ATTACHMENT

For Item

10

WEDNESDAY
April 10, 2024

PUBLIC COMMUNICATION RECEIVED BY THE
CLERK OF THE BOARD

Protect Our Communities
Foundation

April 10, 2024

Chair Nora Vargas and Members of the Board of Supervisors
1600 Pacific Highway, Room 335
San Diego, California 92101

HAND DELIVERED

Re: Agenda Item 10,
April 10, 2024 Board of Supervisors Meeting

Chair Vargas and Members of the Board,

The Protect Our Communities Foundation (PCF) applauded the efforts of Supervisor Jim Desmond in bringing forward Agenda Item 09 at the May 24, 2023 Board of Supervisors meeting nearly one year ago. The need for "a better understanding of local conditions relating to existing residential, commercial and other infill renewable energy generation, with an emphasis on existing solar, including "an analysis of remaining rooftop and infill solar capacity in order to provide information that will inform and guide the Board in our decarbonization efforts,"[1] has only increased over the past year. However, despite the Board's May 24, 2023 direction to staff to issue a solicitation for the necessary study and return to the Board with an update within six months, staff wholly failed to initiate any competitive procurement process.

Item 10 before the County today ignores the Board's previous direction to staff to issue a solicitation for the necessary study. Additionally, the Item has not been presented with sufficient information to ensure that the County will in fact be guided by information "reflective of local reality" that "focuses on ratepayer control over their energy needs" and "the wellbeing of every community in the region, for both existing and future generations"[2] as the County intended when it issued its directives to staff last year to issue solicitations. No statement of work has been provided so that the Board can ascertain the ramifications of approving the single source contract that the Board is asked to approve today in conflict with its prior directives.

[1] Desmond Agenda Item 09 for May 24, 2023, p. 2.
[2] Desmond Agenda Item 09 for May 24, 2023, p. 2.

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The County should not approve Item 10 tomorrow. Instead, the County should (1) require staff to follow its May 24, 2023 directive to issue a solicitation for the much needed work; and (2) should not approve any contract without an adequate statement of work that incorporates an opportunity for stakeholder feedback and responses.

I. The County Should Direct Staff to Follow its May 24, 2023 Directive to Issue a Solicitation.

The County's past failures to adhere to its competitive procurement rules are currently being litigated.[3] The County should not authorize yet another single source contract for substantially the same work that UCSD's School of Global Policy and Strategy was contracted to perform. As the County is already aware, numerous other entities could provide the services called for. Instead of adopting Item 10, the County should require its staff to following its May 24, 2023 direction to issue a solicitation:

> In accordance with Section 401, Article XXIII of the County Administrative Code, authorize the Director, Department of Purchasing and Contracting to issue a solicitation or solicitations for a study of renewable energy generation, transmission, distribution, and storage capacity in the San Diego region that considers resiliency from power outages, economic benefits and costs, and local community context, and upon successful negotiations and determination of a fair and reasonable price, award contracts for a term of two years, with two option years and up to an additional six months if needed, and to amend the contracts as needed to reflect changes to services and funding.[4]

Notably, the Board letter omits any reference to the Board's Mary 24, 2023 directive "to issue a solicitation or solicitations" for the necessary study. Nor does the Board letter include any of the proposed findings that would be necessary to properly approve a single source contract. The County must follow Board Policy A-87 which requires the County to competitively procure the services necessary to perform the Board-directed study.

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[3] Please see attached Petition for Writ of Mandate.
[4] May 24, 2023 Statement of Proceedings, The Minutes of the Board of Supervisors Regular Meeting Planning and Land Use Matters, County of San Diego, p. 31.

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II. The County Should Not Approve Any Contract Without An Adequate Statement of Work That Includes a Mechanism to Incorporate Stakeholder Feedback.

Additionally, no contract should be awarded without first ensuring an unbiased statement of work. Here, any statement of work for the program should be consistent with the Board's 2035 decarbonization directive[5] and should include a process for stakeholder feedback and responses. The attached Appendix includes specific issues that should be included in a statement of work designed with the public interest in mind.

Adequately accounting for the greenhouse gas emissions reduction potential and other benefits of rooftop and parking lot solar, and the high costs of developing transmission lines needed for using power generated from remote, utility-scale renewable energy projects – if done correctly - will allow the County to ensure that its plan for the region reduces greenhouse gas emissions as quickly as possible and to the extent possible, will benefit communities of concern, and will provide maximum mitigation of adverse environmental impacts including climate change, land use, and human health impacts.

Kind regards,

Lori Saldaña

Lori Saldaña, President
Bill Powers, P.E., Secretary
Michael Pinto, PhD, Treasurer
Dianne Jacob, Director
Denis Trafecanty, Director

[5] Please see attached letter dated March 31, 2023 from PCF re Draft Implementation Playbook.

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Attachments (4) submitted via email only (PublicComment@sdcounty.ca.gov; District1community@sdcounty.ca.gov; jim.desmond@sdcounty.ca.gov; joel.anderson@sdcounty.ca.gov; Terra.Lawson-Remer@sdcounty.ca.gov; Monica.MontgomerySteppe@sdcounty.ca.gov)

(1) Letter dated March 31, 2023 from PCF to Board of Supervisors re draft Implementation Playbook, and attachments thereto:
(2) Attachment 1: Verified Petition for Writ of Mandate;
(3) Attachment 2: Center for Biological Diversity, *Rooftop-Solar Justice: Why Net Metering is Good for People and the Planet and Why Monopoly Utilities Want to Kill It* (March 2023);
(4) Attachment 3: Synthesis Report of the IPCC Sixth Assessment Report (AR6) Summary for Policymakers (March 20, 2023).

