency NEPA analyses to date have found that GHG emissions from an individual agency action have small potential effects. Emissions from many proposed Federal actions would not typically be expected to produce an environmental effect that would trigger or otherwise require a detailed discussion in an EIS. Significant national policy decisions for which the action's GHG impacts are expected to be substantial have, on the other hand, required analysis of their GHG effects.

HOW TO EVALUATE GHG EMISSIONS

To describe the impact of an agency action on GHG emissions, once an agency has determined that this is appropriate, CEQ proposes that agencies should consider quantifying those emissions using the

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[2] 25,000 metric tons may provide a useful, presumptive, threshold for discussion and disclosure of GHG emissions because it has been used and proposed in rule-makings under the Clean Air Act (e.g., EPA's Mandatory Reporting of Greenhouse Gases Final Rule, 74 FR 56260, October 30, 2009). This threshold is used in Clean Air Act rule-makings because it provides comprehensive coverage of emissions with a reasonable number of reporters, thereby creating an important data set useful in quantitative analyses of GHG policies, programs and regulations. See 74 FR 56272. This rationale is pertinent to the presentation of NEPA analysis as well.

following technical documents, to the extent that this information is useful and appropriate for the proposed action under NEPA:

- For quantification of emissions from large direct emitters: 40 CFR Parts 86, 87, 89, et al. Mandatory Reporting of Greenhouse Gases; Final Rule, U.S. Environmental Protection Agency (74 Fed. Reg. 56259-56308). Note that "applicability tools" are available (http://www.epa.gov/climatechange/emissions/GHG-calculator/) for determining whether projects or actions exceed the 25,000 metric ton of CO2-equivalent greenhouse gas emissions.
- For quantification of Scope 1 emissions at Federal facilities: Greenhouse gas emissions accounting and reporting guidance that will be issued under Executive Order 13514 Sections 5(a) and 9(b) (http://www.ofee.gov)
- For quantification of emissions and removals from terrestrial carbon sequestration and various other project types: Technical Guidelines, Voluntary Reporting of Greenhouse Gases, (1605(b) Program, U.S. Department of Energy (http://www.eia.doe.gov/oiaf/1605/))

Land management techniques, including changes in land use or land management strategies, lack any established Federal protocol for assessing their effect on atmospheric carbon release and sequestration at a landscape scale. Therefore, at this time, CEQ seeks public comment on this issue but has not identified any protocol that is useful and appropriate for NEPA analysis of a proposed land and resource management actions.

CEQ notes that agencies may also find useful information in the following sources:

- Renewable Energy Requirements Guidance for EPACT 2005 and EO 13423 (http://www.ofee.gov/eo/epact05_fedrenewenergyguid_final_on_web.pdf)
- EPA Climate Leaders GHG Inventory Protocols (http://www.epa.gov/climateleaders/resources/inventory-guidance.html)

For proposed actions that are not adequately addressed in the GHG emission reporting protocols listed above, agencies should use NEPA's provisions for inter-agency consultation with available expertise to identify and follow the best available procedures for evaluating comparable activities. Agencies should consider the emissions source categories, measurement methodologies and reporting criteria outlined in these documents, as applicable to the proposed action, and follow the relevant procedures for determining and reporting emissions. The NEPA process does not require submitting a formal report or participation in the reporting programs. Rather, under this proposed guidance, only the methodologies relevant to the emissions of the proposed project need to be considered and disclosed to decision makers and the public.

WHAT DEPARTMENTS AND AGENCIES SHOULD CONSIDER AS PART OF THEIR GHG EVALUATION

Federal agencies should structure their NEPA processes "to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment." 40 CFR 1502.1. Inherent in NEPA and the CEQ implementing regulations is a "'rule of reason,' which ensures that agencies determine whether and to what extent to prepare an EIS based on the usefulness of any new potential information to the decisionmaking process." *DOT v. Public Citizen,* 541 U.S. 752, 767 (2004). Where a proposed action is evaluated in either an EA or an EIS, the agency may look to reporting thresholds in the technical documents cited above as a point of reference for

determining the extent of direct GHG emissions analysis that is appropriate to the proposed agency decision. As proposed in draft guidance above, for Federal actions that require an EA or EIS the direct and indirect GHG emissions from the action should be considered in scoping and, to the extent that scoping indicates that GHG emissions warrant consideration by the decision maker, quantified and disclosed in the environmental document. 40 CFR 1508.25. In assessing direct emissions, an agency should look at the consequences of actions over which it has control or authority. *Public Citizen,* 541 U.S. at 768. When a proposed federal action meets an applicable threshold for quantification and reporting, as discussed above, CEQ proposes that the agency should also consider mitigation measures and reasonable alternatives to reduce action-related GHG emissions. Analysis of emissions sources should take account of all phases and elements of the proposed action over its expected life, subject to reasonable limits based on feasibility and practicality.

For proposed actions evaluated in an EIS, Federal agencies typically describe their consideration of the energy requirements of a proposed action and the conservation potential of its alternatives. 40 CFR 1502.16(e). Within this description of energy requirements and conservation opportunities, agencies should evaluate GHG emissions associated with energy use and mitigation opportunities and use this as a point of comparison between reasonable alternatives. For proposals normally evaluated in an EA, agencies may consider the GHG emissions as a factor in discussing alternative uses of available resources. 40 CFR 1508.9(b). CEQ proposes that this analysis should also consider applicable Federal, State or local goals for energy conservation and alternatives for reducing energy demand or GHG emissions associated with energy production.

Where an agency concludes that a discussion of cumulative effects of GHG emissions related to a proposed action is warranted to inform decision-making, CEQ recommends that the agency do so in a manner that meaningfully informs decision makers and the public regarding the potentially significant effects in the context of the proposal for agency action. This would most appropriately focus on an assessment of annual and cumulative emissions of the proposed action and the difference in emissions associated with alternative actions. Agencies may incorporate USGCRP studies and reports by reference in any discussion of GHG emissions and their effects. 40 CFR 1502.21.

Agencies apply the rule of reason to ensure that their discussion pertains to the issues that deserve study and deemphasizes issues that are less useful to the decision regarding the proposal, its alternatives, and mitigation options. 40 CFR 1500.4(f), (g), 1501.7, 1508.25. In addressing GHG emissions, consistent with this proposed guidance, CEQ expects agencies to ensure that such description is commensurate with the importance of the GHG emissions of the proposed action, avoiding useless bulk and boilerplate documentation, so that the NEPA document may concentrate attention on important issues. 40 CFR 1502.5, 1502.24.

An agency may decide that it would be useful to describe GHG emissions in aggregate, as part of a programmatic analysis of agency activities that can be incorporated by reference into subsequent NEPA analyses for individual agency actions. In addition, Federal programs that affect emissions or sinks and proposals regarding long range energy, transportation, and resource management programs lend themselves to a programmatic approach. For example, if GHG emissions or climate change and related effects in general are included in a broad (i.e., programmatic) EIS for a program, subsequent NEPA analyses for actions implementing that program at the project level should, if useful in the NEPA analysis for that decision, tier from the programmatic statement and summarize the relevant issues discussed in the programmatic statement. 40 CFR 1502.20, 1508.28. Such aggregated discussion may be useful under the consideration of agency compliance with requirements for Federal agencies to implement sustainable practices for energy efficiency, GHG emissions avoidance or reduction, petroleum products use reduction, and renewable energy, including bioenergy as well as other required sustainable practices. See, Executive Order 13514 – Federal Leadership in Environmental, Energy, and Economic Performance (74

Fed. Reg. 52117-52127); Executive Order 13423 - Strengthening Federal Environmental, Energy, and Transportation Management (http://nepa.gov/nepa/regs/E.O._13423.pdf). In particular, NEPA analyses for individual actions may incorporate by reference agency Strategic Sustainability Plans and account for GHG effects in accordance with Federal GHG reporting and accounting procedures to the extent that they are applicable to actions that carry out agency obligations under subsections 2(a), (b), (c) and (f) of Executive Order 13514. Such reference to the programmatic accounting of Federal agency GHG emissions under EO 13514 should note where appropriate that the scope of this accounting (for Scope 1, 2 and 3 emissions) may be much broader than the emissions that would be reasonable for assessment within the scope of an individual agency action under NEPA.

To the extent that a federal agency evaluates proposed mitigation of GHG emissions, the quality of that mitigation – including its permanence, verifiability, enforceability, and additionality[3] – should also be carefully evaluated. Among the alternatives that may be considered for their ability to reduce or mitigate GHG emissions are enhanced energy efficiency, lower GHG-emitting technology, renewable energy, planning for carbon capture and sequestration, and capturing or beneficially using fugitive methane emissions. In some cases, such activities are part of the purpose and need for the proposed action and the analysis will provide an assessment, in a comparative manner, of the alternatives and their relative ability to advance those objectives.

III. CONSIDERATION OF CURRENT OR PROJECTED EFFECTS OF CLIMATE CHANGE ON PROPOSALS FOR AGENCY ACTION

CEQ proposes that agencies should determine which climate change impacts warrant consideration in their EAs and EISs because of their impact on the analysis of the environmental effects of a proposed agency action. Through scoping of an environmental document, agencies determine whether climate change considerations warrant emphasis or de-emphasis. 40 CFR 1500.4(g), 1501.7; See Scoping Guidance (CEQ 1981) (http://www.nepa.gov/nepa/regs/scope/scoping.htm) When scoping the impact of climate change on the proposal for agency action, the sensitivity, location, and timeframe of a proposed action will determine the degree to which consideration of these predictions or projections is warranted. As with analysis of any other present or future environment or resource condition, the observed and projected effects of climate change that warrant consideration are most appropriately described as part of the current and future state of the proposed action's "affected environment." 40 CFR 1502.15. Based on that description of climate change effects that warrant consideration, the agency may assess the extent that the effects of the proposal for agency action or its alternatives will add to, modify, or mitigate those effects. Such effects may include, but are not limited to, effects on the environment, on public health and safety, and on vulnerable populations who are more likely to be adversely affected by climate change. The final analysis documents an agency assessment of the effects of the actions considered, including alternatives, on the affected environment.

Climate change can affect the environment of a proposed action in a variety of ways. For instance, climate change can affect the integrity of a development or structure by exposing it to a greater risk of floods, storm surges, or higher temperatures. Climate change can increase the vulnerability of a resource, ecosystem, or human community, causing a proposed action to result in consequences that are more damaging than prior experience with environmental impacts analysis might indicate. For example, an industrial process may draw cumulatively significant amounts of water from a stream that is dwindling because of decreased snow pack in the mountains or add significant heat to a water body that is exposed

[3] Regulatory additionality requirements are designed to ensure that GHG reduction credit is limited to an entity with emission reductions that are above regulatory requirements. See http://www.eia.doe.gov/oiaf/1605/FAQ_GenInfoA.htm#Additionality;

to increasing atmospheric temperatures. Finally, climate change can magnify the damaging strength of certain effects of a proposed action.

Using NEPA's "rule of reason" governing the level of detail in any environmental effects analysis, agencies should ensure that they keep in proportion the extent to which they document their assessment of the effects of climate change. The focus of this analysis should be on the aspects of the environment that are affected by the proposed action and the significance of climate change for those aspects of the affected environment. Agencies should consider the specific effects of the proposed action (including the proposed action's effect on the vulnerability of affected ecosystems), the nexus of those effects with projected climate change effects on the same aspects of our environment, and the implications for the environment to adapt to the projected effects of climate change. The level of detail in the analysis and NEPA documentation of these effects will vary among affected resource values. For example, if a proposed project requires the use of significant quantities of water, changes in water availability associated with climate change may need to be discussed in greater detail than other consequences of climate change. In some cases, discussion of climate change effects in an EA or EIS may warrant a separate section, while in others such discussion may be integrated into the broader discussion of the affected environment.

When assessing the effects of climate change on a proposed action, an agency typically start with an identification of the reasonably foreseeable future condition of the affected environment for the "no action" alternative based on available climate change measurements, statistics, observations, and other evidence. See *Considering Cumulative Effects* (CEQ 1997) at www.nepa.gov. The reasonably foreseeable affected environment should serve as the basis for evaluating and comparing the incremental effects of alternatives. 40 CFR 1502.15. Agencies should be clear about the basis for projecting the changes from the existing environment to the reasonably foreseeable affected environment, including what would happen under this scenario and the probability or likelihood of this future condition. The obligation of an agency to discuss particular effects turns on "a reasonably close causal relationship between the environmental effect and the alleged cause." *Public Citizen*, 541 U.S. at 767. Where climate change effects are likely to be important but there is significant uncertainty about such effects, it may also be useful to consider the effects of any proposed action or its alternatives against a baseline of reasonably foreseeable future conditions that is drawn as distinctly as the science of climate change effects will support.

Climate change effects should be considered in the analysis of projects that are designed for long-term utility and located in areas that are considered vulnerable to specific effects of climate change (such as increasing sea level or ecological change) within the project's timeframe. For example, a proposal for long-term development of transportation infrastructure on a coastal barrier island will likely need to consider whether environmental effects or design parameters may be changed by the projected increase in the rate of sea level rise. See *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study,* (http://www.globalchange.gov/publications/reports/scientific-assessments/saps/sap4-7), and *Abrupt Climate Change* ((http://www.globalchange.gov/publications/reports/scientific-assessments/saps/sap3-4 (discussing the likelihood of an abrupt change in sea level). Given the length of time involved in present sea level projections, such considerations typically would not be relevant to an action with only short-term considerations.

The process of adaptive planning requires constant learning to reduce uncertainties and improve adaptation outcomes. The CEQ NEPA regulations recognize the value of monitoring to assure that decisions are carried out as provided in a Record of Decision. 40 CFR 1505.3. In cases where adaptation to the effects of climate change is important, the significant aspects of these changes should be identified in the agency's final decision and adoption of a monitoring program should be considered. Monitoring

strategies should be modified as more information becomes available and best practices and other experiences are shared.

For sources of the best scientific information available on the reasonably foreseeable climate change impacts, Federal agencies may summarize and incorporate by reference the Synthesis and Assessment Products of the U.S. Global Change Research Program (USGCRP, http://www.globalchange.gov/publications/reports/scientific-assessments/saps), and other major peer-reviewed assessments from USGCRP . Particularly relevant is the report on climate change impacts on water resources, ecosystems, agriculture and forestry, health, coastlines and arctic regions in the United States. *Global Climate Change Impacts in the United States* (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts). Research on climate change impacts is an emerging and rapidly evolving area of science. In accordance with NEPA's rule of reason and standards for obtaining information regarding reasonably foreseeable significant adverse effects on the human environment, action agencies need not undertake exorbitant research or analysis of projected climate change impacts in the project area or on the project itself, but may instead summarize and incorporate by reference the relevant scientific literature. See, e.g., 40 CFR 1502.21, 1502.22. Where agencies consider climate change modeling to be applicable to their NEPA analysis, agencies should consider the uncertainties associated with long-term projections from global and regional climate change models. There are limitations and variability in the capacity of climate models to reliably project potential changes at the regional, local, or project level, so agencies should disclose these limitations in explaining the extent to which they rely on particular studies or projections. 40 CFR 1502.21, 1502.22. The outputs of coarse-resolution global climate models, commonly used to project climate change scenarios at a continental or regional scale, require downscaling and bias removal (i.e., the adjustment of future projections for known systematic model errors) before they can be used in regional or local impact studies. See *Climate Models: An Assessment of Strengths and Limitations.* (http://www.globalchange.gov/publications/reports/scientific-assessments/saps/sap3-1).

Agencies should also consider the particular impacts of climate change on vulnerable communities where this may affect the design of the action or the selection among alternatives. Tribal and Alaska Native communities that maintain their close relationship with the cycles of nature have observed the changes that are already underway, including the melting of permafrost in Alaska, disappearance of important species of trees, shifting migration patterns of elk and fish, and the drying of lakes and rivers. These effects affect the survival for both their livelihood and their culture. Further, sovereign tribal governments with legal rights to reservations and trust resources are affected by ecological changes on the landscape in ways that many Americans are not.

IV. BACKGROUND

1. NEPA and Cumulative Effects in General

NEPA was enacted to, *inter alia,* "promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man." NEPA Section 2, 42 U.S.C. § 4321. NEPA is best known for its action-forcing requirement that "all agencies of the federal government shall . . . include in every recommendation or report on . . . major federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on –

(i) the environmental impact of the proposed action,
(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
(iii) alternatives to the proposed action,
(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

NEPA Section 102(2) (C), 42 U.S.C. § 4332(2) (C). This information must be provided for review by agencies with jurisdiction or special expertise regarding the environmental effects described. The agency's "detailed statement," known as an EIS, must be provided to the public, in accordance with NEPA Section 102(2)(C) and the Freedom of Information Act, and be incorporated into the agency decision-making process.

The EIS requirement thus has two purposes. First, it is meant to promote transparency and to ensure public accountability of agency decisions with significant environmental effects. In this sense, it promotes political checks and balances broader public interests against the motivations for agency action. Second, it is meant to ensure that agencies take account of those effects before decisions are made and as part of the agency's own decision-making process. In this sense, it attempts to ensure that agencies consider environmental consequences as they decide how to proceed and take steps, when appropriate, to eliminate or mitigate adverse effects. The agency's "responsibility is not simply to sit back, like an umpire, and resolve adversary contentions . . . Rather, it must itself take the initiative of considering environmental values at every distinctive and comprehensive stage of the process beyond the staff's evaluation and recommendation." *Calvert Cliffs Coordinating Comm., Inc. v. US Atomic Energy Comm'n*, 449 F.2d 1109, 1119 (D.C. Cir. 1971).

Alternatives analysis is an essential element of the NEPA process, both under section 102(2) (C) and in the EA of "conflicts concerning alternative uses of available resources" under Section 102(2) (E). The requirement of consideration of alternatives is meant to ensure that the agency consider approaches whose adverse environmental effects will be insignificant or at least less significant than those of the proposal. "This requirement, like the 'detailed statement' requirement, seeks to ensure that each agency decision maker has before him and takes into proper account all possible approaches to a particular project (including total abandonment of the project) which would alter the environmental impact and the cost-benefit balance. Only in that fashion is it likely that the most intelligent, optimally beneficial decision will ultimately be made." *Calvert Cliffs*, 449 F.2d at 1114.

NEPA analysis and documentation should be designed to both inform Federal agency decisions and provide for collaborative, coordinated decisions by making "advice and information useful in restoring, maintaining, and enhancing the quality of the environment" available to States, Tribes, counties, cities, institutions and individuals. Section 102(2) (G), 42 U.S.C. § 4332(2) (G). NEPA also requires Federal agencies to support international cooperation by recognizing "the global character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment." Section 102(2) (F), 42 U.S.C. § 4332(2) (F).

Federal actions may cause effects on the human environment that are not significant environment effects, in isolation, but that are significant in the aggregate or that will lead to significant effects. Since 1970, CEQ has construed the term "major Federal actions significantly affecting the quality of the human environment" as requiring the consideration of the "overall, cumulative impact of the action proposed (and of further actions contemplated)." 35 Fed. Reg. 7390, 7391 (1970). "Cumulative impact" is defined in CEQ's NEPA regulations as the "impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions . . ." 40 C.F.R. § 1508.7. Cf. *Kleppe v. Sierra Club*, 427 U.S. 390, 413-414 (1976). CEQ interprets this regulation as referring only to the cumulative impact of the direct and indirect effects of the proposed action or its alternatives when added to the aggregate effects of past, present, and reasonably foreseeable future

actions. See, CEQ Guidance on the Consideration of Past Actions in Cumulative Effects Analysis (June 24, 2005) at 2, 3 (www.nepa.gov/nepa/regs/Guidance_on_CE.pdf).

As explained in prior CEQ guidance, and described in its handbook *Considering Cumulative Effects,* the analysis of cumulative effects begins with consideration of the direct and indirect effects on the environment that are expected or likely to result from a proposal for agency action or its reasonable alternatives. See *Considering Cumulative Effects* (CEQ 1997) at www.nepa.gov. Agencies then should consider the affected environment by looking for effects of past, present, and reasonably foreseeable future actions that are, in the judgment of the agency, relevant because their effects would increase or change in combination with the direct and indirect effects of the proposal for agency action or its alternatives. The relevant cumulative effects typically result from human activities with effects that accumulate within the temporal and geographic boundaries of the effects of the proposed action.

The purpose of cumulative effects analysis is to document agency consideration of the context and intensity of the effects of a proposal for agency action, particularly whether the action is related to other actions with individually insignificant but cumulatively significant impacts. 40 CFR 1508.27(b)(7). After such documentation, the dual purposes of NEPA will be satisfied. The public can scrutinize the relevant effects, and the agency, having been made alert to them, can decide how to proceed. The Supreme Court has emphasized that agencies may properly limit the scope of their cumulative effects analysis based on practical considerations. *Kleppe*, 427 U.S at 414 ("Even if environmental interrelationships could be shown conclusively to extend across basins and drainage areas, practical considerations of feasibility might well necessitate restricting the scope of comprehensive statements"). See also 40 CFR 1502.22 (regarding acquisition and disclosure of information that is "relevant to reasonably foreseeable significant adverse impacts" and "essential to a reasoned choice among alternatives").

