CENTER for BIOLOGICAL DIVERSITY

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April 14, 2016

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Via Overnight Mail and electronic mail: blm_nv_bmdo_2016_OG_ea@blm.gov
Aldine Reynolds - aldinereynolds@blm.gov

RE: Center for Biological Diversity Protest of the June 2016 Competitive Oil and Gas Lease Sale, Battle Mountain District - DOI-BLM-NV-B000-2016-0002-EA

Dear Ms. Reynolds:

The Center for Biological Diversity (the "Center") hereby files this Protest of the Bureau of Land Management's ("BLM") planned June 2016 Competitive Oil and Gas Lease Sale and Environmental Assessment DOI-BLM-NV-B000-2016-0002-EA, pursuant to 43 C.F.R. § 3120.1-3. We formally protest the inclusion of each of the 42 parcels, covering 74,701.61 acres in the Battle Mountain District Office in Lander and Nye Counties:

NV-16-06-001	NV-16-06-025	NV-16-06-044
NV-16-06-003	NV-16-06-026	NV-16-06-045
NV-16-06-007	NV-16-06-027	NV-16-06-046
NV-16-06-008	NV-16-06-030	NV-16-06-047
NV-16-06-009	NV-16-06-031	NV-16-06-049
NV-16-06-010	NV-16-06-032	NV-16-06-050
NV-16-06-017	NV-16-06-033	NV-16-06-055
NV-16-06-018	NV-16-06-036	NV-16-06-056
NV-16-06-019	NV-16-06-037	NV-16-06-057
NV-16-06-020	NV-16-06-038	NV-16-06-058
NV-16-06-021	NV-16-06-040	NV-16-06-059
NV-16-06-022	NV-16-06-041	NV-16-06-060
NV-16-06-023	NV-16-06-042	NV-16-06-061
NV-16-06-024	NV-16-06-043	NV-16-06-072

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PROTEST

I. Protesting Party: Contact Information and Interests:

This Protest is filed on behalf of the Center for Biological Diversity, Progressive Leadership Alliance of Nevada, and Great Basin Resource Watch by:

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The Center is a non-profit environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center also works to reduce greenhouse gas emissions to protect biological diversity, our environment, and public health. The Center has over 991,000 members and on-line activists, including those living in Nevada who have visited these public lands in the Battle Mountain District ("BMD") for recreational, scientific, educational, and other pursuits and intend to continue to do so in the future, and are particularly interested in protecting the many native, imperiled, and sensitive species and their habitats that may be affected by the proposed oil and gas leasing.

The Progressive Leadership Alliance of Nevada ("PLAN") was founded in 1994 to bring together diverse and potentially competing organizations into one cohesive force for social and environmental justice in Nevada. Since 1994, PLAN has grown from 12 original founding member groups to a current membership of over 30 organizations.

Great Basin Resource Watch ("GBRW") was founded in 1994 by a coalition of environmental, Native American and scientific community representatives. GBRW is a regional environmental justice organization dedicated to protecting the health and well being of the land, air, water, wildlife, and human communities of the Great Basin from the adverse effects of resource extraction and use.

II. Statement of Reasons as to Why the Proposed Lease Sale Is Unlawful:

BLM's proposed decision to lease the parcels listed above is substantively and procedurally flawed for the reasons discussed below, as well as those discussed in our comments on the Preliminary Environmental Assessment (PEA) and in our scoping comments. This protest incorporates both of our previous letters by reference herein. The proposed lease sale is unlawful for the following additional reasons.

A. BLM's EA Violates the National Environmental Policy Act ("NEPA")

Despite NEPA's requirement that agencies undertake environmental analysis at the earliest possible time and prior to irretrievable commitment of resources, as well as our requests for an adequate environmental analysis, BLM "has chosen to move forward with the Oil and Gas Lease Sale EA" because BLM believes "the combination of stipulations consistent with current RMPs and parcels proposed for deferral afford sufficient protection to important wildlife and water resources."[1] With the exception of last year's amendments for greater sage-grouse management, however, these "current" RMPs, with which these stipulations are in accordance, date from 1986 and 1997 respectively.

With the exception of the September 2015 Nevada and Northeastern California Greater Sage-Grouse Record of Decision and Approved Resource Management Plan Amendment ("2015 GRSG RMP"), which covers only issues relating to greater sage-grouse, these RMPs have not been revised in decades and therefore do not address the emergence of new and significant information, including but not limited to that relating to the new and dangerous extraction methods of fracking and horizontal drilling, or the increased seismic risks from such extraction methods. Nor do the RMPs include any analysis of the foreseeable indirect impacts of greenhouse gas ("GHG") emissions from extraction, transport, and combustion of leasing federal fossil fuels on climate, public health, and wildlife resources.

i. It is Unlawful to Proceed with the Lease Sale without Undertaking a Site-Specific Environmental Assessment.

BLM's deferral of site-specific analysis until the APD stage is unlawful under NEPA, its implementing regulations, and legal precedents. Courts have repeatedly rejected BLM's claim that it is not required to conduct any site-specific environmental review until after the parcels are leased and a proposal is submitted by industry. See, e.g., Center for Biological Diversity & Sierra Club v. BLM, 937 F. Supp. 2d 1140, 1158 (N.D. Cal. 2013) (". . . BLM asserts the now-familiar argument that there is no controversy because any degradation of the local environment from fracking should be discussed, if ever, when there is a site-specific proposal. But the Ninth Circuit has specifically disapproved of this as a reason for holding off on preparing an EIS."); and

[1] EA, Appendix H, at 253.

ascertain the precise extent of the effects of mineral leasing ... is not, however, a justification for failing to estimate what those effects might be before irrevocably committing to the activity.").

BLM is required under NEPA to perform and disclose an analysis of environmental impacts of the 42 parcels offered for lease *before* there are any "irreversible and irretrievable commitments of resources." Center for Biological Diversity, 937 F. Supp. 2d at 1152 (citing Conner v. Burford, 848 F.2d 1441, 1446 (9th Cir. 1988) ("Our circuit has held that an EIS must be prepared *before* any irreversible and irretrievable commitment of resources.") (emphasis added). "[N]on-NSO leases, even if subject to substantial government regulation, do constitute an 'irretrievable commitment of resources.' As a result, unless the lease reserves to the agencies an '*absolute right* to deny exploitation of those resources,' the sale of [] non-NSO leases ... constitutes the go or no-go point where NEPA analysis becomes necessary." Id at 1152. In other words, the specific environmental effects of oil and gas leasing in the project area must be analyzed and disclosed now, at the leasing stage.

Rather than perform the environmental review as required, BLM tiers to the 1997 Tonopah and 1986 Shoshone-Eureka Resource Management Plans ("RMPs") and defers the site-specific analysis until after the parcels are leased. We stated in our previous comment letter, and cited to the proper case law on the matter, that this is unlawful. BLM's response to our comment reiterates the same grounds for this failure as in its draft EA:

> The action of leasing a parcel for potential Oil and Gas exploration does not involve any further action than the issuance of the lease itself. Should any of the lease parcels be pursued for exploration, a site-specific environmental document would be prepared to discuss the particular proposed action, and potential impacts as derived from the site specific information which would include conducting resource surveys/inventories (such as sensitive species, cultural, and water resources) for the potentially impacted areas.[2]

We commented that BLM is required to analyze human health and safety risks, and any seismic risks, posed by unconventional extraction techniques. BLM's response to nearly every issue we have raised has been the same:

> Hydraulic Fracturing is a specific development scenario that will be analyzed at their appropriate APD or project stage with the necessary NEPA document. The impacts to resources affected will also be analyzed under that site specific NEPA document. See page 12, Section 2.4.2 of the lease sale EA, for a general discussion of development in relations to leasing. Since development cannot be reasonably determined at the leasing stage, any site specific impacts cannot realistically be analyzed at this time. At the time of APD proposal, should the parcels be sold and development proposed, an analysis of these resources will be completed.

EA, Appendix H, at 252.

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[2] EA, Appendix H, at 248.

This is the same approach the court rejected in Center for Biological Diversity & Sierra Club v. BLM, 937 F. Supp. 2d 1140, 1152 (N.D. Cal. 2013). In that case, BLM attempted to defer NEPA analysis of hydraulic fracturing ("fracking") on the parcels at issue until it received a site-specific proposal, because the exact scope and extent of drilling that would involve fracking was unknown. The district court held BLM's "unreasonable lack of consideration of how fracking could impact development of the disputed parcels went on to unreasonably distort BLM's assessment," and explained:

> "[T]he basic thrust" of NEPA is to require that agencies consider the range of possible environmental effects before resources are committed and the effects are fully known. "Reasonable forecasting and speculation is thus implicit in NEPA, and we must reject any attempt by agencies to shirk their responsibilities under NEPA by labeling any and all discussion of future environmental effects as 'crystal ball inquiry.'"

Center for Biological Diversity, 937 F. Supp. 2d at 1157 (citing City of Davis v. Coleman, 521 F.2d 661, 676 (9th Cir. 1975)).

NEPA requires that "assessment of all 'reasonably foreseeable' impacts must occur at the earliest practicable point, and must take place before an 'irretrievable commitment of resources' is made." N.M. ex rel. Richardson v. BLM, 565 F.3d 683, 717-18 (10th Cir. 2009) (citing 42 U.S.C. § 4332(2)(C)(v)); compare with Center for Biological Diversity, 937 F. Supp. 2d at 1152 (N.D. Cal. 2013) ("Agencies are required to conduct this review at the 'earliest possible time' to allow for proper consideration of environmental values. . . A review should be prepared at a time when the decisionmakers 'retain a maximum range of options.'"). In Richardson, BLM argued there also that it was not required to conduct any site-specific environmental reviews until the issuance of an APD. The court looked to the Ninth and D.C. Circuits in concluding that "NEPA requires BLM to conduct site-specific analysis before the leasing stage." Richardson, 565 F.3d at 688. Richardson then offered a two-part test to determine whether NEPA has been satisfied: First we must ask whether the lease constitutes an "irretrievable commitment of resources." The Tenth Circuit, again citing to the Ninth and D.C. Circuits, concluded that issuing an oil and gas lease without an NSO stipulation constitutes such a commitment. Second, the agency must ask whether all "foreseeable impacts of leasing" have been taken into account before leasing can proceed. Id. Given the utter lack of any site-specific review of the present surface-occupancy-permitting parcels, for this lease sale, such impacts have not been taken into account.

BLM must take a hard look at the specific parcels that it is offering for oil and gas leasing, and the foreseeable impacts to the resources on these parcels. BLM insists, however, on postponing any such analysis until it has already signed over drilling rights and is unable to preclude all surface disturbing activities to prevent critical environmental impacts that may arise after a proper NEPA analysis.

ii. BLM Failed to Issue a Finding of "No Significant Environmental Impact" or any Convincing Statement of Reasons as to why the Project's Impacts are Insignificant

As the time for NEPA analysis was triggered by the proposal for the sale of the lease, BLM had to analyze whether the proposal might have significant environmental impact. Center for Biological Diversity, 937 F. Supp. 2d at 1153. If BLM finds based on the EA that the proposed actions will not significantly affect the environment, BLM can issue a finding of No Significant Impact ("FONSI") in lieu of the EIS. Id. The FONSI must contain a "convincing statement of reasons" why the project's impacts are insignificant. Id. "The statement of reasons is crucial to determining whether the agency took a 'hard look' at the potential environmental impact of a project." Id. Standing together, the FONSI and EA must be "sufficient to establish the reasonableness of th[e] decision not to prepare an EIS." Id.

BLM never issued a FONSI or any convincing statement of reasons as to why the project's impacts are insignificant. The only mention of such is in BLM's response to our comments, in Appendix H of the EA, that "the BLM determined that the proposed action with the lease stipulations and lease notices identified in the EA is not a major federal action and will not significantly affect the quality of the human environment, individually or cumulatively with other actions in the general area. No environmental effects meet the definition of significance in context or intensity as described in 40 CFR 1508.27. Therefore, preparation of an Environmental Impact Statement is not required per section 102(2)(c) of the National Environmental Policy Act."[3]

In evaluating the significance of the impact of the proposed action, the agency must consider both the context of the action as well as the intensity. The several contexts in which the significance of an action must be analyzed includes: "society as a whole (human, national), the affected region, the affected interests, and the locality." 40 C.F.R. § 1508.27. For site-specific actions, significance usually depends on the impact of the action on the locale, id., but in light of the recent Paris Agreement, it also depends on the impact on the world as a whole. Thus, to determine the significance of the action, BLM needed to look at not only the environmental impacts on the area to be leased, but also the analysis of the cumulative effects of oil and gas leasing on climate change.

> Intensity is determined by scrutinizing the ten factors described in 40 C.F.R. § 1508.27:
>
> (1) Impacts that may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial.
>
> (2) The degree to which the proposed action affects public health or safety.
>
> (3) Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.
>
> (4) The degree to which the effects on the quality of the human environment are likely to be highly controversial.

[3] EA, Appendix H, at 247.

(5) The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

(6) The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

(7) Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

(8) The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

(9) The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

(10) Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.

The presence of any *one* of these factors may be sufficient to require an EIS. Id. As we explained in our previous comment letter, several of these factors are implicated in the lease sale. The one we highlight here in this protest, as an example of BLM's erroneous conclusion that the leases would have no significant impact, is the clear "controversy" regarding the nature of the drilling to occur on the leases and the potential impacts drilling would impose on air, water, soil, and wildlife resources among other things. A proposal is highly controversial when "substantial questions are raised as to whether a project... may cause significant degradation" of a resource. Northwest Envtl. Def. Ctr. v. Bonneville Power Admin., 117 F.3d 1520, 1536 (9th Cir. 1997). A substantial dispute may concern the "size, nature, or effect" of the action. Blue Mts. Biodiversity Project v. Blackwood, 161 F.3d 1208, 1212 (9th Cir. 1998).

We requested in scoping, and again in commenting on the PEA, that BLM take a "hard look" at the potential impacts that leasing these parcels would have on water resources especially. The EA admits that "Hydraulic Fracturing is one of these methods that may be reasonably foreseeable for leases proposed for this sale"[4] and provides very general information on the controversial method, yet failed to provide any analysis of the impacts that the use of such methods in the areas to be leased would have on the water resources specific to that area. BLM's reason for providing "generic," rather than site-specific, analysis of the environmental

[4] EA at 23.

consequences to water resources is that it "cannot determine exactly where a well or wells may be drilled or what technology may be used to drill and produce wells, so the impacts listed below are generic, rather than site-specific. Subsequent development of a lease may result in long-and short term alterations to the hydrologic regime depending upon the location and intensity of development. Clearing, grading, and soil stockpiling activities associated with exploration and development actions could alter short term overland flow and natural groundwater recharge patterns."[5]

As we explained before, unconventional extraction methods such as hydraulic fracturing and horizontal drilling (hereinafter referred to as "fracking") requires the use of tremendous amounts of freshwater. Typically between 2 and 5.6 million gallons of water are required to frack each well.[6] These volumes far exceed the amounts used in conventional natural gas development.[7] Such high levels of water use are unsustainable. Nevada is the driest state in the Union, and water is often in short supply, which makes this a highly controversial matter. Water used in large quantities may lead to several kinds of critically harmful environmental impacts. The extraction of water for fracking can, for example, lower the water table, affect biodiversity, harm local ecosystems, and reduce water available to communities.[8]

However, BLM's generic analysis resulted in the arbitrary conclusion that although "potential exploration and development would likely result in additional water diversion" and "surface water quality could be affected by development," the "incremental increase in these impacts is small when compared to the level of impacts that already exist in the sub-basins as described above in the Affected Environment section. With the relatively small amount of surface disturbance associated with the RFD and through the implementation of site-specific mitigation measures, COAs, and BMPs, the incremental cumulative impacts on water quality and quantity, in combination with past and present actions and RFFAs, would not be significant. This has been confirmed from past experience."[9]

The claim that "the incremental increase in these impacts is small when compared to the level of impacts that already exist in the sub-basins" is not a convincing basis for a finding of no significant impact. The argument that greater impacts already exist does not negate the potential impacts of leasing the parcels at issue.

Furthermore, "the relatively small amount of surface disturbance associated with the RFD" is based on "historic information" which apparently does not take into account the recent sharp increase in leasing nominations and initial instances of fracking use in Nevada.[10] BLM

[5] EA at 51.
[6] U.S. Government Accountability Office, Unconventional Oil and Gas Development – Key Environmental and Public Health Requirements at 17, GAO 12-874 (2012), http://www.gao.gov/products/GAO-12-874.
[7] *See* Clark, Corrie E. et al., Life Cycle Water Consumption for Shale Gas and Conventional Natural Gas, Environ. Sci. Technol., 2013, 47 (20), pp 11829–11836, abstract available at http://pubs.acs.org/doi/abs/10.1021/es4013855.
[8] International Energy Agency, Golden Rules for the Golden Age of Gas at 31-32 (2012).
[9] EA at 105.
[10] *See* BLM Nevada, 2015 and 2016 Expressions of Interest, *available at* *http://www.blm.gov/nv/st/en/prog/minerals/leasable_minerals/oil__gas/oil_and_gas_leasing*.html; Jeff DeLong, "Fracking Hits Home in Nevada," *Reno Gazette-Journal* (April 15, 2014)

should have considered in its EA the increased industry interest in Nevada oil and gas, and the potential for drilling levels to increase, should oil prices rise or well stimulation techniques change the production potential of Nevada hydrocarbon-bearing formations. By methods which are unclear, BLM approximates in the RFD developed for this lease sale EA a maximum of 25 "exploration wells" drilled within the parcels in the Battle Mountain District and no "production wells."[11] However, this is nonsense as there are no such things as exploration-only permits that preclude production. BLM does not sell leases that are limited to exploration. The leases for auction are for oil and gas production. BLM's conclusion that there are no significant impacts is erroneous or otherwise arbitrary and capricious, which shows that BLM failed to take a hard look at the issues that NEPA requires.

iii. BLM Violated its Statutory Duty to Prepare an Environmental Impact Statement ("EIS") under NEPA.

"[T]o prevail on a claim that the agency violated its statutory duty to prepare an EIS, a plaintiff need not show that significant effects will in fact occur. It is enough for the plaintiff to raise substantial questions whether a project may have a significant effect on the environment." Ctr. for Biological Diversity & Sierra Club v. BLM, 937 F. Supp. 2d 1140, 1154 (N.D. Cal. 2013). The significance of the impact of the proposed action depends on both the context of the action as well as the intensity. Id.

We noted in our comments on the PEA the environmental harms that may result from unconventional methods used by the industry to extract oil and gas, including hydraulic fracturing and horizontal drilling, as well as concerns relating to climate change. BLM has asserted either the issues went beyond the scope of the EA or that BLM was not required to look at these issues until it received an APD proposal from the industry. As we have already explained above, this is unlawful. The impact of fracking alone raises substantial questions on whether the proposed project may have significant effects on the environment. Additionally, we raised several highly controversial issues in our comments on the PEA which BLM still has not considered, and which we expand upon below. BLM therefore has a duty to prepare an EIS on the issues required by NEPA, including the issues we raised in scoping and in commenting on the EA.

B. BLM Failed to Take a Hard Look at any of the Potential Impacts of the Proposed Action Raised in our February 5, 2016 Comment Letter

As BLM has not provided any environmental review of the parcels at issue or any site-specific analysis of the potential environmental impacts from the proposed action, we incorporate by reference herein our comments on the PEA, which discuss BLM's failure to take a hard look at the foreseeable impacts from the lease sale, oil and gas development, and the use of hydraulic fracking technologies. In particular, BLM failed to take a hard look at the potential impacts of the proposed action on water resources, air quality, climate change, human health and safety, seismicity, and sensitive species of plants and wildlife. We expand upon the following issues:

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[11] EA at 34.

i. BLM does not Consider Potential Impacts to Greater Sage-Grouse Populations and Habitat in the EA

The greater sage-grouse is a BLM sensitive species. In September 2015, all BLM resource management plans for Nevada and Northeastern California, including Battle Mountain, were amended as part of an effort to secure adequate regulatory mechanisms to prevent the listing of the greater sage-grouse under the Endangered Species Act.[12] Because oil and gas development and associated infrastructure has numerous well-documented adverse effects on GRSG survival, breeding, and behavior, these plan amendments prescribe management measures for BLM-permitted activities, including oil and gas leasing, within various categories (Sagebrush Focal Areas ("SFAs"), Priority Habitat Management Areas ("PHMAs"), General Habitat Management Areas ("GHMAs") and Other Habitat Management Areas ("OHMAs")) of sage-grouse habitat,[13] and prescribed stipulations for all new fluid mineral leases within those designated habitats.[14]

Given the significance of the potential impacts that oil and gas development could have on the species, proper investigation here is crucial. BLM is required under NEPA to collect data particular to the region affected by the leases.[15] Summarizing general data about greater sage-grouse before dismissing the issue as insignificant does not provide the "hard look" that NEPA requires.[16] We pointed out in our previous comment letter that the Preliminary EA contained only the most cursory mention of the presence of greater sage-grouse within the Battle Mountain District and requested discussion of the impacts of oil and gas development on the species, its behavior, survival, and persistence.[17] The Final EA, however, includes three sentences providing only very general information about where greater sage-grouse "are known to occur," and no discussion of the specific concerns relating to the species in the areas to be leased here. BLM then concludes that:

> The proposed action is also in conformance with the 2015 Nevada and Northeastern California Greater Sage-Grouse Approved Resource Management Plan Amendment (ARMPA). The management direction for mineral resources under the heading Unleased Fluid Minerals states, MD MR 1: Review Objective SSS 4 and apply MDs SSS 1 through SSS 4 when reviewing and analyzing projects and activities proposed in GRSG habitat.
>
> Specifically, it is in conformance with MD SSS-1:

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[12] See BLM, Nevada and Northeastern California Greater Sage-Grouse Approved Resource Management Plan Amendment (Sept. 2015) ("NV/NE CA RMPA").
[13] NV/NE CA RMPA at 2-29 to 2-30.
[14] NV/NE CA RMPA Appendix G.
[15] See Center. for Biological Diversity, 937 F. Supp. 2d at 1159 (Preparation of an EIS "is mandated where uncertainty may be resolved by further collection of data, or where collection of such data may prevent speculation on potential effects.").
[16] Id. (Held BLM did not provide the "hard look" that NEPA requires because it "never collected any data particular to the region affected by the leases, instead opting to summarize general data.").
[17] Center for Biological Diversity EA Comments for the June 2016 Competitive Oil and Gas Lease Sale, Battle Mountain District, February 5, 2016.

"In PHMAs and GHMAs, work with the proponent/applicant, whether in accordance with a valid existing right or not, and use the following screening criteria to avoid effects of the proposed human activity on GRSG habitat."[18]

It is not sufficient to merely state that the proposed action is in conformance with an RMP that covers two states. Even assuming for the sake of argument that the plan amendments may, across the entire two-state region, mitigate some adverse impacts to greater sage-grouse, they do not, and cannot, assess the immediate impacts on local, site-dependent breeding populations from a particular set of leases.