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APPENDIX

Resource documents:

1. August 2022 Final Technical Report (TR): Chapter 2, Chapter 7, Table 7.1 (Electricity Generation), p. 267, and Appendix A, pp. 457-471.
2. May 20, 2022 PDF comments on Draft TR deficiencies (pdf pp. 43-54): https://www.sandiegocounty.gov/content/dam/sdc/lueg/regional-decarb-frameworkfiles/2022_comments_final.pdf
3. January 25, 2023 PDF PowerPoint on TR deficiencies: https://tinyurl.com/mr2xpj9b
4. February 27, 2023 Petition for Writ of Mandate re TR deficiencies: https://tinyurl.com/bddfsuf4
5. Clean Coalition, *San Diego Solar Siting Survey*, September 2019: https://clean-coalition.org/wp-content/uploads/2019/09/San-Diego-Solar-Siting-Survey-Final-Summary-Report-09_wb-9-Sep-2019.pdf
6. Clean Coalition, *City of San Diego Draft Final Feed-In Tariff Design*, September 2019: https://clean-coalition.org/wp-content/uploads/2019/09/San-Diego-Final-FIT-Design-Recommendations-31_wb-9-Sep-2019.pdf
7. NREL, 2020 Annual Technology Baseline (xls spreadsheet, attachment)

I. **<u>New transmission capacity capital and delivery costs</u>** – The TR states that increasing transmission capacity by 2,000 MW will be sufficient to accommodate additional electricity transmission between San Diego and Imperial Counties (p. 31).

Confirm That:

a. The TR identifies a new transmission capital cost of $3.9 billion (p. 267) to deliver solar and geothermal power from Imperial County to San Diego County load.
b. "CREZ" means "Competitive Renewable Energy Zone".
c. Imperial County and Eastern San Diego County are identified together as the "Greater Imperial CREZ" by the state.[6]
d. Chapter 2, Appendix 2.F, Table 2.F, p. 63, lists seven proposed transmission projects. Five of these projects are "Non-CREZ" transmission projects located in or near coastal San Diego County locations.
e. Table 2.F lists one of these "Non-CREZ" transmission project as the "Internal San Diego reconductoring" project with a capital cost of $89 million.
f. Table 2.F lists two Imperial County transmission/transformer projects that total ~$3.9 billion, that together increase renewable energy "deliverability" to load centers by over 1,800 MW.[7]

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[6] Brewster Birdsall et al., *Senate Bill 350 Study Volume IX: Environmental Study Prepared for California ISO,* July 8, 2016, p. 6 (Figure 1-1. Competitive Renewable Energy Zone (CREZ) Boundaries): https://www.caiso.com/Documents/SB350Study-Volume9EnvironmentalStudy.pdf.
[7] New Imperial Valley - Serrano (Orange County) 500 kV line, $3,680 million (1,412 MW increase in deliverability from Imperial County); New Imperial Valley 500/230 kV Bank at new substation, $214 million (400 MW increase in deliverability from Imperial County).

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g. The cost per megawatt-hour (MWh) of renewable energy delivery over the $3.9 billion transmission project can be determined by scaling from the known capital and annual cost, and renewable energy power flow, over SDG&E's existing 500 kV Sunrise Powerlink transmission line.[8]

Evaluate:

h. Which, if any, of the transmission projects listed in Chapter 2, Appendix 2.F, Table 2.F are technically capable of accommodating a 2,000 MW increase in electricity transmission between San Diego and Imperial Counties.
i. Whether and to what extent the "Internal San Diego reconductoring" Non-CREZ project can increase renewable energy transfer between Imperial County and San Diego County load.
j. The transmission cost "adder" for any transmission projects listed in Chapter 2, Appendix 2.F, Table 2.F that are technically capable of accommodating a 2,000 MW increase in electricity transmission between San Diego and Imperial Counties.
   a. For reference, The Protect our Communities Foundation presented the following calculation of the transmission cost adder of the $3.9 billion transmission project identified in Table 2.F:

> The cost adder of the new San Diego – Imperial Valley transmission line with transformer capacity project, in dollars per megawatt hour, is calculated first by ascertaining the annual cost of the project, and then by dividing the annual cost of the project by the annual potential generation of the line: $3.894 billion [estimated project cost] x 0.1349[9] [new transmission line capital recovery factor] = $525 million/yr [annual cost]; $525 million/yr [annual cost] ÷ 4,119,351 MWh/yr[10] [annual potential generation] = $127/MWh.

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[8] The 500 kV Sunrise Powerlink is the most recently constructed SDG&E 500 kV line (online 2012). It was approved to increase the delivery of renewable energy from Imperial County to San Diego County demand centers. See D.08-12-058, December 18, 2008: https://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/95750.PDF.

[9] The new transmission line capital recovery factor has been extrapolated from SDG&E's Sunrise
Powerlink application before the California Public Utilities Commission: $254 million/yr [annualized cost] ÷ $1.883 billion [total cost] = 0.1349/yr, with $1.883 billion being the final Sunrise Power Link cost and $254 million/yr being the annualized cost of Sunrise Power Link: ($1.883 billion/$1.265 billion) x $164 million/yr] + $10 million/yr operations and maintenance = $254 million/yr. (*See* D.08-12-058, p. 293 [final Sunrise Power Link cost: $1.883 billion]; A.06-08-010, SDG&E Application Chapter IV (August 4, 2006), p. V-9 [original capital cost = $1.265 billion]; *id.* at p. V-11 [$164 million/yr annualized capital over 40 years + $10 million/yr operations & maintenance].)