2. Climate Change in General.

The science of climate change is rapidly developing, and is only briefly summarized in this guidance to illustrate the sources of scientific information that are presently available for consideration. CEQ's first Annual Report in 1970 discussed climate change, concluding that "man may be changing his weather." Environmental Quality: The First Annual Report at 93. At that time, human activities had increased the mean level of atmospheric carbon dioxide to 325 parts per million (ppm). Since 1970, the concentration of atmospheric carbon dioxide has increased at a rate of about 1.6 ppm per year (1979-2008) to the present level of approximately 385 ppm (2008 globally averaged value). *See* U.S. Department of Commerce, National Oceanic and Atmospheric Administration Earth Systems Research Laboratory (http://www.esrl.noaa.gov/gmd/ccgg/trends/). The atmospheric concentrations of other, more potent GHGs have also increased to levels that far exceed their levels in 1750, at the beginning of the industrial era. As of 2004, human activities annually produced more than 49 billion tons of GHG measured in carbon dioxide equivalency according to the Intergovernmental Panel on Climate Change (IPCC). IPCC Fourth Assessment Report: Synthesis Report at 38 (http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf). Nearly every aspect of energy choices and use affect the development of fossil fuel and other energy resources, either adding to or reducing the cumulative total of GHG emissions.

It is now well established that rising global GHG emissions are significantly affecting the Earth's climate. These conclusions are built upon a scientific record that has been created with substantial contributions from the United States' Global Change Research Program (formerly the Climate Change Science Program), which facilitates the creation and application of knowledge of the Earth's global environment through research, observations, decision support, and communication. (http://www.globalchange.gov/)

Based primarily on the scientific assessments of the USGCRP and NRC, EPA has issued a finding that the changes in our climate caused by GHG emissions endanger public health and welfare. (Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, December 15, 2009, 74 Fed. Reg. 66496). Ambient concentrations of GHGs do not cause direct adverse health effects (such as respiratory or toxic effects), but public health risks and impacts as a result of elevated atmospheric concentrations of GHGs occur via climate change. 74 Fed. Reg. at 66497-98. For example, EPA has estimated that climate change can exacerbate tropospheric ozone levels in some parts of the U.S. Broadly, EPA states that the effects of climate change observed to date and projected to occur in the future include, but are not limited to, more frequent and intense heat waves, more severe wildfires, degraded air quality, more heavy downpours and flooding, increased drought, greater sea-level rise, more intense storms, harm to water resources, harm to agriculture, and harm to wildlife and ecosystems. The Administrator has determined that these impacts are effects on public health and welfare within the meaning of the Clean Air Act. However, the Administrator does not currently believe that it is possible to quantify with great specificity (i.e. geographic), the various health effects from climate change but, because the risks from unusually hot days and nights and from heat waves are very serious, has proposed to find that on balance that these risks support a finding that public health is endangered even if it is also possible that modest temperature increases will have some beneficial health effects. The EPA findings cite IPCC reports that climate change impacts on human health in U.S. cities will be compounded by population growth and an aging population and GCRP reports that climate change has the potential to accentuate the disparities already evident in the American health care systems as many of the expected health effects are likely to fall disproportionately on the poor, the elderly, the disabled, and the uninsured.

V. CONCLUSION

With the purpose of informing decision-making, CEQ proposes that the NEPA process should incorporate consideration of both the impact of an agency action on the environment through the mechanism of GHG emissions and the impact of changing climate on that agency action. This is not intended as a "new" component of NEPA analysis, but rather as a potentially important factor to be considered within the existing NEPA framework. Where an agency determines that an assessment of climate issues is appropriate, the agency should identity alternative actions that are both adapted to anticipated climate change impacts and mitigate the GHG emissions that cause climate change. As noted above, NEPA analysis of climate change issues necessarily will evolve to reflect the scientific information available and the legal and policy context of decisions that the NEPA process is intended to inform. Therefore, once this guidance is issued in final form, CEQ intends to revise it as warranted to reflect developments in the law, policy, and science regarding climate change.

VI. SPECIFIC QUESTIONS FOR PUBLIC REVIEW

In addition to comments on this draft guidance document, CEQ also requests comment on land and resource management issues, including:

1. How should NEPA documents regarding long-range energy and resource management programs assess GHG emissions and climate change impacts?
2. What should be included in specific NEPA guidance for projects applicable to the federal land management agencies?
3. What should be included in specific NEPA guidance for land management planning applicable to the federal land management agencies?
4. Should CEQ recommend any particular protocols for assessing land management practices and their effect on carbon release and sequestration?

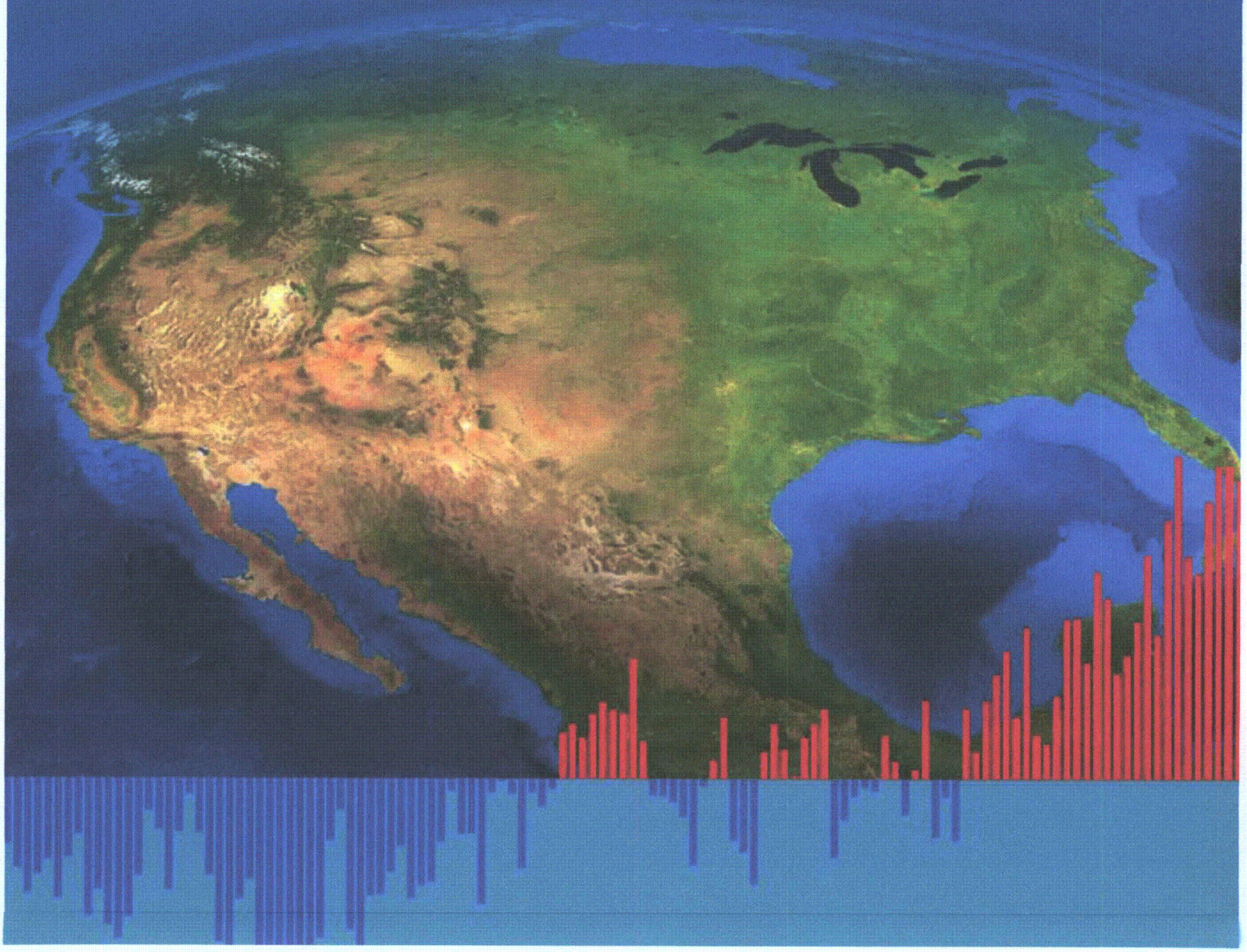
5. How should uncertainties associated with climate change projections and species and ecosystem responses be addressed in protocols for assessing land management practices?
6. How should NEPA analyses be tailored to address the beneficial effects on GHG emissions of Federal land and resource management actions?
7. Should CEQ provide guidance to agencies on determining whether GHG emissions are "significant" for NEPA purposes. At what level should GHG emissions be considered to have significant cumulative effects. In this context, commenters may wish to consider the Supreme Court decision in *Massachusetts v. EPA,* 549 U.S. 497, 524 (2007).

After consideration of public comment, CEQ intends to expeditiously issue this guidance in final form. In the meantime, CEQ does not intend this guidance to become effective until its issuance in final form.

# # #

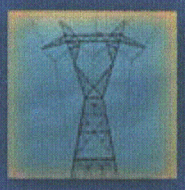
Global Climate Change Impacts in the United States

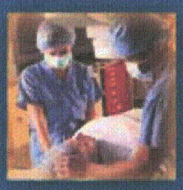
U.S. GLOBAL CHANGE RESEARCH PROGRAM



Global Climate Change Impacts in the United States

A State of Knowledge Report from the U.S. Global Change Research Program





The full report can be found online at www.globalchange.gov/usimpacts

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The bars at the bottom of the front cover show the global annual average temperature from 1900-2008, see page 17.

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This report on Global Climate Change Impacts in the United States was prepared in accordance with Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554) and the information quality act guidelines issued by the Department of Commerce and NOAA pursuant to Section 515 <http://www.noaanews.noaa.gov/stories/iq.htm>.

June 2009

Members of Congress:

On behalf of the National Science and Technology Council, the U.S. Global Change Research Program is pleased to transmit to the President and the Congress this state of knowledge report: "*Global Climate Change Impacts in the United States*." This report summarizes the science of climate change and the impacts of climate change on the United States, now and in the future.

As our nation strives to develop effective policies to respond to climate change, it is critical to have the latest and best scientific information to inform decision making. More than a year in the making, this report provides that information. It is the first report in almost a decade to provide an extensive evaluation of climate change impacts on the United States at the regional level.

An expert team of scientists operating under the authority of the Federal Advisory Committee Act, assisted by communication specialists, wrote the document. The report was reviewed and revised based on comments from experts and the public in accordance with the Information Quality Act guidelines issued by the Department of Commerce and the National Oceanic and Atmospheric Administration.

We highly commend the authors and support personnel of both this report and the underlying Synthesis and Assessment Products for the outstanding quality of their work in providing sound and thorough science-based information for policy formulation and climate change research priority setting. We intend to use the essential information contained in this report as we make policies and decisions about the future, and we recommend others do the same.

Sincerely,

Dr. John Holdren
Director,
Office of Science and Technology Policy

Dr. Jane Lubchenco
Administrator,
National Oceanic and Atmospheric Administration

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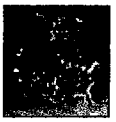

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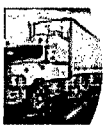

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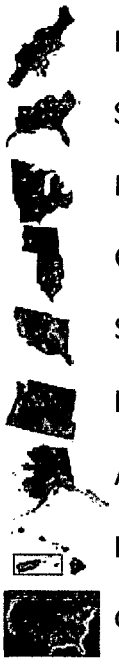

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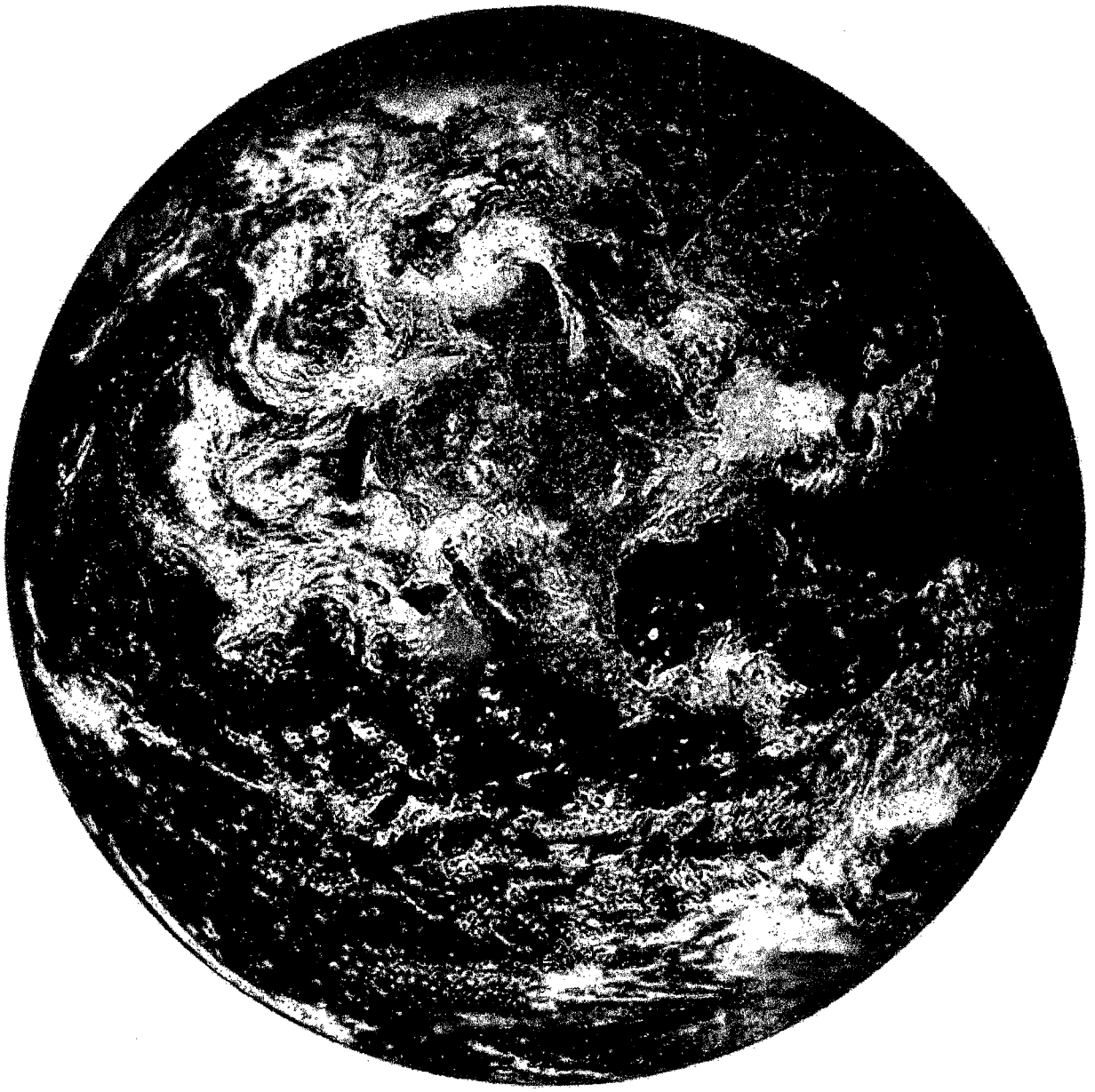


About this Report

What is this report?

This report summarizes the science of climate change and the impacts of climate change on the United States, now and in the future. It is largely based on results of the U.S. Global Change Research Program (USGCRP),[a] and integrates those results with related research from around the world. This report discusses climate-related impacts for various societal and environmental sectors and regions across the nation. It is an authoritative scientific report written in plain language, with the goal of better informing public and private decision making at all levels.

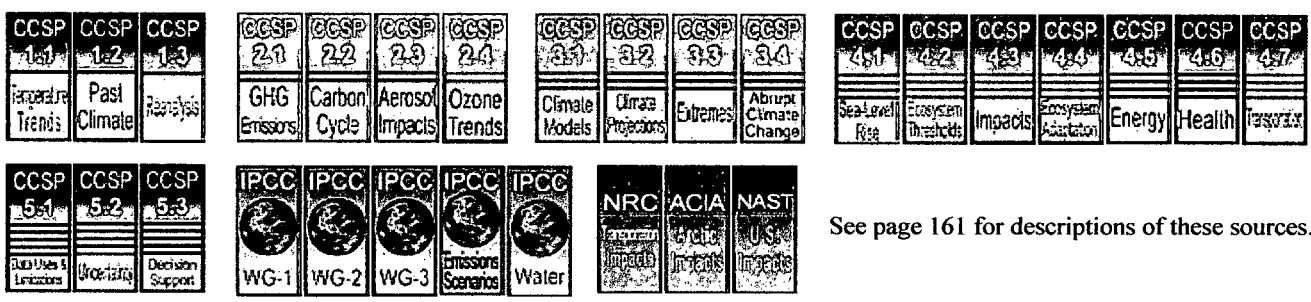
Who called for it, who wrote it, and who approved it?

The USGCRP called for this report. An expert team of scientists operating under the authority of the Federal Advisory Committee Act, assisted by communication specialists, wrote the document. The report was extensively reviewed and revised based on comments from experts and the public. The report was approved by its lead USGCRP Agency, the National Oceanic and Atmospheric Administration, the other USGCRP agencies, and the Committee on the Environment and Natural Resources on behalf of the National Science and Technology Council.[b] This report meets all Federal requirements associated with the Information Quality Act, including those pertaining to public comment and transparency.

What are its sources?

The report draws from a large body of scientific information. The foundation of this report is a set of 21 Synthesis and Assessment Products (SAPs), which were designed to address key policy-relevant issues in climate science (see page 161); several of these were also summarized in the *Scientific Assessment of the Effects of Climate Change on the United States* published in 2008. In addition, other peer-reviewed scientific assessments were used, including those of the Intergovernmental Panel on Climate Change, the U.S. National Assessment of the Consequences of Climate Variability and Change, the Arctic Climate Impact Assessment, the National Research Council's Transportation Research Board report on the Potential Impacts of Climate Change on U.S. Transportation, and a variety of regional climate impact assessments. These assessments were augmented with government statistics as necessary (such as population census and energy usage) as well as publicly available observations and peer-reviewed research published through the end of 2008. This new work was carefully selected by the author team with advice from expert reviewers to update key aspects of climate change science relevant to this report. The icons on the bottom of this page represent some of the major sources drawn upon for this synthesis report.

On the first page of each major section, the sources primarily drawn upon for that section are shown using these icons. Endnotes, indicated by superscript numbers and compiled at the end of the book, are used for specific references throughout the report.



See page 161 for descriptions of these sources.

a. The U.S. Global Change Research Program (USGCRP), which was established in 1990 by the Global Change Research Act, encompasses the Climate Change Science Program (CCSP).

b. A description of the National Science and Technology Council (NSTC) can be found at www.ostp.gov/cs/nstc.

Does this report deal with options for responding to climate change?

While the primary focus of this report is on the impacts of climate change in the United States, it also deals with some of the actions society is already taking or can take to respond to the climate challenge. Responses to climate change fall into two broad categories. The first involves "mitigation" measures to reduce climate change by, for example, reducing emissions of heat-trapping gases and particles, or increasing removal of heat-trapping gases from the atmosphere. The second involves "adaptation" measures to improve our ability to cope with or avoid harmful impacts and take advantage of beneficial ones, now and in the future. Both of these are necessary elements of an effective response strategy. These two types of responses are linked in that more effective mitigation measures reduce the amount of climate change, and therefore the need for adaptation.

This report underscores the importance of mitigation by comparing impacts resulting from higher versus lower emissions scenarios. The report shows that choices made about emissions in the next few decades will have far-reaching consequences for climate change impacts. Over the long term, lower emissions will lessen both the magnitude of climate change impacts and the rate at which they appear.

While the report underscores the importance of mitigation as an essential part of the nation's climate change strategy, it does not evaluate mitigation technologies or undertake an analysis of the effectiveness of various approaches. These issues are the subject of ongoing studies by the U.S. Government's Climate Change Technology Program and several federal agencies including the Department of Energy, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Department of Transportation, and Department of Agriculture. The range of mitigation responses being studied includes more efficient production and use of energy, increased use of non-carbon-emitting energy sources, and carbon capture and storage.

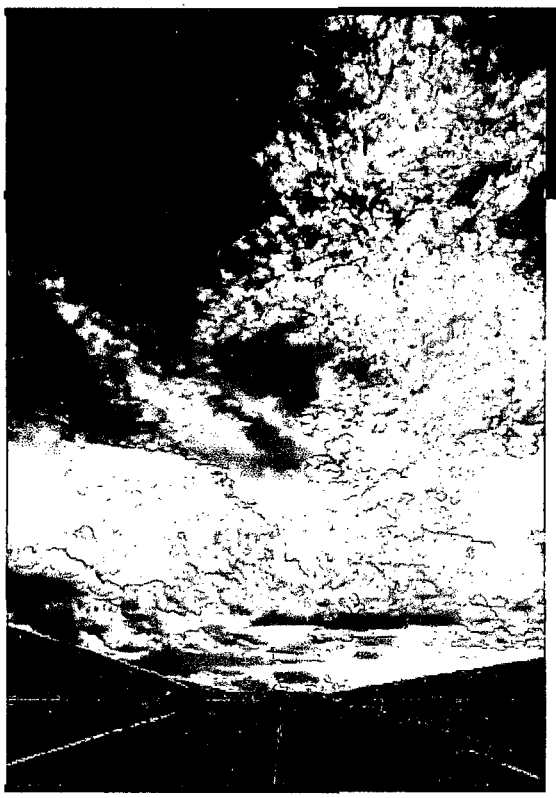
Adaptation options also have the potential to moderate harmful impacts of current and future climate variability and change. While this report does address adaptation, it does not do so comprehensively. Rather, in the context of impacts, this report identifies examples of actions currently being pursued in various sectors and regions to address climate change, as well as other environmental problems that could be exacerbated by climate change such as urban air pollution and heat waves. In most cases, there is currently insufficient peer-reviewed information to evaluate the practicality, effectiveness, costs, or benefits of these measures, highlighting a need for research in this area. Thus, the discussion of various public and private adaptation examples should not be viewed as an endorsement of any particular option, but rather as illustrative examples of approaches being tried.