The EA could have, and should have, provided site-specific analysis based on information regarding the greater-sage population and habitat in or surrounding the area to be leased that may be affected by the oil and gas development on these parcels.[19] It could also have disclosed the substantive science regarding effects of oil and gas development on greater sage-grouse, including discussion of the need for buffers around leks, nesting areas, and winter range. BLM admits that the parcels are within 3.1 miles of leks, and then vaguely promises that BLM will "work with the proponent/applicant" but provides absolutely no information as to what that, practically speaking, entails. A vague assertion that BLM will "work with the proponent/applicant" provides neither a clear and binding lease condition, nor any reasonable basis for assessing the localized impacts of infrastructure and activity on particular lease parcels. Although it is possible that some lease parcels might contain topographic or other features that could allow for mitigation of adverse affects through particularized siting, BLM cannot reasonably make such a determination because the EA does not take a look at any of these site-specific considerations.

BLM's conclusion of no significant impact is based on the unreasonable lack of consideration of how fracking could impact the population and habitat of the GRSG on and surrounding the parcels that are being offered for lease sale, and is therefore arbitrary and capricious.

ii. BLM does not Consider Potential Impacts to Any of the Other Sensitive Species in the EA

In our previous comment letter, we identified in particular several sensitive species occurring on the parcels for lease, including:

- Big Smokey Valley speckled dace, which occur on Parcels NV-16-06-031, -032, and -033;
- Big Smokey Valley tui chub, which occur on Parcels NV-16-06-003, -031, -032, and -033;
- Big Smokey Valley wood nymph, which occur on Parcels NV-16-06-024, -030, and -031;
- Currant milkvetch, which occur on Parcel NV-16-06-072;
- Pallid skipper, which occur on Parcels NV-16-06-030 and -031;

[18] EA at 12.
[19] See Center for Biological Diversity, Map of Greater Sage-Grouse Habitat within 3.1 Miles of Lease Sale Parcels.

- Beatley buckwheat, which occur on the foothills leading out of marshy areas to the mountain bases

All of these species are characterized by the Nevada Natural Heritage Program as "critically imperiled and especially vulnerable to extinction or extirpation due to extreme rarity, imminent threats." As such they should be surveyed for before any ground disturbing activities and protected with appropriate stipulations.

Neither the Final EA nor BLM's response to our comments address our concerns raised with respect to these species. BLM failed to provide any analysis of the foreseeable impacts to these populations or wildlife resources. Instead, BLM argues in its response that:

> Special Status and Sensitive Species were addressed in both chapter 3 of the EA and also in Appendix B, where there are stipulations to protect the species in the event a parcel is leased and an APD is received.
>
> Issuance of an oil and gas lease does not authorize operations on the lease. The possibility or nature of lease development operations cannot be reasonably determined at the leasing stage, nor can impacts realistically be analyzed in more detail at this time. If a lease is issued and development proposed, additional permits will be submitted to the BLM and analyzed in a site specific NEPA document, which will address resource concerns. The impacts to local communities will be analyzed at that time.

EA, Appendix H, at 251

Chapter 3 of the EA and Appendix B do not contain any convincing statement of reasons as to why the potential impacts are insignificant. Rather BLM's argument assumes that the act of leasing is merely administrative paperwork and that BLM is not required to address any resource concerns until the lease is already issued and development proposed. The stipulations BLM relies upon to protect these imperiled species will not allow BLM to deny drilling rights. The courts have already explained this. See Center for Biological Diversity, 937 F. Supp. 2d at 1153 ("[A]lthough BLM retains authority to enforce existing laws to protect T&E species, BLM does not retain absolute authority to preclude any surface disturbing activities that do not protect T&E species.").

As we explained in prior comments, the expansion of oil and gas development activities will harm wildlife through habitat destruction and fragmentation, stress and displacement caused by development-related activities (e.g., construction and operation activities, truck traffic, noise and light pollution), surface water depletion leading to low stream flows, water and air contamination, introduction of invasive species, and climate change. These harms can result in negative health effects and population declines. Studies and reports of observed impacts to wildlife from unconventional oil and gas extraction activities are summarized in the Center's "Review of Impacts of Oil and Gas Exploration and Development on Wildlife," submitted prior.[20] Because the allowance of destructive oil and gas extraction runs contrary to BLM's policy of managing resources in a manner that will protect the quality of ecological values and provide habitat for wildlife,[21] a no-fracking alternative minimizing industrial development and its harmful effects on wildlife must be considered. At the very least, BLM must take a hard look at the imminent threats to the critically imperiled species in the area before dismissing the proposed action as "not a significant federal action."

iii. BLM Must Consider Long-Term Impacts of Oil Infrastructure on Pronghorn

The final EA improperly discounts foreseeable impacts to pronghorn antelope found in the lease area by erroneously assuming both minimal development and a lack of long-term behavioral and population impacts from the oil infrastructure and continuing activity that would remain in place following initial drilling. The EA asserts:

> Direct and indirect effects on specific wildlife species cannot be determined until site specific project proposals are analyzed at the Application for Permit to Drill (APD) stage of development. In general, mammals such as pronghorn antelope would avoid and move away from oil drilling activities. Based on the Reasonable Future Development scenario, oil and gas exploration and production activities are expected to disturb a total of 100 acres over the course of a ten year period. These activities are temporary in nature and wildlife would move back into the area after successful reclamation.[22]

These assumptions are untenable for several significant reasons. First, BLM ignores the well-established scientific evidence that pronghorn avoidance of oil and gas activity and infrastructure can have effects on migration, seasonal nutrition, and reproductive success. For example, the Jonah and PAPA (Pinedale Anticline Project Area) gas fields occur in the wintering home range of the pronghorn — the country's longest terrestrial migrant. The habitat choices of female pronghorn demonstrated a fivefold decrease in the use of high-quality habitat patches and the abandonment of areas with the greatest habitat loss and industrial footprint. These results indicate a decline in the availability of high-quality habitat for pronghorn due to the behavioral impacts of habitat alteration associated with gas field development.[23]

Second, BLM unreasonably assumes, without citing any evidence, that "successful reclamation" of pronghorn habitats is both possible and assured. The EA asserts that "Reclamation includes removal of all manmade objects and restoration of surface disturbance."[24] It offers no specific reclamation standards or evidence, however, that such reclamation can or will actually restore

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[20] *See* Center for Biological Diversity, Review of Impacts of Oil and Gas Exploration and Development on Wildlife (June 20, 2015). This review presents the findings of numerous studies and reports on the impacts of hydraulic fracturing on wildlife.
[21] 43 U.S. Code § 1701(a)(8).
[22] EA at 47.
[23] Beckmann, J.P., K. Murray, R.G. Seidler, and J. Berger. (2012). Human-mediated shifts in animal habitat use: Sequential changes in pronghorn use of a natural gas field in Greater Yellowstone. Biological Conservation 147(1): 222-3
[24] EA at 24.

usable vegetation or habitat function for wildlife species including pronghorn. Moreover, the EA's claims regarding reclamation stem from the untenable assumption, discussed above, that leasing will result only in 20 exploratory wells and no-long term production. Because the act of leasing authorizes much higher levels of development, for a period as long as the wells are held by production, BLM must consider the full effects, including the long-term impacts of only partial reclamation should lessees elect to operate producing wells.

C. BLM Must End All New Fossil Fuel Leasing and Hydraulic Fracturing.

BLM argues that it is required by law to "consider" leasing areas that have been nominated for leasing if leasing is in conformance with the BLM LUP. However, as BLM states and we agree, "[i]f there are known resource conflicts that cannot be addressed using a stipulation, then the parcel may be deferred until the known resource conflict is resolved." In this case, BLM has already demonstrated and exercised its authority to ban leasing by permanently removing from future lease sales several parcels due to resource conflicts.[25] In our comment letter we raised several more conflicts that require these parcels be deferred until such conflicts are resolved.

For one, and as we have already explained, climate change is a problem of global proportions resulting from the cumulative greenhouse gas emissions of countless individual sources. A comprehensive look at the impacts of fossil fuel extraction, and especially fracking, across all of the planning areas affected by the leases in updated RMPs is absolutely necessary. BLM has *never* thoroughly considered the cumulative climate change impacts of *all* potential fossil fuel extraction and fracking (1) within each of the planning areas, (2) across the state, and (3) across all public lands. Proceeding with new leasing proposals *ad hoc* in the absence of a comprehensive plan that addresses climate change and fracking is premature and risks irreversible damage before the agency and public have had the opportunity to weigh the full costs of oil and gas and other fossil fuel extraction and consider necessary limits on such activities. Therefore BLM must defer all new leasing at least until the issue is adequately analyzed in a programmatic review of all U.S. fossil fuel leasing, or at least within amended RMPs. BLM's argument, in response to our comments, that a permanent cessation of leasing would require RMP amendment beyond the scope of the leasing decision ignores the established principle that agencies are obligated to consider all reasonable alternatives. Considering a no-leasing alternative would allow the agency to preserve the status quo and avoid irretrievable commitment of resources until such time as it can consider the regional and national impacts of fossil fuel leasing and undertake appropriate land use plan amendments or other actions.

i. BLM Must Limit Greenhouse Gas Emissions By Keeping Federal Fossil Fuels In the Ground

Expansion of fossil fuel production will substantially increase the volume of greenhouse gases emitted into the atmosphere and jeopardize the environment and the health and well being of future generations. BLM's mandate to ensure "harmonious and coordinated management of the various resources *without permanent impairment of the productivity of the land and the*

[25] EA at 14.

quality of the environment" requires BLM to limit the climate change effects of its actions.[26] Keeping all unleased fossil fuels in the ground and banning fracking and other unconventional well stimulation methods would lock away millions of tons of greenhouse gas pollution and limit the destructive effects of these practices.

A ban on new fossil fuel leasing and fracking is necessary to meet the U.S.'s greenhouse gas reduction commitments. On December 12, 2015, 197 nation-state and supra-national organization parties meeting in Paris at the 2015 United Nations Framework Convention on Climate Change Conference of the Parties consented to an agreement (Paris Agreement) committing its parties to take action so as to avoid dangerous climate change.[27] As the Paris Agreement opens for signature in April 2016[28] and the United States is expected to sign the treaty[29] as a legally binding instrument through executive agreement,[30] the Paris Agreement commits the United States to critical goals—both binding and aspirational—that mandate bold action on the United States' domestic policy to rapidly reduce greenhouse gas emissions.[31]

The United States and other parties to the Paris Agreement recognized "the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge."[32] The Paris Agreement articulates the practical steps necessary to obtain its goals: parties including the United States have to "reach global peaking of greenhouse gas emissions *as soon as possible* . . . and to *undertake rapid reductions* thereafter in accordance *with best available science*,"[33] imperatively commanding that developed countries specifically "should continue taking the lead by undertaking economy-wide absolute emission reduction targets"[34] and that such actions reflect the "highest possible ambition."[35]

The Paris Agreement codifies the international consensus that climate change is an "urgent threat" of global concern,[36] and commits all signatories to achieving a set of global goals. Importantly, the Paris Agreement commits all signatories to an articulated target to hold the long-term global average temperature "to *well below 2°C* above pre-industrial levels and to *pursue efforts to limit the temperature increase to 1.5°C* above pre-industrial levels"[37] (emphasis added).

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[26] *See* 43 U.S.C. §§ 1701(a)(7), 1702(c), 1712(c)(1), 1732(a) (emphasis added); *see also id.* § 1732(b) (directing Secretary to take any action to "prevent unnecessary or undue degradation" of the public lands).
[27] U.N. Framework Convention on Climate Change, Paris Agreement ("Paris Agreement"), Art. 2.
[28] Paris Agreement, Art. 20(1).
[29] For purposes of this Petition, the term "treaty" refers to its international law definition, whereby a treaty is "an international law agreement concluded between states in written form and governed by international law" pursuant to article 2(a) of the Vienna Convention on the Law of Treaties, 1155 U.N.T.S. 331, 8 I.L.M. 679 (Jan. 27, 1980).
[30] *See* U.S. Department of State, Background Briefing on the Paris Climate Agreement, (Dec. 12, 2015), http://www.state.gov/ r/pa/prs/ps/2015/12/250592.htm.
[31] Although not every provision in the Paris Agreement is legally binding or enforceable, the U.S. and all parties are committed to perform the treaty commitments in good faith under the international legal principle of *pacta sunt servanda* ("agreements must be kept"). Vienna Convention on the Law of Treaties, Art. 26.
[32] *Id.*, Recitals.
[33] *Id.*, Art. 4(1).
[34] *Id.*, Art. 4(4).
[35] *Id.*, Art. 4(3).
[36] *Id.*, Recitals.
[37] *Id.*, Art. 2.

In light of the severe threats posed by even limited global warming, the Paris Agreement established the international goal of limiting global warming to 1.5°C above pre-industrial levels in order to "prevent dangerous anthropogenic interference with the climate system," as set forth in the UNFCCC, a treaty which the United States has ratified and to which it is bound.[38] The Paris consensus on a 1.5°C warming goal reflects the findings of the IPCC and numerous scientific studies that indicate that 2°C warming would exceed thresholds for severe, extremely dangerous, and potentially irreversible impacts.[39] Those impacts include increased global food and water insecurity, the inundation of coastal regions and small island nations by sea level rise and increasing storm surge, complete loss of Arctic summer sea ice, irreversible melting of the Greenland ice sheet, increased extinction risk for at least 20-30% of species on Earth, dieback of the Amazon rainforest, and "rapid and terminal" declines of coral reefs worldwide.[40] As scientists noted, the impacts associated with 2°C temperature rise have been "revised upwards, sufficiently so that 2°C now more appropriately represents the threshold between 'dangerous' and 'extremely dangerous' climate change."[41] Consequently, a target of 1.5 °C or less temperature rise is now seen as essential to avoid dangerous climate change and has largely supplanted the 2°C target that had been the focus of most climate literature until recently.

Immediate and aggressive greenhouse gas emissions reductions are necessary to keep warming below a 1.5° or 2°C rise above pre-industrial levels. Put simply, there is only a finite amount of CO_2 that can be released into the atmosphere without rendering the goal of meeting the 1.5°C target virtually impossible. A slightly larger amount could be burned before meeting a 2°C became an impossibility. Globally, fossil fuel reserves, if all were extracted and burned, would release enough CO_2 to exceed this limit several times over.[42]

The question of what amount of fossil fuels can be extracted and burned without negating a realistic chance of meeting a 1.5 or 2°C target is relatively easy to answer, even if the answer is

[38] *See* U.N. Framework Convention on Climate Change, Cancun Agreement. Available at http://cancun.unfccc.int/ (last visited Jan 7, 2015); United Nations Framework Convention on Climate Change, Copenhagen Accord. Available at http://unfccc.int/meetings/copenhagen_dec_2009/items/5262.php (last accessed Jan 7, 2015). The United States Senate ratified the UNFCC on October 7, 1992. *See* https://www.congress.gov/treaty-document/102nd-congress/38.

[39] *See* Paris Agreement, Art. 2(1)(a); U); U.N. Framework Convention on Climate Change, Subsidiary Body for Scientific and Technical Advice, Report on the structured expert dialogue on the 2013-15 review, No. FCCC/SB/2015/INF.1 at 15-16 (June 2015);IPCC AR5 Synthesis Report at 65 & Box 2.4.

[40] *See* Jones, C. et al, Committed Terrestrial Ecosystem Changes due to Climate Change, 2 Nature Geoscience 484, 484–487 (2009); Smith, J. B. *et al.*, Assessing Dangerous Climate Change Through an Update of the Intergovernmental Panel on Climate Change (IPCC) 'Reasons for Concern', 106 Proceedings of the National Academy of Sciences of the United States of America 4133, 4133–37 (2009); Veron, J. E. N. *et al.*, The Coral Reef Crisis: The Critical Importance of <350 ppm CO2, 58 Marine Pollution Bulletin 1428, 1428–36, (2009); Warren, R. J. *et al.*, Increasing Impacts of Climate Change Upon Ecosystems with Increasing Global Mean Temperature Rise, 106 Climatic Change 141–77 (2011); Hare, W. W. *et al.*, Climate Hotspots: Key Vulnerable Regions, Climate Change and Limits to Warming, 11 Regional Environmental Change 1, 1–13 (2011); Frieler, K. M. *et al.*, Limiting Global Warming to 2°C is Unlikely to Save Most Coral Reefs, Nature Climate Change, Published Online (2013) doi: 10.1038/NCLIMATE1674; M. Schaeffer *et al.*, Adequacy and Feasibility of the 1.5°C Long-Term Global Limit, Climate Analytics (2013).

[41] Anderson, K. and A. Bows, Beyond 'Dangerous' Climate Change: Emission Scenarios for a New World, 369 Philosophical Transactions, Series A, Mathematical, Physical, and Engineering Sciences 20, 20–44 (2011).

[42] Cimons, M., Keep It In the Ground 6 (Sierra Club *et al.*, Jan. 25, 2016).

framed in probabilities and ranges. The IPCC Fifth Assessment Report and other expert assessments have established global carbon budgets, or the total amount of remaining carbon that can be burned while maintain some probability of staying below a given temperature target. According to the IPCC, total cumulative anthropogenic emissions of CO_2 must remain below about 1,000 gigatonnes ($GtCO_2$) from 2011 onward for a 66% probability of limiting warming to 2°C above pre-industrial levels.[43] Given more than 100 $GtCO_2$ have been emitted since 2011,[44] the remaining portion of the budget under this scenario is well below 900 $GtCO_2$. To have an 80% probability of staying below the 2°C target, the budget from 2000 is 890 $GtCO_2$, with less than 430 $GtCO_2$ remaining.[45]

To have even a 50% probability of achieving the Paris Agreement goal of limiting warming to 1.5°C above pre-industrial levels equates to a carbon budget of 550-600 $GtCO_2$ from 2011 onward,[46] of which more than 100 $GtCO_2$ has already been emitted. To achieve a 66% probability of limiting warming to 1.5°C requires adherence to a more stringent carbon budget of only 400 $GtCO_2$ from 2011 onward,[47] of which less than 300 $GtCO_2$ remained at the start of 2015. An 80% probability budget for 1.5°C would have far less that 300 $GtCO_2$ remaining. Given that global CO_2 emissions in 2014 alone totaled 36 $GtCO_2$,[48] humanity is rapidly consuming the remaining burnable carbon budget needed to have even a 50/50 chance of meeting the 1.5°C temperature goal.[49]

According to a recent report by EcoShift Consulting commissioned by the Center and Friends of the Earth, unleased (and thus unburnable) federal fossil fuels represent a significant source of potential greenhouse gas emissions:

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[43] IPCC, 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Summary for Policymakers at 27; IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change at 64 & Table 2.2 [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)] at 63-64 & Table 2.2 ("IPCC AR5 Synthesis Report").

[44] From 2012-2014, 107 GtCO2 was emitted (*see* Annual Global Carbon Emissions at http://co2now.org/Current-CO2/CO2-Now/global-carbon-emissions.html).

[45] Carbon Tracker Initiative, Unburnable Carbon – Are the world's financial markets carrying a carbon bubble? available at http://www.carbontracker.org/wp-content/uploads/2014/09/Unburnable-Carbon-Full-rev2-1.pdf; Meinshausen, M. *et al.*, Greenhouse gas emission targets for limiting global warming to 2 degrees Celsius, 458 Nature 1158, 1159 (2009).

[46] Intergovernmental Panel on Climate Change, Climate Change 2014: Synthesis Report, Summary for Policy Makers IPCC Fifth Assessment Synthesis Report, 18 (2014), available at http://ar5-syr.ipcc.ch/ipcc/ipcc/resources/pdf/IPCC_SynthesisReport.pdf.

[47] *Id.*

[48] *See* Global Carbon Emissions, http://co2now.org/Current-CO2/CO2-Now/global-carbon-emissions.html

[49] In addition to limits on the *amount* of fossil fuels that can be utilized, emissions pathways compatible with a 1.5 or 2°C target also have a significant temporal element. Leading studies make clear that to reach a reasonable likelihood of stopping warming at 1.5° or even 2°C, global CO2 emissions must be phased out by mid-century and likely as early as 2040-2045. *See, e.g.* Joeri Rogelj *et al.*, Energy system transformations for limiting end-of-century warming to below 1.5°C, 5 Nature Climate Change 519, 522 (2015). United States focused studies indicate that we must phase out fossil fuel CO2 emissions even earlier—between 2025 and 2040—for a reasonable chance of staying below 2°C. *See, e.g.* Climate Action Tracker, http://climateactiontracker.org/countries/usa. Issuing new legal entitlements to explore for and extract federal fossil fuels for decades to come is wholly incompatible with such a transition.

- Potential GHG emissions of federal fossil fuels (leased and unleased) if developed would release up to 492 gigatons (Gt) (one gigaton equals 1 billion tons) of carbon dioxide equivalent pollution (CO2e); representing 46 percent to 50 percent of potential emissions from all remaining U.S. fossil fuels.
- Of that amount, up to 450 Gt CO2e have not yet been leased to private industry for extraction;
- Releasing those 450 Gt CO2e (the equivalent annual pollution of more than 118,000 coal-fired power plants) would be greater than any proposed U.S. share of global carbon limits that would keep emissions below scientifically advised levels.

Fracking has also opened up vast reserves that otherwise would not be available, increasing the potential greenhouse gas emissions that can be released into the atmosphere. BLM must consider a ban on this dangerous practice and a ban on new leasing to prevent the worst effects of climate change.

Based on our review and analysis of the BLM's proposed lease sale parcels, recoverable oil and gas volumes in BLM's EPCA Phase III inventory, and life-cycle greenhouse gas emissions models developed by EcoShift consulting, the proposed lease sale would make available for extraction and combustion the equivalent of approximately 419,983 tons CO_2.[50] Despite the availability of this BLM data, the EA makes no effort whatsoever to calculate the full climate impacts of leasing[51] – impacts that must include not just on-site emissions from development, but the full life-cycle emissions of processing, transporting, and ultimately burning the oil. Over a ten-year lease term, the emissions of full development of the recoverable reserves proposed for lease would greatly exceed the EPA and CEQ significance threshold of 25,000 tons/year CO_2e. requiring quantitative analysis.[52] Because the lease sale is the final decision-making point at which BLM can avoid irretrievably conveying a right to extract oil and gas, it is impermissible to consider only the effects of 20 exploratory wells. Instead, BLM must consider and quantify now, prior to lease issuance, the full GHG impacts of irretrievable commitment to lease issuance.

ii. BLM Must Consider A Ban on New Oil and Gas Leasing and Fracking in a Programmatic Review and Halt All New Leasing and Fracking in the Meantime.

Development of unleased oil and gas resources will fuel climate disruption and undercut the needed transition to a clean energy economy. As BLM has not yet had a chance to consider

[50] Oil and gas volume estimates were generated in a geographic information system by clipping technically recoverable oil and gas volumes in the Bureau of Land Management's EPCA Phase III spatial data with lease parcel boundaries provided by Bureau of Land Management. Potential lifecycle greenhouse gas emissions for resultant oil and gas volumes were generated using a carbon calculator and lifecycle greenhouse gas emissions models developed by EcoShift consulting. Methods for those models are described in the report. *See* EcoShift Consulting et al., The Potential Greenhouse Gas Emissions of U.S. Federal Fossil Fuels (Aug. 2015), available at http://www.ecoshiftconsulting.com/wp-content/uploads/Potential-Greenhouse-Gas-Emissions-U-S-Federal-Fossil-Fuels.pdf.

[51] *See* EA at 36-37.