[10] Extrapolated production of 1,812 MW of solar and wind generation interconnected to new San Diego –

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k. What changes to Chapter 2 of the TR, if any, are necessary to reflect the results of this evaluation.

II. **Rooftop and parking lot solar potential** – TR identifies 2.7 billion square feet (61,000 acres) of usable residential and commercial solar rooftop potential, and converts this into 3,360 MW_{ac} of solar potential (without calculations showing the conversion).

Confirm That:

a. The conversion factor applied by Southern California Edison of roof area to solar electric output is 125,000 square feet per MW_{dc}.[11,12]
b. The "direct current-to-alternating current" conversion factor applied by Southern California Edison is 0.90.[13]
c. 2.7 billion square feet of solar potential equals 21,600 MW_{dc} using the utility conversion factor.
d. 2.7 billion square feet of solar potential converts to 19,440 MW_{ac} using the utility conversion factor.
e. Google Project Sunroof, using a number of documented assumptions that limit rooftop solar potential, calculates a residential and commercial rooftop solar potential for San Diego County of 14,700 MW_{dc} (13,200 MW_{ac}).
f. The TR excludes commercial parking lots from the rooftop solar potential calculation.
g. San Diego County parking lot solar potential ranges from a low of 3,300 MW_{ac} (25% coverage) to 7,900 MW_{ac} (60% coverage).
h. San Diego County has achieved 60% coverage in practice on its own commercial parking areas.

Imperial Valley transmission line: (1,812 MW [added generation identified in the Technical Report at p.
63] / 1,264 MW [actual renewables capacity connected to Sunrise Power Link]) x 2,873,543 MWh/yr
[Sunrise Power Link annual production] = 4,119,351 MWh/yr. (R.20-08-020, Exhibit PCF-24 [Powers
Rebuttal Testimony], p. 37; Exhibit PCF-60).

[11] SCE is the only California IOU to propose a utility-scale commercial rooftop solar project. See the CPUC press release of the approval of this 500 MW project: https://docs.cpuc.ca.gov/published/News_release/102580.htm.

[12] SCE A.08-03-015, Testimony, March 27, 2008, p. 26: "a crystalline module will generate approximately 12.3
9 W/sq ft."; p. 32: "Generally, a 1 MW array employing crystalline modules will require 125,000 square feet of roof space."

[13] Ibid, p. 1. "Based on sample calculations, the conversion factor of 0.90 will convert from MW dc to MW alternating current (ac) using the California Energy Commission's ac MW conversion (i.e., multiply MW dc by 0.90 to obtain MW CEC-ac Rating)."

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Evaluate:

i. The San Diego County residential and commercial rooftop solar potential, expressed as MW_{ac}.

j. What changes to the TR, if any, are necessary to reflect this commercial rooftop solar potential**.**

III. **<u>Commercial rooftop solar cost</u> –** The TR assumes a "levelized cost of energy" (LCOE) for commercial rooftop solar of $92/MWh referenced from a Clean Coalition City of San Diego solar siting surveyl, while relying on National Renewable Energy Laboratory (NREL) "Annual Technology Baseline" LCOE values for utility-scale solar and wind power capital cost and LCOEs (p. 25).

Confirm That:

a. The Clean Coalition City of San Diego solar siting survey includes no commercial solar LCOE data.
b. The companion Clean Coalition City of San Diego feed-in tariff design proposal (not referenced in the TR) includes proposed feed-in tariff pricing for commercial rooftop solar.
c. A feed-in tariff is a fixed contract price, not a LCOE.
d. None of the commercial rooftop feed-in tariffs listed in the Clean Coalition feed-in tariff design proposal equals $92/MWh.
e. The TR relies on the NREL ATB for utility-scale solar and wind power capital cost and LCOE (p. 25).
f. The TR relied on the 2020 NREL ATB for utility-scale solar and wind cost.
g. NREL publishes a LCOE for commercial rooftop solar in addition to utility-scale solar and wind power.
h. The NREL 2020 LCOE for commercial solar in good sun areas like San Diego is $49/MWh.[14]

Evaluate:

i. The cost of commercial rooftop solar in San Diego County for the base year, expressed as $/MWh.
j. What changes to the TR, if any, are necessary to reflect this cost of commercial rooftop solar.

[14] NREL, *U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020*, January 2021, p. 102 (pdf p. 119), Attachment B [Commercial Rooftop (200 kW), High resource (CF 20.4%), ITC]: https://www.nrel.gov/docs/fy21osti/77324.pdf

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IV. **<u>2050 electricity demand projection</u>** – The TR uses a 2050 electricity demand projection of 49,979 gigawatt-hours (GWh), 2.6x the 2020 demand of 19,158 GWh, with no calculations or substantial evidence to support that projection. In contrast, the California Air Resources Board (CARB), the state agency charged with decarbonization planning, has developed a statewide 2045 decarbonization projection that is only 1.76x the 2022 electricity demand.

Confirm That:

a. The TR projects a 2050 electricity demand of 49,979 GWh.
b. No calculations or substantial evidence are provided to support the 49,979 GWh value.
c. CARB issued its well referenced draft May 2022 "2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY" at about the same time the draft March 2022 TR was issued.[15]
d. CARB issued its final Scoping Plan in November 2022.[16]
e. There is no reference or citation to the draft CARB 2022 Scoping Plan in the TR.
f. The CARB determination that electricity demand will grow by 1.76x at full decarbonization in 2045 is well supported.
g. San Diego County demand is a subset of the CARB statewide demand projection.
h. The TR identifies a 2020 demand of 19,158 GWh.

Evaluate:

i. The projected 2050 San Diego County electricity demand at full decarbonization, based on substantial evidence and reliable sources.
j. What changes to the TR, if any, are necessary to reflect this projected electricity demand.