How is the likelihood of various outcomes expressed given that the future is not certain?

When it is considered necessary to express a range of possible outcomes and identify the likelihood of particular impacts, this report takes a plain-language approach to expressing the expert judgment of the author team based on the best available evidence. For example, an outcome termed "likely" has at least a two-thirds chance of occurring; an outcome termed "very likely," at least a 90 percent chance.[1] In using these terms, the Federal Advisory Committee has taken into consideration a wide range of information, including the strength and consistency of the observed evidence, the range and consistency of model projections, the reliability of particular models as tested by various methods, and most importantly, the body of work addressed in earlier synthesis and assessment reports. Key sources of information used to develop these characterizations of uncertainty are referenced in endnotes.

How does this report address incomplete scientific understanding?

This assessment identifies areas in which scientific uncertainty limits our ability to estimate future climate change and its impacts. The section on *An Agenda for Climate Impacts Science* at the end of this report highlights some of these areas.



Executive Summary

Observations show that warming of the climate is unequivocal. The global warming observed over the past 50 years is due primarily to human-induced emissions of heat-trapping gases. These emissions come mainly from the burning of fossil fuels (coal, oil, and gas), with important contributions from the clearing of forests, agricultural practices, and other activities.

Warming over this century is projected to be considerably greater than over the last century. The global average temperature since 1900 has risen by about 1.5°F. By 2100, it is projected to rise another 2 to 11.5°F. The U.S. average temperature has risen by a comparable amount and is very likely to rise more than the global average over this century, with some variation from place to place. Several factors will determine future temperature increases. Increases at the lower end of this range are more likely if global heat-trapping gas emissions are cut substantially. If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range. Volcanic eruptions or other natural variations could temporarily counteract some of the human-induced warming, slowing the rise in global temperature, but these effects would only last a few years.

Reducing emissions of carbon dioxide would lessen warming over this century and beyond. Sizable early cuts in emissions would significantly reduce the pace and the overall amount of climate change. Earlier cuts in emissions would have a greater effect in reducing climate change than comparable reductions made later. In addition, reducing emissions of some shorter-lived heat-trapping gases, such as methane, and some types of particles, such as soot, would begin to reduce warming within weeks to decades.

Climate-related changes have already been observed globally and in the United States. These include increases in air and water temperatures, reduced frost days, increased frequency and intensity of heavy downpours, a rise in sea level, and reduced snow cover, glaciers, permafrost, and sea ice. A longer ice-free period on lakes and rivers, lengthening of the growing season, and increased water vapor in the atmosphere have also been observed. Over the past 30 years, temperatures have risen faster in winter than in any other season, with average winter temperatures in the Midwest and northern Great Plains increasing more than 7°F. Some of the changes have been faster than previous assessments had suggested.

These climate-related changes are expected to continue while new ones develop. Likely future changes for the United States and surrounding coastal waters include more intense hurricanes with related increases in wind, rain, and storm surges (but not necessarily an increase in the number of these storms that make landfall), as well as drier conditions in the Southwest and Caribbean. These changes will affect human health, water supply, agriculture, coastal areas, and many other aspects of society and the natural environment.

This report synthesizes information from a wide variety of scientific assessments (see page 7) and recently published research to summarize what is known about the observed and projected consequences of climate change on the United States. It combines analysis of impacts on various sectors

such as energy, water, and transportation at the national level with an assessment of key impacts on specific regions of the United States. For example, sea-level rise will increase risks of erosion, storm surge damage, and flooding for coastal communities, especially in the Southeast and parts of Alaska. Reduced snowpack and earlier snow melt will alter the timing and amount of water supplies, posing significant challenges for water resource management in the West.

Society and ecosystems can adjust to some climatic changes, but this takes time. The projected rapid rate and large amount of climate change over this century will challenge the ability of society and natural systems to adapt. For example, it is difficult and expensive to alter or replace infrastructure designed to last for decades (such as buildings, bridges, roads, airports, reservoirs, and ports) in response to continuous and/or abrupt climate change.

Impacts are expected to become increasingly severe for more people and places as the amount of warming increases. Rapid rates of warming would lead to particularly large impacts on natural ecosystems and the benefits they provide to humanity. Some of the impacts of climate change will be irreversible, such as species extinctions and coastal land lost to rising seas.

Unanticipated impacts of increasing carbon dioxide and climate change have already occurred and more are possible in the future. For example, it has recently been observed that the increase in atmospheric carbon dioxide concentration is causing an increase in ocean acidity. This reduces the ability of corals and other sea life to build shells and skeletons out of calcium carbonate. Additional impacts in the future might stem from unforeseen changes in the climate system, such as major alterations in oceans, ice, or storms; and unexpected consequences of ecological changes, such as massive dislocations of species or pest outbreaks. Unexpected social or economic changes, including major shifts in wealth, technology, or societal priorities would also affect our ability to respond to climate change. Both anticipated and unanticipated impacts become more challenging with increased warming.

Projections of future climate change come from careful analyses of outputs from global climate models run on the world's most advanced computers. The model simulations analyzed in this report used plausible scenarios of human activity that generally lead to further increases in heat-trapping emissions. None of the scenarios used in this report assumes adoption of policies explicitly designed to address climate change. However, the level of emissions varies among scenarios because of differences in assumptions about population, economic activity, choice of energy technologies, and other factors. Scenarios cover a range of emissions of heat-trapping gases, and the associated climate projections illustrate that lower emissions result in less climate change and thus reduced impacts over this century and beyond. Under all scenarios considered in this report, however, relatively large and sustained changes in many aspects of climate are projected by the middle of this century, with even larger changes by the end of this century, especially under higher emissions scenarios.

In projecting future conditions, there is always some level of uncertainty. For example, there is a high degree of confidence in projections that future temperature increases will be greatest in the Arctic and in the middle of continents. For precipitation, there is high confidence in projections of continued increases in the Arctic and sub-Arctic (including Alaska) and decreases in the regions just outside the tropics, but the precise location of the transition between these is less certain. At local to regional scales and on time frames up to a few years, natural climate variations can be relatively large and can temporarily mask the progressive nature of global climate change. However, the science of making skillful projections at these scales has progressed considerably, allowing useful information to be drawn from regional climate studies such as those highlighted in this report.

This report focuses on observed and projected climate change and its impacts on the United States. However, a discussion of these issues would be incomplete without mentioning some of the actions society can take to respond to the climate challenge. The two major categories are "mitigation" and "adaptation." Mitigation refers to options for limiting climate change by, for example, reducing

heat-trapping emissions such as carbon dioxide, methane, nitrous oxide, and halocarbons, or removing some of the heat-trapping gases from the atmosphere. Adaptation refers to changes made to better respond to present or future climatic and other environmental conditions, thereby reducing harm or taking advantage of opportunity. Effective mitigation measures reduce the need for adaptation. Mitigation and adaptation are both essential parts of a comprehensive climate change response strategy.

Carbon dioxide emissions are a primary focus of mitigation strategies. These include improving energy efficiency, using energy sources that do not produce carbon dioxide or produce less of it, capturing and storing carbon dioxide from fossil fuel use, and so on. Choices made about emissions reductions now and over the next few decades will have far-reaching consequences for climate-change impacts. The importance of mitigation is clear in comparisons of impacts resulting from higher versus lower emissions scenarios considered in this report. Over the long term, lower emissions will lessen both the magnitude of climate-change impacts and the rate at which they appear. Smaller climate changes that come more slowly make the adaptation challenge more tractable.

However, no matter how aggressively heat-trapping emissions are reduced, some amount of climate change and resulting impacts will continue due to the effects of gases that have already been released. This is true for several reasons. First, some of these gases are very long-lived and the levels of atmospheric heat-trapping gases will remain elevated for hundreds of years or more. Second, the Earth's vast oceans have absorbed much of the heat added to the climate system due to the increase in heat-trapping gases, and will retain that heat for many decades. In addition, the factors that determine emissions, such as energy-supply systems, cannot be changed overnight. Consequently, there is also a need for adaptation.

Adaptation can include a wide range of activities. Examples include a farmer switching to growing a different crop variety better suited to warmer or drier conditions; a company relocating key business centers away from coastal areas vulnerable to sea-level rise and hurricanes; and a community altering its zoning and building codes to place fewer structures in harm's way and making buildings less vulnerable to damage from floods, fires, and other extreme events. Some adaptation options that are currently being pursued in various regions and sectors to deal with climate change and/or other environmental issues are identified in this report. However, it is clear that there are limits to how much adaptation can achieve.

Humans have adapted to changing climatic conditions in the past, but in the future, adaptations will be particularly challenging because society won't be adapting to a new steady state but rather to a rapidly moving target. Climate will be continually changing, moving at a relatively rapid rate, outside the range to which society has adapted in the past. The precise amounts and timing of these changes will not be known with certainty.

In an increasingly interdependent world, U.S. vulnerability to climate change is linked to the fates of other nations. For example, conflicts or mass migrations of people resulting from food scarcity and other resource limits, health impacts, or environmental stresses in other parts of the world could threaten U.S. national security. It is thus difficult to fully evaluate the impacts of climate change on the United States without considering the consequences of climate change elsewhere. However, such analysis is beyond the scope of this report.

Finally, this report identifies a number of areas in which inadequate information or understanding hampers our ability to estimate future climate change and its impacts. For example, our knowledge of changes in tornadoes, hail, and ice storms is quite limited, making it difficult to know if and how such events have changed as climate has warmed, and how they might change in the future. Research on ecological responses to climate change is also limited, as is our understanding of social responses. The section titled *An Agenda for Climate Impacts Science* at the end of this report offers some thoughts on the most important ways to improve our knowledge. Results from such efforts would inform future assessments that continue building our understanding of humanity's impacts on climate, and climate's impacts on us.

Key Findings

1. Global warming is unequivocal and primarily human-induced.
Global temperature has increased over the past 50 years. This observed increase is due primarily to human-induced emissions of heat-trapping gases. (p. 13)

2. Climate changes are underway in the United States and are projected to grow.
Climate-related changes are already observed in the United States and its coastal waters. These include increases in heavy downpours, rising temperature and sea level, rapidly retreating glaciers, thawing permafrost, lengthening growing seasons, lengthening ice-free seasons in the ocean and on lakes and rivers, earlier snowmelt, and alterations in river flows. These changes are projected to grow. (p. 27)

3. Widespread climate-related impacts are occurring now and are expected to increase.
Climate changes are already affecting water, energy, transportation, agriculture, ecosystems, and health. These impacts are different from region to region and will grow under projected climate change. (p. 41-106, 107-152)

4. Climate change will stress water resources.
Water is an issue in every region, but the nature of the potential impacts varies. Drought, related to reduced precipitation, increased evaporation, and increased water loss from plants, is an important issue in many regions, especially in the West. Floods and water quality problems are likely to be amplified by climate change in most regions. Declines in mountain snowpack are important in the West and Alaska where snowpack provides vital natural water storage. (p. 41, 129, 135, 139)

5. Crop and livestock production will be increasingly challenged.
Many crops show positive responses to elevated carbon dioxide and low levels of warming, but higher levels of warming often negatively affect growth and yields. Increased pests, water stress, diseases, and weather extremes will pose adaptation challenges for crop and livestock production. (p. 71)

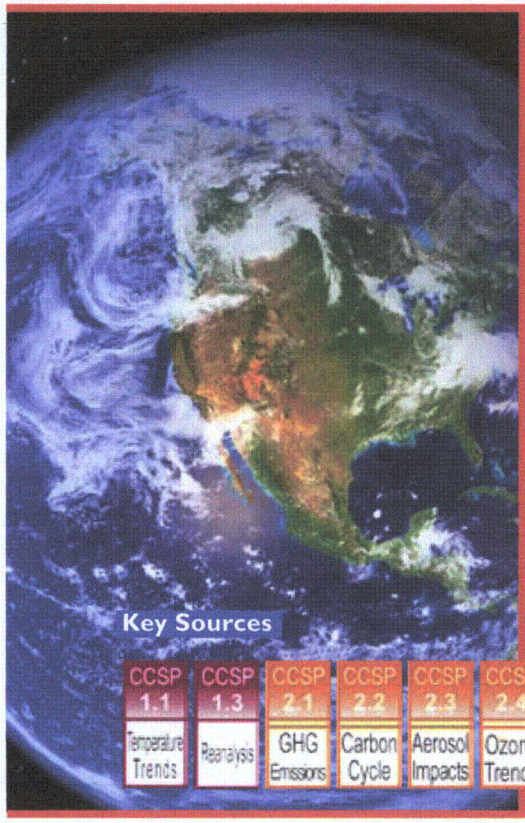
6. Coastal areas are at increasing risk from sea-level rise and storm surge.
Sea-level rise and storm surge place many U.S. coastal areas at increasing risk of erosion and flooding, especially along the Atlantic and Gulf Coasts, Pacific Islands, and parts of Alaska. Energy and transportation infrastructure and other property in coastal areas are very likely to be adversely affected. (p. 111, 139, 145, 149)

7. Risks to human health will increase.
Harmful health impacts of climate change are related to increasing heat stress, waterborne diseases, poor air quality, extreme weather events, and diseases transmitted by insects and rodents. Reduced cold stress provides some benefits. Robust public health infrastructure can reduce the potential for negative impacts. (p. 89)

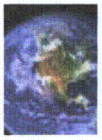
8. Climate change will interact with many social and environmental stresses.
Climate change will combine with pollution, population growth, overuse of resources, urbanization, and other social, economic, and environmental stresses to create larger impacts than from any of these factors alone. (p. 99)

9. Thresholds will be crossed, leading to large changes in climate and ecosystems.
There are a variety of thresholds in the climate system and ecosystems. These thresholds determine, for example, the presence of sea ice and permafrost, and the survival of species, from fish to insect pests, with implications for society. With further climate change, the crossing of additional thresholds is expected. (p. 76, 82, 115, 137, 142)

10. Future climate change and its impacts depend on choices made today.
The amount and rate of future climate change depend primarily on current and future human-caused emissions of heat-trapping gases and airborne particles. Responses involve reducing emissions to limit future warming, and adapting to the changes that are unavoidable. (p. 25, 29)



Global Climate Change



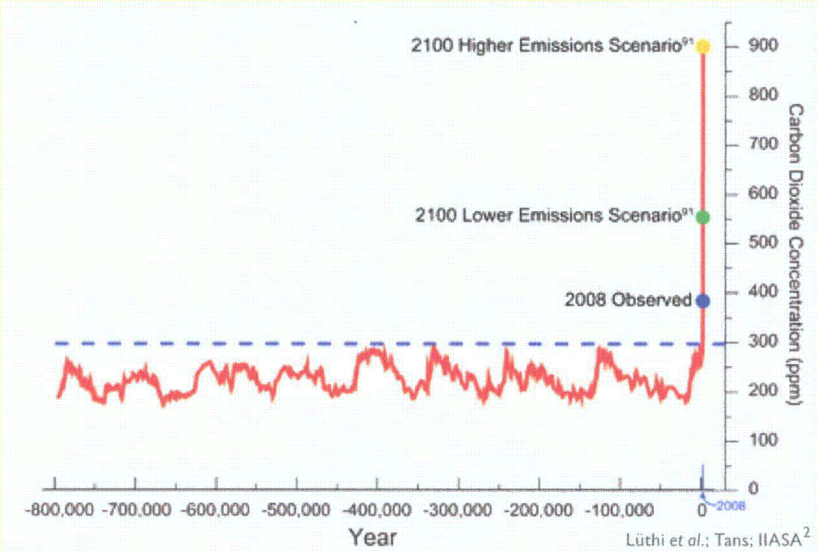
Key Messages:

- Human activities have led to large increases in heat-trapping gases over the past century.
- Global average temperature and sea level have increased, and precipitation patterns have changed.
- The global warming of the past 50 years is due primarily to human-induced increases in heat-trapping gases. Human "fingerprints" also have been identified in many other aspects of the climate system, including changes in ocean heat content, precipitation, atmospheric moisture, and Arctic sea ice.
- Global temperatures are projected to continue to rise over this century; by how much and for how long depends on a number of factors, including the amount of heat-trapping gas emissions and how sensitive the climate is to those emissions.

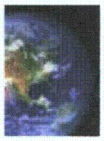
This introduction to global climate change explains very briefly what has been happening to the world's climate and why, and what is projected to happen in the future. While this report focuses on climate change impacts in the United States, understanding these changes and their impacts requires an understanding of the global climate system.

Many changes have been observed in global climate over the past century. The nature and causes of these changes have been comprehensively chronicled in a variety of recent reports, such as those by the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Climate Change Science Program (CCSP). This section does not intend to duplicate these comprehensive efforts, but rather to provide a brief synthesis, and to integrate more recent work with the assessments of the IPCC, CCSP, and others.

800,000 Year Record of Carbon Dioxide Concentration



Analysis of air bubbles trapped in an Antarctic ice core extending back 800,000 years documents the Earth's changing carbon dioxide concentration. Over this long period, natural factors have caused the atmospheric carbon dioxide concentration to vary within a range of about 170 to 300 parts per million (ppm). Temperature-related data make clear that these variations have played a central role in determining the global climate. As a result of human activities, the present carbon dioxide concentration of about 385 ppm is about 30 percent above its highest level over at least the last 800,000 years. In the absence of strong control measures, emissions projected for this century would result in the carbon dioxide concentration increasing to a level that is roughly 2 to 3 times the highest level occurring over the glacial-interglacial era that spans the last 800,000 or more years.

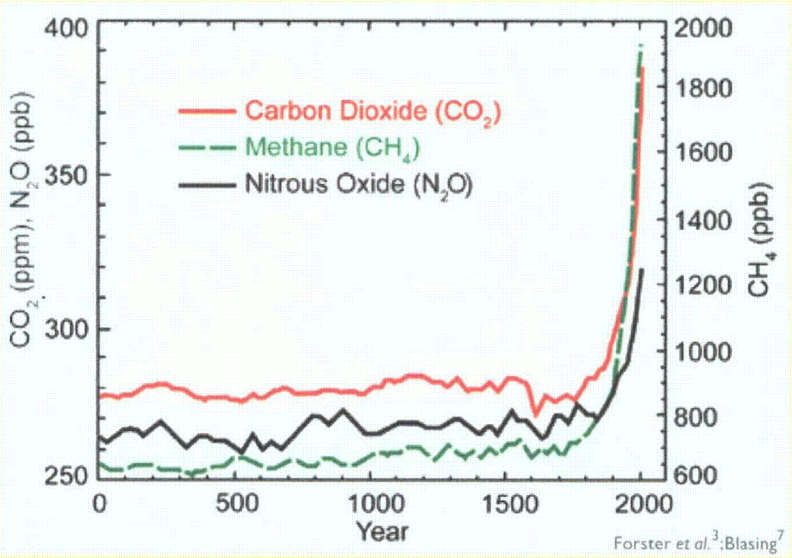


Human activities have led to large increases in heat-trapping gases over the past century.

The Earth's climate depends on the functioning of a natural "greenhouse effect." This effect is the result of heat-trapping gases (also known as greenhouse gases) like water vapor, carbon dioxide, ozone, methane, and nitrous oxide, which absorb heat radiated from the Earth's surface and lower atmosphere and then radiate much of the energy back toward the surface. Without this natural greenhouse effect, the average surface temperature of the Earth would be about 60°F colder. However, human activities have been releasing additional heat-trapping gases, intensifying the natural greenhouse effect, thereby changing the Earth's climate.

Climate is influenced by a variety of factors, both human-induced and natural. The increase in the carbon dioxide concentration has been the principal factor causing warming over the past 50 years. Its concentration has been building up in the Earth's atmosphere since the beginning of the industrial era in the mid-1700s, primarily due to the burning of fossil fuels (coal, oil, and natural gas) and the clearing of forests. Human activities have also increased the emissions of other greenhouse gases, such as methane, nitrous oxide, and halocarbons.[3]

2,000 Years of Greenhouse Gas Concentrations



Increases in concentrations of these gases since 1750 are due to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion molecules of air.

These emissions are thickening the blanket of heat-trapping gases in Earth's atmosphere, causing surface temperatures to rise.

Heat-trapping gases

Carbon dioxide concentration has increased due to the use of fossil fuels in electricity generation, transportation, and industrial and household uses. It is also produced as a by-product during the manufacturing of cement. Deforestation provides a source of carbon dioxide and reduces its uptake by trees and other plants. Globally, over the past several decades, about 80 percent of human-induced carbon dioxide emissions came from the burning of fossil fuels, while about 20 percent resulted from deforestation and associated agricultural practices. The concentration of carbon dioxide in the atmosphere has increased by roughly 35 percent since the start of the industrial revolution.[3]

Methane concentration has increased mainly as a result of agriculture; raising livestock (which produce methane in their digestive tracts); mining, transportation, and use of certain fossil fuels; sewage; and decomposing garbage in landfills. About 70 percent of the emissions of atmospheric methane are now related to human activities.[4]

Nitrous oxide concentration is increasing as a result of fertilizer use and fossil fuel burning.

Halocarbon emissions come from the release of certain manufactured chemicals to the atmosphere. Examples include chlorofluorocarbons (CFCs), which were used extensively in refrigeration and for other industrial processes before their presence in the atmosphere was found to cause stratospheric ozone depletion. The abundance of these gases in the atmosphere is now decreasing as a result of international regulations designed to protect the ozone layer. Continued decreases in ozone-depleting halocarbon emissions are expected to reduce their relative influence on climate change in the future.[3,5] Many halocarbon replacements, however, are potent greenhouse gases, and their concentrations are increasing.[6]

Ozone is a greenhouse gas, and is continually produced and destroyed in the atmosphere by chemical reactions. In the troposphere, the lowest 5 to 10 miles of the atmosphere near the surface, human activities have increased the ozone concentration through the release of gases such as carbon monoxide, hydrocarbons, and nitrogen oxides. These gases undergo chemical reactions to produce ozone in the presence of sunlight. In addition to trapping heat, excess ozone in the troposphere causes respiratory illnesses and other human health problems.