[52] *See* Council on Environmental Quality, Draft Guidance on Consideration of Greenhouse Gas Emissions 18 (Dec. 2014).

no leasing and no-fracking alternatives as part of any of its RMP planning processes or a comprehensive review of its federal oil and gas leasing program, BLM should suspend new leasing until it properly considers this alternative in updated RMPs or a programmatic EIS for the entire leasing program. BLM demonstrably has tools available to consider the climate consequences of its leasing programs, and alternatives available to mitigate those consequences, at either a regional or national scale.[53]

BLM would be remiss to continue leasing when it has never stepped back and taken a hard look at this problem at the programmatic scale. Before allowing more oil and gas extraction in the planning area, BLM must: (1) comprehensively analyze the total greenhouse gas emissions which result from past, present, and potential future fossil fuel leasing and all other activities across all BLM lands and within the various planning areas at issue here, (2) consider their cumulative significance in the context of global climate change, carbon budgets, and other greenhouse gas pollution sources outside BLM lands and the planning area, and (3) formulate measures that avoid or limit their climate change effects. By continuing leasing and allowing new fracking in the absence of any overall plan addressing climate change BLM is effectively burying its head in the sand.

A programmatic review and moratorium on new leasing would be consistent with the Secretary of Interior's recent order to conduct a comprehensive, programmatic EIS (PEIS) on its coal leasing program, in light of the need to take into account the program's impacts on climate change, among other issues, and "the lack of any recent analysis of the Federal coal program as a whole." *See* Secretary of Interior, Order No. 3338, § 4 (Jan. 15, 2016). Specifically, the Secretary directed that the PEIS "should examine how best to assess the climate impacts of continued Federal coal production and combustion and how to address those impacts in the management of the program to meet both the Nation's energy needs and its climate goals, as well as how best to protect the public lands from climate change impacts." Id. § 4(c).

The Secretary also ordered a moratorium on new coal leasing while such a review is being conducted. The Secretary reasoned:

> Lease sales and lease modifications result in lease terms of 20 years and for so long thereafter as coal is produced in commercial quantities. Continuing to conduct lease sales or approve lease modifications during this programmatic review risks locking in for decades the future development of large quantities of coal under current rates and terms that the PEIS may ultimately determine to be less than optimal. This risk is why, during the previous two programmatic reviews, the Department halted most lease sales with limited exceptions.... Considering these factors and given the extensive recoverable reserves of Federal coal currently under lease, I have decided that a similar policy is warranted here. A pause on leasing, with limited exceptions, will allow future leasing decisions to

[53] *See, e.g.*, BLM Montana, North Dakota and South Dakota, Climate Change Supplementary Information Report (updated Oct. 2010) (conducting GHG inventory for BLM leasing in Montana, North Dakota and South Dakota); BLM, Proposed Rule: Waste Prevention, Production Subject to Royalties, and Resource Conservation, 81 Fed. Reg. 6615 (Feb. 8, 2016) (proposing BLM-wide rule for prevention of methane waste).

benefit from the recommendations that result from the PEIS while minimizing any economic hardship during that review.

Id. § 5.

The Secretary's reasoning is also apt here. A programmatic review assessing the climate change effects of public fossil fuels is long overdue. And there is no shortage of oil and gas that would preclude a moratorium while such a review is conducted, as evidenced by very low natural oil and gas prices. More importantly, BLM should not "risk[] locking in for decades the future development of large quantities of [fossil fuels] under current…terms that a [programmatic review] may ultimately determine to be less than optimal." Id. BLM should cancel the sale and halt all new leasing and fracking until a programmatic review is completed.

BLM claims that in order to halt all leasing, it would have to amend the "current" RMPs through a public process which is beyond the scope of the EA. The Shoshone-Eureka RMP is 30 years old – it should have expired and been replaced with an amended RMP many years ago. The 1997 Tonopah RMP, which states that it "will guide management for the next 10-20 years," is similarly due for a replacement. Nevertheless, BLM is only required to "consider" leasing of areas that have been nominated for lease. As BLM explained in its EA, "[i]f there are known resource conflicts that cannot be addressed using a stipulation, then the parcel may be deferred until the known resource conflict is resolved."

iii. BLM Must Study the Greenhouse Gas Impacts of New Leasing

As explained in the Center's comment PEA, social cost of carbon analysis is an appropriate tool for analyzing the cumulative impacts of greenhouse gas emissions, which the EA inexplicably fails to perform and BLM's response to comments fails to address. The effects of cumulative greenhouse gas emissions will have far-reaching impacts on natural and social systems, but the EA fails to provide any meaningful analysis of the proposed action's contribution to these effects.

1. *The effects of cumulative GHG emissions will inflict extraordinary harm to natural systems and communities*

The Paris Agreement codified the international consensus that the climate crisis is an urgent threat to human societies and the planet, with the parties recognizing that:

> Climate change represents an *urgent and potentially irreversible threat to human societies and the planet* and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions.[54]

Numerous authoritative scientific assessments have established that climate change is causing grave harms to human society and natural systems, and these threats are becoming

[54] Paris Agreement, Decision, Recitals. (emphasis added)

increasingly dangerous. The Intergovernmental Panel on Climate Change (IPCC), in its 2014 Fifth Assessment Report, stated that: "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" and that "[r]ecent climate changes have had widespread impacts on human and natural systems."[55]

The 2014 Third National Climate Assessment, prepared by a panel of non-governmental experts and reviewed by the National Academy of Sciences and multiple federal agencies similarly stated that "That the planet has warmed is 'unequivocal,' and is corroborated though multiple lines of evidence, as is the conclusion that the causes are very likely human in origin"[56] and "[i]mpacts related to climate change are already evident in many regions and are expected to become increasingly disruptive across the nation throughout this century and beyond."[57] The United States National Research Council similarly concluded that: "[c]limate change is occurring, is caused largely by human activities, and poses significant risks for—and in many cases is already affecting—a broad range of human and natural systems."[58]

The IPCC and National Climate Assessment further decisively recognize the dominant role of fossil fuels in driving climate change:

> While scientists continue to refine projections of the future, observations unequivocally show that climate is changing and that the warming of the past 50 years is primarily due to human-induced emissions of heat-trapping gases. These emissions come mainly from burning coal, oil, and gas, with additional contributions from forest clearing and some agricultural practices.[59]
> ***
>
> CO_2 emissions from fossil fuel combustion and industrial processes contributed about 78% to the total GHG emission increase between 1970 and 2010, with a contribution of similar percentage over the 2000–2010 period (*high confidence*).[60]

These impacts ultimately emanating from the extraction and combustion of fossil fuels are harming the United States in myriad ways, with the impacts certain to worsen over the coming decades absent deep reductions in domestic and global GHG emissions. EPA recognized these threats in its 2009 Final Endangerment Finding under Clean Air Act Section 202(a),

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[55] IPCC AR5 Synthesis Report at 2.
[56] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment(U.S. Global Change Research Program). doi:10.7930/J0Z31WJ2 ("Third National Climate Assessment") at 61 (quoting IPCC, 2007:. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, Eds., Cambridge University Press, 1-18.).
[57] Third National Climate Assessment at 10.
[58] National Research Council, Advancing the Science of Climate Change (2010), available at www.nap.edu. ("Advancing the Science of Climate Change") at 2.
[59] Third National Climate Assessment at 2.
[60] IPCC AR5 Synthesis Report at 46.

concluding that greenhouse gases from fossil fuel combustion endanger public health and welfare: "the body of scientific evidence compellingly supports [the] finding" that "greenhouse gases in the atmosphere may reasonably be anticipated both to endanger public health and to endanger public welfare."[61] In finding that climate change endangers public health and welfare, EPA has acknowledged the overwhelming evidence of the documented and projected effects of climate change upon the nation:

Effects on air quality: "The evidence concerning adverse air quality impacts provides strong and clear support for an endangerment finding. Increases in ambient ozone are expected to occur over broad areas of the country, and they are expected to increase serious adverse health effects in large population areas that are and may continue to be in nonattainment. The evaluation of the potential risks associated with increases in ozone in attainment areas also supports such a finding."[62]

Effects on health from increased temperatures: "The impact on mortality and morbidity associated with increases in average temperatures, which increase the likelihood of heat waves, also provides support for a public health endangerment finding."[63]

Increased chance of extreme weather events: "The evidence concerning how human induced climate change may alter extreme weather events also clearly supports a finding of endangerment, given the serious adverse impacts that can result from such events and the increase in risk, even if small, of the occurrence and intensity of events such as hurricanes and floods. Additionally, public health is expected to be adversely affected by an increase in the severity of coastal storm events due to rising sea levels."[64]

Impacts to water resources: "Water resources across large areas of the country are at serious risk from climate change, with effects on water supplies, water quality, and adverse effects from extreme events such as floods and droughts. Even areas of the country where an increase in water flow is projected could face water resource problems from the supply and water quality problems associated with temperature increases and precipitation variability, as well as the increased risk of serious adverse effects from extreme events, such as floods and drought. The severity of risks and impacts is likely to increase over time with accumulating greenhouse gas concentrations and associated temperature increases."[65]

Impacts from sea level rise: "The most serious potential adverse effects are the increased risk of storm surge and flooding in coastal areas from sea level rise and more intense storms. Observed sea level rise is already increasing the risk of storm surge and flooding in some coastal areas. The conclusion in the assessment literature that there is the potential for hurricanes to become more intense (and even some evidence that Atlantic hurricanes have already become more intense) reinforces the judgment that coastal communities are now endangered by human-induced climate change, and may face substantially greater risk in the future. Even if there is a

[61] Final Endangerment Finding, 74 Fed. Reg. at 66,497.
[62] *Id.*
[63] *Id.*
[64] *Id.* at 66,497-98.
[65] *Id.* at 66,498.

low probability of raising the destructive power of hurricanes, this threat is enough to support a finding that coastal communities are endangered by greenhouse gas air pollution. In addition, coastal areas face other adverse impacts from sea level rise such as land loss due to inundation, erosion, wetland submergence, and habitat loss. The increased risk associated with these adverse impacts also endangers public welfare, with an increasing risk of greater adverse impacts in the future."[66]

Impacts to energy, infrastructure, and settlements: "Changes in extreme weather events threaten energy, transportation, and water resource infrastructure. Vulnerabilities of industry, infrastructure, and settlements to climate change are generally greater in high-risk locations, particularly coastal and riverine areas, and areas whose economies are closely linked with climate-sensitive resources. Climate change will likely interact with and possibly exacerbate ongoing environmental change and environmental pressures in settlements, particularly in Alaska where indigenous communities are facing major environmental and cultural impacts on their historic lifestyles."[67]

Impacts to wildlife: "Over the 21st century, changes in climate will cause some species to shift north and to higher elevations and fundamentally rearrange U.S. ecosystems. Differential capacities for range shifts and constraints from development, habitat fragmentation, invasive species, and broken ecological connections will likely alter ecosystem structure, function, and services, leading to predominantly negative consequences for biodiversity and the provision of ecosystem goods and services."[68]

In addition to these acknowledged impacts on public health and welfare more generally, climate change is causing and will continue to cause serious impacts on natural resources that the Department of Interior is specifically charged with safeguarding.[69]

Impacts to Public Lands: Climate change is causing and will continue to cause specific impacts to public lands ecosystem services. Although public lands provide a variety of difficult-to-quantify public benefits, one recent Forest Service attempt at quantification estimates the public land ecosystem services at risk from climate change at between $14.5 and $36.1 billion annually.[70] In addition to the general loss of ecosystem services, irreplaceable species and aesthetic and recreational treasures are at risk of permanent destruction. High temperatures are causing loss of glaciers in Glacier National Park; the Park's glaciers are expected to disappear entirely by 2030, with ensuing warming of stream temperatures and adverse effects to aquatic ecosystems.[71] With effects of warming more pronounced at higher latitudes, tundra ecosystems on Alaska public lands face serious declines, with potentially serious additional climate

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[66] *Id.*
[67] *Id.*
[68] *Id.*; *see also* Third National Climate Assessment at 195-219.
[69] *See* Federal Land Policy and Management Act of 1976, 43 U.S.C. §§ 1701(a)(8), 1712(c)(1); Multiple-Use Sustained Yield Act of 1960, 16 U.S.C. § 528; National Environmental Policy Act of 1969, 42 U.S.C. §§ 4331-4332.
[70] Esposito, Valerie et al., Climate Change and Ecosystem Services: The Contribution and Impacts on Federal Public Lands in the United States, USDA Forest Service Proceedings RMRS-P-64 at 155-164 (2011).
[71] U.S. Environmental Protection Agency, Climate Change and Public Lands (1999).

feedbacks from melting permafrost.[72] In Florida, the Everglades face severe ecosystem disruption from already-occurring saltwater incursion.[73] Sea level rise will further damage freshwater ecosystems and the endangered species that rely on them.

Impacts to Biodiversity and Ecosystems: Across the United States ecosystems and biodiversity, including those on public lands, are directly under siege from climate change—leading to the loss of iconic species and landscapes, negative effects on food chains, disrupted migrations, and the degradation of whole ecosystems.[74] Specifically, scientific evidence shows that climate change is already causing changes in distribution, phenology, physiology, genetics, species interactions, ecosystem services, demographic rates, and population viability: many animals and plants are moving poleward and upward in elevation, shifting their timing of breeding and migration, and experiencing population declines and extirpations.[75] Because climate change is occurring at an unprecedented pace with multiple synergistic impacts, climate change is predicted to result in catastrophic species losses during this century. For example, the IPCC concluded that 20% to 30% of plant and animal species will face an increased risk of extinction if global average temperature rise exceeds 1.5°C to 2.5°C relative to 1980-1999, with an increased risk of extinction for up to 70% of species worldwide if global average temperature exceeds 3.5°C relative to 1980-1999.[76]

In sum, climate change, driven primarily by the combustion of fossil fuels, poses a severe and immediate threat to the health, welfare, ecosystems and economy of the United States. These impacts are felt across the nation, including upon the public lands the Secretary of the Interior is charged with safeguarding. A rapid and deep reduction of emissions generated from fossil fuels is essential if such threats are to be minimized and their impacts mitigated.

2. *The EA ignores the social cost of carbon tool to analyze the cumulative contribution of increased oil and gas development on climate change*

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[72] *See* National Climate Assessment at 48; MacDougall, A. H., et al., Significant contribution to climate warming from the permafrost carbon feedback, 5 Nature Geoscience 719-721 (2012), doi:10.1038/ngeo1573.
[73] *See* National Climate Assessment at 592; Foti, R., Met al., Signs of critical transition in the Everglades wetlands in response to climate and anthropogenic changes, 110 Proceedings of the National Academy of Sciences6296-6300, (2013), doi:10.1073/pnas.1302558110.
[74] National Climate Assessment at 13.
[75] *See* Parmesan, C. and G. Yohe, A globally coherent fingerprint of climate change impacts across natural systems, 421 Nature 37–42 (2003); Root, T. et al., Fingerprints of global warming on wild animals and plants, 421 Nature 57–60 (2003); Chen, I. et al., Rapid range shifts of species associated with high levels of climate warming, 333 Science 1024–1026 (2011).
[76] IPCC, 2007: Synthesis Report: An Assessment of the Intergovernmental Panel on Climate Change. Other studies have predicted similarly severe losses: 15%-37% of the world's plants and animals committed to extinction by 2050 under a mid-level emissions scenario, *see* Thomas et al., Extinction risk from climate change, 427 Nature 145–8 (2004)); the potential extinction of 10% to 14% of species by 2100 if climate change continues unabated, *see* Maclean, I. M. D. and R. J. Wilson, Recent ecological responses to climate change support predictions of high extinction risk, 108 Proceedings of the National Academy of Sciences of the United States of America 12337-12342 (2011); and the loss of more than half of the present climatic range for 58% of plants and 35% of animals by the 2080s under the current emissions pathway, in a sample of 48,786 species, *see* Warren, R. J. et al., Increasing Impacts of Climate Change Upon Ecosystems with Increasing Global Mean Temperature Rise, 106 Climatic Change 141–77 (2011).

As explained in the Center's comment on the PEA, although cost-benefit analysis is not necessarily the ideal or exclusive method for assessing contributions to an adverse effect as enormous, uncertain, and potentially catastrophic as climate change, BLM does have tools available to provide one approximation of external costs and has previously performed a "social cost of carbon" analysis in prior environmental reviews.[77] Its own internal memo identifies one available analytical tool: "For federal agencies the authoritative estimates of [social cost of carbon] are provided by the 2013 technical report of the Interagency Working Group on Social Cost of Carbon, which was convened by the Council of Economic Advisers and the Office of Management and Budget."[78] As explained in that report:

> The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions. The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.[79]

Further, other analytical tools exist to evaluate the cost of methane emissions.[80] EPA has peer reviewed and employed such a tool in its "Regulatory Impact Analysis of the Proposed Emission Standards for New and Modified Sources in the Oil and Natural Gas Sector."[81]

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[77] *See High Country Conserv'n Advocates v. United States Forest Serv.*, 2014 U.S. Dist. Lexis 87820 (D. Colo. 2014) (invalidating environmental assessment ["EA"] for improperly omitting social cost of carbon analysis, where BLM had included it in preliminary analysis); Taylor, P., "BLM crafting guidance on social cost of carbon -- internal memo," Greenwire, April 15, 2015, *available at* http://www.eenews.net/greenwire/stories/1060016810/; BLM Internal Memo from Assistant Director of Resources and Planning Ed Roberson ("Roberson Internal Memo"), April 2015, *available at* http://www.eenews.net/assets/2015/04/15/document_gw_01.pdf (noting "some BLM field offices have included estimates of the [social cost of carbon] in project-level NEPA documents") (accessed July 29, 2015); *see also* Council on Environmental Quality, Revised Draft Guidance for Greenhouse Gas Emissions and Climate Change Impacts, p. 18, *available at* www.whitehouse.gov/administration/eop/ceq/initiatives/nepa/ghg-guidance (accessed Jul 29, 2015) (quantitative analysis required if GHGs > 25k tons/yr).

[78] BLM, Roberson Internal Memo.

[79] *See* Interagency Working Group on Social Cost of Carbon, United States Government, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, May 2013, *available at* https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf (accessed July 29, 2015); *see also* Interagency Working Group on Social Cost of Carbon, United States Government, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Feb. 2010, *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf (accessed July 29, 2015).

[80] *See* Marten A.L., Kopits K.A., Griffiths C.W., Newbold S.C., Wolverton A. 2014, online publication (2015, print publication). "Incremental CH4 and N2O mitigation benefits consistent with the US Government's SC-CO2 estimates," Climate Policy 15(2):272-298, abstract available at http://www.tandfonline.com/doi/abs/10.1080/14693062.2014.912981.

[81] *See* USEPA, Social Cost of Carbon, *available at* http://www3.epa.gov/climatechange/EPAactivities/economics/scc.html (noting application of social cost of methane supported by peer review); USEPA, Regulatory Impact Analysis of the Proposed Emission Standards for New and

Leasing and development of unconventional wells could exact extraordinary financial costs to communities and future generations, setting aside the immeasurable loss of irreplaceable, natural values that can never be recovered. BLM's environmental review must provide an accounting of these potential harms and costs. The EA and BLM's response to comments fail to adequately respond to our comments on this issue.

iv. The Significant Public Health Impacts of Increased Fracking Compel Consideration of No-Leasing and No-Fracking Alternatives

In addition to climate change effects, oil and gas leasing and fracking entail significant public health risks that should compel BLM to consider a ban on these practices in a programmatic review and in the current leasing proposal. The EA fails to study these public health risks, precluding meaningful review of the proposed action. BLM's refusal to look at these impacts is grounded on the claim that "The June 2016 Oil and Gas Lease Sale is an administrative leasing action. The act of leasing land for oil and gas development in itself does not directly cause a risk to human health and safety."[82] Our discussion above on the case law explains why BLM's claim is incorrect.

Ample scientific evidence indicates that well development and well stimulation activities have been linked to an array of adverse human health effects, including carcinogenic, developmental, reproductive, and endocrine disruption effects. The EA does not consider how close development could potentially take place to schools, residences, and businesses under BLM's proposed leasing decision. Just as troubling, is how much is *unknown* about the chemicals used in well stimulation activities.[83] The potential human health dangers and the precautionary principle should further compel BLM to consider not allowing further development of oil and gas minerals in the areas for lease. In comparing the no-leasing and no-fracking alternatives to leasing and continued unconventional well development scenarios, BLM should include a health impact assessment, or equivalent, of the aggregate impact that unconventional extraction techniques, including fracking, will have on human health and nearby communities.

Due to the heavy and frequent use of chemicals, proximity to fracked wells is associated with higher rates of cancer, birth defects, poor infant health, and acute health effects for nearby residents who must endure long-term exposure:

- In one study, residents living within one-half mile of a fracked well were significantly more likely to develop cancer than those who live more than one-half mile away, with exposure to benzene being the most significant risk.[84]

Modified Sources in the Oil and Natural Gas Sector, Ch. 4, available at http://www3.epa.gov/airquality/oilandgas/pdfs/og_prop_ria_081815.pdf.

[82] EA, Appendix H, at 252.

[83] *See, e.g.* U.S. Environmental Protection Agency, Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources, External Review Draft at 5-73, 10-7 (June 2015) available at http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=523539 ("EPA 2015").

[84] McKenzie, L. et al., Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources, 424 Science of the Total Environment 79 (2012) ("McKenzie 2012").

- Another study found that pregnant women living within 10 miles of a fracked well were more likely to bear children with congenital heart defects and possibly neural tube defects.[85] A separate study independently found the same pattern; infants born near fracked gas wells had more health problems than infants born near sites that had not yet conducted fracking.[86, 87]

- A study analyzed Pennsylvania birth records from 2004 to 2011 to assess the health of infants born within a 2.5-kilometer radius of natural-gas fracking sites. They found that proximity to fracking increased the likelihood of low birth weight by more than half, from about 5.6 percent to more than 9 percent.[88] The chances of a low Apgar score, a summary measure of the health of newborn children, roughly doubled, to more than 5 percent.[89] Another recent Pennsylvania study found a correlation between proximity to unconventional gas drilling and higher incidence of lower birth weight and small-for-gestational-age babies.[90]

- A recent study found increased rates of cardiology-patient hospitalizations in zip codes with greater number of unconventional oil and gas wells and higher well density in Pennsylvania.[91] The results suggested that if a zip code went from having zero wells to well density greater than 0.79 wells/km^2, the number of cardiology-patient hospitalizations per 100 people (or "cardiology inpatient prevalence rate") in that zip code would increase by 27%. If a zip code went from having zero wells to a well density of 0.17 to 0.79 wells/km^2, a 14% increase in cardiology inpatient prevalence rates would be expected. Further, higher rates of neurology-patient hospitalizations were correlated with zip codes with higher well density.

- Recently published reports indicate that people living in proximity to fracked gas wells commonly report skin rashes and irritation, nausea or vomiting, headache, dizziness, eye irritation and throat irritation.[92]

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[85] McKenzie, L. et al., Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, Advance Publication Environmental Health Perspectives (Jan. 28, 2014), http://dx.doi.org/10.1289/ehp.1306722 ("McKenzie 2014").

[86] Hill, Elaine L., Unconventional Natural Gas Development and Infant Health: Evidence from Pennsylvania, Cornell University (2012).

[87] Whitehouse, Mark, *Study Shows Fracking is Bad for Babies*, Bloomberg View, Jan. 4, 2014, *available at* http://www.bloombergview.com/articles/2014-01-04/study-shows-fracking-is-bad-for-babies.

[88] *Id.*, citing Janet Currie of Princeton University, Katherine Meckel of Columbia University, and John Deutch and Michael Greenstone of the Massachusetts Institute of Technology.