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[15] CARB, *DRAFT 2022 SCOPING PLAN UPDATE*, May 10, 2022, p. 161: https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp.pdf. ". . growing electricity demand of about 50 percent by 2035 to nearly 80 percent by 2045 . ."

[16] CARB, *2022 SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY*, November 16, 2022, p. 202: https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf. ". . growing electricity demand of 26 percent by 2030 and 76 percent by 2045 . ."

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March 31, 2023

San Diego County Board of Supervisors
c/o Clerk of the Board of Supervisors
1600 Pacific Highway, Fourth Floor, Room 402
San Diego, California 92101

Via email only (*PublicComment@sdcounty.ca.gov*)

Re: The Draft Implementation Playbook Should Be Corrected to Avoid and Mitigate Adverse Environmental Impacts

Dear Honorable Members of the Board of Supervisors,

To avoid and mitigate adverse environmental impacts likely to result from the County's approval of the draft Regional Decarbonization Framework Implementation Playbook (Playbook), corrections must be made to the Playbook and to the Technical Report upon which the Playbook is based. Without corrections, adoption of the Playbook will result in uninformed decision-making and will likely fail to avoid or mitigate the most devasting impacts of climate change and fail to achieve the environmental and economic benefits available by deploying rooftop and parking lot solar projects throughout the region.

1. **The Playbook fails to comply with the Board's 2035 decarbonation directive, despite scientific consensus that urgent action is required to avoid or mitigate the most devastating climate change impacts.**

The Playbook does not even attempt to achieve decarbonization by 2035 as the Board of Supervisors directed on January 27, 2021.[1] Instead, the Playbook looks to the year 2050, explaining that it "contains a menu of policies, programs, and projects that can contribute to reaching our region's collective goal of zero carbon emissions by mid-century."[2] These delays in reducing greenhouse gas (GHG) emissions are likely to result in devastating climate change impacts, as the County itself admits.[3]

[1] January 27, 2021 Statement of Proceedings, p. 4 [Item 3: directing Chief Administrative Officer "to develop a framework for a regional zero carbon sustainability plan in partnership with the University of California San Diego School of Global Policy and Strategy which shall include strategies and initiatives to achieve zero carbon in the region by 2035."].
[2] Playbook, p. 1.
[3] Board Letter dated January 27, 2021, p. 3 ["to avert the worst impacts of climate change, the region needs to take a carbon neutral approach to climate action planning immediately"].

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The recently published Syntheses Report of the IPCC Sixth Assessment Report (AR6) highlights the urgent need for near-term climate action:

> Climate change is a threat to human well-being and planetary health (very high confidence). There is a rapidly closing window of opportunity to secure a liveable and sustainable future for all (very high confidence)…The choices and actions implemented in this decade will have impacts now and for thousands of years (high confidence)…Evidence of observed adverse impacts and related losses and damages, projected risks, levels and trends in vulnerability and adaptation limits, demonstrate that worldwide climate resilient development action is more urgent than previously assessed in AR5…Climate resilient development pathways have been constrained by past development, emissions and climate change and are progressively constrained by every increment of warming, in particular beyond 1.5°C. (very high confidence)…[4]
>
> Deep, rapid and sustained mitigation and accelerated implementation of adaptation actions in this decade would reduce projected losses and damages for humans and ecosystems (very high confidence), and deliver many co-benefits, especially for air quality and health (high confidence). Delayed mitigation and adaptation action would lock-in high-emissions infrastructure, raise risks of stranded assets and cost-escalation, reduce feasibility, and increase losses and damages (high confidence)…[5]

In short, the AR6 Synthesis Report makes clear that dramatic GHG reductions must be achieved as quickly as possible to avoid exceeding 1.5°C and the associated impacts.[6]

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[4] IPCC AR6 Synthesis Report, Summary for Policymakers, p. 25, available at https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf.

[5] IPCC AR6 Synthesis Report, Summary for Policymakers, p. 27, available at https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf; *see also* Peter Schlosser, Julie Ann Wrigley, *The 1.5°C global warming limit is still within grasp – here's how we can reach it* (December 5, 2022; World Economic Forum), available at https://www.weforum.org/agenda/2022/12/1-5-degrees-global-warming-limit-climate-change-cop-27/;

[6] IPCC AR6 Synthesis Report, p. 46, available at https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_LongerReport.pdf ["Limiting human-caused global warming requires net zero anthropogenic CO2 emissions. Pathways consistent with 1.5°C and 2°C carbon budgets imply rapid, deep, and in most cases immediate GHG emission reductions in all sectors (*high confidence*). Exceeding a warming level and returning (i.e., overshoot) implies increased risks and potential irreversible impacts; achieving and sustaining global net negative CO2 emissions would reduce warming (*high confidence*)."].

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2. **The Playbook should be revised so that it does not attempt to "bridge" the erroneous findings in Chapter 2 of the Technical Report with "action to reduce GHG emissions."**

The Playbook states that it "is intended to be the bridge between the findings of the Technical Report and Workforce Development Study and action to reduce GHG emissions."[7] If the County were to approve of the Playbook as bridging the Technical Report with action to reduce GHG emissions, the County would dramatically undercut the region's potential to quickly reduce GHG emissions and therefore avoid or mitigate climate change impacts.