In the stratosphere, the layer above the troposphere, ozone exists naturally and protects life on Earth from exposure to excessive ultraviolet radiation from the Sun. As mentioned previously, halocarbons released by human activities destroy ozone in the stratosphere and have caused the ozone hole over Antarctica.[8] Changes in the stratospheric ozone layer have contributed to changes in wind patterns and regional climates in Antarctica.[9]

Water vapor is the most important and abundant greenhouse gas in the atmosphere. Human activities produce only a very small increase in water vapor through irrigation and combustion processes.[3] However, the surface warming caused by human-produced increases in other greenhouse gases leads to an increase in atmospheric water vapor, since a warmer climate increases evaporation and allows the atmosphere to hold more moisture. This creates an amplifying "feedback loop," leading to more warming.

Other human influences

In addition to the global-scale climate effects of heat-trapping gases, human activities also produce additional local and regional effects. Some of these activities partially offset the warming caused by greenhouse gases, while others increase the warming. One such influence on climate is caused by tiny particles called "aerosols" (not to be confused with aerosol spray cans). For example, the burning of coal produces emissions of sulfur-containing compounds. These compounds form "sulfate aerosol" particles, which reflect some of the incoming sunlight away from the Earth, causing a cooling influence at the surface. Sulfate aerosols also tend to make clouds more efficient at reflecting sunlight, causing an additional indirect cooling effect. Another type of aerosol, often referred to as soot or black carbon, absorbs incoming sunlight and traps heat in the atmosphere. Thus, depending on their type, aerosols can either mask or increase the warming caused by increased levels of greenhouse gases.[13] On a globally averaged basis, the sum of these aerosol effects offsets some of the warming caused by heat-trapping gases.[10]

The effects of various greenhouse gases and aerosol particles on Earth's climate depend in part on how long these gases and particles remain in the atmosphere. After emission, the atmospheric concentration of carbon dioxide remains elevated for thousands of years, and that of methane for decades, while the elevated concentrations of aerosols only persist for days to weeks.[11,12] The climate effects of reductions in emissions of carbon dioxide and other long-lived gases do not become apparent for at least several decades. In contrast, reductions in emissions of short-lived compounds can have a rapid, but complex effect since the geographic patterns of their climatic influence and the resulting surface temperature responses are quite different. One modeling study found that while the greatest emissions of short-lived pollutants in summertime by late this century are projected to come from Asia, the strongest climate response is projected to be over the central United States.[13]

Human activities have also changed the land surface in ways that alter how much heat is reflected or absorbed by the surface. Such changes include the cutting and burning of forests, the replacement of other areas of natural vegetation with agriculture and cities, and large-scale irrigation. These transformations of the land surface can cause local (and even regional) warming or cooling. Globally, the net effect of these changes has probably been a slight cooling of the Earth's surface over the past 100 years.[14,15]

Natural influences

Two important natural factors also influence climate: the Sun and volcanic eruptions. Over the past three decades, human influences on climate have become increasingly obvious, and global temperatures have risen sharply. During the same period, the Sun's energy output (as measured by satellites since 1979) has followed its historical 11-year cycle

Clean Energy

Calculations and References

This page describes the calculations used to convert greenhouse gas emission numbers into different types of equivalent units. Go to the equivalency calculator page for more information.

Electricity use (kilowatt-hours)

The Greenhouse Gas Equivalencies Calculator uses the Emissions & Generation Resource Integrated Database (eGRID) U.S. annual non-baseload CO_2 output emission rate to convert reductions of kilowatt-hours into avoided units of carbon dioxide emissions. Most users of the Equivalencies Calculator who seek equivalencies for electricity-related emissions want to know equivalencies for emissions **reductions** from energy efficiency or renewable energy programs. These programs are not generally assumed to affect baseload emissions (the emissions from power plants that run all the time), but rather non-baseload generation (power plants that are brought online as necessary to meet demand).

Emission Factor

7.18×10^{-4} metric tons CO_2 / kWh
(eGRID2007 Version 1.1, U.S. annual non-baseload CO_2 output emission rate, year 2005 data)

Notes:

This calculation does not include any greenhouse gases other than CO_2 and does not include line losses.
Individual subregion non-baseload emissions rates are also available on the eGRID Web site.
To estimate indirect greenhouse gas emissions from electricity use, please use Power Profiler or use eGRID subregion annual output emission rates as a default emission factor (see eGRID2007 Version 1.1 Year 2005 GHG Annual Output Emission Rates (PDF) (1 p, 200K, About PDF).

Sources

(EPA 2009) eGRID2007 Version 1.1, U.S. annual non-baseload CO_2 output emission rate, year 2005 data U.S. Environmental Protection Agency, Washington, DC.

Passenger vehicles per year

Passenger vehicles are defined as 2-axle 4-tire vehicles, including passenger cars, vans, pickup trucks, and sport/utility vehicles.

In 2007, the weighted average combined fuel economy of cars and light trucks combined was 20.4 miles per gallon (FHWA 2008). The average vehicle miles traveled in 2007 was 11,720 miles per year.

In 2007, the ratio of carbon dioxide emissions to total emissions (including carbon dioxide, methane, and nitrous oxide, all expressed as carbon dioxide equivalents) for passenger vehicles was 0.977 (EPA 2009).

The amount of carbon dioxide emitted per gallon of motor gasoline burned is $8.89*10^{-3}$ metric tons, as calculated in the "Gallons of gasoline consumed" section.

To determine annual greenhouse gas emissions per passenger vehicle, the following methodology was used: vehicle miles traveled (VMT) was divided by average gas mileage to determine gallons of gasoline consumed per vehicle per year. Gallons of gasoline consumed was multiplied by carbon dioxide per gallon of gasoline to determine carbon dioxide emitted per vehicle per year. Carbon dioxide emissions were then divided by the ratio of carbon dioxide emissions to total vehicle greenhouse gas emissions to account for vehicle methane and nitrous oxide emissions.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

$8.89*10^{-3}$ metric tons CO_2/gallon gasoline * 11,720 VMT $_{car/truck\ average}$ * 1/20.4 miles per gallon $_{car/truck\ average}$ * 1 CO_2, CH_4, and N_2O/0.977 CO_2 = **5.23 metric tons CO_2E /vehicle/year**

Sources

EPA (2009). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007. Chapter 3 (Energy), Tables 3-12, 3-13, and 3-14. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-09-004 (PDF) (66 pp, 737K, About PDF)
FHWA (2008). Highway Statistics 2007. Office of Highway Policy Information, Federal Highway Administration. Table VM-1.

Gallons of gasoline consumed

To obtain the number of grams of CO_2 emitted per gallon of gasoline combusted, the carbon content of the fuel per gallon is multiplied by the oxidation factor and the ratio of CO_2's molecular weight to that of carbon. The average carbon content of gasoline is 2,425 grams of carbon per gallon (EPA, 2005) Fraction oxidized to CO_2 is 100 percent (IPCC 2006). The ratio of the molecular weight of CO_2 to carbon is 44/12.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

2,425 grams C/gallon * 100% oxidation factor * 44 g CO_2/12 g C * 1 metric ton/1,000,000 g = **$8.89*10^{-3}$ metric tons CO_2/gallon of gasoline**

Sources

EPA (2005). Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel. EPA420-F-05-001. Available at http://www.epa.gov/oms/climate/420f05001.htm.
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Therms of natural gas

Average heat content of natural gas is 0.1 mmbtu per therm (EPA 2008). Average carbon coefficient of natural gas is 14.47 kg carbon per million btu (EPA 2008). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

Carbon dioxide emissions per therm were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight ratio of carbon dioxide to carbon (44/12).

Note: When using this equivalency, please keep in mind that it represents the CO_2 equivalency for natural gas **burned** as a fuel, not natural gas released to the atmosphere. Direct methane emissions released to the atmosphere (without burning) are about 21 times more powerful than CO_2 in terms of their warming effect on the atmosphere.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

0.1 mmbtu/1 therm * 14.47 kg C/mmbtu * 44 g CO_2/12 g C * 1 metric ton/1000 kg = **0.005 metric tons CO_2/therm**

Sources

EPA (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2006. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-08-005 (PDF) (2 pp, 430K, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Barrels of oil consumed

Average heat content of crude oil is 5.80 million btu per barrel (EPA 2007). Average carbon coefficient of crude oil is 20.33 kg carbon per million btu (EPA 2007). Fraction oxidized is 100 percent (IPCC 2006).

Carbon dioxide emissions per barrel of crude oil were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12).

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

5.80 mmbtu/barrel * 20.33 kg C/mmbtu * 44 g CO_2/12 g C * 1 metric ton/1000 kg = **0.43 metric tons CO_2/barrel**

Sources

EPA (2007). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2005. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-R-07-002 (PDF) (2 pp, 216K, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Tanker trucks filled with gasoline

Average heat content of conventional motor gasoline is 5.22 million btu per barrel (EPA 2008). Average carbon coefficient of motor gasoline is 19.33 kg carbon per million btu (EPA 2008). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

Carbon dioxide emissions per barrel of gasoline were determined by multiplying heat content times the carbon coefficient time the fraction oxidized times the ratio of the molecular weight ratio of carbon dioxide to carbon (44/12). A barrel equals 42 gallons. A typical gasoline tanker trunk contains 8,500 gallons.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

5.22 mmbtu/barrel * 19.33 kg C/mmbtu * 1 barrel/42 gallons * 44 g CO_2/12 g C * 1 metric ton/1000 kg = $8.81*10^{-3}$ metric tons CO_2/gallon

$8.81*10^{-3}$ metric tons CO_2/gallon * 8,500 gallons/tanker truck = **74.89 metric tons CO_2/tanker truck**

Sources

EPA (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2006. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-08-005 (PDF) (2 pp, 430K, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Home electricity use

In 2005, there were 111.1 million homes in the United States; of those, 72.1 million were single-family detached homes and 7.6 million were single-family attached homes for a total 79.7 million single-family homes* nationally (EIA 2008). On average, each single-family home consumed 12,773 kWh of delivered electricity (EIA 2008). The national average carbon dioxide output rate for electricity generated in 2005 was 1,329 lbs CO_2 per megawatt-hour (EPA 2009), which translates to 1,422 lbs CO_2 per megawatt-hour for delivered electricity (assuming 7 percent in transmission and distribution losses).

Annual single-family home electricity consumption was multiplied by the carbon dioxide emission rate (per unit of electricity delivered) to determine annual carbon dioxide emissions per home.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

12,773 kWh per home * 1,422.40 lbs CO_2 per megawatt-hour delivered * 1 mWh/1000 kWh * 1 metric ton/2204.6 lb = **8.24 metric tons CO_2/home.**

*A single-family home is defined in the U.S. Department of Energy's Residential Energy Consumption Survey as follows: A housing unit, detached or attached, that provides living space for one home or family. Attached houses are considered single-family houses as long as they are not divided into more than one housing unit and they have independent outside entrance. A single-family house is contained within walls extending from the basement (or the ground floor, if there is no basement) to the roof. A mobile home with one or more rooms added is classified as a single-family home. Townhouses, rowhouses, and duplexes are considered single-family attached housing units, as long as there is no home living above another one within the walls extending from the basement to the roof to separate the units.

Sources

EIA (2008). 2005 Residential Energy Consumption Survey. Table US-3, Total Consumption by Fuels Used, 2005, Physical Units (PDF) (4 pp, 50K, About PDF).
EPA (2009). eGRID2007 Version 1.1. U.S. Environmental Protection Agency, Washington, DC.

Home energy use

In 2005, there were 111.1 million homes in the United States; of those, 72.1 million were single-family detached homes and 7.6 million were single-family attached homes for a total 79.7 million single-family homes* nationally (EIA 2008). On average, each single-family home consumed 12,773 kWh of delivered electricity, 47,453 cubic feet of natural gas, 59.1 gallons of liquid petroleum gas, 58.0 gallons of fuel oil, and 0.85 gallons of kerosene. (EIA 2008).

The national average carbon dioxide output rate for generated electricity in 2005 was 1,329 lbs CO_2 per megawatt-hour (EPA 2009), which translates to 1,422 lbs CO_2 per megawatt-hour for delivered electricity (assuming 7 percent in transmission and distribution losses).

The average carbon dioxide coefficient of natural gas is 0.0546 kg CO_2 per cubic foot (EPA 2008). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of distillate fuel oil is 426.1 kg CO_2 per 42-gallon barrel (EPA 2008). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of liquefied petroleum gases is 227.2 kg CO_2 per 42-gallon barrel (EPA 2008). Fraction oxidized is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of kerosene is 410.0 kg CO_2 per 42-gallon barrel (EPA 2008). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

Total single-family home electricity, natural gas, distillate fuel oil, and liquefied petroleum gas consumption figures were converted from their various units to metric tons of CO_2 and added together to obtain total CO_2 emissions per home.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

1. Delivered electricity: 12,773 kWh per home * 1,422.40 lbs CO_2 per megawatt-hour delivered * 1 mWh/1000 kWh * 1 metric ton/2204.6 lb = 8.24 metric tons CO_2/home.

2. Natural gas: 47,453 cubic feet per home * 0.0546 kg CO_2/cubic foot * 1/1000 kg/metric ton = 2.59 metric tons CO_2/home

3. Liquid petroleum gas: 59.1 gallons per home * 1/42 barrels/gallon * 227.2 kg CO_2/barrel * 1/1000 kg/metric ton = 0.32 metric tons CO_2/home

4. Fuel oil: 58.0 gallons per home * 1/42 barrels/gallon * 426.1 kg CO_2/barrel * 1/1000 kg/metric ton = 0.59 metric tons CO_2/home

5. Kerosene: 0.85 gallons per home * 1/42 barrels/gallon * 410 kg CO_2/barrel *1/1000 kg/metric ton = 0.01 metric tons CO_2/home

Total CO_2 emissions for energy use per single-family home: 8.24 metric tons CO_2 for electricity + 2.59 metric tons CO_2 for natural gas + 0.32 metric tons CO_2 for liquid petroleum gas + 0.59 metric tons CO_2 for fuel oil + 0.01 metric tons CO_2 for kerosene = **11.75 metric tons CO_2 per home per year**.

*A single-family home is defined in the U.S. Department of Energy's Residential Energy Consumption Survey as follows: A housing unit, detached or attached, that provides living space for one home or family. Attached houses are considered single-family houses as long as they are not divided into more than one housing unit and they have independent outside entrance. A single-family house is contained within walls extending from the basement (or the ground floor, if there is no basement) to the roof. A mobile home with one or more rooms added is classified as a single-family home. Townhouses, rowhouses, and duplexes are considered single-family attached housing units, as long as there is no home living above another one within the walls extending from the basement to the roof to separate the units.

Sources

EIA (2008). 2005 Residential Energy Consumption Survey. Table US-3, Total Consumption by Fuels Used, 2005, Physical Units (PDF) (4 pp, 50K, About PDF). Per-home averages were obtained by dividing the physical units of total consumption for each fuel used by the total number of single-family homes.
EPA (2009). eGRID2007 Version 1.1. U.S. Environmental Protection Agency, Washington, DC.
EPA (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2006. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-08-005 (PDF) (2 pp, 430K, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Number of tree seedlings grown for 10 years

A medium growth coniferous tree, planted in an urban setting and allowed to grow for 10 years, sequesters 23.2 lbs of carbon. This estimate is based on the following assumptions:

The medium growth coniferous trees are raised in a nursery for one year until they become 1 inch in diameter at 4.5 feet above the ground (the size of tree purchased in a 15-gallon container).
The nursery-grown trees are then planted in a suburban/urban setting; the trees are not densely planted.
The calculation takes into account "survival factors" developed by U.S. DOE (1998). For example, after 5 years (one year in the nursery and 4 in the urban setting), the probability of survival is 68 percent; after 10 years, the probability declines to 59 percent. For each year, the sequestration rate (in lb per tree) is multiplied by the survival factor to yield a probability-weighted sequestration rate. These values are summed for the 10-year period, beginning from the time of planting, to derive the estimate of 23.2 lbs of carbon per tree.

Please note the following caveats to these assumptions:

While most trees take 1 year in a nursery to reach the seedling stage, trees grown under different conditions and trees of certain species may take longer – up to 6 years.
Average survival rates in urban areas are based on broad assumptions, and the rates will vary significantly depending upon site conditions.
Carbon sequestration is dependent on growth rate, which varies by location and other conditions.
This method estimates only direct sequestration of carbon, and does not include the energy savings that result from buildings being shaded by urban tree cover.

To convert to units of metric tons CO_2 per tree, we multiplied by the ratio of the molecular weight of carbon dioxide to that of carbon (44/12) and the ratio of metric tons per pound (1/2204.6).

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

23.2 lbs C/tree * (44 units CO_2 / 12 units C) * 1 metric ton / 2204.6 lbs = **0.039 metric ton CO_2 per urban tree planted**

Sources

U.S. DOE (1998). Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings. Voluntary Reporting of Greenhouse Gases, U.S. Department of Energy, Energy Information Administration (16 pp, 111K, About PDF)

Acres of pine or fir forests storing carbon for one year

Growing forests store carbon. Through the process of photosynthesis, trees remove CO_2 from the atmosphere and store it as cellulose, lignin, and other compounds. The rate of accumulation is equal to growth minus removals (i.e., harvest for the production of paper and wood) minus decomposition. In most U.S. forests, growth exceeds removals and decomposition, so there has been an overall increase in the amount of carbon stored nationally.

The estimate of the annual average rate of carbon accumulation is based on two studies, one on Douglas fir in the Pacific Northwest (Nabuurs and Mohren, 1995), and the other on slash pine in Florida (Shan et al., 2001). These two studies represent commercially important species from different regions and with different rotation periods (i.e., time between planting and harvesting). The calculations below include both above-ground and below-ground carbon stored in these two species of plantation trees. They do not include litter or soil carbon.

Calculation for Slash Pine

The calculation uses the Gain Loss method, as outlined in the 2006 IPCC Guidelines, in order to estimate carbon stored annually per hectare in the slash pine plantation system described in the Shan et al. paper. The general equation for this method is shown below. Here, carbon losses due to harvested wood products, firewood foraging, and other sources of wood removals are assumed to be zero.

$$\Delta CB = \Delta CG - \Delta CL$$

Where:
ΔCB = annual change in carbon stocks in biomass for each land sub-category, considering the total area, metric tons of carbon per year
ΔCG = annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, metric tons of carbon per year
ΔCL = annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, metric tons of carbon per year (Here assumed to be 0).

Gains:

$$\Delta CG = \Sigma(A_{i,j} * Gtotal_{i,j} * CF_{i,j})$$

Where:
Gtotal = Σ (Gw*(1+R)
A = area of land remaining in the same land-use category, here assumed to be 1
Gtotal= mean annual biomass growth
i = ecological zone
j = climate domain
CF = carbon fraction of dry matter

Gw = average annual above-ground biomass growth for a specific woody vegetation type
R = ratio of below-ground biomass to above ground biomass for a specific vegetation type.

Since this paper measured growth in a plantation of trees harvested at age 17, the value is for relatively young trees that are growing more quickly than older trees would. The paper included several options in terms of management. The value used in the calculations below is the "control" – meaning that there was no fertilization (which had a big impact on growth) and no trimming of the understory for these trees. The calculation below uses the IPCC assumption that the carbon fraction is 47 percent of dry biomass.

The final result (3.052 MT C/ha/yr) * 0.4048 hectares/acre = **1.24 MT C/acre/year**

	Reference	Aboveground biomass growth rate (MT/ha/yr) (averaged over 17 years)	Root:Shoot ratio (R)	Total Biomass Growth Rate (MT/ha/yr)	Carbon Fraction (MT C per MT dry matter)	Net Sequestration Rate (MT C/ha/yr)
Slash Pine, age 17	Shan et al 2001	5.209	0.2912	6.493	0.47	3.052

Calculation for Douglas Fir

This calculation is based on results found in a 1995 paper by Nabuurs et al. The paper uses a model to calculate the amount of carbon sequestered in plots of various tree types across the world. The model uses turnover rates in order to calculate carbon stored in forests over time during different types of logging intervals. Parameters included in the model include basic wood density, allocation of net primary production, turnover rates of tree organs, resident times of litter and humus, current volume increment, and allocation of harvested wood. The parameters are specific for each of the six sites chosen for the study. Within each site, three areas of fertility and production are measured, although the study uses sample data from the "moderate" site during the discussion and results sections. The numbers presented below are also from the "moderate" site.

Since this paper is concerned with carbon sequestered in forests undergoing selective logging, the designers of this calculator had to choose at what point during the harvesting cycle to measure the carbon sequestered. We decided to use the total carbon stock stored (including biomass and forest products, not including soil carbon) after 100 years of accumulation. The model in this paper assumes that the carbon fraction is 50 percent.

		Total C Stock After 100 Years (Mg C per ha)	**Net Sequestration Rate (MT C/ha/yr)**
Douglas-Fir, age 100	**Nabuurs et al 1995**	327	3.27

The final result (3.27 MT C/ha/yr) * 0.4048 hectares/acre = **1.32 MT C/acre/year.**
One reason why this value is higher than the slash pine plantation number is because the Douglas fir trees had 100 years to accumulate biomass – including more years at a relatively fast-growing maturity than the slash-pine trees.