[89] *Id.*

[90] Stacy, Shaina L. et al. (2015) Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania. PLoS ONE 10(6): e0126425. doi:10.1371/journal.pone.0126425, *available at* http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0126425.

[91] Jemielital, T. et al. Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates. PLoS ONE 10(7): e0131093, *available at* http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0131093.

[92] Rabinowitz, P.M. et al., Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania. Environmental Health Perspectives Advance Publication (2014); Bamberger, Michelle and R.E. Oswald, Impacts of Gas Drilling on Human and Animal Health, 22 New Solutions 51

- In Texas, a jury awarded nearly $3 million to a family who lived near a well that was hydraulically fractured.[93] The family complained that they experienced migraines, rashes, dizziness, nausea and chronic nosebleeds. Medical tests showed one of the plaintiffs had more than 20 toxic chemicals in her bloodstream.[94] Air samples around their home also showed the presence of BTEX — benzene, toluene, ethylbenzene and xylene —colorless but toxic chemicals typically found in petroleum products.[95]

Chemicals used for fracking also put nearby residents at risk of endocrine disruption effects. A study that sampled water near active wells and known spill sites in Garfield County Colorado found alarming levels of estrogenic, antiestrogenic, androgenic, and antiandrogenic activities, indicating that endocrine system disrupting chemicals (EDC) threaten to contaminate surface and groundwater sources for nearby residents.[96] The study concluded:

> [M]ost water samples from sites with known drilling-related incidents in a drilling-dense region of Colorado exhibited more estrogenic, antiestrogenic, and/or antiandrogenic activities than the water samples collected from reference sites[,] and 12 chemicals used in drilling operations exhibited similar activities. Taken together, the following support an association between natural gas drilling operations and EDC activity in surface and ground water: [1] hormonal activities in Garfield County spill sites and the Colorado River are higher than those in reference sites in Garfield County and in Missouri, [2] selected drilling chemicals displayed activities similar to those measured in water samples collected from a drilling-dense region, [3] several of these chemicals and similar compounds were detected by other researchers at our sample collection sites, and [4] known spills of natural gas fluids occurred at these spill sites.

The study also noted a linkage between EDCs and "negative health outcomes in laboratory animals, wildlife, and humans":

> Despite an understanding of adverse health outcomes associated with exposure to EDCs, research on the potential health implications of exposure to chemicals used in hydraulic fracturing is lacking. Bamberger and Oswald (26) analyzed the health consequences associated with exposure to chemicals used in natural gas operations and found respiratory, gastrointestinal, dermatologic, neurologic, immunologic, endocrine, reproductive, and other negative health outcomes in humans, pets, livestock, and wildlife species.

(2012); Steinzor, N. et al., Gas Patch Roulette: How Shale Development Risks Public Health in Pennsylvania, Earthworks Gas & Oil Accountability Project (2012).

[93] *Parr v. Aruba Petroleum, Inc.*, Case No. 11-01650-E (Dallas Cty., filed Sept.13, 2013).

[94] Deam, Jenny, *Jury Awards Texas family Nearly $3 million in Fracking Case*, Los Angeles Times (Apr. 3, 2014) http://www.latimes.com/nation/la-na-fracking-lawsuit-20140424-story.html.

[95] *Id.*

[96] Kassotis, Christopher D. et al., Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region. Endocrinology, March 2014, 155(3):897–907, pp. 905-906, *available at* http://press.endocrine.org/doi/full/10.1210/en.2013-1697.

Of note, site 4 in the current study was used as a small-scale ranch before the produced water spill in 2004. This use had to be discontinued because the animals no longer produced live offspring, perhaps because of the high antiestrogenic activity observed at this site. There is evidence that hydraulic fracturing fluids are associated with negative health outcomes, and there is a critical need to quickly and thoroughly evaluate the overall human and environmental health impact of this process. It should be noted that although this study focused on only estrogen and androgen receptors, there is a need for evaluation of other hormone receptor activities to provide a more complete endocrine-disrupting profile associated with natural gas drilling.[97]

Operational accidents also pose a significant threat to public health. For example in August 2008, Newsweek reported that an employee of an energy-services company got caught in a fracking fluid spill and was taken to the emergency room, complaining of nausea and headaches.[98] The fracking fluid was so toxic that it ended up harming not only the worker, but also the emergency room nurse who treated him. Several days later, after she began vomiting and retaining fluid, her skin turned yellow and she was diagnosed with chemical poisoning.[99]

Harmful chemicals are also found in the flowback fluid after well stimulation events. Flowback fluid is a key component of oil-industry wastewater from stimulated wells. A survey of chemical analyses of flowback fluid dating back to April 2014 in California revealed that concentrations of benzene, a known carcinogen, were detected at levels over 1,500 times the federal limits for drinking water.[100] Of the 329 available tests that measured for benzene, the chemical was detected at levels in excess of federal limits in 320 tests (97 percent).[101] On average, benzene levels were around 700 times the federal limit for drinking water.[102]Among other carcinogenic or otherwise dangerous chemicals found in flowback fluid from fracked wells are toluene and chromium-6.[103] These hazardous substances were detected in excess of federal limits for drinking water in over one hundred tests. This dangerous fluid is commonly disposed of in injection wells, which often feed into aquifers, including some that could be used for drinking water and irrigation.

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97 *Id.*, p. 905.

98 Wiserman, Hannah, Untested Waters: the Rise of Hydraulic Fracturing in Oil and Gas Production and the Need to Revisit Regulation, Fordham Envtl. Law Rev. 115 (2009),138-39.

99 *Id.*

100 California Department of Conservation Division of Oil, Gas, & Geothermal Resources, California Well Stimulation Public Disclosure Report, *available at* http://www.conservation.ca.gov/dog/Pages/WellStimulationTreatmentDisclosure.aspx. The highest concentration was 7,700 parts per billion (ppb) for a well with API number 03052587. The US EPA's maximum contaminant level for benzene is 5 ppb.

101 *Id.*

102 *Id., see also* Cart, J., High Levels of Benzene Found in Fracking Wastewater, Los Angeles Times, Feb. 11, 2015, http://www.latimes.com/local/california/la-me-fracking-20150211-story.html#page=1.

103 *Id.*; *see also* Center for Biological Diversity, Cancer-causing Chemicals Found in Fracking Flowback from California Oil Wells (2015) Feb. 11, 2015, *available at* http://www.biologicaldiversity.org/news/press_releases/2015/fracking-02-11-2015.html.

Acidizing presents similarly alarming risks to public health and safety. In acidizing operations, large volumes of hydrochloric and hydrofluoric acid are transported to the site and injected underground. These chemicals are highly dangerous due to their corrosive properties and ability to trigger tissue corrosion and damage to sensory organs through contact.

While many risks are known, much more is unknown about the hundreds of chemicals used in fracking. The identity and effects of many of these additives is unknown, due to operators' claims of confidential business information. But, as the EPA recognizes, chemical identities are "necessary to understand their chemical, physical, and toxicological properties, which determine how they might move through the environment to drinking water resources and any resulting effects."[104] Compounds in mixtures can have synergistic or antagonistic effects, but again, it is impossible to know these effects without full disclosure.[105] The lack of this information also precludes effective remediation: "Knowing their identities would also help inform what chemicals to test for in the event of suspected drinking water impacts and, in the case of wastewater, may help predict whether current treatment systems are effective at removing them."[106]

Even where chemical identities are known, chemical safety data may be limited. In EPA's study of the hazards of fracking chemicals to drinking water, EPA found that "[o]ral reference values and oral slope factors meeting the criteria used in this assessment were not available for the majority of chemicals used in hydraulic fracturing fluids [87%], representing a significant data gap for hazard identification."[107] Without this data, EPA could not adequately assess potential impacts on drinking water resources and human health.[108] Further, of 1,076 hydraulic fracturing fluid chemicals identified by the EPA, 623 did not have estimated physiochemical properties reported in EPA's toxics database, although this information is "essential to predicting how and where it will travel in the environment."[109] The data gaps are actually much larger, because EPA excluded 35% of fracking chemicals reported to FracFocus from its analysis because it could not assign them standardized chemical names.[110]

The EA fails to incorporate a literature review of the harmful effects of each of the chemicals known to be used in fracking and other unconventional oil and gas extraction methods. Without knowing the effects of each chemical, the EA cannot accurately project the true impact of unconventional oil and gas extraction.

The EA also fails to study the human health and safety impacts of noise pollution, light pollution, and traffic accidents resulting from oil and gas development. A recent study found that automobile and truck accident rates in counties in Pennsylvania with heavy unconventional oil and gas extraction activity were between 15 and 65 percent higher than accident rates in counties

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[104] EPA 2015 at 10-18.
[105] Souther, Sara et al. Biotic Impacts of Energy Development from Shale: Research Priorities and Knowledge Gaps, Front Ecol Environ 2014; 12(6): p. 334.
[106] EPA 2015 at 10-18.
[107] *Id.* at 10-7, 9-7.
[108] *Id.* at 9-37-38.
[109] *Id.* at 5-73.
[110] *Id.* at 9-38.

without unconventional oil and gas extraction activities.[111] Rates of traffic fatalities and major injuries may be higher in areas with heavy drilling activity than areas without.[112]

IV. Conclusion

Unconventional oil and gas development and coal extraction not only fuel the climate crisis but entail significant public health risks and harms to the environment. Accordingly, the EIS should thoroughly analyze the alternative of no new fossil fuel leasing and no fracking or other unconventional well stimulation methods within the BMD planning area. Thank you for consideration of these comments. The Center trusts that you will take our requests for deferrals to protect species and wetlands seriously and in addition will issue a legally adequate EIS for this proposed oil and gas leasing action.

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[111] Graham, J., Irving et al., Increased Traffic Accident Rates Associated with Shale Gas Drilling in Pennsylvania. 74 Accident Analysis and Prevention 203 (2015).
[112] *Id.*

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April 14, 2016

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BLM NVSO IAC

Aldine Reynolds
Land Law Examiner
Bureau of Land Management
1340 Financial Blvd
Reno, NV 89520

RE: Center for Biological Diversity Protest of the June 2016 Competitive Oil and Gas Lease Sale, Battle Mountain District - DOI-BLM-NV-B000-2016-0002-EA Referenced Documents

Dear Ms. Reynolds:

Enclosed is the CD of documents referenced in our April 14, 2016 letter protesting the June 2016 Competitive Oil and Gas Lease Sale in the Battle Mountain District. The CD does not include documents that have already been submitted with prior comment letters on the same lease sale.

We also included a paper copy of the 2013 Schaeffer study (Schaeffer, M., et al., Adequacy and Feasibility of the 1.5°C Long-Term Global Limit, Climate Analytics (2013)), as the file on the CD appears to be corrupted. Thank you.

Sincerely,

My-Linh Le
Legal Fellow
Center for Biological Diversity

Alaska . Arizona . California . Minnesota . Nevada . New Mexico . New York . Oregon . Vermont . Washington, DC
P.O. Box 710 . Tucson, AZ 85702-0710 tel: (520) 623.5252 fax: (520) 623.9797 www.BiologicalDiversity.org

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CLIMATE ACTION NETWORK
Europe

CLIMATE ANALYTICS

Adequacy and feasibility of the 1.5°C long-term global limit

July 2013

Authors: Michiel Schaeffer, Bill Hare, Marcia Rocha, Joeri Rogelj (Climate Analytics)

With contributions from Kirsten Macey, Marion Vieweg and Dim Coumou (PIK)

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Executive Summary

Scientific assessments have shown that impacts are projected to worsen significantly above a global warming of 1.5, or 2°C from pre-industrial levels. Such assessments have contributed to the adoption of 2°C as a global goal during the climate talks in Copenhagen in 2009. In Cancun in 2010 Climate Convention Parties agreed to review the global goal with the perspective of strengthening this to 1.5°C. Three considerations play a role in opinions about a long-term global goal:

1) Does a long-term global goal actually help streamlining global efforts to reduce greenhouse-gas emissions and inspire local initiatives?
2) Is the level adequately low to prevent dangerous interference with the climate system?
3) Is the goal feasible, given socio-economic and technical constraints?

A long-term global goal facilitates international negotiations and inspires policy worldwide

There is significant evidence that the 2°C limit and 2020 targets consistent with this goal as assessed by IPCC in its Fourth Assessment Report have already influenced the targets and policies of countries, including the European Union, Australia, Japan, Mexico, South Korea, Brazil, Indonesia and South Africa. A few developing countries (e.g. the Maldives) have even announced goals to become carbon neutral within the next decade. Some countries have embedded these long-term goals into national legislation.

This and the fact that governments are implementing more climate and energy policies than ever before provide a strong message that the temperature limit is helpful, and, in fact, a necessary condition to enable the international community to jointly tackle the potentially catastrophic challenges of climate change. The fact that no country has yet taken sufficient action does not undermine the significance a global goal as a focal point for policy.

From 1.5 to 2°C warming, impacts are projected to worsen and tipping points are approached

Current warming
The past century, and in particular the last few decades, have seen signals of anthropogenic climate change emerging as diverse as rapid sea-ice thinning in the Arctic, monthly and seasonal temperature extremes, extreme droughts in the Mediterranean, decline of coral reefs and negatively effected agricultural yields.

1.5°C above preindustrial
A 1.5°C rise by 2100 would prevent some of the worst impacts, but still poses serious challenges worldwide, especially in the LDCs, SIDS and Africa, including due to a decline in subtropical precipitation. In general, precipitation changes will increase water stress in regions that are already drought-affected today. Recent science shows that coral reef ecosystems are likely to be extremely adversely affected by the combined effects of ocean acidification and warming, already at levels as low as 1.5°C, compounded by the effects of global sea-level projected for this level of warming of 75 cm above 2000 by 2100. However, with temperatures dropping well below a 1.5°C increase, sea-level rise might stabilize beyond 2100 below levels 1.5 m higher than today. Sea-level rise of only 45 cm would already result in a loss of 10% of land area in Bangladesh, with flood risk there increasing most rapidly between 0 and 2°C warming. Without

adaptation such moderate sea level rise will increase the number of people flooded by storm surges more than five fold, with South and South-east Asia being especially at risk due to vulnerable low-lying and populated deltas.

2°C above preindustrial

For a warming of 2°C, severe and widespread droughts would occur in the next 30–90 years over many densely populated areas, including regions like southern Europe, Australia and large parts of Africa and North and South America. Water- and heat-stress will negatively affect crop yields in regions that are already drought prone today, putting pressure on food security. Drought disaster frequency in major crop sowing areas is expected to double. Sub-Sahelian crop damages might exceed 7%, with a small chance of 27% damages. In general however, crop models probably underestimate yield losses for a 2°C warming by as much as 50% for some sowing dates. 10-15% of Sub-Saharan ecosystem species would be at risk of extinction and a projected decrease in precipitation over the Amazonian forests may result in substantial forest retreat. Due to ocean acidification, coral reefs would become impeded in growth at a CO_2 concentration of 450 ppm, a level reached around 2050 on a 2°C pathway. Sea level would rise to 80 cm above 2000 by 2100, only 5cm above 1.5°C projections, thus resulting in comparable impacts. Long-term stabilization at 2°C warming however implies a continuous sea-level rise for centuries, with levels to approach 3 m by 2300. The threshold for the Greenland ice sheet to irreversibly melt down in the very long term is now estimated to be 1.6°C above preindustrial, compared to the IPCC AR4 estimate of 3.1°C.

4°C above preindustrial

Current emission trends and reduction pledges put the world on a trajectory towards a temperature increase of roughly 4°C by 2100. At such levels of warming impacts are most severe and might be beyond the limits of adaptation. The conditions of some of the most extraordinary heat waves experienced today will become the new norm and a completely new class of heat waves, with magnitudes never experienced before, will occur regularly. This will have severe but as yet un-quantified impacts on agricultural production and human health. Timing of warming is critical as the world population is expected to grow until the second half of the 21st century.

The proportion of arid and semi-arid lands in Africa is likely to increase by 5% to 8%. Globally, drought disaster-affected areas in major crop sowing areas is predicted to increase three-fold (from 15.4% to 44.0%) by 2100. Wheat production is likely to disappear from Africa by 2080, while millet yield in Sahelian Africa is projected to decrease by 40%. In a 4°C world, climate change may become the dominant driver of ecosystem shifts, surpassing habitat destruction as the greatest threat to biodiversity. Due to ocean acidification, corals around the world are likely to start dissolving above 550 ppm CO_2, a level reached by 2050 on a 4°C pathway. The Amazonian forest area is expected to contract to 25% of its original size and up to 30% of other tropical rainforests, in central Sumatra, Sulawesi, India and the Philippines, is threatened by forest retreat. In Africa, 25%–42% of plant species could lose all suitable range by 2085. Substantial loss of tropical forest would release large amounts of carbon dioxide into the atmosphere, which would accelerate climate change further. Sea-level rise would exceed 1 m by 2100, while post-2100 sea level is hard to project, due to large knowledge gaps in understanding of the response of the ice caps to such strong warming. The potential impact of 1m sea-level rise or more would be severe, with the real risk of the forced displacement of up to 187 million people over the century (up to 2.4% of global population). East Asia, South-east Asia and South Asia are most affected with an expected 53-125 million people displaced. The Small islands states, Africa and parts of Asia are the most likely to see coastal abandonment as the likelihood of successful protection measures is lowest here. The frequency of the most damaging (category 4 and 5) Atlantic tropical cyclones is projected to nearly double by the end of the 21st century.

Climate change has the potential to catalyze rapid shifts in dynamic, out-of-equilibrium ecosystems, such as sudden forest loss or regional loss of agricultural productivity due to desertification. The ramifications of these shifts would be far-reaching, ranging from extensive loss of biodiversity and diminished land cover, through to loss of ecosystems services. 4°C warming by 2100 would likely result in global temperatures stabilizing at 6°C above pre-industrial over the next few centuries. No geological-historic analogue exists for the rapid warming projected under unmitigated climate change and it is fair to say that this will lead at least to widespread extinctions in ecosystems that are shown to have happened 55 million years ago during the Palaeocene-Eocene thermal maximum, which reached such a level of warming at a slower pace.

Warming can be limited to 1.5°C and below

Geophysically, warming can be limited to below 1.5°C

Hypothetically, if all emissions were to be eliminated immediately, delays in the climate system and abrupt changes in atmospheric radiative forcing would let warming continue to rise to a best-guess level of 1.2°C above pre-industrial, before embarking on a gradual decline. In the very long term, a warming limit of 1.5°C requires total greenhouse-gas concentrations plus the effects of aerosols to be below a level of 400 ppm CO_2eq. Since an immediate stop to all global emissions is obviously impossible, any mitigation pathway aiming at 1.5°C and below necessarily involves a peak-and-drop concentration profile.

Socio-economic options for warming below 1.5°C are emerging from the scientific literature

Energy-economic models are able to achieve the required low emission levels, also without expansion of nuclear energy, but this crucially depends on:

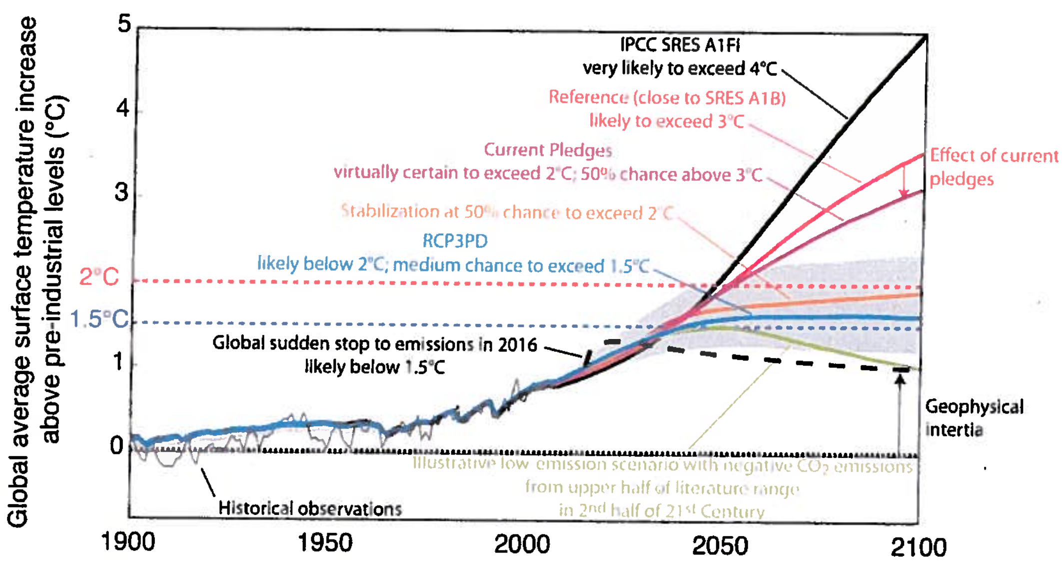
- Early and globally concerted mitigation, emission reductions implemented from 2013 onwards and global emission peak by 2020
- Rapid up-scaling and feasibility of large-scale bio energy, and availability of forest sinks
- High rates of energy efficiency improvements
- Availability of carbon capture and storage technologies (CCS)

Large-scale deployment of biomass with CCS seems necessary for a return to below 1.5°C

Until the 2030s, long-term 1.5 and 2°C emission scenarios overlap, but a 1.5°C scenario requires deeper reductions in the rest of the 21st century. Constrained by actual emissions until 2010 and the limited energy-economic reduction potential until the 2020s, 1.5°C scenarios necessarily require net-negative CO_2 emissions in the 2nd half of the 21st century. The later the emissions peak, the more CO_2 needs to be removed from the atmosphere starting around the 2050s. Due to slowly responding carbon pools in the Earth system, a large part of emitted CO_2 stays in the atmosphere for centuries, which is why emissions need to be reduced to near zero for stabilizing concentrations. However, this also means that concentrations decrease only slowly, unless CO_2 is taken out of the atmosphere by human interventions. As biomass takes up carbon from the atmosphere through photosynthesis, capturing the CO_2 from biomass energy systems and storing it underground, in effect produces useful forms of energy for society (electricity) while taking CO_2 out of the atmosphere – a negative emission. CO_2 removal also helps limiting acidification of the oceans.

So-called "Short-Lived Climate Forcers" do not help in the long term, but might slow near-term warming

Non-CO_2 measures must never be interpreted as a means for "buying time" to allow delayed reductions in CO_2. The probability of exceeding a 2°C warming in the 21st century more than doubles from 20% to 50%, if CO2 reductions were delayed by just 10 years, with compensation in the near term by SLCF reductions. Given the slow removal of CO_2 from the atmosphere, this effect is set to linger for centuries. Also, after a delay in CO_2 reductions, energy-related CO_2 reduction rates need to be almost double those in a "least-cost" low-emission pathway with early CO_2 measures. Without these higher reduction rates to "catch up", the CO_2 concentration and warming by 2100 will be even higher. From a multi-decadal perspective, delay scenarios have been shown to be riskier, with required faster CO_2 reductions after a 10-year delay too expensive and/or technically infeasible. The IEA's "World Energy Outlook 2011" states that "Delaying action is a false economy: for every $1 of investment avoided in the power sector before 2020 an additional $4.3 would need to be spent after 2020 to compensate for the increased emissions."