It remains critical to correct the errors in the Technical Report before approving any "bridge" between the Technical Report and climate action. Rooftop and parking lot solar saturation will maximize GHG emissions reductions before the planet exceeds heating of 1.5°C above preindustrial levels, will eliminate any need for more transmission lines and the associated utility industry profits, will benefit communities of concern, and will mitigate or avoid the worst climate change impacts and other significant land use and human health impacts. The new transmission line construction that would be required to be developed to deliver power from remote locations to the urban centers where the power is used would not only be unnecessarily expensive but will also take at least a decade to develop, whereas rooftop and parking lot solar can be deployed immediately to achieve GHG emissions reductions quickly. The attached Petition for Writ of Mandate and the attached report by the Center for Biological Diversity, entitled *Rooftop-Solar Justice: Why Net Metering is Good for People and the Planet and Why Monopoly Utilities Want to Kill It*, further detail the environmental impacts that can be mitigated or avoided by implementing robust distributed energy policies and practices.

In contrast, establishing strategies, policies, plans, or pathways with reference to an unrealistic and arbitrary baseline and timeframe -- one that does not adequately account for the GHG reduction potential and other benefits of rooftop and parking lot solar, and that dramatically overstates the benefits of remote, utility-scale renewable energy projects -- would not allow for GHG emissions reductions as quickly as possible and to the extent possible, and would result in adverse climate change, land use, and human health impacts.

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[7] Playbook, p. 7 ["The Implementation Playbook is intended to be the bridge between the findings of the Technical Report and Workforce Development Study and action to reduce GHG emissions. Possible next steps include expansion of the online Playbook to include additional information, such as co-benefits; a regional analysis of all GHG emissions sources and the measures that could be necessary to reach regional GHG emissions targets; and, working together with other local governments to explore a regional Climate Action Plan (Figure 2). This voluntary effort among participating local governments could collectively propose GHG emissions targets, GHG reduction measures, and timelines for reaching mutually agreed upon goals."]

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3. **The Playbook should be revised to avoid any reference to the Chapter 2 of the Technical Report as a "baseline" assessment or as "science-based."**

The Playbook explains that it "builds off"[8] and is "interconnected"[9] with and the "natural extension"[10] of the Technical Report, which the Playbook describes as the "[d]ata and scientific modeling for baseline emissions assessments."[11] However, the Technical Report does <u>not</u> in fact consist of a science or fact-based analysis with respect to decarbonization of the electric sector; and it cannot be utilized as a baseline assessment of the electric sector or renewable energy production in the region.

The blatant errors contained within Chapter 2 of the Technical Report have been detailed in the attached Petition for Writ of Mandate. The Technical Report dramatically under-valued the region's rooftop solar potential and the cost of transmission line construction; failed to quantify the benefits of customer generated solar or account for parking lot solar potential; and over-valued the region's 2050 electricity demand and commercial rooftop solar costs.

Action taken utilizing the Technical Report as a "baseline" in the electric sector – as the Playbook proposes – would be woefully inadequate to reduce greenhouse gas emissions in the near term, and would fail to achieve the tremendous GHG emissions reduction and other benefits that could be quickly achieved by rooftop solar and parking lot solar (especially when combined with battery storage to enable 24/7 power, connected to the distribution grid).

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[8] Playbook, p. 1 ["The RDF has three key components that build off each other: the Technical Report, the Workforce Development Study, and the Implementation Playbook."].

[9] Playbook, p. 1 ["Recognizing the need for a regional approach to address climate change, in January 2021, the San Diego County Board of Supervisors voted to create a Regional Decarbonization Framework (RDF). The goal is to guide decision makers toward scientifically proven, scalable approaches and activities to reduce greenhouse gas (GHG) emissions in the San Diego region…each component is interconnected..."]

[10] Playbook, p. 5 ["The Playbook is a natural extension of the RDF Technical Report, which provides the scientific basis for a regional discussion on decarbonization…when an organization, city or county, or the region as a whole seeks to develop a plan of action or to identify discrete actions to reduce GHG emissions, the Playbook can serve as a helpful starting point by providing a menu of GHG reduction actions to consider."]

[11] Playbook, p. 2 [The Playbook also describes the Technical Report as "a scientific report by experts to assess how the region can get to zero carbon emissions," that provides "baseline assessments of GHG emissions and science-based pathways to reduce carbon emissions in the areas of transportation, electricity, buildings, and land use throughout the region."].

4. The Playbook should be revised to avoid any reference to the erroneous conclusion in the Technical Report that renewable energy infrastructure and facilities will "require new and upgraded transmission infrastructure."

The Playbook describes one of the "key takeaways" from the Technical Report as having "[i]dentified low-environmental-impact, high-quality, and technically feasible areas for renewable energy infrastructure development in the San Diego region and neighboring Imperial County..." and concludes that siting renewable energy infrastructure and facilities…will require new and upgraded transmission infrastructure."[12] However, the Playbook's erroneous conclusion that "new and upgraded transmission infrastructure" is required directly results from the fundamental errors in Chapter 2 of the Technical Report as described in the Petition.[13] In reality, the County can more quickly and effectively reduce greenhouse gas emissions with rooftop and parking lot solar saturation – which does not require new transmission capacity to be deliverable because rooftop and parking lot solar energy flows over the lower voltage distribution grid in the urban and suburban areas where the power is used.

The attached Petition and the *Rooftop-Solar Justice* report describe the reasons why the investor-owned utility industry has an interest in thwarting distributed energy deployment in favor of developing remote, utility-scale projects. Here, unfortunately, the Technical Report was developed with the guidance of a consultant also engaged by San Diego Gas & Electric Company (SDG&E). Unfortunately, the Playbook – like the Technical Report upon which it is based – similarly promotes without factual analysis or basis SDG&E's so-called "Path to Net Zero," SDG&E's plans for so-called "green hydrogen,"[14] and even SDG&E's size.