The average of these two values is 1.28 metric tons of C per acre per year, which corresponds to **4.69 metric tons of CO_2 per acre of pine or fir forests.**

Sources

Nabuurs, G.J., and G.M.J. Mohren. 1995. Modelling analysis of potential carbon sequestration in selected forest types. Canadian Journal of Forest Research 25(7):1157-1172.
Shan, J.P., L.A. Morris, and R.L. Hendrick. 2001. The effects of management on soil and plant carbon sequestration in slash pine plantations. Journal of Applied Ecology 38(5):932-941.
IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Volume 4. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

Acres of forest preserved from deforestation

According to the 2009 U.S. Greenhouse Gas Inventory, the average carbon density of U.S. forests in 2007 was 76 metric tons per hectare, or 30.76 metric tons per acre (EPA, 2009).

For crop or pasture land, IPCC guidance on characterizing land use change suggests that an average value of aboveground cropland dry biomass is 10 metric tons per hectare (IPCC 2006). We assumed that the carbon content of dry biomass is 50 percent. Therefore, the carbon content of cropland was calculated to be 5.0 metric tons of carbon per hectare, or 2.02 metric tons per acre.

The change in carbon density from converting forested land to crop or pasture land would thus be 30.76 MT carbon/acre minus 2.02 MT carbon/acre, or 28.74 MT carbon/acre. To convert to a carbon dioxide basis, we

multiplied by the ratio of the molecular weight of carbon dioxide to that of carbon (44/12), yielding a value of 105.38 MT CO_2/acre.

> This method assumes that all of the forest biomass is oxidized during burning (i.e. none of the burned biomass remains as charcoal or ash).

Note: The conversion provided may be an underestimate due to the omission of soil C in the calculation. Forest soil C stocks will likely decline with conversion. If the forests exist on organic soils, conversion would cause C stocks to decline, unless they are converting to wetland agriculture. However, most forests in the contiguous United States are growing on mineral soils. In the case of mineral soils forests, soil C stocks could be replenished or even increased, depending on the starting stocks, how the agricultural lands are managed, and the time frame over which lands are managed.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

5.0 metric tons C biomass/ hectare * 1 hectare/ 2.47 acres = 2.02 metric tons C/acre of cropland

30.76 metric tons C/acre forest – 2.02 metric ton C/acre of cropland = 28.74 metric tons C/acre converted * 44 units CO_2/12 units C = **105.38 metric tons CO_2/acre converted**

Sources

EPA (2009). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007. Chapter 7 (Land Use, Land-Use Change, and Forestry), p. 7-13. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-09-004. (PDF) (70 pp, 9.11MB, About PDF).
IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Volume 4.

Propane cylinders used for home barbeques

Propane is 81.8 percent carbon (EPA 2009). Fraction oxidized is 100 percent (IPCC 2006).

Carbon dioxide emissions per pound of propane were determined by multiplying the weight of propane in a cylinder times the carbon content percentage times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12). Propane cylinders vary with respect to size - for the purpose of this equivalency calculation, a typical cylinder for home use was assumed to contain 18 pounds of propane.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

18 pounds propane/1 cylinder * 0.818 pound C/pound propane * 0.4536 kilograms/pound * 44 kg CO_2/12 kg C * 1 metric ton/1000 kg = **0.024 metric tons CO_2/cylinder**

Sources

EPA (2009). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007. Annex 2, Table A-41. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-09-004 (PDF) (80 pp, 743K, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Railcars of coal burned

Average heat content of coal in 2006 was 22.68 million btu per metric ton (EPA 2008). Average carbon coefficient of coal in 2006 was 25.34 kilograms carbon per million btu (EPA 2008). Fraction oxidized is 100 percent (IPCC 2006).

Carbon dioxide emissions per ton of coal were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12). The amount of coal in an average railcar was assumed to be 100.19 short tons, or 90.89 metric tons (Hancock 2001).

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

22.68 mmbtu/metric ton coal * 25.34 kg C/mmbtu * 44g CO_2/12g C * 90.89 metric tons coal/railcar * 1 metric ton/1000 kg = **191.5 metric tons CO_2/railcar**

Sources

EPA (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2006. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-08-005 (PDF) (2 pp, 430K, About PDF).
Hancock (2001). Hancock, Kathleen and Sreekanth, Ande. *Conversion of Weight of Freight to Number of Railcars. Transportation Research Board*, Paper 01-2056, 2001.
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Tons of waste recycled instead of landfilled

To develop the conversion factor for recycling rather than landfilling waste, emission factors from EPA's WAste Reduction Model (WARM) were used (EPA 2009). These emission factors were developed following a life-cycle assessment methodology using estimation techniques developed for national inventories of greenhouse gas (GHG) emissions. According to WARM, the net emission reduction from recycling mixed recyclables (e.g., paper, metals, plastics), compared to a baseline in which the materials are landfilled, is 0.81 metric tons of carbon equivalent (MTCE) per short ton. This factor was then converted to metric tons of carbon dioxide equivalent ($MTCO_2E$) by multiplying by 44/12, the molecular weight ratio of carbon dioxide to carbon.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

0.81 MTCE/ton * 44 g CO_2/12 g C = **2.97 metric tons CO_2E/ton of waste recycled instead of landfilled**

http://www.epa.gov/RDEE/energy-resources/refs.html
Last updated on Tuesday, March 23, 2010

Sources

EPA (2009). WAste Reduction Model (WARM). U.S. Environmental Protection Agency. [note: click "view emission/energy factors" at bottom of form to see recycling and landfilling emission factors]

Coal-fired power plant emissions for one year

In 2005 there were 1,973,625,358 tons of CO_2 emitted from power plants whose primary source of fuel was coal (EPA, 2009).

In 2005 a total of 465 power plants that used coal to generate at least 95% of their electricity (EPA, 2009).

Carbon dioxide emissions per power plant were calculated by dividing the number of power plants by the total emissions from power plants whose primary source of fuel was coal. The quotient was then converted from tons to metric tons.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

1,973,625,358 tons of CO_2 * 1/465power plants * 0.9072 metric tons / 1 short ton = **3,850,479 metric tons CO_2/power plant**

Sources

EPA (2009). eGRID2007 Version 1.1, year 2005 data. Available at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

Zalcman, Barry

From: Zalcman, Barry
Sent: Thursday, April 01, 2010 9:09 PM
To: Harvey, Brad; Martin, Jody
Cc: Clayton, Brent; Pessin, Andrew
Subject: Greenhouse Gas Treatment in NRO NEPA Documents (1 of 2)
Attachments: 100401 GHG and Climate Change.doc

As a courtesy to those who invested time in reviewing the earlier drafts and offered improvements, I want to share the attached before I finalize the Memorandum. I have addressed all of the comments from OGC, RENV and RSAC staff as best I can. I would like to release this on Tuesday. My apologies that this is not a track change version, so I would like to share each of your inbounds (2 of 2) with the other so that you can see what prompted a change. I took very few editorial liberties outside of your inputs.

Zalcman, Barry

From: Harvey, Brad
Sent: Tuesday, March 23, 2010 5:06 PM
To: Zalcman, Barry
Cc: Clayton, Brent; Samaddar, Sujit; Raione, Richard; Schaaf, Robert; Whited, Ryan; Hatchett, Gregory
Subject: RE: Greenhouse Gas Treatment in NRO NEPA Documents
Attachments: 100318 GHG and Climate Change_rbh.doc

Barry:

Thank you for the opportunity to review this document. I generally find it to be well-written and very comprehensive. My comments include the following:

- There are several places within the document where you are providing guidance to the SER writers. For example, on page 11:

  > A changing climate may introduce uncertainty in the practice of relying solely upon the historical record to assess severe natural phenomena related to safe design and operation; certain effects of climate change on safety should be considered in NRC safety evaluation reports (SERs).

  This guidance is unnecessary because it goes beyond the Commission's guidance in CLI-09-21 that

  > We expect the Staff to include consideration of carbon dioxide and other greenhouse gas emissions in its **environmental reviews** for major licensing actions under the National Environmental Policy Act.

  I believe your SER guidance also conflicts with our current approach (as established by Dave Matthews) that given the large uncertainties in projecting future climate change, the NRC staff has limited ability to increase the level of safety margins for its applicants, just as it is disinclined to approve a reduction in safety margins based on an applicant's assessment which has a high degree of uncertainty. Consequently, we have been including the following paragraph in our COL SERs, which has been approved by Scott Flanders as well as OGC for the North Anna and Vogtle COL SERs:

  > The NRC staff acknowledges that long-term climatic change resulting from human or natural causes may introduce changes into the most severe natural phenomena reported for the site. However, no conclusive evidence or consensus of opinion is available on the rapidity or nature of such changes. There is a level of uncertainty in projecting future conditions because the assumptions regarding the future level of emissions of heat trapping gases depends on projections of population, economic activity, and choice of energy technologies. If it becomes evident that long-term climatic change is influencing the most severe natural phenomena reported at the site, the COL holder has a continuing obligation to ensure that its plants stay within the licensing basis.

- It is unclear to me what type of new reactor reviews are intended to be covered by this document. For example, I was assuming that ESP reviews are included, but then there is the following statement under the *Building Related Impacts* subsection in the *Environmental Consequence Analysis* discussion which leads me to believe otherwise:

  > Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner.

- Is this guidance intended to be applicable to the Vogtle COL DEIS which is undergoing camera ready review this week?

Additional comments are provided in the attached file.

Brad
415-4118

From: Zalcman, Barry
Sent: Monday, March 22, 2010 9:54 AM
To: Harvey, Brad; Samaddar, Sujit; Raione, Richard; Schaaf, Robert; Whited, Ryan; Hatchett, Gregory
Cc: Clayton, Brent
Subject: Greenhouse Gas Treatment in NRO NEPA Documents

Attached is the instruction that was prepared to describe the Staff's consideration of CO_2 and other greenhouse gas (GHG) emissions and of climate change in NRO EISs. This represents a departure from NUREG-1555, the environmental standard review plan; as such, this and the other departures are being compiled as supplemental guidance that will be issued by Mr. Flanders to the staff before this round of EISs are noticed in the *Federal Register* this Friday. I am forwarding it to OGC for a quick turnaround. I do not expect substantive changes, but if you are aware of an oversight on my part, then I would appreciate feedback.

The instruction is embedded with hot links (for example, the Attachment 1 heading is the link to the Commission's Order), so that the user has all of the background information readily available. Our obligation was to fulfill the Commission's direction in CLI-09-21; we did that and more. Most of the document is focused on setting context (i.e., heavy reliance on EPA and CEQ information) and providing template language so that there is a measure of consistency from project to project.

Barry Zalcman
Sr. PM
NRO/DSER/RENV
(301)415-2419

Supplemental Staff Guidance to NUREG 1555, "Environmental Standard Review Plan," (ESRP) for Consideration of the Effects of Greenhouse Gases and of Climate Change

PURPOSE

The purpose of this guidance is to clarify the consideration of greenhouse gas (GHG) emissions and the treatment of climate change in developing draft environmental impact statements (EISs) for new reactor reviews. This complex contemporary issue has gained prominence worldwide and it is important that decisionmakers consider the full suite of environmental impacts of proposed actions before acting. A National Environmental Policy Act (NEPA) analysis is the appropriate forum to consider the interface and potential consequences of new projects and the environment. In addition to disclosing the benefits and risks associated with proposed actions, NEPA provides the opportunity for public involvement to provide additional insights and inform decisionmakers.

Comment [RBH1]: You may want to clarify what type of new reactor reviews this document covers (e.g., CP and OL reviews under Part 50; ESP, DCD and COL reviews under Part 52)

In recent licensing actions, NRC's Atomic Safety Licensing Board Panels have referred rulings to the Commission suggesting that it may want to consider the "... potential generic significance of the issue ..." In CLI-09-21 (Attachment 1, ML093070690), the Commission provided additional guidance to the staff. The principal purpose of this supplemental guidance document is to provide the detailed analytical framework and the format for presentation of ~~its~~ the staff's evaluation to implement the Commission's direction for new reactor application reviews. The staff outlined its general plan in a memorandum from M. Johnson to R. Borchardt on January 15, 2010 (Attachment 2, ML093520734); this guidance is consistent with that plan.

Comment [RBH2]: I am confused by this sentence

Additional information is provided in the following Background section to highlight allied issues and actions that may have more prominence in the Executive Branch. As an independent executive agency, the NRC is informed by the requirements and findings of other Federal agencies and guidance that is developed to assist them in fulfilling their responsibilities.

BACKGROUND

PROPOSED ACTION

The NRC's proposed action related to issuing combined licenses (COLs) is to authorize construction (as defined in 10 CFR 51.4) for an undefined period of time and to authorize operation for a period not to exceed 40 years. Pursuant 10 CFR 51.20(b)(2), the issuance of a COL requires the preparation of an EIS. Other new reactor application reviews, early site permits and limited work authorizations [10 CFR 51.20(b)(1)], also require the preparation of an EIS. The ESRP directs the staff's assessment of potential impacts of the proposed action on air quality. In addition to the direct effects of the action, the Staff considers the indirect and cumulative effects of the proposed action. Finally, insofar as the staff recognizes that the affected environment is a changing environment, the staff should now consider changes in climate that may occur during the period of the proposed action on susceptible environmental resources; the staff considers air and water resources, ecological resources, and human health issues as the areas to consider the dynamic effects of climate change.

For most of the new reactor license applications, the U.S. Army Corps of Engineers (Corps) will participate with the NRC as a cooperating agency (10 CFR 51.14) because it has jurisdiction by law and special expertise with respect to environmental impacts of the applicants' proposals. The regulatory authority of the NRC is under the Atomic Energy Act; the regulatory authority of the Corps is under the Rivers and Harbor Act and the Federal Water Pollution Control Act (also known as the Clean Water Act). The proposal may differ in some respects between the proposed actions of the NRC and the Corps because authorities differ.

COMMISSION GUIDANCE AND STAFF PLANS

In its Memorandum and Order of November 3, 2009, related to CLI-09-21, the Commission provided the following guidance to the NRC Staff:

> *We expect the Staff to include consideration of carbon dioxide and other greenhouse gas emissions in its environmental reviews for major licensing actions under the National Environmental Policy Act. The Staff's analysis for reactor applications should encompass emissions from the uranium fuel cycle as well as from construction and operation of the facility to be licensed. The Staff should ensure that these issues are addressed consistently in agency NEPA evaluations and, as appropriate, update Staff guidance documents to address greenhouse gas emissions.*

Formatted: Highlight

The Staff outlined its general plan to implement the Commission's guidance in its Memorandum dated January 15, 2010:

> *After gaining experience on the initial set of pending combined license (COL) reviews and other agency licensing actions, the staff will update the regulatory guidance contained in its environmental standard review plans (i.e., NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants," and NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs") and in other guidance documents as appropriate.*
>
> *The staff's efforts will be informed by the work of other key stakeholders such as Federal agencies charged with the responsibility to assess and report on the science of climate change, the Council on Environmental Quality, and the practices of other Federal agencies. For example, the staff has reviewed the U.S. Global Change Research Program report, June 2009, "Global Climate Change Impacts in the United States" (http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf). The staff is already using insights from the report to provide the context for the discussion of GHG emissions in upcoming draft EISs for COL reviews.*
>
> *Additionally, the staff recognizes that the issue of GHG emissions will continue to gain additional attention with the evolution of public policy and science. The staff will remain vigilant for and be informed by insights from all stakeholders.*

significant quantities of water, changes in water availability associated with climate change may need to be discussed in greater detail than other consequences of climate change. In some cases, discussion of climate change effects in an EA or EIS may warrant a separate section, while in others such discussion may be integrated into the broader discussion of the affected environment.

CEQ suggests that each agency has discretion in determining which climate change impacts should be considered:

> *CEQ proposes that agencies should determine which climate change impacts warrant consideration in their EAs and EISs because of their impact on the analysis of the environmental effects of a proposed agency action. ... As with analysis of any other present or future environment or resource condition, the observed and projected effects of climate change that warrant consideration are most appropriately described as part of the current and future state of the proposed action's "affected environment." ... Based on that description of climate change effects that warrant consideration, the agency may assess the extent that the effects of the proposal for agency action or its alternatives will add to, modify, or mitigate those effects. Such effects may include, but are not limited to, effects on the environment, on public health and safety, and on vulnerable populations who are more likely to be adversely affected by climate change. The final analysis documents an agency assessment of the effects of the actions considered, including alternatives, on the affected environment.*

For some Federal agencies, it may be entirely appropriate for their EISs to consider "public health and safety." As a regulatory agency with its organic statute principally focused on public health and safety, the NRC's responsibilities under the Atomic Energy Act already include consideration of natural phenomena on the safe design and operation of reactors. A changing climate may introduce uncertainty in the practice of relying solely upon the historical record to assess severe natural phenomena related to safe design and operation; certain effects of climate change on safety should be considered in NRC safety evaluation reports (SERs). Public health is considered as part of the NRC's NEPA review as well, but public safety is considered in the NRC's SERs developed concomitant with its EIS for the regulatory action.

Comment [RBH3]: These statements go beyond what needs to be addressed in this document. There is no consensus within DSER was to whether GDC 2 provides the basis for considering climate change in determining the design-basis for new reactors. Such a policy is not currently being implemented in the SERs and therefore should not be included in this document.

Finally, as for scientific resources that may be used and manner in which they may be invoked, CEQ recommends the seminal work of the USGCRP first among resources:

> *For sources of the best scientific information available on the reasonably foreseeable climate change impacts, Federal agencies may summarize and incorporate by reference the Synthesis and Assessment Products of the U.S. Global Change Research Program (USGCRP), and other major peer-reviewed assessments from USGCRP. Particularly relevant is the report on climate change impacts on water resources, ecosystems, agriculture and forestry, health, coastlines and arctic regions in the United States: Global Climate Change Impacts in the United States. Research on climate change impacts is an emerging and rapidly evolving area of science. In accordance with*

GUIDANCE

Consideration of greenhouse gas (GHG) emissions and climate change are not to be considered "new" components of the National Environmental Policy Act (NEPA) review for new reactor applications, but rather as important factors to be considered within the existing NEPA framework. While it may appear to be appealing to draw specific attention to the contemporary topic, GHG emissions and climate change should be given the appropriate consideration commensurate with the importance of the issues related to the proposed action; the NRC Staff is to avoid providing useless bulk and boilerplate documentation, so that the NEPA document may concentrate attention on important issues. The EPA and CEQ are attempting to establish a discriminator to help guide Federal agencies in determining which activities requiring the development of EISs could result in potentially important contributions to atmospheric loading of GHGs and, by extension, potential effects on climate change. The discriminator is not a threshold value or "bright line" marker, but it informs Federal agencies in deciding which issues are important and, consequently, which issues should be assessed in greater detail. The current discussion focuses on the direct emissions of GHGs as a result of the proposed action and is in the range of 25,000 to 75,000 metric tons per year of carbon dioxide (CO_2) emissions; CO_2 serves as a surrogate for a variety of GHGs. The emissions of CO_2 (or CO_2 equivalent) resulting from the operation of a new reactor (and its attendant infrastructure, including the indirect effects of worker transportation), accounting for the infrequent use of GHG emitting equipment, is expected to be less than 5000 metric tons per year; consequently, the issues do not require detailed atmospheric transport modeling, but can be expressed in terms of atmospheric loading and placed in context with other emission sources and society as a whole.

For new reactor licensing actions where an EIS is being prepared to fulfill its responsibilities under NEPA, the NRC Staff will consider certain aspects of climate change. These aspects include (1) the potential impacts of the proposed action on the environment and (2) the dynamic changes in significant resource areas during the lifetime of the proposed action that may be manifest as a result of climate change. In addition to the direct effects of the action, the Staff considers the ~~indirect and~~indirect and cumulative effects of the proposed action and alternatives (sites and energy sources) to the proposed action. The Staff should now consider changes in climate that may occur during the period of the proposed action on susceptible environmental resources; the Staff considers air and water resources, ecological resources, and human health issues as the areas to consider the dynamic effects of climate change for new reactor applications. Notwithstanding information from CEQ suggesting consideration should be given to matters related to the change in climate that may affect public safety (for NRC purposes, the safe design or operation of a new reactor), such issues should be considered by the NRC Staff in its SER to fulfill the NRC Staff's safety review responsibilities under the Atomic Energy Act.

Comment [RBH4]: What is the period of the proposed action for an ESP?

Comment [RBH5]: As stated previously, this "policy" statement should not be included in this document.

As outlined in the NRC Staff plan for implementing the Commission's guidance for considering greenhouse gas (GHG) emissions and climate change, the NRC Staff will rely principally on the State of Knowledge report produced by the U.S. Climate Change Research Program. This

report currently synthesizes the work of the Federal Government on all matters related to climate change.

Comment [RBH6]: This is a pretty strong statement - "all matters related to climate change"?

The report is not intended to dissuade meaningful research into the topic, but to provide the Federal Government and the general public with a basis for making informed decisions regarding the complex scientific and public policy issues related to climate change. As updates are made to the seminal work, the NRC Staff should review such changes and determine if they warrant a change in regulatory guidance.

AFFECTED ENVIRONMENT

As a rule, the affected environment discusses the baseline condition in all resource areas. For the purposes of recognizing that the climate may change during the period of the proposed action (taken to be of the order of a half century for new reactor proposals, which is the sum of the period required by the proponent to build the plant and the period, if the approval is granted, allowed by the NRC to operate the plant), climate change effects are to be addressed in two ways.

Comment [RBH7]: What about ESPs?