Internationally pledges emission reductions are inadequate, but options remain to close the "Gap"

2020 emission pledges are inadequate

1.5 and 2°C pathways overlap until the 2030s. For 2020 an "Emissions Gap" is estimated between, on the one hand, the global emissions level implied by current emission reduction pledges by countries and, on the other hand, the lower 2020 global emission level required to put the world on a feasible long-term emission pathway to hold warming below 1.5 and 2°C. The Emissions Gap was estimated as 6-11 GtCO2e. Avoiding double-counting of CDM credits is required to prevent the gap from *increasing* by up to 2 $GtCO_2e$.

Options remain to close the Emissions Gap

Options to close the 2020 Emissions Gap are:

Internationally pledged emission reductions for 2020 are inadequate, but options remain to close the "Emissions Gap":

1) Increase the global share of renewables from an estimated 10% at present to 15% by 2020. This will help to close the Gap by 4 $GtCO_2$.
   - Increase further to a 20% share to close the Gap completely.
2) Intensify energy efficiency improvements, which would have a major impact on global energy and climate trends and would postpone a lock-in in emissions from 2017 to 2022
3) Reduce subsidies for fossil fuels to decrease global emissions by 2 $GtCO_2$ by 2020
   - Eliminating subsidies reduces fossil-fuel demand and emissions.
   - Fossil-fuel consumption subsidies worldwide amounted to $409 billion in 2010 and may grow to $660 billion in 2020.
   - Global renewable-energy subsidies were only $66 billion in 2010
4) In the international negotiations context:
   - Implementing the more ambitious "conditional" pledges. This would reduce the gap by 2 $GtCO_2e$.
   - Minimizing the use of lenient Land Use, Land Use Change and Forestry (LULUCF) credits and surplus emission credits. This would reduce the gap by around 3 $GtCO_2e$.
   - Minimizing the use of the surplus Assigned Amounts from the 2008-2012 Kyoto period. This would reduce the gap by 1.8 $GtCO_2e$.
   - Avoiding the double-counting of offsets and improving the additionality of CDM projects. This would reduce the gap by up to 1.5 $GtCO_2e$.
   - Reducing emissions from international shipping and aviation.

The required deep reductions by 2050 can only be achieved by both developed and developing countries

Global emissions must be reduced to at least 50% and probably, for a less risky pathway, to 80% below 1990 by 2050 for a 1.5°C limit in the long term. Although 2020 levels are important, mid-century levels are critical to achieving 1.5 or 2°C. For the two extreme ends of the 50-80% global reduction range, developed-country emissions need to be reduced to 85-95% below 1990, assuming developed (Annex I) and developing (non-Annex I) countries reach equal per-capita emissions by 2050, as a very simple measure of equity. Obviously, this indicator does not account for historical responsibility and other more sophisticated considerations of equity, which would in some cases imply negative emission allowances for developed countries. Some such more sophisticated considerations would also imply some developing countries (like currently 'Newly Industrialized Countries' and 'Rapidly Industrializing Countries') to take on large reductions below 1990 by 2050, while for example Least Developed Countries would be exempt.

Published scenarios for EU "energy road map" go a long way, but fall short

The European Commission's energy road map 2050 is the document that details scenarios to achieve the EU's commitment to reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050. However, as the accompanying documents specify, the actual scenarios described achieve a reduction of only 80% by 2050. As noted above, developed-countries as a group need to reduce to 85-95% below 1990 by 2050, so that the EU's commitment is roughly consistent with a 1.5°C target, but the reductions achieved by the scenarios in the Energy Road Map fall short.

Contents

1 Introduction

Over the past years, scientific assessments have shown that impacts are projected to worsen significantly above a global warming of 1.5, or 2°C from pre-industrial levels. Such assessments have prompted the EU to spearhead 2°C as a global goal, or limit, at the international climate negotiations and contributed to the adoption of 2°C as a global goal during the climate talks in Copenhagen in 2009. Although 2°C as a limit is not perceived universally as an uncontroversial and constructive goal, on the other hand a large group of countries proposes a lower limit of 1.5°C (See Appendix 1). Three considerations play a role in opinions about a long-term global goal:

1) Does a long-term global goal actually help streamlining global efforts to reduce greenhouse-gas emissions and inspire local initiatives?
2) Is the level adequately low to prevent dangerous interference with the climate system?
3) Is the goal feasible, given socio-economic and technical constraints?

We recently wrote a brief discussion on the first question in the lead-up to the 2012 UNFCCC climate talks in Doha, Qatar. The following is a reproduction of that discussion[1]:

"The setting of the 2°C goal, and the corresponding call by the most vulnerable countries for the global goal to be lower, 1.5°C, reflects a common approach to resolving a wide range of 'public good' problems with similar characteristics. What is, for example, the 'right' level for standards on various air pollutants? What is the 'correct' speed limit that allows citizens to reach their destination in an acceptable time that minimizes risk of accidents and air pollution? There is no exact scientific answer for any of these questions. However, resolving these issues requires standards – or focal points - to organize decisions around, to generate sufficient action by all parties.

The 2°C and 1.5°C limits have emerged as well-reasoned focal points for mitigating dangerous climate change. There is significant evidence that the 2° limit has already influenced the targets and policies of countries:

- The European Union has set its 2020 policies and goals and its longer term 2050 ambitions of an 80-95% reduction with a view to achieving the 2°C goal
- Australia has related the upper end range of its pledges and its longer term ambitions to conditions to a global CO2 eq concentrations limit of 450 ppm (about 40% chance to stay below 2°C in the long term)
- Japan set its 2020 target at 25% below 1990, i.e. within the oft-discussed 25% to 40% range compatible with the 2°C limit.
- Mexico increased its ambition in 2009 from 20% below BAU to 30% below BAU in 2020, the most ambitious end of the range compatible with 2°C discussed for developing countries.
- South Korea chose an unconditional target of 30% below BAU in 2020, similarly influenced by the range discussed for developing countries.
- Brazil, Indonesia, South Africa pledged reductions are even more ambitions than 30% below BAU in 2020.

Apart from these pledges for 2020, we also observe many countries that have announced long-term emission reduction goals for 2050, for example, Mexico, Australia and the EU. A few developing countries - Costa Rica and the Maldives - have even announced goals to become carbon neutral within the next decade. Some countries have embedded these long-term goals into national legislation.

Governments are implementing more climate and energy policies than ever before. All major economies have renewable energy targets, most supported with policies. Standards for electric appliances and buildings are used widely. Efficiency standards for passenger cars have recently been increased by, for example, USA and Canada. Emission trading systems are spreading globally with systems adopted in Australia, South Korea and China. Brazil succeeded in reducing its deforestation rate significantly, one the biggest contributions to reductions globally by a single policy.

Together, these arguments provide a strong message that the temperature limit is helpful, and, in fact, a necessary condition to enable the international community to jointly tackle the potentially catastrophic challenges of climate change. The fact that no country has yet taken sufficient action does not undermine the significance of the 2°C goal as a focal point for policy."

The rest of this report focuses on climate-science and energy-economic considerations to address questions 2 and 3 above, with special focus on the 1.5°C limit. As the next section shows, even at warming levels of 1.5 and 2°C, large overall negative impacts of climate change are projected over the coming century and beyond, so that a stabilization at such warming levels does not necessarily avoid 'dangerous climate change'. To frame the long-term warming limits, we note that these limits need to be linked back to concentrations and subsequently to emissions. Uncertainties in the climate system's response to increased GHG concentrations mean that for a given emission pathway, it cannot be stated with absolute certainty whether a global-warming limit will be crossed or not. Instead, one has to base decisions on a certain probability whether a target will be reached. Figure 1 illustrates greenhouse-gas concentration levels that are associated with a range of warming levels. At a total greenhouse-gas concentration of 450 ppm CO2eq, there is a likelihood of less than 50% that warming stays below 2°C in the long term. The concentration needs to stabilize at, or below 400 ppm CO2eq for warming to stay below 2°C with a probability larger than 66%, i.e. at a 'likely' probability using IPCC uncertainty guidelines. At this concentration level, however, there is still not a higher than 50% probability to stay below 1.5°C in the long term, which requires concentrations at, or below 350 ppm CO2eq. Section 3 will assess considerations of feasibility of holding warming below 1.5°C in the long term, which would require to stabilize concentrations in the long term below present-day values (Figure 1).

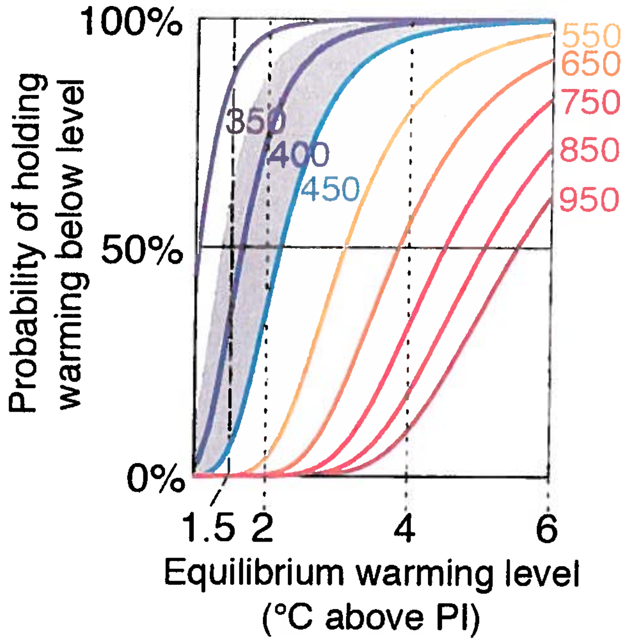


Figure 1 Probability to hold warming below temperature targets after the climate system reached equilibrium with a range of long-term fixed CO2-equivalent concentration levels (ppm CO2eq). The grey shaded area shows present-day CO_2-equivalent concentration without the cooling effect of aerosols (around 450 ppm) and with this cooling included (below 400 ppm). Adapted from Ref. [2].

2 Climate-change risks and impacts

Although for a single level of global warming the associated impacts are different for different regions, global-mean warming is a reasonable indicator for overall severity of climate-change impacts, generally increasing for higher levels of warming. The latest climate-model results using the new RCP[a] scenarios prepared for IPCC's Fifth Assessment Report (AR5) show that the pattern of regions that are exposed to relatively large climate changes is roughly the same for global warming reaching from present-day levels to about 2.5°C above pre-industrial [3]. Below 2.5°C, particularly strong climate change occur over the tropics, western China and the Arctic, compared to other regions. Above 2.5°C, however, climate change is further accelerating in particular over southern Africa, the Mediterranean and northern high latitudes, including over Siberia, Canada and US Alaska, while south-eastern Latin America, Australia, the southern Indian subcontinent and South-East Asia change at a relatively lower rate.

[a] RCP – Representative Concentration Pathway.

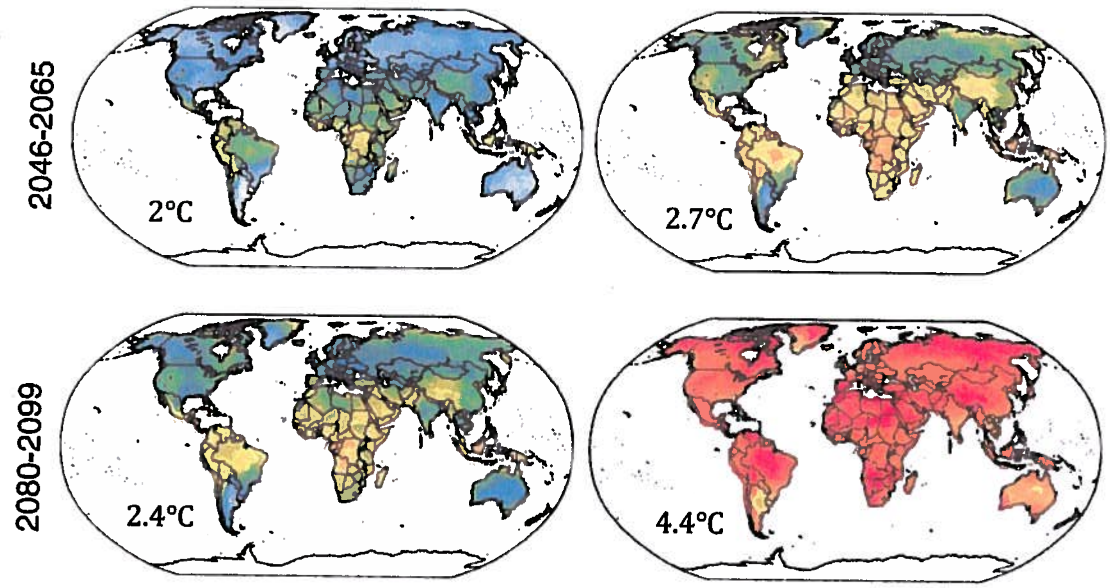


Figure 2 The relative aggregate climate change (an aggregate climate-change indicator including changes in temperatures, precipitation and extremes) between the 1986–2005 period and the 2046–2065 and 2080–2099 periods of RCP4.5 (left panels) and RCP8.5 (right panels). Source: Ref. [3].

Note that assessments of relatively high/low exposure to climate change in a certain region does not unambiguously imply that impacts are higher/lower as well, which also depends on the sensitivity of geophysical systems, ecosystems and society to changes in the physical climate system. The rest of this section provides an overview of projected impacts across warming levels, combining exposure with sensitivity. Given the wide range of sectors, systems, regions etc., this overview needs to be seen as illustrative and far from exhaustive. As such, it is useful as a brief update of some of the findings of IPCC's 2007 Fourth Assessment Report, ahead of AR5, for these illustrative sectors etc. only.

2.1 *Impacts at different levels of warming*[b]

2.1.1 Present: 0.8°C above pre-industrial

Impact-attribution studies try to quantify the underlying forcings, of which greenhouse gas emissions is one, which could have contributed to impacts from actual extreme weather events[4]. Such end-to-end attribution science is in its infancy but qualitatively the causality between some meteorological extremes and their impact is clear. For some type of meteorological extremes there is now strong scientific evidence linking specific events or an increase in their number to the human influence on climate[5]. The frequency of extremely warm monthly and seasonal temperatures increased rapidly since the 1960s[6,7]. This increase can largely be attributed to anthropogenic greenhouse gas forcing[8-10]. This implies that we can say with a high degree of confidence that recent high-impact heat waves, like the ones in Europe 2003, Russia 2010 and Texas 2011, are a consequence of the limited global warming to date[7].

[b] This section is adapted from Coumou, D. and M. Schaeffer (2012) "Science Update: Loss and Damage - Climate Change Today and under Future Scenarios", Climate Analytics, November 2012.

Further, anthropogenic greenhouse gas and aerosol forcing are key attributable factors for the increased drying in the Eastern Mediterranean[11], accumulating in several extremely dry-years in Syria recently. As the vast majority of crops here are non-irrigated and therefore dependent on winter-time precipitation[12], the region is highly vulnerable to meteorological drought. In combination with water mismanagement, the meteorological drought in 2008 thus rapidly lead to water-stress with more than 40% of the cultivated land affected, strongly reducing wheat and barley production[12]. Globally, warming-induced drying has already increased the area under drought by 8%[13], increasing water-stress in vulnerable regions. Since the 1960s, sown areas for all major crops were increasingly affected by drought, with drought-affected areas for maize more than doubling from 8.51% to 18.63%[14]. The robustness of observed drought trends on a global scale however remains disputed (i.e. Ref. [15]).

Apart from droughts, yields from annual crops like wheat and maize are negatively affected by warmer seasonal temperatures since the crop duration shortens. In addition, more frequent and intense extreme weather events, like drought and heat waves, can severely damage crop yields and thereby contribute to food price volatility[16]. Since the 1980s global crop production has been negatively affected by climate trends with maize and wheat production declining respectively 3.8% and 5.5% compared to a case without climate trends[17]. Moreover, extreme heat waves in recent years, of which some can be attributed to global warming with high confidence, caused severe damage to agricultural production in Russia (2010)[18], Texas (2011)[19] and U.S. (2012)[20]. Disruptions in supply, even when relatively small, can still generate large price swings on the international market especially when stocks are limited, and hence have strong effects on vulnerable countries far removed from the location of the heat waves[21]. As an example, wheat production in Russia and Ukraine in 2010 was down by ~25% and ~20% respectively[18]. Since these countries are major global wheat exporters[22], grain prices increased strongly on the international market. The effects were magnified when the Russian government banned grain export to protect local consumers[21]. This can lead to a panic-driven price spike due to a highly nonlinear process: Other major exporting countries limit exports in response to uncertainty in the global market, which in turn is exacerbated by these bans[21].

Climate change to date also clearly played a role in observed ecosystem changes. Coral reefs are very sensitive to elevated sea temperatures, which cause coral bleaching[23]. The sensitivity is amplified by local pollution and other human influences. Mass coral bleaching and mortality events have been observed worldwide since the early 1980s and have affected reefs at regional scales[24]. Recent modeling studies indicate that a 1°C warming above pre-industrial levels, likely to be surpassed already in the next decade, puts about 16% of reef locations at risk[25]. Tree dieback related to heat and drought has already been observed in boreal forest over substantial areas of North America (Allen et al., 2010).

2.1.2 1.5°C

A 1.5°C rise by 2100 would prevent some of the worst impacts, but still poses serious challenges worldwide, especially in the LDCs, SIDS and Africa. An estimated 75 to 250 million people would be at risk of increased water stress in just the next few decades[26]. A robust response in 21st century climate simulations is a decline in subtropical precipitation and increase in high latitude precipitation[27,28]. Thus, in general, precipitation changes will increase water stress in regions that are already drought-affected today. In Tanzania, reduced power generation from hydro-electric plants (due to water stress) alone is estimated to produce a climate-induced loss in national GDP of up to 1.7% by 2030[29].

Recent science shows that coral reef ecosystems are likely to be extremely adversely affected by the combined effects of ocean acidification and warming, already at levels as low as 1.5°C[25]. Global sea-level is projected to rise to 75 cm above 2000 by 2100, but can be stabilized beyond 2100 below levels 1.5 m higher than today, with temperatures dropping well below a 1.5°C increase[30]. Sea-level rise of only 45 cm would already result in a loss of 10% of land area in Bangladesh, with flood risk increasing most rapidly between 0 and 2°C warming[31]. Without adaptation such moderate sea level rise will increase the number of people flooded by storm surges more than five fold, with South and South-east Asia being especially at risk due to vulnerable low-lying and populated deltas[32].

2.1.3 2°C

For global warming up to roughly 2.5°C[33], the hydrological response is approximately linear with regions experiencing drier conditions under 1.5°C warming becoming even drier under warmer conditions[34]. Severe and widespread droughts would occur in the next 30–90 years over many densely populated areas[35], including regions like southern Europe, Australia and large parts of Africa and North and South America. The population at risk of increased water stress would reach 350-600 million people by 2050[26]. Still, in a 2°C warmer world, water stress will be mostly dominated by population changes rather than climate change[34].

Water- and heat-stress will negatively affect crop yields in regions that are already drought prone today, putting pressure on food security. Even under low-emission scenarios, drought disaster frequency in major crop sowing areas is expected to double[14]. Sub-Sahelian crop damages might exceed 7%, with a small chance of 27% damages[36]. In general however, models tend to underestimate the damaging effects of temperature and drought extremes on crop yields[16,37], giving quantitative impact projections limited validity. Field experiments have shown that crops are highly sensitive to temperatures above thresholds of 30-36°C, something which is not accounted for in most crop models[16,37]. Therefore, crop models probably underestimate yield losses for a +2°C by as much as 50% for some sowing dates[16], an effect which is likely to be significantly stronger for higher levels of warming.

10-15% of Sub-Saharan ecosystem species would be at risk of extinction[26] and a projected decrease in precipitation over the Amazonian forests may result in substantial forest retreat here[38]. At 2°C of warming roughly 25% of the original land extent of the humid tropical forest is at threat[38].

Sea-level would rise to 80 cm above 2000 by 2100, only 5cm above 1.5°C projections, thus resulting in comparable impacts. Long-term stabilization at 2°C warming however implies a continuous sea-level rise for centuries, with levels to approach 3 m by 2300[30]. The threshold for the Greenland ice sheet to irreversibly melt down is now estimated to be 1.6°C above preindustrial, compared to the IPCC AR4 estimate of 3.1°C[39].

2.1.4 4°C

Current emission trends and reduction pledges put the world in a trajectory towards a temperature increase of roughly 4°C by 2100. At such levels of warming impacts are most severe impacts, some of which might be beyond the limits of adaptation. The conditions of some of the most extraordinary heat waves experienced today will become the new norm and a completely new class of heat waves, with magnitudes never experienced before, will occur regularly[40,41].

This will have severe but as yet un-quantified impacts on agricultural production and human health. Climate impacts become large enough to dominate changes in water stress, and the changes in water run-off projected for 4°C warming are roughly double those of a 2°C world[42]. Timing of warming is critical as the world population is expected to grow until the second half of the 21st century. Under high-emission scenarios, the adverse impacts on water availability may thus coincide with maximum demand as the world population peaks[34].

The proportion of arid and semi-arid lands in Africa is likely to increase by 5% to 8%[43]. When accounting for the amount of water needed to produce a certain amount of food in a given location, it is estimated that the global population living in water-scarce countries will double compared to today[44]. Globally, drought disaster-affected areas in major crop sowing areas is predicted to increase three-fold (from 15.4% to 44.0%) in 2100[14]. Crop yields for maize are expected to decrease between -13% and -23% and for beans between -47% and -87%, implying that "...the kind of changes that would occur in a 4°C world would be way beyond anything experienced in recent times"[45]. Wheat production is likely to disappear from Africa by 2080[43], while millet yield in Sahelian Africa is projected to decrease by 40%[46].

In a 4°C world, climate change may become the dominant driver of ecosystem shifts, surpassing habitat destruction as the greatest threat to biodiversity[47,48]. Due to ocean acidification, corals around the world are likely to start dissolving above 550 ppm CO_2[49]. The Amazonian forest area is expected to contract to 25% of its original size[38] and up to 30% of other tropical rainforests, in central Sumatra, Sulawesi, India and the Philippines, is threatened by forest retreat[38]. In Africa, 25%–42% of plant species could lose all suitable range by 2085[50]. The interactions between impacts of climatic change, human actions (like deforestation), and forest responses (like fire) represent potential positive feedbacks that could lead to widespread Amazon forest degradation or loss[51]. Substantial loss of tropical forest would release large amounts of carbon dioxide into the atmosphere, which would accelerate climate change further. Between 2°C and 3°C of global-mean warming the global terrestrial plants carbon sink is actually expected to strengthen, due to the CO_2 fertilization effect, but it saturates above 3°C[52].

Climate change has the potential to catalyze rapid shifts in dynamic, out-of-equilibrium ecosystems, such as sudden forest loss or regional loss of agricultural productivity due to desertification[53]. The ramifications of these shifts would be far-reaching, ranging from extensive loss of biodiversity and diminished land cover, through to loss of ecosystems services[54]. Ecosystem degradation diminishes biodiversity, which decreases the overall stability of the ecosystem again. Recent work on competition and habitat suggests models generally underestimate the impact of climate change in biodiversity[55]. 4°C warming by 2100 would likely result in global temperatures stabilizing at 6°C above pre-industrial over the next few centuries[56]. The most recent geological analogue for a 6°C world, the Palaeocene-Eocene thermal maximum 55 million years ago, saw a period of rapid global change, though still at a slower pace than projected for a future 4-6°C world[57]. No paleo-analogue exists for the rapid warming projected under unmitigated climate change and it is fair to say that this will lead at least to widespread extinctions in ecosystems that are shown to have happened 55 million years ago[58].