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[12] Playbook, p. 2-3 [Key takeaways include that the Technical Report: "Identified low-environmental-impact, high-quality, and technically feasible areas for renewable energy infrastructure development in the San Diego region and neighboring Imperial County as electricity accounted for approximately 20% of the 2016 GHG emissions in the San Diego region and comprise the second largest GHG emissions source in the region. Decarbonizing electricity production will require substantial deployment of new renewable resources. However, siting renewable energy infrastructure and facilities can have significant impacts on the environment and will require new and upgraded transmission infrastructure."]; *see also* Playbook, p. 13 ["The RDF Technical Report found that the region has sufficient available land area within San Diego County for large-scale wind and solar generation to approach a fully decarbonized the energy system..."].

[13] Playbook, p. 2-3 [Key takeaways include that the Technical Report: "Identified low-environmental-impact, high-quality, and technically feasible areas for renewable energy infrastructure development in the San Diego region and neighboring Imperial County as electricity accounted for approximately 20% of the 2016 GHG emissions in the San Diego region and comprise the second largest GHG emissions source in the region. Decarbonizing electricity production will require substantial deployment of new renewable resources. However, siting renewable energy infrastructure and facilities can have significant impacts on the environment and will require new and upgraded transmission infrastructure."].

[14] *See* Playbook, p. 11, 31, 67, 69.

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5. The County and other agencies cannot "waive or expedite permitting requirements" for remote, utility-scale renewable energy projects without first complying with CEQA.

The Playbook admits that "siting renewable energy infrastructure and facilities can have significant impacts on the environment,"[15] but later promotes adoption of "a policy to waive or expedite permitting requirements for projects with renewable generation and energy storage."[16] Incentivizing remote, utility-scale renewable energy projects and associated new transmission line construction (which is expensive and takes at least a decade to develop) will fail to reduce greenhouse gas emissions as quickly as possible as is necessary to avoid the most devastating climate change impacts. Artificially tipping the scales toward development of remote, utility-scale renewable energy projects will also fail to mitigate or avoid the adverse land use impacts implicit in remote renewable energy and transmission line development. In contrast, full saturation deployment of distributed generation rooftop and parking lot solar will benefit communities of concern and provide maximum mitigation of adverse environmental impacts including climate change, land use, and human health impacts.

Kind regards,

Malinda Dickenson
Legal & Executive Director

cc. Murtaza Baxamusa, Program Manager for Regional Sustainability, Land Use & Environment Group (*murtaza.baxamusa@sdcounty.ca.gov*)
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Encls. (3)
(1) Verified Petition for Writ of Mandate;
(2) Center for Biological Diversity, *Rooftop-Solar Justice: Why Net Metering is Good for People and the Planet and Why Monopoly Utilities Want to Kill It* (March 2023);
(3) Synthesis Report of the IPCC Sixth Assessment Report (AR6) Summary for Policymakers (March 20, 2023).

[15] Playbook, p. 3.
[16] Playbook, p. 44.

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SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF SAN DIEGO

THE PROTECT OUR COMMUNITIES FOUNDATION, a California nonprofit corporation,

Petitioner,

v.

COUNTY OF SAN DIEGO, a municipal corporation; and DOES 1-100,

Respondent(s).

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, on behalf of its San Diego Campus' School of Global Policy and Strategy; and ROES 101-200,

Real Parties In Interest(s).

CASE NO. 37-2023-00008265-CU-TT-CTL

VERIFIED PETITION FOR WRIT OF MANDATE UNDER THE CALIFORNIA ENVIRONMENTAL QUALITY ACT AND OTHER LAWS

(CCP §§ 1085, 1094.5; Public Resources Code § 21000 et seq. ("CEQA"))

"The science is unequivocal, the changes are unprecedented, and there is no more time for delay."[1]

[1] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change ("IPCC Sixth Assessment Working Group I Report") [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391, p. v.

Petitioner THE PROTECT OUR COMMUNITIES FOUNDATION (Petitioner) alleges as follows in this Verified Petition for Writ of Mandate (Petition) pursuant to the California Environmental Quality Act (CEQA), the County's competitive bidding mandates, and other laws:

INTRODUCTION

1. This case challenges certain actions by Respondent COUNTY OF SAN DIEGO (County) related to its decision to implement the County's Regional Decarbonization Framework (RDF) based on a document entitled San Diego Regional Decarbonization Framework Technical Report (Technical Report) that fails to comport with the County's own decarbonization timeframe (Project). While Petitioner fully supports the preparation of a regional plan to reduce carbon emissions as much as possible, as quickly as possible, such a plan is only as good as the technical analysis it is based on. And here, the Technical Report contains a renewable energy production geospatial analysis that does not reflect reality, lacks evidentiary support, and arbitrarily minimizes rooftop and parking lot solar potential in San Diego which constitutes the region's simplest and best mechanism to quickly reduce greenhouse gas (GHG) emissions.

2. The Technical Report was prepared by a consultant that failed to publicly disclose its close ties to the investor-owned-utility industry, and specifically to San Diego Gas & Electric Company (SDG&E). The investor-owned-utility industry financially benefits from construction of capital projects like transmission lines, but does not enjoy such profits from rooftop and parking lot solar; thus, to protect its constituent shareholders' financial interests, the industry has been actively working to minimize distributed energy projects like rooftop and parking lot solar throughout the nation.

3. Instead achieving "zero carbon in the region by 2035," as the County had directed, the consultant aimed for a "low carbon 2050 future for the San Diego region," and made no attempt to establish any basis for the rapid reductions in GHG emissions required by climate science in order to avoid or mitigate the most devastating climate change impacts.