First, under the current organization of EISs for new reactor application reviews, the initial discussion is to be provided in Chapter 2 for the proposed site location following the discussion of climatic conditions based on the historical record. Information regarding the estimated changes in climate conditions on a regional basis is provided in the USGCRP report. A convenient source for this information is the Regional Climate Information tab from the USGCRP home page (www.globalchange.gov); this site disaggregates the report by region and allows for ease of access. It is appropriate to consider on the anticipated changes in precipitation, temperature, frequency and severity of storms, sea level, floods and droughts.

Second, under the current organization of EISs for new reactor application reviews, the discussion of the reasonably foreseeable effects of climate change on specific resource areas during the period of the proposed action is to be provided in the cumulative impacts sections of Chapter 7 for the proposed site location and in Chapter 9 for each of the alternative sites. The Staff considers air and water resources, ecological resources, and human health issues as the resource areas to consider the dynamic effects of climate change for new reactor applications. While there are other resource areas that can be affected by climate change, the NRC Staff has determined that the geographic and temporal extent of such effects related to the proposed action do not warrant further examination. Information regarding the estimated changes in climate conditions on a sector basis is provided in the USGCRP report. A convenient source for this information is the Sectoral Climate Information tab from the USGCRP home page; this site disaggregates the report by resource area and allows for ease of access.

from the underlying generic analysis; therefore, this manner of use is consistent with the use of Table S—3.

EIS Format and Content for CO_2 and GHG Discussions

Comment [RBH8]: Do you also want provide suggested language to be added to Section 2?

In the following discussion, this supplemental guidance provides the level of detail and the manner of presentation of the 7 areas of analysis and their results, relying upon the information in Attachment 3 to be scaled by activity, number of units, power level, capacity factor, etc. considered to be appropriate for the NEPA review of the proposed action relative to CO_2 and GHG emissions and impacts. The affected sections, principally synthesized with the other air quality aspects of the review, are highlighted. In the section-by-section texts, there need not be a repetitive referral to CO_2 equivalent emission, however, the term CO_2 "footprint" is, in fact, the CO_2 equivalent as outlined in Attachment 3.

Prior to each of the discussions is the admonition that the NRC Staff can rely upon the generic analysis as a starting point; however, the unique aspects of each proposal must be reflected in the material included in the air quality sections of the EIS. For example, the discussions provided reflect a proposal of two new units at an existing site with two units in an area of attainment of the National Ambient Air Quality Standards with cumulative impacts involving a nearby power project that has not been completed (and, thus, not within the baseline). For "greenfield" sites, different mix of major emitters, different cooling system systems, different numbers of units proposed, etc., the unique attributes of the proposal (at times reflected in bracketed text) are to be reflected in the discussion of effects at the appropriate life-cycle stage (building the plant, operating the plant, decommissioning the plant, the fuel cycle impacts for the plant, etc.).

The discussions also include material that is not affected by consideration of CO_2 and other GHG emissions and is presented solely for the purposes of illustrating the location of affected text. Table values, either reported or computed, and citations from applicant or other source documents are to reflect appropriate information consistent with the proposal.

(1) Building related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when reported repeatedly. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may place during this phase of the project.

Comment [RBH9]: Are ESPs classified as new reactor applications in the context of this document?

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

4.7 Meteorological and Air Quality Impacts

...

4.7.1 Construction and Preconstruction Activities

Development activities at the ZZZZZZZZ site would result in temporary impacts on local air quality. Activities including earthmoving, concrete batch plant operation and vehicular traffic generate fugitive dust. In addition, emissions from these activities would contain carbon monoxide, oxides of nitrogen, and volatile organic compounds. As discussed in Section 2.9.2, FFFF County is an attainment area for all criteria pollutants for which National Ambient Air Quality Standards have been established (40 CFR citation). As a result, a conformity analysis for direct and indirect emissions is not required (40 CFR citation). [ENSURE THAT THE REGION IS IN ATTAINMENT AND NOT A MAINTENANCE OR NON-ATTAINMENT AREA; OTHERWISE, REFER TO CONFORMITY GUIDANCE].

Prior to beginning construction and preconstruction activities, AAAAAAAA stated that it would develop a "GGGG Plan" that implements HHHH requirements. This plan would describe the management controls and measures that AAAAAAAA intends to implement to minimize impacts of these activities on air quality. The plan would provide for site inspections and environmental inspection reports that document the results of the inspections (citation). Current policies and

(2) Operations related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when reported repeatedly. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may place during this phase of the project.

Comment [RBH10]: Are ESPs classified as new reactor applications in the context of this document?

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

5.7 Meteorological and Air Quality Impacts

...

5.7.1 Air Quality Impacts

Proposed Units MMMM and NNNN at the ZZZZZZZZ site would each have [PROJECT SPECIFIC NUMBER OF] standby diesel generators and [PROJECT SPECIFIC NUMBER OF] combustion turbine generators. These generators, each of which would be operated about 4 hours per month, [PROJECT SPECIFIC COOLING SYSTEM EMITTER, FOR EXAMPLE, "and the UHS cooling towers] would be the largest stationary sources of emission that could affect air quality. Table 5-IIII lists the expected annual emissions from these sources. There would be other minor emission sources onsite [FOR EXAMPLE, "such as diesel-driven fire water pumps"], but their impact on air quality would be negligible because of infrequent use. There would also be auxiliary boilers onsite. These boilers would not impact air quality because they would be electric [ENSURE THAT THIS IS ACCURATE]. AAAAAAAA has stated that air emissions sources would be managed in accordance with Federal, HHHH, and local air quality control laws and regulations. (citation)

Comment [RBH11]: I think electric boilers are an exception.

In its ER, AAAAAAAA briefly addresses fugitive dust during plant operations. AAAAAAAA states that fugitive dust generated by the commuting work force would be minimized by [FOR

(3) Fuel cycle related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when reported repeatedly. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may place during this phase of the project.

Comment [RBH12]: Are ESPs classified as new reactor applications in the context of this document?

Comment [RBH13]: Aren't the air quality impacts from fuel cycle related impacts going to be in a different location than the NPP?

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

6.1 Fuel Cycle Impacts and Solid Waste Management

...

6.1.3 Fossil Fuel Impacts

Electric energy and process heat are required during various phases of the fuel cycle process. Electric energy is usually produced by the combustion of fossil fuel at conventional power plants. Electric energy associated with the fuel cycle represents about 5 percent of the annual electric power production of the reference 1000-MW(e) LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.4 percent of the electrical output from the model plant.

The largest source of carbon dioxide (CO_2) emissions associated with nuclear power is from the fuel cycle, not the operation of the plant, as indicated above and in Table S-3. The CO_2 emissions from the fuel cycle are about 5 percent of the CO_2 emissions from an equivalent fossil fuel-fired plant.

The largest use of electricity in the fuel cycle comes from the enrichment process. It appears that gas centrifuge (GC) technology is likely to eventually replace gaseous diffusion (GD) technology for uranium enrichment in the United States. The same amount of enrichment from

(4) Decommissioning related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when reported repeatedly. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may place during this phase of the project.

Comment [RBH14]: Are ESPs classified as new reactor applications in the context of this document?

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

6.3 Decommissioning Impacts

At the end of the operating life of a power reactor, NRC regulations require that the facility undergo decommissioning. Decommissioning is the safe removal of a facility from service and the reduction of residual radioactivity to a level that permits termination of the NRC license. The regulations governing decommissioning of power reactors are found in 10 CFR 50.75.

An applicant for a COL is required to certify that sufficient funds will be available to assure radiological decommissioning at the end of power operations. As part of its COL application for the proposed Units MMMM and NNNN on the ZZZZZZZZ site, AAAAAAAA included a Decommissioning Funding Assurance Report (citation). AAAAAAAA would establish an external sinking funds account to accumulate funds for decommissioning.

Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in the *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement I, Regarding the Decommissioning of Nuclear Power Reactors* (GEIS-DECOM), NUREG-0586 Supplement 1 (NRC 2002). Environmental impacts of the DECON, SAFSTOR, and ENTOMB decommissioning methods are evaluated in the GEIS-DECOM. A COL applicant is not required to identify a decommissioning method at the time of the COL application. The NRC staff's

evaluation of the environmental impacts of decommissioning presented in the GEIS-DECOM, identifies a range of impacts for each environmental issue for a range of different reactor designs. The NRC staff concludes that the construction methods that would be used for the ABWR are not sufficiently different from the construction methods used for the current plants to significantly affect the impacts evaluated in the GEIS-DECOM. Therefore, the NRC staff concludes that the impacts discussed in the GEIS-DECOM remain bounding for reactors deployed after 2002, including the ABWR.

Comment [RBH15]: Aren't some of the other new reactors contractors are considering modular construction? Could this "new" construction technique significant affect the impacts evaluated in the GEIS-DECOM?

The GEIS-DECOM does not specifically address the carbon footprint of decommissioning activities. However, it does list the decommissioning activities and states that the decommissioning workforce would be expected to be smaller than the operational workforce and that the decontamination and demolition activities could take up to 10 years to complete. Finally, it discusses SAFSTOR, in which decontamination and dismantlement are delayed for a number of years. Given this information, the NRC staff estimated the CO_2 footprint of decommissioning to be of the order of 6.3×10^4 63,000 metric tons without SAFSTOR. This footprint is about equally split between decommissioning workforce transportation and equipment usage. The details of the NRC staff's estimate are presented in Appendix YYYY. A 40-yr SAFSTOR period would increase the footprint of decommissioning by about 40 percent. These CO_2 footprints are roughly three orders of magnitude lower than the CO_2 footprint presented in Section 6.1.3 for the uranium fuel cycle.

The NRC staff relies upon the bases established in the GEIS-DECOM and concludes the following:

1. Doses to the public would be well below applicable regulatory standards regardless of which decommissioning method considered in GEIS-DECOM is used.

2. Occupational doses would be well below applicable regulatory standards during the license term.

3. The quantities of Class C or greater than Class C wastes generated would be comparable or less than the amounts of solid waste generated by reactors licensed before 2002.

4. Air quality impacts of decommissioning are expected to be negligible at the end of the operating term.

5. Measures are readily available to avoid potential significant water quality impacts from erosion or spills. The liquid radioactive waste system design includes features to limit release of radioactive material to the environment, such as pipe chases and tank collection basins. These features will minimize the amount of radioactive material in spills and leakage that would have to be addressed at decommissioning.

6. Ecological impacts of decommissioning are expected to be negligible.

(5) Cumulative impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when reported repeatedly. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may place during this phase of the project.

Comment [RBH16]: Are ESPs classified as new reactor applications in the context of this document?

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project.. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

7.6 Air Quality

...

7.6.1 Criteria Pollutants

...

7.6.2 Greenhouse Gas Emissions

As discussed in the state of the science report issued by the GCRP, it is the ... production and use of energy that is the primary cause of global warming, and in turn, climate change will eventually affect our production and use of energy. The vast majority of U.S. greenhouse gas emissions, about 87 percent, come from energy production and use ... Approximately one third of the greenhouse gas emissions are the result of generating electricity and heat (Karl et al. 2009). This assessment is focused on greenhouse gas emissions.

Greenhouse gas emissions associated with building, operating, and decommissioning a nuclear power plant are addressed in Sections 4.7, 5.7.1, 6.1.3, and 6.3. The review team concluded that the atmospheric impacts of the emissions associated of each aspect of building, operating and decommissioning a single plant are minimal. The review team also concludes that the impacts of the combined emissions for the full plant life cycle are minimal.

(6) Alternative Energy Sources

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when reported repeatedly. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may place during this phase of the project.

Comment [RBH17]: Are ESPs classified as new reactor applications in the context of this document?

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

9.2 Energy Alternatives

...

9.2.2 Alternatives Requiring New Generating Capacity

...

9.2.2.1 Coal-Fired Generation

...

Air Quality

The impacts on air quality from coal-fired generation would vary considerably from those of nuclear generation because of emissions of SO_2, nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM), volatile organic compounds (VOCs), and hazardous air pollutants such as mercury and lead. In its environmental report (ER), AAAAAAAA assumed a coal-fired plant design that would minimize air emissions through a combination of boiler technology and post combustion pollutant removal. AAAAAAAA estimated that annual emissions for a supercritical pulverized coal-fired generation alternative using sub-bituminous coal would be approximately as follows (citation):

- SO_2 – 2900 tons/yr
- NO_X – 2000 tons/yr

- CO – 2800 tons/yr
- PM_{10} – 50 tons/yr
- $PM_{2.5}$ – 13 tons/yr
- Mercury – 0.46 tons/yr.

Comment [RBH18]: Note that this set of numbers varied from COL applicant to COL applicant.

PM_{10} is particulate matter with a diameter equal to or less than 10 microns (40 CFR 50.6). $PM_{2.5}$ is particulate matter with a diameter equal to or less than 2.5 microns (40 CFR 50.7).

Based on data from previous NRC EIS documents, the review team determined the preceding emission estimates are reasonable. A new coal-fired plant at the ZZZZZZZZ site would also have approximately 2.7 million tons/yr of unregulated carbon dioxide emissions (citation) that could affect climate change.

Comment [RBH19]: This proved to be a very contentious statement in the CC, STP, and VCS DEISs.

The acid rain requirements of the Clean Air Act capped the nation's SO_2 emissions from power plants. AAAAAAAA would need to obtain sufficient pollution credits either from a set-aside pool or purchases on the open market to cover annual emissions from the plant.

A new coal-fired generation plant at the ZZZZZZZZ site would likely need a prevention of significant deterioration (PSD) permit and an operating permit from the HHHH. The plant would need to comply with the new source performance standards for such plants in 40 CFR 60, Subpart Da. The standards establish emission limits for PM and opacity (40 CFR 60.42Da), SO_2 (40 CFR 60.43Da), NO_X (40 CFR 60.44Da), and mercury (40 CFR 60.45Da). Fugitive dust emissions from construction activities would be mitigated using best management practices (BMPs); such emissions would be temporary (citation).

The U.S. Environmental Protection Agency (EPA) has various regulatory requirements for visibility protection in 40 CFR Part 51, Subpart P, including a specific requirement for review of any new major stationary source in areas designated as in attainment or unclassified under the Clean Air Act. The ZZZZZZZZ site is in an area designated as in attainment or unclassified for criteria pollutants (40 CFR citation).

Section 169A of the Clean Air Act (42 USC 7491) establishes a national goal of preventing future impairment of visibility and remedying existing impairment in mandatory Class I Federal areas when impairment is from air pollution caused by human activities. In addition, the EPA regulations provide that for each mandatory Class I Federal area located within a State, the State must establish goals that provide for reasonable progress toward achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most impaired days over the period of the implementation plan and confirm no degradation in visibility for the least-impaired days over the same period [40 CFR 51.308(d)(1)]. If a new coal-fired power plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed. No mandatory Class I Federal areas are within 50 mi of the ZZZZZZZZ site.

The GEIS for license renewal considers global warming from unregulated carbon dioxide emissions and acid rain from sulfur oxides and nitrogen oxide emissions as a potential impact (NRC 1996). Adverse human health effects, such as cancer and emphysema, have been associated with the byproducts of coal combustion. Overall, the review team concludes that air quality impacts from new coal-fired power generation at the ZZZZZZZZ site would be MODERATE. The impacts would be clearly noticeable but would not destabilize air quality.

9.2.2.2 Natural Gas-Fired Generation

...

Air Quality

Natural gas is a relatively clean-burning fuel. When compared to a coal-fired plant, a natural gas-fired plant would release similar types of emissions but in lower quantities. A new natural gas-fired power generation plant would likely need a PSD permit and an operating permit from the TCEQ. A new natural gas-fired combined-cycle plant would also be subject to the new source performance standards in 40 CFR 60, Subparts Da and GG. These regulations establish emission limits for particulates, opacity, SO_2, and NO_X. The EPA has various regulatory requirements for visibility protection in 40 CFR 51, Subpart P, including a specific requirement for review of any new major stationary source in areas designated as in attainment or unclassified under the Clean Air Act. The ZZZZZZZZ site is in an area designated as in attainment or unclassified for criteria pollutants (40 CFR citation).

Section 169A of the Clean Air Act (42 USC 7491) establishes a national goal of preventing future impairment of visibility and remedying existing impairment in mandatory Class I Federal areas when impairment is from air pollution caused by human activities. In addition, the EPA regulations provide that for each mandatory Class I Federal area located within a State, the State must establish goals that provide for reasonable progress toward achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most impaired days over the period of the implementation plan and ensure no degradation in visibility for the least-impaired days over the same period (40 CFR 51.308(d)(1)). If a new natural gas-fired power plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed. No mandatory Class I Federal areas are within 50 mi of the ZZZZZZZZ site.

AAAAAAAA estimated that a natural gas-fired plant equipped with pollution control technology to meet emission limits would have approximately the following emissions (citation):

- SO_2 – 41 tons/yr
- NO_x – 680 tons/yr
- CO – 141 tons/yr
- $PM_{2.5}$ – 119 tons/yr

Based on data from previous NRC EIS documents, the review team determined the preceding emission estimates are reasonable. A natural gas-fired power plant would also have

Comment [RBH20]: See previous set of comments.

(7) Alternative Sites

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when reported repeatedly. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may place during this phase of the project.

Comment [RBH21]: Are ESPs classified as new reactor applications in the context of this document?

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

9.3 Alternative Sites

...

9.3.BBBB Alternative Site BBBB-1 (Repeated as often as needed and peculiarized for the Alternative Site circumstances)

...

9.1.1.1 Air Quality

The following impact analysis includes impacts from building activities and operations. The analysis also considers other past, present, and reasonably foreseeable future actions that impact air quality, including other Federal and non-Federal projects listed in Table 9-CCCC. The geographic area of interest for the BBBB-1 site is DDDD County, which is in the EEEE Air Quality Control Region (40 CFR citation).

The emissions related to building and operating a nuclear power plant at the BBBB-1 alternative site would be similar to those at the ZZZZZZZZ site. The air quality attainment status for DDDD County, as set forth in 40 CFR (citation), reflects the effects of past and present emissions from

Zalcman, Barry

From: Martin, Jody
Sent: Wednesday, March 31, 2010 1:34 PM
To: Zalcman, Barry
Cc: Clayton, Brent; Kirkwood, Sara
Subject: FW: CO2 and GHG Guidance for Flanders Memo
Attachments: OGC Comments-100318 GHG and Climate Change (2).doc

Barry,

Attached are the OGC comments on your GHG and climate change memo/ESRP section. Also see Andy Pessin's comments in the below e-mail. I suggested language in the text that I think addresses Andy's comments. If you want to discuss any of those changes let me know.

Overall, I don't see any major issues, so I am going to NLO with comments and send the hard copy back through the mailroom (but the only intelligible comments are on the electronic copy). Most of my comments are suggestions, so if you disagree let me know (I'm sure you would anyways) and we can discuss.

Thanks,

Jody

Jody C. Martin
Attorney
Office of the General Counsel
U.S. Nuclear Regulatory Commission
(301)415-1569
jody.martin@nrc.gov

This Message may contain attorney/client or attorney work product information. Limited to the NRC unless the Commission determines otherwise.

From: Kirkwood, Sara
Sent: Friday, March 26, 2010 9:13 AM
To: Martin, Jody
Subject: FW: CO2 and GHG Guidance for Flanders Memo

From: Pessin, Andrew
Sent: Wednesday, March 24, 2010 6:34 PM
To: Kirkwood, Sara
Cc: Jones, Bradley
Subject: FW: CO2 and GHG Guidance for Flanders Memo

Hi Sara,

Given the time constraints--I think Barry indicated that NRO (Brent Clayton) wanted this by mid-week--I have only been able to give this draft a very cursory review. I did not spot any "show-stopper" legal issues.

My comments:

The draft cites to EPA's December 15, 2009 final rule, which is fine. The draft also cites, however, to the CEQ's draft GHG guidance, which is presently out for public comment. The CEQ public comment period does not end until May 24, 2010. As such, the CEQ draft GHG guidance may be much different than what it is now and I recommend that NRC wait until the CEQ guidance is final.

With respect to the EPA rule (the draft does not have page numbers--the relevant section is entitled "EPA Endangerment Finding" and is towards the beginning of the document), I have some concern about the statement "the Staff has no reason to believe that the USGCRP report is anything but the highest quality and is a reliable source for information regarding climate change in the U.S." As GHG emissions analyses and climate change studies seem to be evolving, I recommend not making this statement. Rather, I recommend waiting until CEQ has finalized its guidance. In all probability, the CEQ guidance will endorse the USGCRP, but I don't see any reason for NRC to get out ahead. If the CEQ guidance does not endorse the USGCRP or if lists other reports/models in addition to the USGCRP, then I suggest the draft guidance be revised accordingly.

Finally, I know FSME staff is interested in commenting upon this document. It is not clear whether this draft went out for office concurrent clearance.

Andy

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Mail Stop: O-15D21

****** ATTORNEY WORK-PRODUCT DOCUMENT --- NOT FOR PUBLIC DISCLOSURE ******

From: Zalcman, Barry
Sent: Friday, March 19, 2010 1:56 PM
To: Hampton, Saprina; Kirkwood, Sara; Pessin, Andrew
Cc: Clayton, Brent; Martin, Karnisha; Cushing, Jack; Biggins, James
Subject: CO2 and GHG Guidance for Flanders Memo

Saprina-

Attached is the proposed supplemental guidance for CO_2 and other GHG emissions and climate change; this will be referenced from the overarching memorandum from Mr. Flanders to the staff.

Unfortunately, I am on travel starting Wednesday next week. If changes are suggested, then they should be coordinated through Brent or his designee.

Sara-

Thought you could escape from me on a Friday afternoon?

I know that you are working on the other pieces of the overarching memo from Scott Flanders. While this appears to be a large document, I hope to think that it will be the easiest to review.