Sea-level rise (SLR) would exceed 1 m by 2100[30], with regionally possibly up to 20% higher values[41]. Post-2100 sea-level is hard to project, due to large knowledge gaps in understanding of the response of the ice caps to such strong warming. The potential impact of 1m sea-level rise or more would be severe, with the real risk of the forced displacement of up to 187 million people over the century (up to 2.4% of global population)[59]. East Asia, South-east Asia and South Asia are most affected with an expected 53-125 million people displaced. The Small islands states, Africa and parts of Asia are the most likely to see coastal abandonment as the likelihood of successful protection measures is lowest here. Coastal cities in developing regions are especially vulnerable to SLR, due to high population densities and the often-inadequate urban planning and coastal protection. Including demographic information, Brecht et al.[60] estimate the future impact of climate change on storm surges that will strike coastal populations, economies, and ecosystems. They identify 10 Asian cities that account for 50% of the future exposure of SLR with over 40% falling on Manila, Karachi, and Jakarta alone. In Africa, countries with the highest total impacts under a 126 cm SLR scenario are Egypt, Mozambique and Nigeria with respectively 8, 5 and 3 million people displaced annually[61].

The frequency of the most damaging (category 4 and 5) Atlantic tropical cyclones is projected to nearly double by the end of the 21st century[62]. New research shows mortality risk depends on tropical cyclone intensity, exposure, levels of poverty and governance[63].

2.2 *Ocean acidification*[c]

The previous section focused on impacts projected for different levels of global warming. However, the atmospheric CO_2 concentration has surpassed 380 ppm recently, which has not only led to climate change, but also to increased absorption of CO_2 by the oceans and an increase of the ocean's acidity, estimated at a reduction of 0.1 units of pH since pre-industrial[64]. A lower pH value indicates higher acidity and since pH is a logarithmic scale, a reduction of 0.1 represents approximately a 30% increase in acidity. Higher acidity of ocean waters leads to reduced availability of calcium carbonate (aragonite), the resource vital for coral species and ecosystems to build skeletons and shells. Reduced reef calcification due to acidification has been observed in the last decades[65-67]. Especially vulnerable are warm-water coral reefs, cold-water corals and ecosystems in the Southern Ocean. Identified impacts of reduced pH on these systems are a reduction in coral calcification (reduced growth), coral skeleton weakening and strong temperature dependence, the latter potentially increasing the risk of bleaching due to a rising temperature of surface waters[68].

IPCC AR4 projections for SRES scenarios indicate a further increase of the ocean's acidity of 0.14 to 0.35 units of pH over the 21st Century[64], equivalent to an increase in acidity of 80-180% since pre-industrial. A recent review shows that the anthropogenic rate of carbon input into the oceans appears to be greater than during any of the ocean acidification events identified so far over the geological past, dating back millions of years and including mass-extinction events[69]. Recent research estimates that if atmospheric CO_2 reaches 450 ppm, coral reefs around the world will slow down growth considerably and at 550 ppm will start to dissolve[49,70]. The effects of acidification have already been observed and will gradually worsen as acidification increases. Hence, reduced growth, coral skeleton weakening and increased temperature dependence will start to affect coral reefs below 450 ppm. A deterioration of coral reefs will have negative impacts on dependent species, fisheries, coastal protection and tourism in many regions.

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[c] This section is adapted from Schaeffer, M. and B. Hare (2012) "Ocean Acidification: Causes and Consequences", Climate Analytics, 1 October 2010.

A scenario that is consistent with a 1.5°C warming limit may start to drop down to CO_2 concentration of 350 ppm by the end of this century. A recent assessment concluded a CO_2 level of below 350 ppm is required for the long-term survival of coral reefs, if multiple stressors are included, like high ocean surface-water temperature events, sea-level rise and deterioration in water quality[71].

2.3 *Overview of impacts*[d]

As mentioned in the introduction and clear from the previous sections, even limiting warming to 1.5°C will not prevent far-reaching impacts, particular for vulnerable countries, like LDCs and SIDS, nor for vulnerable ecosystems, like coral reefs. Above 1.5°C, however, not only will gradually increasing impacts become worse, but parts of the Earth system might enter a different state, including through some identified 'tipping elements', like irreversible melting of the Greenland ice sheet and risk of Amazon dieback. The graphic illustration in Figure 3 provides an overview of some impacts and tipping elements across temperature levels.

[d] This section is adapted from Höhne, N., B. Hare, M. Schaeffer, M. Vieweg-Mersmann, M. Rocha, C. Chen, J. Rogelj, M. Mengel, M. Perrette (2011) "After Durban: Risk of delay in raising ambition lowers chances for 2°C, while heading for 3.5°C", Climate Action Tracker – Climate Analytics, PIK, Ecofys, 11 December 2011.

A SNAPSHOT OF A WARMING WORLD

As the agreements in Durban do not propose additional action before 2020 the risk of exceeding 2°C remains very high. Action to implement the Durban Agreements will need to be quick to increase emission mitigation, for having a chance of deviating projected warming from the current pathway leading to 3.5°C by 2100. A limit of 1.5°C will already lead to considerable impacts, and more with 2°C. But with temperature increases heading towards 3.5°C, the impacts reach a distinctly higher level of risk. The impact examples in this figure are illustrative and not comprehensive.

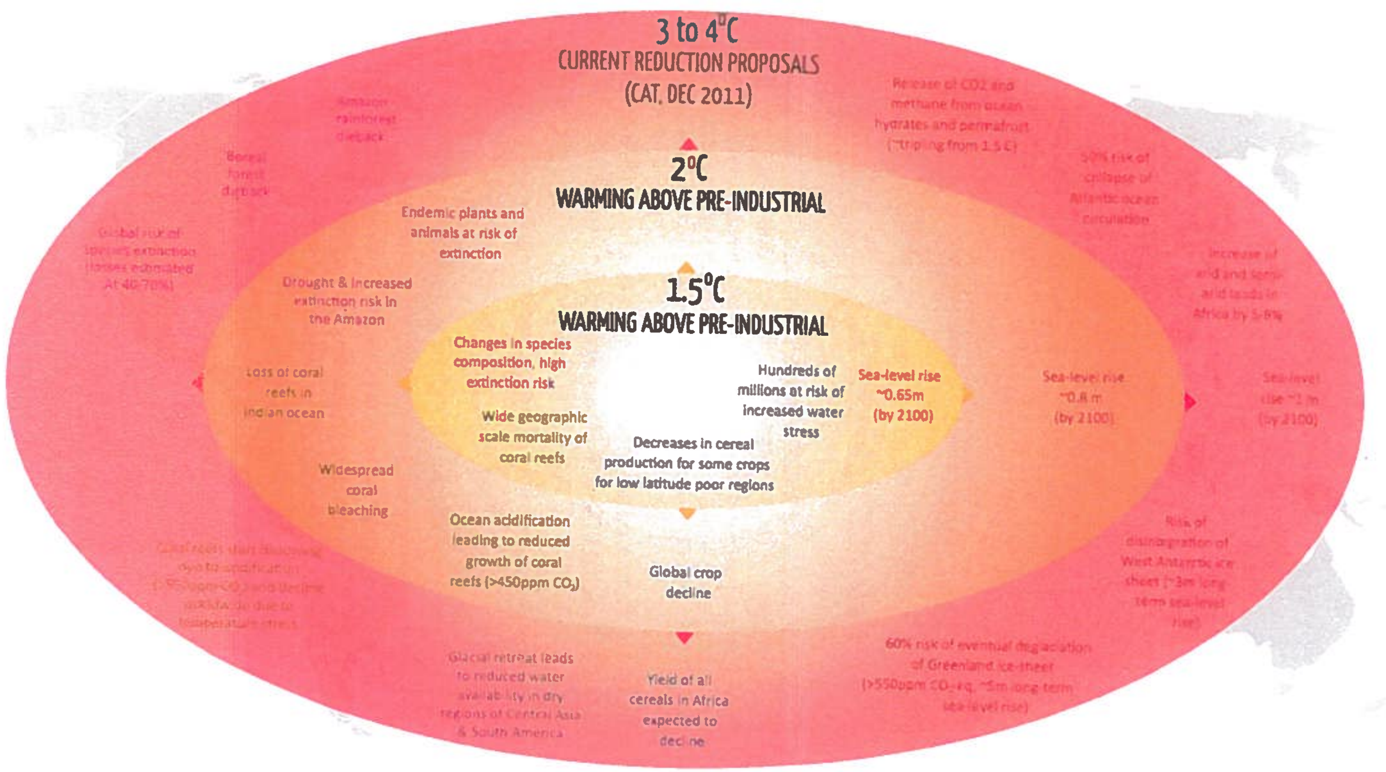

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Figure 3. Overview of some of the impacts and tipping points at warming levels of 1.5 to 4 °C above pre-industrial temperature levels.

3 Can warming be limited to 1.5°C?

3.1 *Geophysical feasibility of 1.5°C*

Present-day global warming is about 0.8°C. If all emissions were to be eliminated immediately, delays in the climate system and abrupt changes in atmospheric radiative forcing would let warming continue to rise to a best-guess level of 1.2°C above pre-industrial, before embarking on a gradual decline (black dashed line in Figure 4).

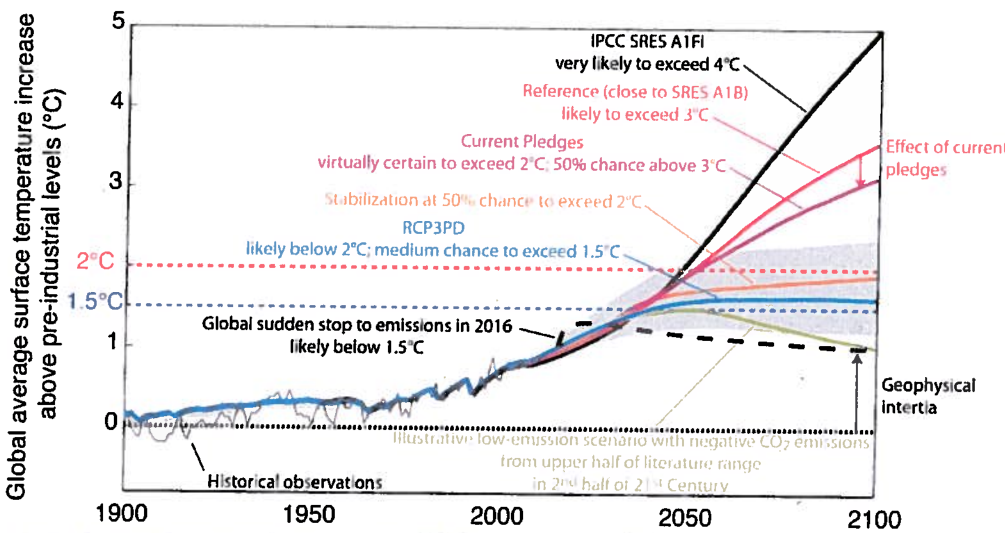

Figure 4. Median estimates (lines) from probabilistic temperature projections estimates for business-as-usual emission scenarios (SRES A1FI and Reference), as well as a wide range of mitigation scenarios holding warming below 2°C with a 50% chance or more[30,72,73]. The 15-85% uncertainty range is provided for one scenario only to enhance readability.

Obviously, an immediate stop to all global emissions is infeasible, but in the long term, concentrations will only stabilize, if global CO_2 emissions were reduced to near zero[74]. Delaying emission reductions results in higher cumulative emissions. Even if CO_2 emissions are brought down to zero after such a delay, the higher cumulative emissions lead to both concentrations and warming stabilizing at a higher level.

The slow response of concentrations and warming might also be turned into an advantage. It would take decades to centuries for human-induced temperature increase to fully stabilize, at a level indicate in Figure 1, for example at more than 2°C for a concentration of 450 ppm CO_2eq. Until this full temperature response is reached, warming remains below the level achieved in full equilibrium. This delay means there is an option for emissions and concentrations to peak and decline, aiming to bring down concentrations from a peak level, before the entire climate system has time to warm up to that peak. If concentrations go down far enough and quickly enough, warming might even decline within the 21st century, as illustrated by the hypothetical sudden-stop scenario. Geophysically speaking, there is therefore no reason to see 1.5°C as beyond reach.

For 2005 the IPCC AR4 estimated that the total CO_2eq concentration of all long-lived greenhouse gases amounted to about 455 ppm CO_2 equivalent, although with the cooling effects of aerosols and other air pollutants taken into account the net greenhouse gas concentration was estimated to be in the range 311 to 435 ppm CO2eq. As shown in Figure 1 in the Introduction, a warming limit of 1.5°C requires concentrations below 400 ppm CO_2eq. Any mitigation pathway aiming to achieve stabilization at 350 ppmv CO_2-equivalent taking into account all Kyoto gases (CO_2, CH_4, N_2O and F-gases) hence necessarily involves a peak-and-drop concentration profile, dropping down from current concentrations to a value around 350 ppm CO_2eq.

3.1.1 Role of air pollutants[5]

Recent publications[75-77] have suggested that so-called Short-Lived Climate Forcers (SLCFs) might help to reduce near-term warming and stay below 2°C. The term SLFCs has evolved to cover, for example, methane, HFCs and air pollutants like Black Carbon and Organic Carbon. The relatively short lifetime in the atmosphere ranges from 12 years (methane) to a few days or weeks (Black Carbon, Organic Carbon, etc.).

Non-CO_2 measures must never be interpreted as a means for "buying time" to allow delayed reductions in CO_2. This can be shown by considering a scenario where the full implementation of all air-pollutant measures as identified by Ref 75-77 is accompanied by a 10-year delay in CO_2 and related sulphur reductions. After a delay to 2030, CO_2 emissions[6] are reduced rapidly to ultimately reach the same level as the original low-emission pathway by 2100. In the short term, warming is lower (up to 0.1°C by the 2020s) than in the original low- emission scenario. This reduced warming is mainly the result of higher SOx emissions, which have a cooling effect, associated with the delayed reductions in CO_2. However, if a high value for present-day radiative forcing of BC is assumed, cooling from lower BC and related emissions roughly equals that of the higher SOx emissions. However, such a pathway of accelerated pollutant measures combined with delayed CO_2 measures has two important disadvantages, even if assuming a high present-day BC forcing.

Firstly, the probability of exceeding a 2°C warming in the 21st century more than doubles from 20% to 50%. Median warming is projected to be 0.3°C higher in 2100 and, crucially, given the slow removal of CO_2 from the atmosphere, this effect is set to linger for centuries. Note that this delayed-CO_2 pathway still includes fully all of the incremental effects of reductions in HFCs, CH_4 and others of the original low- emission pathway and the higher warming by 2100 is solely the effect of the 10-year delay in CO_2 measures.

Secondly, energy-related CO_2 reduction rates between 2030 and 2050 on average need to be 2.4% of 2010 levels per year, rather than the 1.5% per year in the original low-emission pathway with early CO_2 measures. Without these higher reduction rates to "catch up", the CO_2 concentration and warming by 2100 will be even higher. From a multi-decadal perspective, delay scenarios have been shown to be riskier, requiring faster CO_2 reductions after a 10-year delay, and generally too expensive and/or technically infeasible[78,79].

[5] This section is adapted from Hare, B., M. Schaeffer, M. Rocha, J. Rogelj, N. Höhne, K. Blok, K. van der Leun and N. Harrison (2012) "Closing the 2020 emissions gap: Issues, options and strategies", Berlin, Germany, Climate Analytics and Ecofys.

[6] SOx emissions would follow this downward path

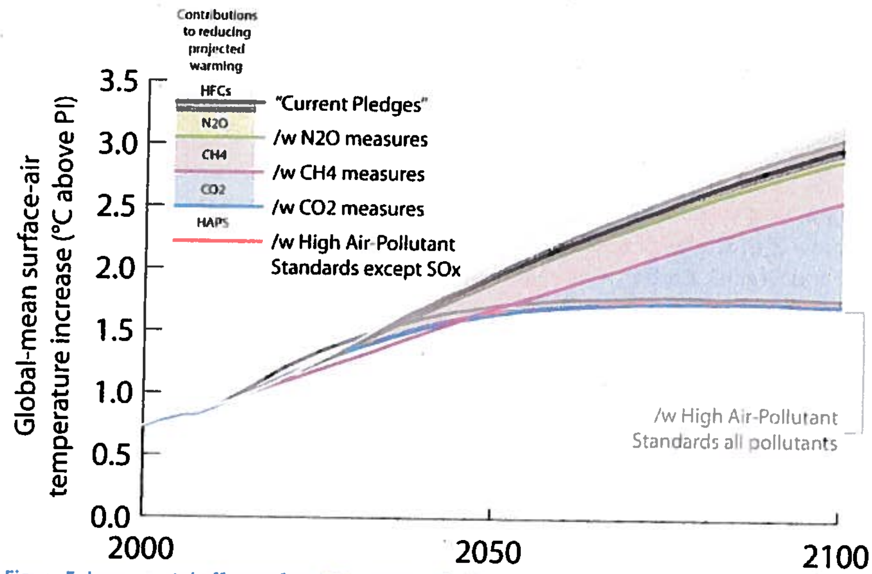

Figure 5. Incremental effects of emissions reductions of different greenhouse gases HFCs, N_2O, CH_4, CO_2, as well as air pollutants. The /wCO2 measures includes only those air pollution reductions consistent with energy system changes. This can be compared to low CO2 emissions with high air pollutant standards including SOx (grey) and without additional SOx controls (red). The difference between the red and the blue curves is thus due mainly to additional action on BC, on top of those associated with the low-carbon energy-system transformation. The difference between the grey and the red is essentially the effect of lower SOx emissions under a high air-pollutant standards scenario.

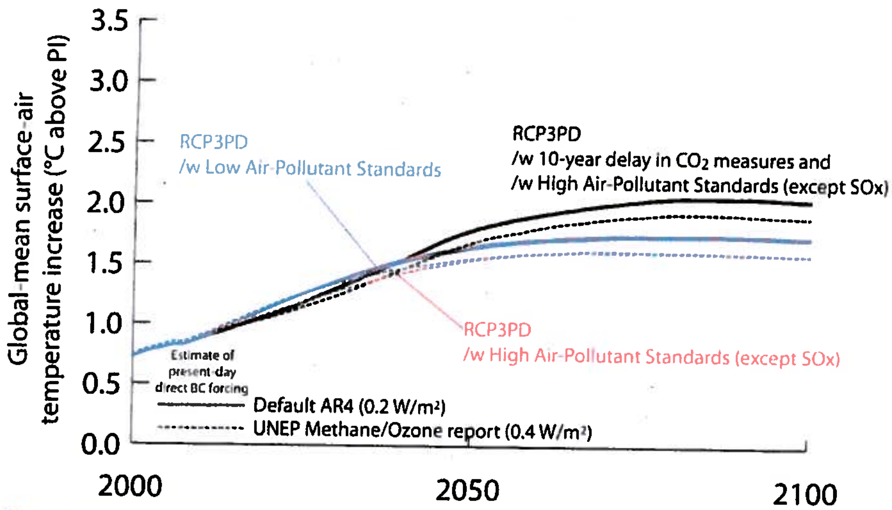

Figure 6 Global warming projections for low-carbon pathway RCP3PD (blue line) and a scenario where CO_2 reductions are delayed until 2030 but with large reductions in black carbon and related air pollutants, according to a shift from Low to High Air-Pollutant Standards, which exclude sulphur (black). In the delay case CO_2 and SOx emissions follow a scenario implied by current reduction pledges until 2030, where after they are reduced rapidly towards RCP3PD levels by 2100. The red line shows the relative cooling benefits of only implementing accelerated air-pollutant reductions, without a delay in CO_2 measures. For comparison, the dashed lines show results for the same scenarios, applying present-day direct radiative forcing from BC as assumed in the UNEP Methane and Ozone reports[76,77], which is about double the estimate in IPCC AR4[80]. Such higher forcing estimates would imply that BC measures have a larger cooling effect (compare dashed red with dashed blue line), but these are as temporary as in the default (AR4) cases.

3.2 *Energy-economic scenarios*[7]

Since the publication of IPCC's AR4, a range of cost estimates was published for mitigation pathways leading to greenhouse gas concentrations in, or below, the lowest-emission category assessed in AR4. These studies have produced feasible pathways leading to stabilization levels down to 400 ppm CO_2eq.

Most energy-economic models are able to achieve low emission levels, but this crucially depends on:

- Early and globally concerted mitigation, emission reductions implemented from 2013 onwards and global emission peak by 2020
- Rapid up-scaling and feasibility of large-scale bio energy, and availability of forest sinks
- High rates of energy efficiency improvements
- Availability of carbon capture and storage technologies (CCS)

A recent study published by the Energy Modelling Forum (EMF) explored these key determinants of the feasibility of low-emission scenarios. The study re-confirmed that low emissions could be rendered infeasible, if no globally concerted mitigation is achieved and/or emission concentration profiles are not allowed to reach a temporary peak, before declining, the latter depending on the availability of CCS technology to achieve negative emissions later on in the 21st century.

"Where climate-action cases could not be modeled solely for model solution or high initial price reasons, this is an indication of particularly high rates of change in the energy and other climate-related sectors, which may prove politically difficult to produce, but does not imply a lack of physical feasibility." [81]

3.2.1 Role of negative emissions: biofuel-energy with carbon capture and storage

The UNEP Gap reports identified a range of energy-economic scenarios that achieve 2°C with a probability higher than 66% and a return to below 1.5°C by 2100 with a probability of 50%. Until the 2030s, these two classes of scenarios overlap, but a 1.5°C scenario requires deeper reductions in the rest of the 21st century. Constrained by real emissions until 2010 and energy-economic reduction potential until the 2020s, the 1.5°C scenarios necessarily require net-negative CO_2 emissions in the 2nd half of the 21st century (Figure 7). The later the emissions peak, the more CO_2 needs to be removed starting around the 2050s (Figure 8).

Due to slowly responding carbon pools in the Earth system, a large part of emitted CO_2 stays in the atmosphere for centuries, which is why emissions need to be reduced to near zero for stabilizing concentrations, as mentioned above. However, this also means that concentrations decrease only slowly, unless CO_2 is taken out of the atmosphere by human interventions. The main technology foreseen by the present generation energy-system models to achieve this is known as Biomass Energy Carbon Capture and Storage (BECCS)[8]. As biomass takes up carbon from the atmosphere through photosynthesis, extracting the CO_2 from biomass energy systems and storing it underground, in effect producing useful forms of energy for society (electricity) while taking CO_2 out of the atmosphere – a negative emission. This is not necessarily an example of geo-engineering: 'cleaning up the mess' through an energy-system transformation involving BECCS is not more a form of geo-engineering than 'making the mess' by fossil-fuel consumption was in the first place. What is also important to realize is that CO_2 removal helps solve the issue of ocean acidification, which is not

[7] This section is adapted from Schaeffer, M. and F. Fallasch (2010) "Feasibility of low-emission pathways", Berlin, Germany, Climate Analytics, 11 June 2010.

[8] For example: Azar et al. (2006) "Carbon Capture and Storage From Fossil Fuels and Biomass – Costs and Potential Role in Stabilizing the Atmosphere", Climatic Change 74 (1), 47-79; Knopf et al. (2008) "Report on first assessment of low stabilisation scenarios", D-M2.6, PIK, Potsdam, Germany; Rao et al. (2008) "IMAGE and MESSAGE Scenarios Limiting GHG Concentration to Low Levels", Interim Report IR-08-020, IIASA, Laxenburg, Austria.

addressed by geo-engineering options that intervene in warming, for example by reducing the solar radiation input into the Earth system.