4. The Technical Report arbitrarily calculated transmission line construction costs utilizing irrelevant data that has nothing to do with new east-west transmission line construction to move power from remote utility-scale solar and wind projects to coastal demand centers, while ignoring admissions made elsewhere in the report about the costs and significant delays involved with developing remote, utility-scale projects and new transmission infrastructure.

5. Echoing the pro-utility and anti-customer messaging of the investor-owned-utility industry to which the County's consultant was beholden, the Technical Report vastly underestimated the GHG emissions reductions available from commercial rooftop solar and arbitrarily avoids quantifying the tremendous benefits of rooftop and parking lot solar (which can be deployed quickly to maximize near-term GHG emissions reductions, which avoid land use impacts, and which minimize impacts to human health in disadvantaged communities) in favor of remote, utility-scale renewable energy projects (which require long-term development of new transmission lines and involve adverse environmental impacts).

6. As a result of these and other fundamental errors, the Technical Report fails to constitute a fact-based assessment that could serve as a basis for implementing the region's most promising decarbonization strategies – and in the timeframe necessary to for the region to do its part to avert the worst climate change impacts.

7. Nevertheless, the County authorized development of an "Implementation Playbook" based on the Technical Report without first making the necessary corrections and revisions to the Technical Report and without properly analyzing, disclosing, avoiding, or mitigating the environmental impacts the County itself admits will occur.

PARTIES

8. Petitioner is a nonprofit public benefit corporation formed and existing under California law with headquarters in San Diego. It is organized exclusively for charitable and public purposes. Petitioner represents the interests of San Diego and Southern California residential ratepayers in proceedings before the California Public Utilities Commission and other California agencies and in the courts. Petitioner advocates against unreasonably costly and unnecessary fossil-fueled utility projects, against investor-owned utility decarbonization

strategies designed to maximize utility profits over consumer and GHG emissions reduction benefits, in support of just and reasonable utility rates, and in support of fair, reasonable, and in support of responsible energy practices, polices, rules, and laws. Petitioner seeks to obtain enforcement of the public duties that are the subject of this lawsuit.

9. Respondent County is a public agency under section 21063 of the Public Resources Code. The County is authorized and required by law to hold public hearings, to determine the adequacy of and certify environmental documents prepared pursuant to CEQA, and to take other actions in connection with the approval of projects within its jurisdiction.

10. Real Party in Interest The Regents of the University of California is the governing body of the University of California which entered into the contract to produce the Technical Report that is the subject of this litigation on behalf of its San Diego Campus' School of Global Policy and Strategy (GPS).

11. The true names and capacities of Respondents identified as DOES 1 through 100 and Real Parties in Interest identified as ROES 101 through 200 are unknown to Petitioner, which will seek the Court's permission to amend this pleading in order to allege the true names and capacities as soon as they are ascertained. Petitioner is informed and believes, and on that basis alleges, that each of the fictitiously-named Respondents 1 through 100 has jurisdiction by law over one or more aspects of the project that is the subject of this proceeding and that each of the fictitiously-named Real Parties in Interest 101 through 200 has some cognizable interest in the allegations or the project challenged herein.

BACKGROUND

A. The County Authorizes Development of a "Zero Carbon Sustainability Plan" in Partnership with GPS to Achieve Zero Carbon by 2023.

12. On January 27, 2021, the County, through its Board of Supervisors, directed its Chief Administrative Officer "to develop a framework for a regional zero carbon sustainability plan in partnership with the University of California San Diego School of Global Policy and Strategy which shall include strategies and initiatives to achieve zero carbon in the region by 2035." (January 27, 2021 Statement of Proceedings, p. 4 [Item 3].)

13. The County also authorized the negotiation and award of a no-bid contract with GPS to develop "a regional framework and report to the Board as described below, with an option for additional research and leadership on subsequent actions as directed by the Board..." (January 27, 2021 Statement of Proceedings, p. 4-5; January 27, 2021 Board Letter for Agenda Item 3, p. 3).

B. The County and GPS Enter Into a "Single Source" Contract to Produce the Technical Report.

14. On or about July 12, 2021, the County entered into a "single source" contract with GPS, without competitive bidding, to produce the Technical Report. (Contract No. 564557.)

15. Although the contract between the County and GPS claimed that GPS had no direct or indirect conflict of interest (*id.* at p. 12), in fact GPS is heavily funded and influenced by the investor-owned electric utility industry which financially benefits from construction of capital projects like transmission lines; and, correspondingly, from minimizing distributed generation projects like rooftop and parking lot solar projects. Unlike remote, utility-scale renewable energy projects which require construction of long lead-time transmission lines to carry the output from remote solar and wind energy development areas to coastal areas, distributed generation projects like rooftop and parking lot solar generate energy at or near the end user of the energy and can be quickly deployed. Thus, rooftop and parking lot solar saturation can maximize GHG emissions reductions before the planet exceeds heating of 1.5°C above preindustrial levels, eliminate any need for more transmission lines and the associated utility industry profits, and mitigate or avoid the worst climate change impacts and other significant land use and human health impacts.

16. The investor-owned-utility industry is incentivized to oppose distributed generation projects like rooftop and parking lot solar, even though they make the most sense for the public from both the environmental (*e.g.* GHG emissions reduction, land use, and human health) and cost perspective for the San Diego region. As Edison Electric Institute (EEI), the trade association representing all U.S. investor-owned electric companies, warned its investor-owned-utility company constituents a decade ago, distributed generation like rooftop solar

"would bring the 'prospect of declining retail sales and earnings; financing of major investments in the T&D [transmission and distribution]…; potential obsolescence of existing business and regulatory models," and that net metering programs that are used in connection with rooftop solar deployment would have "significant potential adverse impact to utility investors."[2]

17. David Victor (Victor) is a professor at GPS, served as an advisor throughout preparation of the Technical Report, and led the policy analysis to "connect the infrastructure plan to policy levers at the County level and a discussion of state policy that can support San Diego" after "detailing the physical system transformation." (Contract No. 564557, p. 22.)