I am also sharing this with Andy Pessin as the OGC lead on this issue; he plans to provide input to you for a consolidated OGC position. As background, we compiled this in the form of a primer so that projects staff as well as technical staff have the proper context. This is a contemporary issue that appears to be drawing more

attention as though it is as much a significant contributor to the NEPA deliberations as the key issues in particular locations; this has to be tempered.

We have heavily quoted from the Commission's direction, the Staff plan, the EPA endangerment finding and the CEQ guidance. As quotables, such text is not subject to change, but can be deleted or reframed. We do recognize that the latter has only been issued for public comment and that the NRC has not taken a position on the CEQ guidance; we will track the evolution of the guidance to determine whether changes are warranted. It is important, however, to demonstrate that we are considering the information as we establish NRC NEPA procedures on the subject; we have seen these issues gaining attention in the EPA Section 309 reviews.

At the end of the supplemental guidance, we identified the seven areas [Chapters 4, 5, 6 (two topics), 7, and 9 (two topics)] that CO_2 and GHG play into the EIS and have provided format and content examples (which still must be peculiarized for each application) that should be useful for the upcoming EISs. The introduction (i.e., the admonition to the Staff) is the same for each of the seven areas; we want to have them focus on the highlighted text. The example text for each area is drawn from the STP EIS (I cannot imagine that OGC would want to change this text either now that it has been delivered to EPA).

Each region of the U.S. can experience a different set of effects on resource areas (our focus is on air and water resources, ecology and non-rad public health) from potential changes in climate. Consequently, we intentionally did not provide sample text for the affected area in Chapter 2 for the climate discussion, or for Chapters 7 and 9 for the climate change impacts considered in the cumulative effects evaluation for the proposed site area and for the alternative sites, respectively. In addition, we do not address the front or back matter (including Chapter 10) in this guidance.

We have linked many of the cited works to the document; they happen to be in my G: drive, so I hope that they are accessible to you as well; if not, then the ML numbers, FR citations, and web locations are also included. The hard copy that we will send to the OGC mailroom will have the Commission's Order and the Mike Johnson Memo to Bill Borchardt attached.

Barry Zalcman
Sr. PM
NRO/DSER/RENV
(301)415-2419

Supplemental Staff Guidance to NUREG 1555, "Environmental Standard Review Plan," (ESRP) for Consideration of the Effects of Greenhouse Gases and of Climate Change

PURPOSE

The purpose of this guidance is to clarify the consideration of greenhouse gas (GHG) emissions and the treatment of climate change in developing draft environmental impact statements (EISs) for new reactor reviews. This complex contemporary issue has gained prominence worldwide and it is important that decisionmakers consider the full suite of environmental impacts of proposed actions before acting. A National Environmental Policy Act (NEPA) analysis is the appropriate forum to consider the interface and potential consequences of new projects and the environment. In addition to disclosing the benefits and risks associated with proposed actions, NEPA provides the opportunity for public involvement to provide additional insights and inform decisionmakers.

In recent licensing actions, NRC's Atomic Safety Licensing Board Panels have referred rulings to the Commission suggesting that it may want to consider the "... potential generic significance of the issue ..." In CLI-09-21 (Attachment 1, ML093070690), the Commission provided additional guidance to the staff. The principal purpose of this supplemental guidance document is to provide the detailed analytical framework and the format for presentation of its evaluation to implement the Commission's direction for new reactor application reviews. The staff outlined its general plan in a memorandum from M. Johnson to R. Borchardt on January 15, 2010 (Attachment 2, ML093520734); this guidance is consistent with that plan.

Additional information is provided in the following Background section to highlight allied issues and actions that may have more prominence in the Executive Branch. As an independent executive agency, the NRC is informed by the requirements and findings of other Federal agencies and guidance that is developed to assist them in fulfilling their responsibilities.

Comment [jcm1]: Not sure what you are saying here. Are you saying that you are highlighting issues taken by the executive branch, or issues that are more important to the executive branch? Do we even need this, or can we just say that the background portion of this paper provides more information regarding the development of these issues, and efforts the federal government has undertaken to address them?

BACKGROUND

PROPOSED ACTION

The NRC's proposed action related to issuing combined licenses (COLs) is to authorize construction (as defined in 10 CFR 51.4) for an undefined period of time and to authorize operation for a period not to exceed 40 years. Pursuant 10 CFR 51.20(b)(2), the issuance of a COL requires the preparation of an EIS. Other new reactor application reviews, early site permits and limited work authorizations [10 CFR 51.20(b)(1)], also require the preparation of an EIS. The ESRP directs the staff's assessment of potential impacts of the proposed action on ~~air quality~~the environment. In addition to the direct effects of the action, the Staff considers the indirect and cumulative effects of the proposed action. Finally, insofar as the staff recognizes that the affected environment is a changing environment, the staff should now consider changes in climate that may occur during the period of the proposed action on susceptible environmental resources; the staff considers air and water resources, ecological resources, and human health issues as the areas to consider the dynamic effects of climate change.

For most of the new reactor license applications, the U.S. Army Corps of Engineers (Corps) will participate with the NRC as a cooperating agency (10 CFR 51.14) because it has jurisdiction by law over certain portions of the applicants' activities and special expertise with respect to environmental impacts of the applicants' proposals. The regulatory authority of the NRC is under the Atomic Energy Act; the regulatory authority of the Corps is under the Rivers and Harbor Act and the Federal Water Pollution Control Act (also known as the Clean Water Act). The proposal may differ in some respects between the proposed actions of the NRC and the Corps because authorities differ.

Comment [jcm2]: What proposal? Do you mean this guidance or the proposed action?

COMMISSION GUIDANCE AND STAFF PLANS

In its Memorandum and Order of November 3, 2009, related to CLI-09-21, the Commission provided the following guidance to the NRC Staff:

> *We expect the Staff to include consideration of carbon dioxide and other greenhouse gas emissions in its environmental reviews for major licensing actions under the National Environmental Policy Act. The Staff's analysis for reactor applications should encompass emissions from the uranium fuel cycle as well as from construction and operation of the facility to be licensed. The Staff should ensure that these issues are addressed consistently in agency NEPA evaluations and, as appropriate, update Staff guidance documents to address greenhouse gas emissions.*

The Staff outlined its general plan to implement the Commission's guidance in its Memorandum dated January 15, 2010:

> *After gaining experience on the initial set of pending combined license (COL) reviews and other agency licensing actions, the staff will update the regulatory guidance contained in its environmental standard review plans (i.e., NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants," and NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs") and in other guidance documents as appropriate.*
>
> *The staff's efforts will be informed by the work of other key stakeholders such as Federal agencies charged with the responsibility to assess and report on the science of climate change, the Council on Environmental Quality, and the practices of other Federal agencies. For example, the staff has reviewed the U.S. Global Change Research Program report, June 2009, "Global Climate Change Impacts in the United States" (http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf). The staff is already using insights from the report to provide the context for the discussion of GHG emissions in upcoming draft EISs for COL reviews.*

In addition to vetting the USGCRP report, the EPA finding also included insights on the geographic and temporal scope of impacts. These attributes are particularly important in the NRC Staff's analysis of the direct and indirect impacts of the proposed action as well as cumulative impacts of the proposed action when combined with other past, present, and reasonably foreseeable impacts. Regarding the geographic and temporal scope of GHG emissions and climate change, EPA stated:

> *It is the Administrator's view that the primary focus of the vulnerability, risk, and impact assessment is the United States. As described in Section IV of these Findings, the Administrator gives some consideration to climate change effects in world regions outside of the United States. Given the global nature of climate change, [the Administrator] has also examined potential impacts in other regions of the world. Greenhouse gases, once emitted, become well mixed in the atmosphere, meaning U.S. emissions can affect not only the U.S. population and environment, but other regions of the world as well. Likewise, emissions in other countries can affect the United States.*
>
> *The timeframe over which vulnerabilities, risks, and impacts are considered should be consistent with the timeframe over which greenhouse gases, once emitted, have an effect on climate. Thus the relevant time frame is decades to centuries for the primary greenhouse gases of concern. Therefore, in addition to reviewing recent observations, the underlying science upon which the Administrator is basing her findings generally considers the next several decades—the time period out to around 2100, and for certain impacts, the time period beyond 2100.*

Unlike many major Federal actions of natural resource, land management, and facility management agencies of the Federal government, the NRC is a regulatory agency. NRC's major Federal actions are usually associated with a grant of permission to perform specific activities associated with the use of nuclear materials in private facilities on private lands for a fixed period of time. The issuance of a permit, license or authorization is the major Federal action; amendments to a permit, license, or authorization are separate actions and may not be of such significance to warrant the preparation of an EIS.

Comment [jcm3]: I'm not sure you need this paragraph. It is good background, but I don't think it adds much to this discussion.

For the purposes of developing EISs for new reactor license reviews, the NRC Staff is informed by the EPA finding that the current effects of GHG emissions nationwide on climate change is detectable and endangers public health and welfare. For the purposes of evaluating the cumulative impacts of the proposed action, the NRC Staff is informed by the EPA finding that the effects may be far-reaching geographically and long-lived temporally.

FEDERAL GUIDANCE ON GHG EMISSIONS AND CLIMATE CHANGE

On February 23, 2010, the Council on Environmental Quality (CEQ) issued (75 FR 8046) draft guidance for public comment on "Consideration of the Effects of Climate Change and Greenhouse Gas Emissions." The CEQ draft guidance was published for a 90-day public

comment period; given the public interest in this complex, contemporary, and controversial topic, an extraordinary number of public comments are anticipated. It may take some time to consider, weigh and disposition public comments before any guidance is finalized. ~~Nevertheless, the draft guidance provides meaningful insight that can be use even on an interim basis.~~The Staff should consider the information in the draft guidance while reviewing GHG emissions; however, because this guidance is subject to change, the Staff's analysis should not rest solely on the draft guidance.

Consistent with CEQ's objectives of advising Federal agencies on NEPA implementation issues, the CEQ states that:

> *This draft guidance affirms the requirements of the statute and regulations and their applicability to GHGs and climate change impacts. CEQ proposes to advise Federal agencies that they should consider opportunities to reduce GHG emissions caused by proposed Federal actions and adapt their actions to climate change impacts throughout the NEPA process and to address these issues in their agency NEPA procedures.*

Clearly, the CEQ guidance is directed at Executive Branch agencies; however, it can be useful to independent executive agencies when developing their NEPA procedures. In the following, the excerpted text from the CEQ's draft guidance are considered relevant by the NRC staff in shaping its consideration of GHG emissions and the effects of climate change as part of its NEPA reviews of new reactor applications and its preparation of draft EISs:

> *Because climate change is a global problem that results from global GHG emissions, there are more sources and actions emitting GHGs (in terms of both absolute numbers and types) than are typically encountered when evaluating the emissions of other pollutants. From a quantitative perspective, there are no dominating sources and fewer sources that would even be close to dominating total GHG emissions. The global climate change problem is much more the result of numerous and varied sources, each of which might seem to make a relatively small addition to global atmospheric GHG concentrations. CEQ proposes to recommend that environmental documents reflect this global context and be realistic in focusing on ensuring that useful information is provided to decision makers for those actions that the agency finds are a significant source of GHGs.*
>
> *Under this proposed guidance, agencies should use the scoping process to set reasonable spatial and temporal boundaries for this assessment and focus on aspects of climate change that may lead to changes in the impacts, sustainability, vulnerability and design of the proposed action and alternative courses of action. At the same time, agencies should recognize the scientific limits of their ability to accurately predict climate change effects, especially of a short-term nature, and not devote effort to analyzing wholly speculative effects.*

aspects of the environment that are affected by the proposed action and the significance of climate change for those aspects of the affected environment. Agencies should consider the specific effects of the proposed action (including the proposed action's effect on the vulnerability of affected ecosystems), the nexus of those effects with projected climate change effects on the same aspects of our environment, and the implications for the environment to adapt to the projected effects of climate change. The level of detail in the analysis and NEPA documentation of these effects will vary among affected resource values. For example, if a proposed project requires the use of significant quantities of water, changes in water availability associated with climate change may need to be discussed in greater detail than other consequences of climate change. In some cases, discussion of climate change effects in an EA or EIS may warrant a separate section, while in others such discussion may be integrated into the broader discussion of the affected environment.

CEQ suggests that each agency has discretion in determining which climate change impacts should be considered:

CEQ proposes that agencies should determine which climate change impacts warrant consideration in their EAs and EISs because of their impact on the analysis of the environmental effects of a proposed agency action. ... As with analysis of any other present or future environment or resource condition, the observed and projected effects of climate change that warrant consideration are most appropriately described as part of the current and future state of the proposed action's "affected environment." ... Based on that description of climate change effects that warrant consideration, the agency may assess the extent that the effects of the proposal for agency action or its alternatives will add to, modify, or mitigate those effects. Such effects may include, but are not limited to, effects on the environment, on public health and safety, and on vulnerable populations who are more likely to be adversely affected by climate change. The final analysis documents an agency assessment of the effects of the actions considered, including alternatives, on the affected environment.

For some Federal agencies, it may be entirely appropriate for their EISs to consider "public health and safety." As a regulatory agency with its organic statute principally focused on public health and safety, the NRC's responsibilities under the Atomic Energy Act already include consideration of natural phenomena on the safe design and operation of reactors. A changing climate may introduce uncertainty in the practice of relying solely upon the historical record to assess severe natural phenomena related to safe design and operation; certain effects of climate change on safety should be considered in NRC safety evaluation reports (SERs). Public health is considered as part of the NRC's NEPA review as well, but public safety is considered in the NRC's SERs developed concomitant with its EIS for the regulatory action.

Finally, as for scientific resources that may be used and the manner in which they may be invoked, CEQ recommends the using the~~seminal~~ work of the USGCRP~~ first among resources~~:

GUIDANCE

Consideration of greenhouse gas (GHG) emissions and climate change are not to be considered "new" components of the National Environmental Policy Act (NEPA) review for new reactor applications, but rather as important factors to be considered within the existing NEPA framework. While it may appear to be appealing to draw specific attention to the contemporary topic, GHG emissions and climate change should be given the appropriate consideration commensurate with the importance of the issues related to the proposed action; the NRC Staff is to avoid providing useless bulk and boilerplate documentation, so that the NEPA document may concentrate attention on important issues. The EPA and CEQ are attempting to establish a discriminator to help guide Federal agencies in determining which activities requiring the development of EISs could result in potentially important contributions to atmospheric loading of GHGs and, by extension, potential effects on climate change. The discriminator is not a threshold value or "bright line" marker, but it informs Federal agencies in deciding which issues are important and, consequently, which issues should be assessed in greater detail. The current discussion focuses on the direct emissions of GHGs as a result of the proposed action and is in the range of 25,000 to 75,000 metric tons per year of carbon dioxide (CO_2) emissions; CO_2 serves as a surrogate for a variety of GHGs. The emissions of CO_2 (or CO_2 equivalent) resulting from the operation of a new reactor (and its attendant infrastructure, including the indirect effects of worker transportation), accounting for the infrequent use of GHG emitting equipment, is expected to be less than 5000 metric tons per year; consequently, the issues do not require detailed atmospheric transport modeling, but can be expressed in terms of atmospheric loading and placed in context with other emission sources and society as a whole.

Comment [jcm4]: Can you specify where this is from. Is this from the draft CEQ guidance, informal discussions, endangerment finding?

For new reactor licensing actions where an EIS is being prepared to fulfill its responsibilities under NEPA, the NRC Staff ~~will~~ should consider certain aspects of climate change. These aspects include (1) the potential impacts of the proposed action on the environment and (2) the dynamic changes in significant resource areas during the lifetime of the proposed action that may be manifest as a result of climate change. In addition to the direct effects of the action, the Staff should consider~~s~~ the indirect -and cumulative effects of the proposed action and alternatives (sites and energy sources) to the proposed action. The Staff should now consider changes in climate that may occur during the period of the proposed action on susceptible environmental resources; the Staff considers air and water resources, ecological resources, and human health issues as the areas to consider the dynamic effects of climate change for new reactor applications. Notwithstanding information from CEQ suggesting consideration should be given to matters related to the change in climate that may affect public safety (for NRC purposes, the safe design or operation of a new reactor), such issues should be considered by the NRC Staff in its SER to fulfill the NRC Staff's safety review responsibilities under the Atomic Energy Act.

Comment [jcm5]: I agree with this statement legally, but before we publish this we should make sure that the safety side is actually planning on discussing these issues, because this may cause people to ask questions or file contentions on safety issues.

As outlined in the NRC Staff plan for implementing the Commission's guidance for considering ~~greenhouse gas (~~GHG~~)~~ emissions and climate change, the NRC Staff will rely principally on the State of Knowledge report produced by the U.S. Climate Change Research Program. This report synthesizes the work of the Federal Government on all matters related to climate change.

The report is not intended to dissuade meaningful research into the topic, but to provide the Federal Government and the general public with a basis for making informed decisions regarding the complex scientific and public policy issues related to climate change. As updates are made to ~~the seminal work~~this report, the NRC Staff should review such changes and determine if they warrant a change in regulatory guidance.

AFFECTED ENVIRONMENT

As a rule, the discussion of the affected environment in an EIS ~~discusses~~ addresses the baseline condition in all resource areas. For the purposes of recognizing that the climate may change during the period of the proposed action (taken to be of the order of a half century for new reactor proposals, which is the sum of the period required by the proponent to build the plant and the period, if the approval is granted, allowed by the NRC to operate the plant), climate change effects are to be addressed in two ways.

First, under the current organization of EISs for new reactor application reviews, the initial discussion is to be provided in Chapter 2 for the proposed site location following the discussion of climatic conditions based on the historical record. Information regarding the estimated changes in climate conditions on a regional basis is provided in the USGCRP report. A convenient source for this information is the Regional Climate Information tab from the USGCRP home page (www.globalchange.gov); this site disaggregates the report by region and allows for ease of access. It is appropriate to consider ~~on~~ the anticipated changes in precipitation, temperature, frequency and severity of storms, sea level, floods and droughts.

Second, under the current organization of EISs for new reactor application reviews, the discussion of the reasonably foreseeable effects of climate change on specific resource areas during the period of the proposed action is to be provided in the cumulative impacts sections of Chapter 7 for the proposed site location and in Chapter 9 for each of the alternative sites. The Staff considers air and water resources, ecological resources, and human health issues as the resource areas to consider the ~~dynamic~~ effects of climate change for new reactor applications. While there are other resource areas that can be affected by climate change, the NRC Staff has determined that the geographic and temporal extent of such effects related to the proposed action do not warrant further examination. Information regarding the estimated changes in climate conditions on a sector basis is provided in the USGCRP report. A convenient source for this information is the Sectoral Climate Information tab from the USGCRP home page; this site disaggregates the report by resource area and allows for ease of access.

ENVIRONMENTAL CONSEQUENCES

Carbon Dioxide and Other Greenhouse Gas Emissions

The NRC Staff evaluates air quality conditions (i.e., status with regard to National Ambient Air Quality Standards) and potential emissions from sources and activities associated with building and operating a new nuclear power plant. In addition to consideration of the traditional criteria pollutants, conformity reviews, visibility impairment in Prevention of Significant Deterioration Class I areas, etc., the NRC Staff should~~is~~ consider~~ing~~ the emergence of CO_2 and other GHGs as an important air quality issue. Consistent with CEQ's ~~perspective~~draft guidance, "[T]his is not intended as a 'new' component of NEPA analysis, but rather as a potentially important factor to be considered within the existing NEPA framework." Consequently, discussions related to the consequences of CO_2 and other GHG emissions ~~will~~ should be included within the context of air quality issues in EISs for new reactor application reviews.

While CO_2 is often used as a surrogate for GHGs, other gases with similar potential to implicate greenhouse behavior may be emitted at the same time as CO_2; this could result in a slight underestimation of the total potential GHG emissions and the effects resulting from them if the Staff considered only CO_2. To ensure that the NRC Staff meets the Commission's expectation that it consider both CO_2 and other GHG emissions for new reactor applications, the Staff considered methods that would meet the purposes of its NEPA analysis.

In EPA's periodic reports on the inventory of GHG emissions and sinks in the U.S., EPA provides ~~the~~ context for the contribution of GHG to "global warming potential" (GWP); these reports are available at www.epa.gov/climatechange/emissions. EPA described the GWP concept, as developed by the Intergovernmental Panel on Climate Change (IPCC), as a means "... to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas." Consequently, not all GHG species have an equal role in contributing to potential environmental effects. Although water vapor has the potential to contribute to global warming, it has not been targeted by the IPCC or the EPA as in need of control. The GWP for CO_2 is 1, for methane it is 21, and for nitrous oxide it is 310; the GWP is much greater for yet other GHGs, but the more exotic GHGs are not related to the activities associated with building and operating a new nuclear power plant in any appreciable quantities. In addition, the proportional presence of individual GHG species in the atmosphere and the species' life cycle (short-lived *v.* long-lived) add to the complexity of the scientific analysis. The largest source of U.S. GHG emissions, CO_2, from fossil fuel combustion has accounted for more than 75% of GWP-weighted emissions since 1990 and at an increasing pace, and transportation activities accounted for more than 30%. In its 2007 inventory report, EPA reported that "... [C]hanges in CO_2 emissions from fossil fuel combustion are influenced by many long-term and short-term factors, including population and economic growth, energy price fluctuations, technological changes, and seasonal temperatures." Furthermore, "[U]ncertainties in the emission estimates ... also result from the data used to allocate CO_2 emissions from the transportation end-use sector to individual vehicle types and transportation modes." By these accounts, maintaining

the inventory of sources and sinks has been a challenging undertaking by EPA and translation of the relationship between emissions and effects requires synthesis and has some uncertainty.