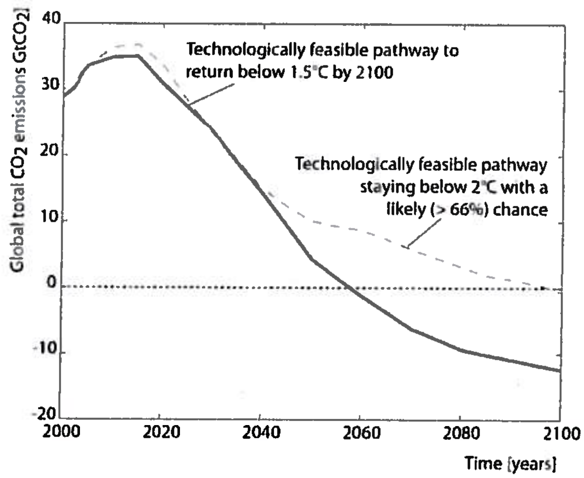

Figure 7 CO2 emissions in a 1.5°C scenarios overlap with a 2°C scenario until the 2030s, but require deeper reductions in the rest of the 21st century.

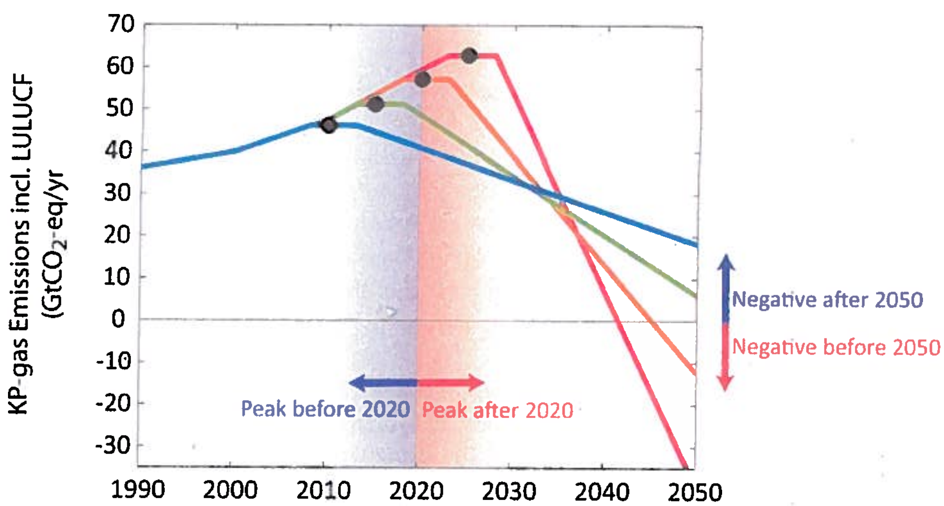

Figure 8 The effect of a delay in 2020 reductions, but keeping a fixed cumulative emissions in the period up to 2050 (hence a fixed probability of exceeding temperature targets) is to increase the required reduction rate up to 2050 and deepen the reductions needed by 2050. The blue line is comparable to a scenario with a 50% reduction below 1990 by 2050, as is the blue line in Figure 4. A longer delay is illustrated here by following business-as-usual paths for a longer time (in this case IPCC SRES Marker scenario A2).

Growing biomass has the potential to sequester carbon from the atmosphere in terrestrial ecosystems, by changing agricultural practices and forest management. In addition biomass in the form of biofuels is seen as a near-CO_2-neutral substitute for fossil fuels in both the transport and power sectors. If the latter use is combined with CCS, the system has the potential of generating negative net CO_2 emissions over the full lifecycle of the process. In this system of Biomass Energy with Carbon Capture and Storage (BECCS), CO_2 sequestered during biomass growth before harvest is only partly re-released to the atmosphere, the other part being stored for geological time scales.

The extent of the ethical, political, ecological and legislative obstacles of the required large-scale overhaul of current land-use practices are under debate, but the technical potential may be sufficient to draw down CO_2 concentrations back to current levels before the end of the 21st century[9]. From an engineering perspective, a coupling of two systems is required, both of which are currently being explored in numerous projects. Various bio-energy systems are already being applied commercially, or have reached the commercial implementation phase. Exploration of CCS technology and further scientific and engineering analysis of full CCS lifecycle emissions and costs need expansion. The latter is also crucial if a more industrial approach to reach negative emissions is to be deployed. Direct air capture[10] of CO_2 by chemical processes is seen by some as an ultimate 'back-stop' technology to bring down CO_2 concentrations below dangerous levels as soon as observational evidence and scientific advancement deem this necessary. Current projections of costs are high, but they may be higher still if a comparably low level of CO_2 concentration needs to be achieved without such technologies. As with bio-energy systems, air capture requires a combination with CCS to achieve negative emissions.

There is a need for an active research program into the technology choices for limiting CO_2 concentrations to low levels, in order to identify the potential synergies and conflicts between fossil carbon capture and storage, biomass carbon capture and storage, renewable energy systems and energy efficiency. The rate of growth of renewable energy in recent years has been extraordinary and is indicative that in many markets renewable energy (in the form of wind energy) is one of the best short-term options for capacity expansion in the electric supply area. With declining prices in photovoltaics in many markets there is an expectation of grid parity within the next 5 to 10 years, which could revolutionize the market in this area. A scaled up research program covering technological, economic and legislative and regulatory issues should not conflict with the short-term need to introduce technologies that reduce emissions.

In addition to the legislative issues raised for CCS in general, a number of social, legal and legislative issues are relevant in particular for the combination of CCS with biomass in BECCS systems[11]:

- The recent bio-fuels boom demonstrates two side of the issue: the potential of a short-term, large-scale deployment of bio-energy, while on the other side potentially inducing fundamental social problems, including price distortion on the World food markets and environmental concerns. The latter pose legislative challenges of regulating competing land uses, including production of food and fodder, and nature conservation. The technological challenge here is to move away from the present generation of biomass energy technologies to those based more on woody plants that do not compete for food production in the same way as first-generation biomass systems.
- Given the geographic distribution of productive land, a large-scale deployment of biomass production would likely require substantial areas of land in developing countries. The implementation of an effective BECS system requires commercialization wood -based crop technologies for energy production that would not adversely affect food production or water supply, as well as the carbon capture and storage technology. Beyond the middle decades of this century biomass carbon capture and storage appears to be necessary to achieve low CO_2 concentrations. If there are to be substantial negative emissions technologies introduced after the 2050s there would need to be substantial

[9] For an overview of the energy systems involved and their potentials in a strategy for drawing down the CO_2 concentration, see e.g. Read, P. (2008) "Biosphere carbon stock management: addressing the threat of abrupt climate change in the next few decades: an editorial essay", Climatic Change 87, 305-320, and comments on Read's paper by Rhodes and Keith (2008) "Biomass with capture: negative emissions within social and environmental constraints: an editorial comment", Climatic Change 87, 321-328

[10] For an informal discussion, see Jones, N., Nature 458, 30 April, 2009, 1094-1097.

[11] For a discussion, see Rhodes and Keith (2008) "Biomass with capture: negative emissions within social and environmental constraints: an editorial comment", Climatic Change 87, 321-328

investment in research, development and demonstration and commercialization well before then. Hence there would need to be a scaled up investment in research and development of CCS technologies, and on environmentally sustainable ways of growing, producing and transporting biomass fuels. In order to develop the required scale there would need to be introduction into the energy system of technologies designed to achieve negative CO_2 emissions within a few decades. The role and potential of this technology would need to be set against a role for fossil carbon capture and storage to verify any conflicts or synergies between fossil and biomass systems. In the short run (2020s to 2030s), biomass carbon capture and storage will not play a significant role in reducing emissions to the atmosphere, although what happens in this period may be quite fundamental in the longer term for reducing CO_2 concentrations quickly, depending on the ability to scale up this technology.

The true technological feasibility of negative emissions technology is at present not well-established. There is a need for an upgraded research program into all aspects of this technology, including the policies and measures required to introduce this into energy markets and to investigate the synergies and potential conflicts with biomass and fossil carbon capture and storage technologies.

Whilst the successful introduction of carbon capture and storage technologies would help lower CO_2 emissions in the longer term, an emerging risk for climate mitigation policies in the short term is posed by demands for the large-scale approval of new coal-fired power plants on the basis that these may be retrofitted later with CCS technology as soon as this technology will have proven viable on a large scale. The latter is not without doubt and a failure of large-scale implementation of CCS in the short term will leave the electric power system depending on newly-constructed coal-fired plants without CCS for another 30 or 40 years of operation, when this could have been avoided through reliance at present on an expansion of renewable energy capacity and energy efficiency in many cases. Another concern with CCS outfitted plants, as well as retrofitting, is that the CCS capacity might be filled up with carbon captured from fossil-fuel plants, whereas this capacity might be needed later for BECCS systems.

3.2.2 Role of nuclear energy

A phase out of nuclear capacity, as envisioned for Germany, offers a window of opportunity, if it is combined with a smart investment strategy reaching a full decarbonisation by 2050. Various studies show that a transition to a completely renewable power infrastructure is possible within a relatively short time frame.[12] Japan might still pursue this road as well, as was stated by top government spokesman Yukio Edano in the wake of the Fukushima incident, although there have been mixed signals on their future strategy since:

> *"Pursuit of solar power, bioenergy and other clean energy sources will be a key pillar of the government's reconstruction strategy to be drawn up for areas hit by a massive quake and tsunami following the country's worst nuclear accident"*[13].

If the opportunity is used to transform the power sector the effects on CO_2 emissions will be positive in the medium and long term. For Germany, for example, various studies come to the conclusion that a nuclear free power sector is possible to achieve in a very short time, but could also benefit climate by strengthening efforts in energy efficiency and renewable energy.[14]

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[12] See for example: Matthes, F. et al. (2011). "Schneller Ausstieg aus der Kernenergie in Deutschland. Kurzfristige Ersatzoptionen, Strom- und CO2-Preiseffekte"; Schwartzman, P.D. and D.W. Schwartzman (2011). A Solar Transition is Possible.

[13] Kyodo News, 29 March 2011. http://english.kyodonews.jp/news/2011/03/81780.html

[14] Greenpeace Germany (2011). "Der Plan: Ein aktuelles Energiekonzept für Deutschlands Atomausstieg bis 2015"; Matthes, F. et al. (2011)

The opportunity is even higher where this change in strategy leads to a replacement of newly planned nuclear capacity. Due to the high investment cost of new nuclear plants the same investment saving could be redirected towards low carbon power sources, smart grid infrastructure and demand management systems and produce larger emissions reductions for the same investment. Each dollar spent on a new reactor buys about 2-10 times less carbon savings, 20-40 times slower, than spending that dollar on the cheaper, faster, safer solutions: efficient use of electricity, making heat and power together in factories or buildings ("cogeneration"), and renewable energy[15]. Nuclear power is also one of the few energy technologies to exhibit negative learning, in other words, increasing costs with time rather than decreases[16].

The characteristics of nuclear energy infrastructure and investments discussed here play a role in energy-economic modelling of cost-optimal 21st century mitigation scenarios. Nuclear energy is one in a range of non-fossil fuel options in most emission-reduction scenarios aimed at limiting emissions to a level consistent with 2°C warming. For example, in IEA's "Energy technology perspectives 2010", nuclear energy provides 6% of the reductions from the baseline needed by 2050 to reach a 2°C-concistent scenario[17]. A wide inter-comparison of energy-economic models and scenarios[18] found that

> *"Nuclear power does not play an important additional role in mitigation scenarios in any of the models beyond the role it plays in their baselines where nuclear energy is attractive in most models; fixing nuclear power to its baseline values leads only to a marginal increase in costs. With a phase out of nuclear, however, costs do increase. However, this is less than with an economically severely limited CCS potential".*

Hence, required emission reductions are possible without nuclear energy, but whether they are achieved, depends on structural long-term choices: for equal reductions at somewhat higher costs, or weakened mitigation at equal costs. A recent economic analysis showed this assessment to hold in an energy-economic modeling framework, showing that the economic impact of imposing a stringent carbon budget on the economy is the first-order effect, and much larger than restrictive nuclear power policies[82].

3.3 Overview of climate response to emission scenarios

The previous sections provided a review of climate-system constraints and energy-economic constraints to achieve 1.5°C. In summary:

- Holding global warming below 2°C is physically possible
- Likewise, returning warming to below 1.5°C by 2100 is physically possible, after exceeding it temporarily in the 2050s
- Technologically and economically feasible scenarios that achieve the 1.5 and 2°C targets have been published in the scientific literature
- In the short term, scenarios consistent with 1.5°C and 2°C have been shown to overlap until the 2030s. Afterwards, stronger emission reductions are required for 1.5°C
- Emission reductions required by 2020 to keep below 1.5°C and 2°C are feasible and can be achieved at moderate cost, requiring only well-known technology options
- The reductions are most feasible if action starts before 2015: the longer the delay, the more difficult and expensive

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[15] see e.g. Amory Lovins at http://www.huffingtonpost.com/amory-lovins/nuclear-power-fukushima-_b_837643.html

[16] Grubler, A. The costs of the French nuclear scale-up: A case of negative learning by doing. Energy Policy 38, 5174-5188 (2010)

[17] IEA. (2010). *Energy technology perspectives*. International Energy Agency (IEA), Paris, France, 18 pp.

[18] Edenhofer, O., Knopf, B., Barker, T., Baumstark, L., Bellevrat, E., Chateau, B., Criqui, P., Isaac, M., Kitous, A., Kypreos, S., Leimbach, M., Lessmann, K., Magne, B., Scrieciu, S., Turton, H. and van Vuuren, D. (2010). "The Economics of Low Stabilization: Model Comparison of Mitigation Strategies and Costs", The Energy Journal 31(Special Issue): 11-48.

- Important technologies in post-2020 pathways identified as required to increase the probability to stay below 2°C and return to below 1.5°C need much further consideration and research
- Given the uncertainties in the large-scale viability of technological options, a delay in action is further risky by reducing the future flexibility in deploying all technological options: the longer the delay, the less luxury the world has to NOT deploy certain technologies

To put the scenarios discussed above into perspective, we show in Figures 6-9 projections for other global-mean climate indicators, using the same emission scenarios used for the warming projections in Figure 5.

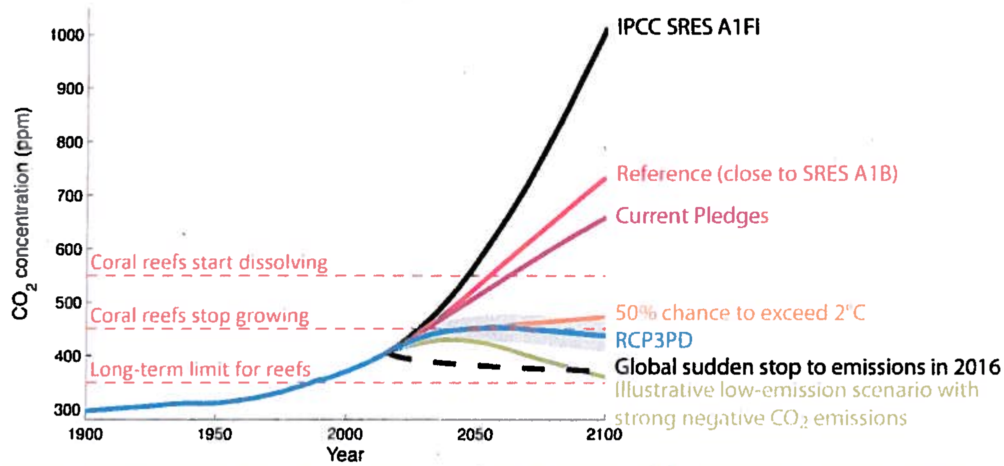

Figure 9. As Figure 4 for atmospheric CO2 concentration. Coral reef survival limits from Silverman et al. (2009) and Veron et al. (2009)[49,71].

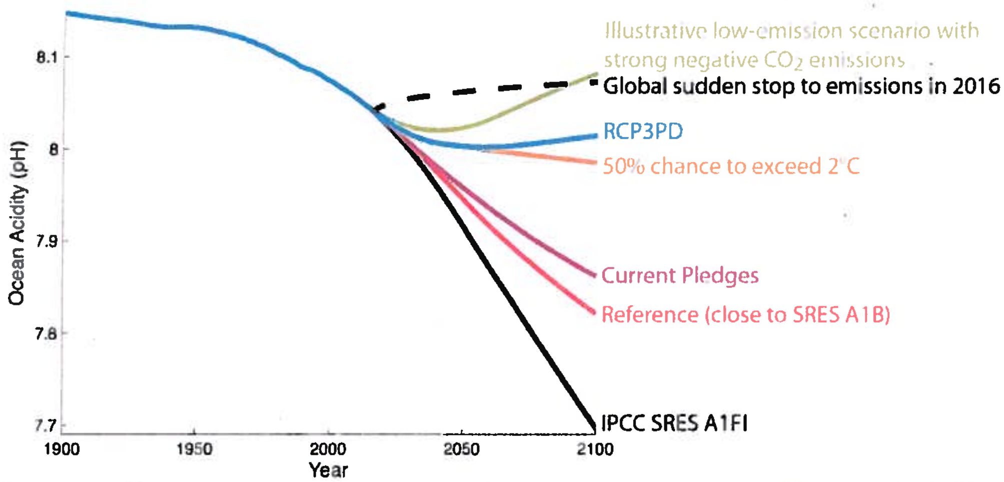

Figure 10. As Figure 4 for surface-ocean pH. Lower pH indicates more severe ocean acidification, which inhibits growth for calcifying organisms, including shellfish, calcareous phytoplankton and coral reefs. Method for estimating pH from Bernie et al. (2010)[83].

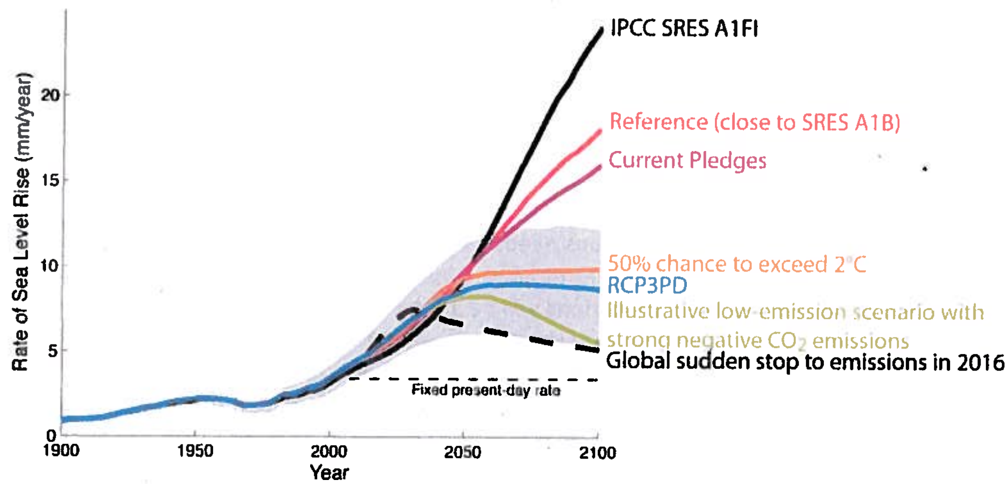

Figure 11. As Figure 4 for annual rate of global-mean sea-level rise. The indicative/fixed present-day rate of 3.3 $mm.yr^{-1}$ is the satellite-based mean rate 1993–2007[84].

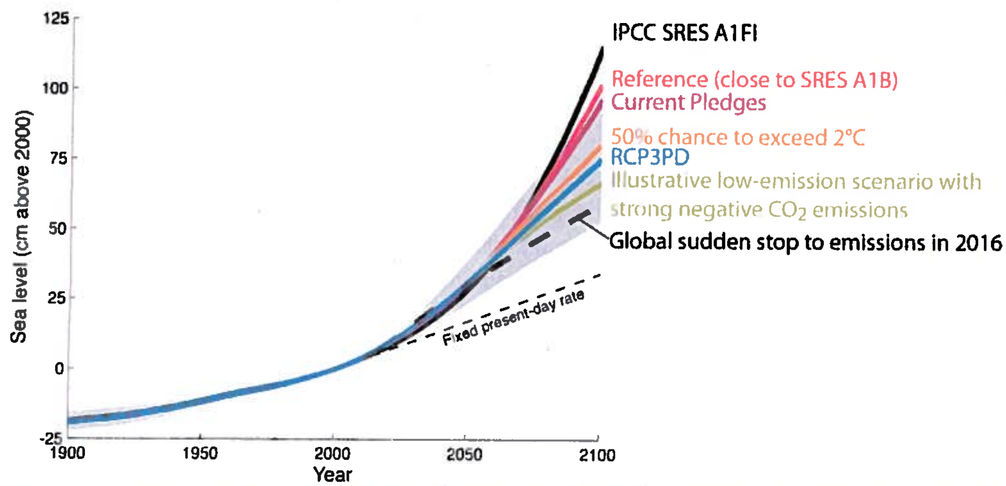

Figure 12. As Figure 4 for global-mean sea-level rise above 2000 levels. "Fixed present-day rate" illustrates sea-level rise of the 21[st] century if hypothetically the mean rate of change equals the rate observed by satellites over 1993-2007[84].

4 Ambition level of emission reduction proposals

4.1 2020 ambition of pledges and emissions levels consistent with 1.5°C

As explained in the previous section, 1.5 and 2°C pathways overlap until the 2030s. In recent years, UNEP coordinated scientific reports on global 2020 emission levels[19]. The scientists involved in the reports estimated that a large gap exists (the 'Emissions Gap'). This gap is between, on the one hand, the 2020 global emission level implied by current emission reduction pledges by countries and, on the other hand, the lower 2020 global emission level required to put the world on a feasible long-term emission pathway to hold warming below 2°C. The reports further showed that until after 2020 this 2°C pathway overlaps with a pathway that achieves a warming limit of 1.5°C in the long term, as mentioned above.

[19] UNEP (2010) "The Emissions Gap Report. Are the Copenhagen Accord Pledges Sufficient to Limit Global Warming to 2° C or 1.5° C? A preliminary assessment", United Nations Environment Programme, Nairobi, Kenya; UNEP (2011) "Bridging the Emissions Gap. A UNEP Synthesis Report", United Nations Environment Programme, Nairobi, Kenya; UNEP (2012) "Bridging the Emissions Gap 2012. A UNEP Synthesis Report", United Nations Environment Programme, Nairobi, Kenya.

The Emissions Gap was estimated as 8-13 GtCO2e, which shows unambiguously that currently proposed emission reductions for 2020 are insufficient to put the world on track for 1.5 or 2°C. The report further noted that avoiding double-counting of CDM credits is required to prevent the gap from *increasing* by up to 2 $GtCO_2e$. CDM double-counting results when a single emission reduction achieved by a particular CDM project is claimed as a reduction by the developed country providing the funding, as well as by the developing country that hosts the project.

The 2020 Emissions Gap refers to the further reductions needed to put the world on track for a chance of staying below 2°C of at least 66%, or "likely" in IPCC terminology. The UNEP report states that the higher the emissions in 2020 are, the more expensive the reductions will be afterward, and the more one has to rely on technologies which are not yet established on a large scale. The recent IEA "World Energy Outlook 2011" arrived at a similar conclusion and states that "Delaying action is a false economy: for every $1 of investment avoided in the power sector before 2020 an additional $4.3 would need to be spent after 2020 to compensate for the increased emissions."