In a recent rule promulgated by EPA (74 FR 56260), certain categories of sources of emissions are now required to report annual GHG emissions. The suite of GHGs, which are the same as those listed by the IPCC, include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and other fluorinated gases [e.g., nitrogen trifluoride (NF_3) and hydrofluorinated ethers (HFEs)]. EPA indicated that "... accurate and timely information on GHG emissions is essential for informing many future climate change policy decisions." This reporting requirement is placed on certain classes of pollution sources, is forward looking, and will inform future decisionmaking with improved technical bases and refined analytical methods. Of the specific GHGs that are required to be reported, detailed methods for calculating GHG emissions were provided in Subpart C—General Stationary Fuel Combustion Sources of the rule. Notably, one of the types of fuel combustion sources at an operating nuclear power plant, the emergency generator, is exempt because "... the reporting of GHG emissions is unreasonable given the cost of monitoring and the relative level of GHG emissions." This is instructive; however, while the operator of an emergency generator may be exempt from reporting, the generator, however infrequent it may be used, would still be an emitter of GHGs and ~~will~~ should be considered in the NEPA analysis of new reactor applications.

Accounting for the complexity and uncertainty in attempting to estimate CO_2 and other GHG emissions, the NRC Staff principally focused on the use of the information for sound NEPA decisionmaking and the development of information commensurate with the importance of the impact. Consequently, to account for the Commission's direction to consider "other greenhouse gases," the NRC Staff is adopt~~ed~~ing the EPA practice of calculating "CO_2-equivalent emissions."

EPA maintains a GHG Equivalencies Calculator and updates it periodically based on the inventories of GHG emissions and sinks discussed above. The CO_2 equivalent factor is "... the ratio of carbon dioxide emissions to total emissions (including carbon dioxide, methane, and nitrous oxide, all expressed as carbon dioxide equivalents..." Therefore, the NRC Staff will ~~does~~ consider "... carbon dioxide and other greenhouse gas emissions in its environmental reviews for major licensing actions under the National Environmental Policy Act ..." for new reactor application reviews in the context of *CO_2 equivalent* emissions. The equivalent factor ~~does~~ changes based on updates of the inventories as the higher valued GWP GHG emissions are reduced. For example, the NRC Staff analysis of vehicle emissions is based on a factor of .971; while the factor was updated to a value of .977, the lower value used by the NRC Staff is bounding because it assumes a higher proportion of other (high-value GWP) GHGs to CO_2.

Environmental Consequence Analyses

The Commission directed that the NRC Staff's NEPA analysis for reactor applications should "... encompass emissions from the uranium fuel cycle as well as from construction and operation of the facility to be licensed." For new reactor EISs, the NRC Staff encompasses the

direction outlined by the Commission and will consider CO_2 and other GHG as CO_2 equivalent emissions in the following air quality analyses:

(1) the direct and indirect impacts of building the nuclear power plant, but not to the extent of considering the manufacturing of components;
(2) the direct and indirect impacts of operating the nuclear power plant;
(3) the indirect impacts of fuel cycle activities;
(4) the direct and indirect impacts of decommissioning the nuclear power plant;
(5) the incremental impacts of the proposed project within the analysis of cumulative impacts of other past, present and reasonably foreseeable activities;
(6) the comparison of the proposed project impacts at the proposed site to alternative energy source impacts that meet the purpose and need (i.e., baseload generation); and
(7) the comparison of the proposed project impacts at the proposed site to potential impacts at alternative sites in the context of cumulative impacts.

While a nuclear power plant may not combust hydrocarbons to produce electrical energy, the electrical energy that is used to produce and manage the nuclear fuel is highly likely to require the combustion of fossil fuels; this is to be considered in the analysis of the indirect CO_2 and GHG emissions associated with the operation of a nuclear power plant. The NRC has established a ~~unique~~ framework for assessing the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and management of low-level wastes and high-level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power plant. The environmental data for this framework is presented in Table S—3, Table of Uranium Fuel Cycle Environmental Data, in 10 CFR 51.51. Among the analyses that were performed to support these requirements, is the assessment of electrical energy needed by the fuel cycle to produce and manage the fuel so that it could be used to generate electrical energy. This framework is reported as a reference power level [i.e., reference reactor year of 1000 MW(e)] and the environmental costs would be scaled proportionately to the reference; e.g., a 500 MW(e) facility would have half of the environmental costs as the reference.

The NRC Staff reported its analysis of carbon monoxide (CO) emissions in Table S—3; it did not consider CO_2. Relying upon the convenient structure of Table S—3, i.e., environmental data scaled to a 1000 MW(e) reference model, the NRC Staff has developed a generic analysis of CO_2 and other GHG emissions, reported as CO_2 equivalent emissions, scaled to a 1000 MW(e) reference unit. Just as the NRC Staff includes Table S—3 in its EIS for a new reactor application, the NRC Staff is to include the results of its generic analysis as an Appendix in its EIS for a new reactor application; the Appendix is provided in Attachment 3. To account for two units, for example, certain values, such as those for construction-related activities, should be doubled, etc. To account for a higher power level or a different assumption regarding capacity factor, an appropriate multiplier should be use to scale the values up or down. The analysis is to be made unique to the project using project-specific adjustment factors without departure

from the underlying generic analysis; therefore, this manner of use is consistent with the use of Table S—3.

EIS Format and Content for CO_2 and GHG Discussions

In the following discussion, this supplemental guidance provides the level of detail and the manner of presentation of the 7 areas of analysis and their results, relying upon the information in Attachment 3 to be scaled by activity, number of units, power level, capacity factor, etc. considered to be appropriate for the NEPA review of the proposed action relative to CO_2 and GHG emissions and impacts. The affected sections, principally synthesized with the other air quality aspects of the review, are highlighted. In the section-by-section texts, there need not be a repetitive referral to CO_2 equivalent emission, however, the term CO_2 "footprint" is, in fact, the CO_2 equivalent as outlined in Attachment 3.

Prior to each of the discussions is the admonition that the NRC Staff can rely upon the generic analysis as a starting point; however, the unique aspects of each proposal must be reflected in the material included in the air quality sections of the EIS. For example, the discussions provided reflect a proposal of two new units at an existing site with two units in an area of attainment of the National Ambient Air Quality Standards with cumulative impacts involving a nearby power project that has not been completed (and, thus, not within the baseline). For "greenfield" sites, different mix of major emitters, different cooling ~~system~~ systems, different numbers of units proposed, etc., the unique attributes of the proposal (at times reflected in bracketed text) are to be reflected in the discussion of effects at the appropriate life-cycle stage (building the plant, operating the plant, decommissioning the plant, the fuel cycle impacts for the plant, etc.).

The discussions also include material that is not affected by consideration of CO_2 and other GHG emissions and is presented solely for the purposes of illustrating the location of affected text. Table values, either reported or computed, and citations from applicant or other source documents are to reflect appropriate information consistent with the proposal.

(1) Building related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when ~~reported~~ repeated~~ly~~. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may take place during this phase of the project.

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

4.7 Meteorological and Air Quality Impacts

...

4.7.1 Construction and Preconstruction Activities

Development activities at the ZZZZZZZZ site would result in temporary impacts on local air quality. Activities including earthmoving, concrete batch plant operation and vehicular traffic generate fugitive dust. In addition, emissions from these activities would contain carbon monoxide, oxides of nitrogen, and volatile organic compounds. As discussed in Section 2.9.2, FFFF County is an attainment area for all criteria pollutants for which National Ambient Air Quality Standards have been established (40 CFR citation). As a result, a conformity analysis for direct and indirect emissions is not required (40 CFR citation). [ENSURE THAT THE REGION IS IN ATTAINMENT AND NOT A MAINTENANCE OR NON-ATTAINMENT AREA; OTHERWISE, REFER TO CONFORMITY GUIDANCE].

Prior to beginning construction and preconstruction activities, AAAAAAAA stated that it would develop a "GGGG Plan" that implements HHHH requirements. This plan would describe the management controls and measures that AAAAAAAA intends to implement to minimize impacts of these activities on air quality. The plan would provide for site inspections and environmental inspection reports that document the results of the inspections (citation). Current policies and

(2) Operations related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when ~~reported~~ repeated~~ly~~. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may take place during this phase of the project.

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

5.7 Meteorological and Air Quality Impacts

...

5.7.1 Air Quality Impacts

Proposed Units MMMM and NNNN at the ZZZZZZZZ site would each have [PROJECT SPECIFIC NUMBER OF] standby diesel generators and [PROJECT SPECIFIC NUMBER OF] combustion turbine generators. These generators, each of which would be operated about 4 hours per month, [PROJECT SPECIFIC COOLING SYSTEM EMITTER, FOR EXAMPLE, "and the UHS cooling towers] would be the largest stationary sources of emission that could affect air quality. Table 5-IIII lists the expected annual emissions from these sources. There would be other minor emission sources onsite [FOR EXAMPLE, "such as diesel-driven fire water pumps"], but their impact on air quality would be negligible because of infrequent use. There would also be auxiliary boilers onsite. These boilers would not impact air quality because they would be electric [ENSURE THAT THIS IS ACCURATE]. AAAAAAAA has stated that air emissions sources would be managed in accordance with Federal, HHHH, and local air quality control laws and regulations. (citation)

In its ER, AAAAAAAA briefly addresses fugitive dust during plant operations. AAAAAAAA states that fugitive dust generated by the commuting work force would be minimized by [FOR

(3) Fuel cycle related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when ~~reported~~ repeated~~ly~~. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may take place during this phase of the project.

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

6.1 Fuel Cycle Impacts and Solid Waste Management

...

6.1.3 Fossil Fuel Impacts

Electric energy and process heat are required during various phases of the fuel cycle process. Electric energy is usually produced by the combustion of fossil fuel at conventional power plants. Electric energy associated with the fuel cycle represents about 5 percent of the annual electric power production of the reference 1000-MW(e) LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.4 percent of the electrical output from the model plant.

The largest source of carbon dioxide (CO_2) emissions associated with nuclear power is from the fuel cycle, not the operation of the plant, as indicated above and in Table S–3. The CO_2 emissions from the fuel cycle are about 5 percent of the CO_2 emissions from an equivalent fossil fuel-fired plant.

The largest use of electricity in the fuel cycle comes from the enrichment process. It appears that gas centrifuge (GC) technology is likely to eventually replace gaseous diffusion (GD) technology for uranium enrichment in the United States. The same amount of enrichment from

(4) Decommissioning related impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when ~~reported~~ repeated~~ly~~. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may take place during this phase of the project.

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

6.3 Decommissioning Impacts

At the end of the operating life of a power reactor, NRC regulations require that the facility undergo decommissioning. Decommissioning is the safe removal of a facility from service and the reduction of residual radioactivity to a level that permits termination of the NRC license. The regulations governing decommissioning of power reactors are found in 10 CFR 50.75.

An applicant for a COL is required to certify that sufficient funds will be available to assure radiological decommissioning at the end of power operations. As part of its COL application for the proposed Units MMMM and NNNN on the ZZZZZZZZ site, AAAAAAAA included a Decommissioning Funding Assurance Report (citation). AAAAAAAA would establish an external sinking funds account to accumulate funds for decommissioning.

Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in the *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement I, Regarding the Decommissioning of Nuclear Power Reactors* (GEIS-DECOM), NUREG-0586 Supplement 1 (NRC 2002). Environmental impacts of the DECON, SAFSTOR, and ENTOMB decommissioning methods are evaluated in the GEIS-DECOM. A COL applicant is not required to identify a decommissioning method at the time of the COL application. The NRC staff's

(5) Cumulative impacts

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when ~~reported~~ repeated~~ly~~. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may take place during this phase of the project.

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

7.6 Air Quality

...

7.6.1 Criteria Pollutants

...

7.6.2 Greenhouse Gas Emissions

As discussed in the state of the science report issued by the GCRP, it is the "... production and use of energy that is the primary cause of global warming, and in turn, climate change will eventually affect our production and use of energy. The vast majority of U.S. greenhouse gas emissions, about 87 percent, come from energy production and use. ... Approximately one third of the greenhouse gas emissions are the result of generating electricity and heat (Karl et al. 2009). This assessment is focused on greenhouse gas emissions.

Greenhouse gas emissions associated with building, operating, and decommissioning a nuclear power plant are addressed in Sections 4.7, 5.7.1, 6.1.3, and 6.3. The review team concluded that the atmospheric impacts of the emissions associated of each aspect of building, operating and decommissioning a single plant are minimal. The review team also concludes that the impacts of the combined emissions for the full plant life cycle are minimal.

(6) Alternative Energy Sources

Generic guidance and generic analysis is useful to ensure that the depth of analysis is appropriate for the importance of the issue and the documentation provides consistent meaning when ~~reported~~ repeated~~ly~~. Every new reactor application is to be considered a unique request for one or more particular reactors (and attendant infrastructure) of a specific design to be located at a particular location on a specific site and is planned to be operated in a specific manner. Certain analyses related to this aspect of CO_2 and other GHG emissions effects are to be adjusted to account for the reactor type, number of units, power level, capacity factor, schedule and types of activities to be undertaken as part of the project, the baseline environmental setting (affected area), and other activities that may affect the air quality resources that may take place during this phase of the project.

In the format and content presented below, the highlighted text reflects an acceptable example; however, in performing the analysis and reporting conclusions, the reviewer is required to account for the unique circumstances of the project. If the project circumstances differ significantly from the assumptions made in the Appendix and are outside the bounds of the generic analysis and the scaling adjustments are not adequate to analyze environmental effects, then the reviewer is expected to provide an alternative analysis and the technical bases in the EIS.

The recommended format and content should be similar to:

9.2 Energy Alternatives

...

9.2.2 Alternatives Requiring New Generating Capacity

...

9.2.2.1 Coal-Fired Generation

...

Air Quality

The impacts on air quality from coal-fired generation would vary considerably from those of nuclear generation because of emissions of SO_2, nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM), volatile organic compounds (VOCs), and hazardous air pollutants such as mercury and lead. In its environmental report (ER), AAAAAAAA assumed a coal-fired plant design that would minimize air emissions through a combination of boiler technology and post combustion pollutant removal. AAAAAAAA estimated that annual emissions for a supercritical pulverized coal-fired generation alternative using sub-bituminous coal would be approximately as follows (citation):

- SO_2 – 2900 tons/yr
- NO_X – 2000 tons/yr

approximately 6.9 million tons/yr of unregulated carbon dioxide emissions that could affect climate change (citation).

The combustion turbine portion of the combined-cycle plant would be subject to EPA's National Emission Standards for Hazardous Air Pollutants for Stationary Combustion Turbines (40 CFR 63) if the site is a major source of hazardous air pollutants. Major sources have the potential to emit 10 tons/yr or more of any single hazardous air pollutant or 25 tons/yr or more of any combination of hazardous air pollutants (40 CFR 63.6085(b)).

The review team assumes fugitive dust emissions from construction activities would be mitigated using BMPs, similar to mitigation discussed in Chapter 4 for proposed Units MMMM and NNNN. Such emissions would be temporary.

The impacts of emissions from a natural gas-fired power generation plant would be clearly noticeable, but would not be sufficient to destabilize air resources. Overall, the review team concludes that air quality impacts resulting from construction and operation of new natural gas-fired power generation at the ZZZZZZZZ site would be SMALL to MODERATE.

9.2.3 Other Alternatives

...

9.2.4 Combination of Alternatives

...

9.2.5 Summary Comparison of Alternatives

Table 9-4 provides a summary of the review team's environmental impact characterizations for constructing and operating new nuclear, coal-fired, and natural gas-fired combined-cycle generating units at the ZZZZZZZZ site. The combination of alternatives shown in Table 9-4 assumes siting of natural gas combined-cycle generating units at the ZZZZZZZZ site and siting of other generating units within AAAAAAAA's ROI.

The review team reviewed the available information on the environmental impacts of power generation alternatives compared to the building new nuclear units at the ZZZZZZZZ site. Based on this review, the review team concludes that, from an environmental perspective, none of the viable energy alternatives are clearly preferable to building a new baseload nuclear power generation plant at the ZZZZZZZZ site.

Because of current concerns related to greenhouse gas emissions, it is appropriate to specifically discuss the differences among the alternative energy sources regarding carbon dioxide (CO_2) emissions. The CO_2 emissions for the proposed action and energy generation alternatives are discussed in Sections 5.7.1, 9.2.2.1, 9.2.2.2, and 9.2.4. Table 9-5 summarizes the CO_2 emission estimates for a 40-year period for the alternatives considered by the review team to be viable for baseload power generation. These estimates are limited to the emissions from power generation and do not include CO_2 emissions for workforce transportation, building fuel cycle, or decommissioning. Among the viable energy generation alternatives, the CO_2 emissions for nuclear power are a small fraction of the emissions of the other viable energy generation alternatives. Even adding in the transportation emissions for the nuclear plant

Comment [jcm6]: I know we approved this before, but I would consider changing this intro. We are not discussing GHG emissions because of "current concerns related" to them. We are discussing them because they are a potential environmental impact and are within the scope of NEPA. In fact, I don't think you need the first sentence at all. (I think we made this change in Summer).

Appendix YYYY

Carbon Dioxide Footprint Estimates for a Reference 1000-MW(e) Reactor

The review team has estimated the carbon dioxide (CO_2) footprint of various activities associated with nuclear power plants. These activities include building, operating, and decommissioning a plant. The estimates include direct emission from the nuclear facility and indirect emissions from workforce transportation and the fuel cycle.

Construction equipment estimates listed in Table YYYY-1~~Table YYYY-1~~ are based on hours of equipment use estimated for a single nuclear power plant at a site requiring a moderate amount of terrain modification. Equipment usage for a multiple unit facility would be larger, but it is likely that it would not be a factor of 2 larger. A reasonable set of emission factors used to convert the hours of equipment use to CO_2 emissions are based on carbon monoxide emissions (UniStar 2007) scaled to CO_2 using a scaling factor of 165 tons of CO_2 per ton of CO. The scaling factor is based on emissions factors in Table 3.3-1 of AP-42 (EPA 1995). Equipment emissions estimates for decommissioning are one half of those for construction.

Table YYYY-1. Construction Equipment CO_2 Emissions (metric tons equivalent)

Equipment	Construction Total[a]	Decommissioning Total[b]
Earthwork and Dewatering	1.1×10^4	5.4×10^3
Batch Plant Operations	3.3×10^3	1.6×10^3
Concrete	4.0×10^3	2.0×10^3
Lifting and Rigging	5.4×10^3	2.7×10^3
Shop Fabrication	9.2×10^2	4.6×10^2
Warehouse Operations	1.4×10^3	6.8×10^2
Equipment Maintenance	9.6×10^3	4.8×10^3
Total[c]	3.5×10^4	1.8×10^4

(a) Based on hours of equipment usage over 7-year period
(b) Based on equipment usage over 10-year period
(c) Total not equal to the sum due to rounding

Workforce estimates are typical workforce numbers for new plant construction and operation based on estimates in various (COL) applications, and decommissioning workforce emissions estimates are based on decommissioning workforce estimates in NUREG-0586 S1, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, Supplement 1 Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002). A typical construction workforce averages about 2500 for a 7-year period with a peak workforce of about 4000. A typical operations workforce for the 40-year life of the plant is assumed to be about 400, and the decommissioning workforce during a decontamination and dismantling period of 10

Comment [jcm7]: Is the Corps joining us with this analysis? I don't see why they wouldn't, but just want to make sure the terminology is correct.

The review team assumed an average of 600 hrs of emergency diesel generator operation per year (for a total of 4 generators) and 200 hrs of station blackout diesel generator operation per year (total for 2 generators).

Given the various sources of CO_2 emissions discussed above, the review team estimates the total life CO_2 footprint for a reference 1000 MW(e) nuclear power plant to be about 18 million metric tons. The components of the footprint are summarized in Table YYYY-3~~Table YYYY-3~~. The uranium fuel cycle component of the footprint dominates all other components. It is directly related to power generated. As a result, it is reasonable to use reactor power to scale the footprint to larger reactors.

In closing, the review team considers the footprint estimated in Table YYYY-3~~Table YYYY-3~~ to be appropriately conservative. The CO_2 emissions estimates for the dominant component (uranium fuel cycle) are based on 30 year old enrichment technology assuming that the energy required for enrichment is provided by coal-fired generation. Different reasonable assumptions related to the source of energy used for enrichment or the enrichment technology ~~that would be just as reasonable~~ could lead to a significantly reduced footprint.

Table YYYY-3 Nuclear Power Plant Lifetime Carbon Dioxide Footprint

Source	Activity Duration (yr)	Total Emissions (metric tons)
Construction Equipment	7	3.5×10^{5}
Construction Workforce	7	1.5×10^{5}
Plant Operations	40	1.9×10^{6}
Operations Workforce	40	1.3×10^{6}
Uranium Fuel Cycle	40	1.4×10^{7}
Decommissioning Equipment	10	1.8×10^{5}
Decommissioning Workforce	10	1.7×10^{5}
SAFSTOR Workforce	40	1.3×10^{6}
TOTAL		1.5×10^{7}

Emissions estimates presented in the body of this EIS have been scaled to values that are appropriate for the proposed project. The uranium fuel cycle emissions have been scaled by reactor power using the scaling factor determined in Chapter 6 and by the number of reactors to be built. Plant operations emissions have been adjusted to represent the number of large CO_2 emissions sources (diesel generators, boilers, etc.) associated with the project. The workforce emissions estimates have been scaled to account for differences in workforce numbers and commuting distance. Finally, equipment emissions estimates have been scaled by estimated equipment usage. As can be seen in Table YYYY-3~~Table YYYY-3~~, only the scaling of the uranium fuel-cycle emissions estimates makes a significant difference in the total carbon footprint of the project.