4.2 Options to close the 2020 Emissions Gap

UNEP, the International Energy Agency[20] and others, have provided clear guidance on how to close the 2020 Emissions Gap:

1) Increase the global share of renewables from an estimated 10% at present to 15% by 2020. This will help to close the Gap by 4 GtCO2.
   - Increase further to a 20% share to close the Gap completely.
2) Intensify energy efficiency improvements, which would have a major impact on global energy and climate trends and would postpone a lock-in in emissions from 2017 to 2022.
3) Reduce subsidies for fossil fuels to decrease global emissions by 2 GtCO2 by 2020 (Figure 13).
   - Fossil-fuel consumption subsidies worldwide amount to $409 billion in 2010 and may grow to $660 billion in 2020. Eliminating subsidies reduces fossil-fuel demand and emissions.
   - Global renewable-energy subsidies were only $66 billion in 2010.
4) In international negotiations context:
   - Implementing the more ambitious "conditional" pledges. This would reduce the gap by 2 GtCO2e.
   - Minimizing the use of lenient Land Use, Land Use Change and Forestry (LULUCF) credits and surplus emission credits. This would reduce the gap by around 3 GtCO2e.
   - Minimizing the use of the surplus Assigned Amounts from the 2008-2012 Kyoto period. This would reduce the gap by 1.8 GtCO2e.
   - Avoiding the double-counting of offsets and improving the additionality of CDM projects. This would reduce the gap by up to 1.5 GtCO2e.
   - Reducing emissions from international shipping and aviation.

[20] IEA (2011) "World Energy Outlook 2011", Paris, France

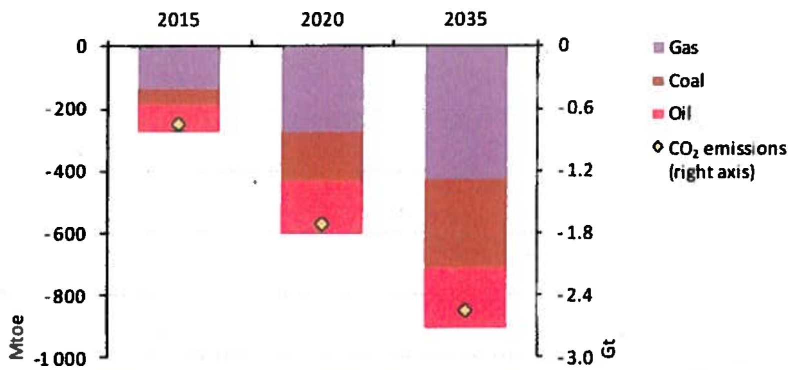

Figure 13 Impact of fossil-fuel consumption subsidy phase-out on global energy demand and CO2 emissions, 2012-2035. Source: "Joint report by IEA, OPEC, OECD and World Bank on fossil-fuel and other energy subsidies: An update of the G20 Pittsburgh and Toronto Commitments" Prepared for the G20 Meeting of Finance Ministers and Central Bank Governors (Paris, 14-15 October 2011) and the G20 Summit (Cannes, 3-4 November 2011).

4.2.1 Complementary measures

In the discussions on the Emissions Gap, several sources have suggested 'complementary measures' might help close the Gap, including measures on Short-Lived Climate Forcers (SLCFs) such as methane, HFCs and black carbon. Regarding methane and HFCs, a crucial piece of information on 'complementary measures' is whether the effects come unambiguously on top of reductions achieved by current pledges, and lead to overall deeper reductions than these. If so, this will help, but there should be no objection against including such deeper methane or HFC reductions in the overall reduction pledges themselves, and thereby increasing the ambition of those pledges.

By contrast, reductions in Black Carbon and related air pollutants have highly uncertain effects on climate and their long-term climate benefit is at best partially in addition to that achieved in a low-carbon development pathway (see Section 3.1.1). There are already large air-pollutant reduction benefits from the energy-system transformation required to reach a low-carbon development pathway, because the phase-out of fossil-fuel activities and technologies will eliminate co-emitted pollutants. Given the large associated health and other benefits of improved air quality, this reduces the net costs of CO_2 measures[85,86]. By contrast, more rapid air-pollutant reductions, beyond those achieved from energy-system transformation alone, add relatively little to reduced warming, even when excluding comparably rapid action on SO_x emissions. However, such deep reductions in air pollutants still have large human health and other benefits.

Although some complementary measures might help, if additional to current pledges, from the perspective of implementing effective mitigation strategies, a very unhelpful argument has been used relating to pollutant reductions, i.e. that such measures can be implemented to "buy time" to figure out how to act on CO_2. There is no lack of clarity about the energy-economic measures required to reduce CO_2, so buying time should not be necessary to "figure this out". Worse, climate models show that even a delay of just 10 years in reducing CO_2 leads to warming after 2050 that is higher by an amount larger than any cut in short-lived forcers, now or in the future, would be able to compensate[21] (see Figure 6). Without strong CO_2 reductions the warming goals considered here cannot be achieved. This is important to bear in mind as in some cases there is confusion about the role of non-CO_2 emissions in keeping to a 1.5 or 2°C pathway.

4.2.2 Ambition Gap or Participation Gap?

Without question, the effort that is required to close the global Emissions Gap will require political will from all countries. However, the stark reality of the Emissions Gap has prompted some UNFCCC delegations, including of the USA, to bring forward an argument for why the Emissions Gap is not really the key problem: *Rather than*

[21] Hare, B., M. Schaeffer, M. Rocha, J. Rogelj, N. Höhne, K. Blok, K. van der Leun and N. Harrison (2012) "Closing the 2020 emissions gap: Issues, options and strategies" Berlin, Germany, Climate Analytics and Ecofys.

an 'Ambition Gap', there is a 'Participation Gap': the required global 2020 reductions will be achieved if the Parties that have not taken on reduction pledges will do so.

Parties that have not yet put forward emission reduction targets account for about 20% of current global emissions. At maximum, a contribution to close the 2020 Emissions Gap of about 1 GtCO2e can be expected from full participation of these Parties, if they pledge reductions at the maximum level of currently pledged ambition of already participating Annex-I Parties, even with strict accounting rules. Clearly the 6-11 GtCO_2e 'Ambition Gap' is a much broader problem than the maximum estimated 1 GtCO_2e 'Participation Gap'

A good example to compare with is the USA, which by itself accounts for about 16% of current emissions. The current 2020 pledge of the USA amounts to 17% below 2005, which equals about 3% below 1990. This falls far short of the 25-40% reduction range estimated in IPCC AR4 to be required from Annex-I Parties, and is also above their pledge of -7% below 1990 levels associated with the Kyoto Protocol, which the USA signed in 1997, but has never been ratified. Compared to the USA's current 2020 pledge of 17% below 2005, the global Emissions Gap would be narrowed by 1-2 GtCO_2e just by strengthening the pledge of the USA alone to 25-40% below 1990.

4.3 2030-2050 and further

Beyond 2020, emission reductions will have to intensify, as apparent in Figure 7. For a 2°C pathway (with a 'likely' chance), global emissions need to be reduced by 2050 to about 50% below 1990, including emissions from deforestation and international aviation and marine transport, or 'bunkers'. The climate projections for such a pathway are illustrated in Figures 4 and 9-12 by the blue line.

For a 1.5°C pathway the reductions need to be deeper. How much deeper, however, depends on how fast one requires warming to drop below 1.5°C. In a pathway with a roughly 50% chance of *peaking* below 1.5°C, global emission reductions by 2050 should be around 80% from 1990 levels and global emissions need to peak within the next 5 years. The latter implies there is no flexibility in allowing delayed participation by some countries. This default 1.5°C pathway is illustrated by the green line in Figures 4 and 9-12.

Alternatively, one could gamble on a temporary overshoot above 1.5°C and a drop down to 1.5°C not too long after 2100. Obviously, this is more risky, since it depends on our current best estimate of the reversibility of the climate system's warming course. Some mechanisms might prevent this: a recent study suggested that crossing the threshold to large-scale disintegration of ocean-floor methane hydrates might initiate a structural release of methane large enough to prevent warming to drop below 2°C for multiple centuries, or even millennia[87], even if anthropogenic emissions were eliminated. Also, during the time period of warming-limit overshoot important thresholds to tipping points as presented in Section 2 might be crossed. Some might be resilient to warming temporary exceeding a threshold, but for others reversibility is questionable at best and losses in biodiversity, for example, are irretrievable on a human time scale. If one excepts these risks, one illustrative pathway would require global reductions by 2050 comparable to a 2°C pathway (50% by 2050), but to compensate the high pre-2050 emissions a post-2050 global removal rate of CO_2 from the atmosphere is required on the very edge of what is currently seen as feasible in the literature regarding, for example, BECCS deployment and potential – and sustained for at least a century. Hence, such a pathway is not only risky from a climate-system point of view, but also regarding feasibility and potential of CO_2 removal technologies.

5 Role of Europe in a 1.5°C pathway

5.1 Annex-I vs non-Annex I

As explained in Section 4.3, global emissions must be reduced to at least 50% and probably, for a less risky pathway, to 80% below 1990 by 2050 for a 1.5°C limit in the long term. Although 2020 levels are important, mid-century levels are critical to achieving 1.5 or 2°C[88]. For the two extreme ends of this 2050 global reduction range, we show in Tables 1 and 2 that Annex-I emissions need to be reduced to 85-95% below 1990, assuming developed (Annex I) and developing (non-Annex I) countries reach equal per capita emissions by 2050, as a very simple measure of equity. Obviously, this indicator does not account for historical responsibility and other more sophisticated considerations of equity, which would in some cases imply negative emission allowances for developed countries[89]. Some such more sophisticated considerations would also imply that some developing countries (like currently 'Newly Industrialized Countries' and 'Rapidly Industrializing Countries'[22]) take on large reductions below 1990 by 2050, while, for example, Least Developed Countries would be exempt[90].

5.2 Are the EU 2050 road map reductions enough?

The European Commission's low carbon and energy road map 2050[91] is the document that details scenarios to achieve the EU's commitment to reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050. However, as the accompanying documents[92] specify, the scenario's achieve a reduction of 80% by 2050. As noted above, Annex I as a group needs to reduce to 85-95% below 1990 by 2050, so that the EU's commitment is roughly consistent with a 1.5°C target, but the reductions achieved by the Energy road map fall somewhat short. Given more sophisticated considerations of equity, the EU's commitment will probably have to be more ambitious. This implies that the EU's commitment itself, as well as a reduction consistent with 1.5°C would need to rely on continued carbon trading.

Table 1 A reduction of global emissions to 50% below 1990 by 2050 constrains both Annex I and non-Annex I emissions. Only if Annex-I emissions were reduced to 85% below 1990 would per capita emissions of the two groups converge by 2050.

	2050	2050	2050	2050	2050
Annex I emissions reductions from 1990	60%	80%	85%	95%	100%
Global emissions reductions from 1990	**50%**	**50%**	**50%**	**50%**	**50%**
Non Annex I emissions reductions from 1990	30%	0%	*increase* of 7%	*increase* of 22%	*increase* of 29%
Annex I emissions per capita tCO2e/cap	5.5	2.8	2.1	0.7	0.0
Non Annex I emissions per capita tCO2e/cap	1.4	2.0	2.1	2.4	2.5

[22] Including countries like Argentina, Brazil, China, India, Indonesia, Mexico, and South Africa[90].

Table 2 As Table 1 for a reduction of global emissions to 80% below 1990 by 2050 constraining both Annex I and non-Annex I emissions. Only if Annex-I emissions were reduced to 95% below 1990 would per capita emissions of the two groups converge by 2050.

	2050	2050	2050	2050	2050
Annex I emissions reductions from 1990	60%	80%	85%	95%	100%
Global emissions reductions from 1990	**80%**	**80%**	**80%**	**80%**	**80%**
Non Annex I emissions reductions from 1990	107%	78%	70%	56%	48%
Annex I emissions per capita tCO2e/cap	5.5	2.8	2.1	0.7	0.0
Non Annex I emissions per capita tCO2e/cap	(0.1)	0.4	0.6	0.9	1.0

6 Conclusions

In this report, we showed that a long-term global goal facilitates international negotiations and inspires policy worldwide. An assessment of the adequacy of a long-term goal of 1.5, or 2°C critically depends on the level of impacts associated with such levels of warming.

The past century, and in particular the last few decades, have seen signals of anthropogenic climate change emerging as diverse as rapid sea-ice thinning in the Arctic, extreme seasonal heat, extreme droughts in the Mediterranean, decline of coral reefs and negatively effected agricultural yields. A 1.5°C rise by 2100 would prevent some of the worst impacts, but still poses serious challenges worldwide, especially in the LDCs, SIDS and Africa. From 1.5 to 2°C warming, impacts are projected to worsen and tipping points approached. For a warming of 2°C, severe and widespread droughts would occur in the next 30–90 years over many densely populated areas, including regions like southern Europe, Australia and large parts of Africa and North and South America. Water- and heat-stress will negatively affect crop yields in regions that are already drought prone today, putting pressure on food security. 10-15% of Sub-Saharan ecosystem species would be at risk of extinction and a projected decrease in precipitation over the Amazonian forests may result in substantial forest retreat here. Due to ocean acidification, coral reefs would become impeded in growth at a CO_2 concentration of 450 ppm, a level reached around 2050 on a 2°C pathway. Sea-level would rise to 80 cm above 2000 by 2100, only 5cm above 1.5°C projections, thus resulting in comparable impacts. However, long-term stabilization at 2°C warming implies a continuous sea-level rise for centuries, with levels to approach 3 m by 2300. The threshold for the Greenland ice sheet to irreversibly melt down in the very long term is now estimated to be 1.6°C above preindustrial, compared to the IPCC AR4 estimate of 3.1°C.

Current emission trends and reduction pledges put the world in a trajectory towards a temperature increase of roughly 4°C by 2100. At such levels of warming impacts are most severe impacts, much of which might be beyond the limits of adaptation. The conditions of some of the most extraordinary heat waves experienced today will become the new norm and a completely new class of heat waves, with magnitudes never experienced before, will occur regularly. This will have severe but as yet un-quantified impacts on agricultural production and human health. Timing of warming is critical as the world population is expected to grow until the second half of the 21st century. Due to ocean acidification, corals around the world are likely to start dissolving above 550 ppm CO_2, a level reached by 2050 on a 4°C pathway. The Amazonian forest area is expected to contract to 25% of its original size and up to 30% of other tropical rainforests, in central Sumatra, Sulawesi, India and the Philippines, is threatened by forest retreat. In Africa, 25%–42% of plant species could lose all suitable range by 2085. Climate change has the potential to catalyze rapid shifts in dynamic, out-of-equilibrium ecosystems, such as sudden forest loss or regional loss of agricultural productivity due to desertification. The ramifications of these shifts would be far-reaching, ranging from extensive loss of biodiversity and diminished land cover, through to loss of ecosystems services. 4°C warming by 2100 would likely result in global temperatures stabilizing at 6°C above pre-industrial over the next few centuries. No geological-historic analogue exists for the rapid warming projected under unmitigated climate change and it is fair to say that this will lead at least to widespread extinctions in ecosystems that are shown to have happened 55 million years ago during the Palaeocene-Eocene thermal maximum, which reached such a level of warming at a slower pace.

Warming can be limited to 1.5°C and below. Hypothetically, if all emissions were to be eliminated immediately, delays in the climate system and abrupt changes in atmospheric radiative forcing would let warming continue to rise to a best-guess level of 1.2°C above pre-industrial, before embarking on a gradual decline. In the very long term, a warming limit of 1.5°C requires total greenhouse-gas concentrations plus the effects of aerosols to be below a level of 400 ppm CO_2eq. Since an immediate stop to all global emissions is obviously impossible, any mitigation pathway aiming at 1.5°C and below necessarily involves a peak-and-drop concentration profile. Energy-economic models are able to achieve the required low emission levels, also without expansion of nuclear energy, but this crucially depends on:

- Early and globally concerted mitigation, emission reductions implemented from 2013 onwards and global emission peak by 2020,
- Rapid up-scaling and feasibility of large-scale bio energy, and availability of forest sinks,
- High rates of energy efficiency improvements,
- Availability of carbon capture and storage technologies (CCS).

Constrained by real emissions until 2010 and energy-economic reduction potential until the 2020s, 1.5°C scenarios necessarily require net-negative CO_2 emissions in the 2nd half of the 21st century. The later the emissions peak, the more CO_2 needs to be removed starting around the 2050s. As biomass takes up carbon from the atmosphere through photosynthesis, extracting the CO_2 from biomass energy systems and storing it underground, in effect produces useful forms of energy for society (electricity) while taking CO_2 out of the atmosphere – a negative emission. CO_2 removal also helps to limit ocean acidification. So-called "Short-Lived Climate Forcers" do not help in the long term, but might slow near-term warming. Non-CO_2 measures must never be interpreted as a means for "buying time" to allow delayed reductions in CO_2. The probability of exceeding 2°C warming in the 21st century more than doubles from 20% to 50%, if CO_2 reductions were delayed by just 10 years, with compensation in the near term by SLCF reductions. Given the slow removal of CO_2 from the atmosphere, its effect is set to linger for centuries.

Internationally pledged emission reductions for 2020 are inadequate, but options remain to close the "Emissions Gap":

1). Increase the global share of renewables from an estimated 10% at present to 15% by 2020. This will help to close the Gap by 4 GtCO2.
    - Increase further to a 20% share to close the Gap completely.
2) Intensify energy efficiency improvements, which play a key role
3) Reduce subsidies for fossil fuels to decrease global emissions by 2 GtCO2 by 2020
    - Eliminating subsidies reduces fossil-fuel demand and emissions.
    - Fossil-fuel consumption subsidies worldwide amount to $409 billion in 2010 and may grow to $660 billion in 2020.

- Global renewable-energy subsidies were only $66 billion in 2010

4) In international negotiations context:
   - Implementing the more ambitious "conditional" pledges. This would reduce the gap by 2 $GtCO_2e$
   - Minimizing the use of lenient Land Use, Land Use Change and Forestry (LULUCF) credits and surplus emission credits. This would reduce the gap by around 3 $GtCO_2e$
   - Minimizing the use of the surplus Assigned Amounts from the 2008-2012 Kyoto period. This would reduce the gap by 1.8 $GtCO_2e$
   - Avoiding the double-counting of offsets and improving the additionality of CDM projects. This would reduce the gap by up to 1.5 $GtCO_2e$.
   - Reducing emissions from international shipping and aviation

Global emissions must be reduced to at least 50% and probably, for a less risky pathway, to 80% below 1990 by 2050 for a 1.5°C limit in the long term. Although 2020 levels are important, mid-century levels are critical to achieving 1.5 or 2°C. For the two extreme ends of the 50-80% global reduction range, developed-country emissions need to be reduced to 85-95% below 1990, assuming developed (Annex I) and developing (non-Annex I) countries reach equal per-capita emissions by 2050, as a very simple measure of equity. Although the EU's commitment of 80-95% reductions below 1990 by 2050 is consistent with a 1.5°C pathway, published scenarios for the EU "energy road map" fall short at a maximum reduction of 80%.

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Appendix 1: Countries calling to limit warming to 1.5°C or 2°C above preindustrial

Contributed by Kirsten Macey

For many years the European Union has been calling for a limit to global warming to 2°C above preindustrial. In 2008, AOSIS and LDCs called for this limit to stay well below 1.5°C above preindustrial levels. Since then, many other Parties have been agreeing to this limit. Below is a summary of all the Parties who have called for a limit of 1.5 °C or 2°C warming above pre-industrial levels.

Those countries calling for global temperature to stay **well below 1.5°C** comprise together a total of 107 countries, accounting for 7% of global energy and industry related CO_2 emissions and about 26% of global population in 2005[23].

Those countries calling for global temperature **to stay below 2°C** comprise together a total of 45 countries, accounting for 81% of global energy and industry related CO_2 and about 64% of global population in 2005[1].

These groups together comprise a total of 152 countries.

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[23] Sources:
Emissions - PRIMAP Baseline Reference: PRIMAP3 (2009) Potsdam Real-time Integrated Model for probabilistic Assessment of emissions Paths (PRIMAP), www.primap.org
Population - UN (2008) 'World Population Prospects: The 2008 Revision Population Database.', http://esa.un.org/unpp.

Group of countries supporting 1.5°C

1. Afghanistan
2. Algeria
3. Angola
4. Antigua and Barbuda
5. Bahamas
6. Bangladesh
7. Barbados
8. Belize
9. Benin
10. Bhutan
11. Bolivia
12. Botswana
13. Burkina Faso
14. Burundi
15. Cambodia
16. Cameroon
17. Cape Verde
18. Central African Republic
19. Chad
20. Colombia
21. Comoros
22. Congo, People's Republic
23. Cook Islands
24. Costa Rica
25. Cote D'Ivoire
26. Cuba
27. Democratic Republic of the Congo
28. Djibouti
29. Dominica
30. Dominican Republic
31. El Salvador
32. Egypt
33. Equatorial Guinea
34. Eritrea
35. Ethiopia
36. Fiji
37. Gabon
38. Gambia
39. Ghana
40. Grenada
41. Guatemala
42. Guinea
43. Guinea-Bissau
44. Guyana
45. Haiti
46. Honduras
47. Jamaica
48. Kenya
49. Kiribati
50. Lao People's Democratic Republic
51. Lesotho
52. Liberia
53. Libya
54. Madagascar
55. Malawi
56. Maldives
57. Mali
58. Marshall Islands
59. Mauritania
60. Mauritius
61. Micronesia, Federated States of
62. Morocco
63. Mozambique
64. Myanmar
65. Namibia
66. Nauru
67. Nepal
68. Nicaragua
69. Niger
70. Nigeria
71. Niue
72. Pakistan
73. Palau
74. Panama
75. Papua New Guinea
76. Peru
77. Philippines
78. Rwanda
79. Samoa
80. Sao Tome and Principe
81. Senegal
82. Seychelles
83. Sierra Leone
84. Singapore
85. Solomon Islands
86. Somalia
87. South Africa
88. Sri Lanka
89. St. Kitts and Nevis
90. St. Lucia
91. St. Vincent and the Grenadines
92. Sudan
93. Suriname
94. Swaziland
95. Timor-Leste
96. Togo
97. Tonga
98. Trinidad and Tobago
99. Tunisia
100. Tuvalu
101. Uganda
102. United Republic of Tanzania
103. Vanuatu
104. Vietnam
105. Yemen
106. Zambia
107. Zimbabwe

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1 Argentina	24 Kazakhstan
2 Australia	25 Korea, Republic of
3 Austria	26 Latvia
4 Belgium	27 Lebanon
5 Brazil	28 Lithuania
6 Bulgaria	29 Luxembourg
7 Canada	30 Malta
8 China	31 Mexico
9 Cyprus	32 Netherlands
10 Czech Republic	33 New Zealand
11 Denmark	34 Norway
12 Estonia	35 Poland
13 Finland	36 Portugal
14 France	37 Romania
15 Germany	38 Russian Federation
16 Greece	39 Slovakia
17 Hungary	40 Slovenia
18 Iceland	41 Spain
19 India	42 Sweden
20 Indonesia	43 Switzerland
21 Ireland	44 United Kingdom
22 Italy	45 United States of America
23 Japan	

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