18. GPS failed to disclose that Victor has long been involved with the investor-owned-utility companies' research and development arm, the Electric Power Research Institute (EPRI), where Victor currently serves as the longest-serving member of EPRI's Advisory Council. Most of EPRI's members are electric utility companies that provide funding to EPRI for specific research projects.[3] The same investor-owned utility CEOs that lead the EEI board of directors also sit on the EPRI board of directors.[4]

19. According to documents obtained under the California Public Records Act, GPS accepted a pledge from EPRI in the amount of $900,000 on or about January 7, 2021, paid in installments in 2021 and 2022, all of which were earmarked to support research "being conducted by David G. Victor."

20. According to disclosures required by California Public Utilities Commission General Order 77-M, SDG&E contributed $843,411.00 to EPRI in 2021: a more than $700,000 increase from SDG&E's contribution to EPRI two years earlier. (SDG&E 2021 GO 77-M Report, p. 46; SDG&E 2019 GO 77-M Report, p. 38.)[5] In the three-year period from 2019 through 2021, SDG&E contributed $3.06 million to EEI and $1.26 million to EPRI.

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[2] Gideon Weissman, Bret Fanshaw, *Blocking the Sun -12 Utilities and Fossil Fuel Interests That Are Undermining American Solar Power* (Environment America Research & Policy Center: 2015), p. 12.
[3] Electric Power Research Institute, Inc., *Notes to Consolidated Financial Statements as of and for the Years Ended December 31, 2021 and 2020* (April 11, 2022), p. 8, 16;
[4] EEI Newsroom, *Warner Baxter Elected EEI Chair; Pedro J. Pizarro and Maria Pope Elected Vice Chairs* (June 20, 2022).
[5] SDG&E's 2022 GO 77-M Report has not yet been made publicly available.

21. On or about June 29, 2022, the County amended the contract with GPS by adding "additional scope for the finalization of the RDF Technical Analysis Report." (Contract No. 564557, Modification 1, p. 1.) The amendment increased the compensation paid to GPS and resulted in a new total contact price of $641,000. (*Ibid.*) The amendment supplemented the scope of work to include finalizing the technical analysis and supporting the "implementation process." (Contract No. 564557, Modification 1, Exhibit A, p. 1.)

22. The amendment required further work regarding the electric sector, including "[s]patial analysis to identify low-impact, high quality areas for wind and solar development, and to coordinate the early planning of the transmission network needed to interconnect new low-impact renewable energy power plants to the grid" and regarding the policy analysis led by Victor. (Contract No. 564557, Modification 1, Exhibit A, p. 1.) The amendment added a subtask described as follows: "Building on the chapter on Key Policy Considerations in the RDF Technical Report, the RDF team will advise the County on institutional arrangements in order to promote science-based climate policy across the San Diego region's jurisdictions and agencies," work that would be co-led by Victor. (Contract No. 564557, Modification 1, Exhibit A, p. 3.)

23. At the time they entered into the amendment, GPS and the County knew but failed to disclose that Victor co-authored the so-called "decarbonization plan" published in April 2022 by SDG&E.[6] During the County's April 7, 2022 Energy Sector Workshop, Emily Leslie, the lead author of the renewable energy production geospatial analysis in Chapter 2 of the Technical Report, stated in the virtual workshop chat: "There is cross pollination between this project team and the SDG&E project team. David Victor has been contributing to both."

24. Both the original contract and the amendment stated that "Prof. David Victor will be providing significant in-kind hours to the project, financed by UC San Diego" (Contract No. 564557, p. 27; Contract No. 564557, Modification 1, Exhibit A, p. 6), without disclosing that EPRI had paid money to GPS to support work by Victor and did not make reference to SDG&E's payments to EPRI.

[6] SDG&E, *The Path to Net Zero* (April 2022).

C. GPS Lacked "Unique Knowledge, Skill, or Ability" Required for a Technical Assessment of Regional Decarbonization Pathways.

25. Board of Supervisors Policy A-87 requires the County to "competitively procure goods and/or services unless otherwise allowed for under this Policy or required by State or federal law." (Policy A-87, p. 1.) Policy A-87 states that single source contracts can be utilized where "Only one manufacturer, distributer, supplier or service provider can provide the required goods and/or services." (Policy A-87, p. 2.).

26. The County claimed that an agreement with GPS "qualifies for a single source exception to Board Policy A-87 under paragraph D.3 of that policy" solely because GPS "has been a leader in global and national research on decarbonization strategies and is well-positioned and uniquely-qualified to scale this work to the San Diego County region" (January 27, 2021 Board Letter for Agenda Item 3, p. 3) and without justifying the exception pursuant to the policy.

27. The County did not address the terms of D.3 which on its face applies only when "[t]he procurement is for services from a provider with unique knowledge, skill, or ability not available from other sources." (Policy A-87, p. 2). In fact, numerous consultants could have performed the technical analysis necessary to establish a basis for development of meaningful regional decarbonization policies and actions.

28. Far from procuring services from a provider with unique knowledge, skill, or ability not available from other sources, the contract itself recognized that GPS would need to engage subcontractors in order to perform the work. (Contract No. 564557, p. 1.)

D. A Critical Chapter of the Technical Report Demonstrates that GPS Failed to Perform the Contract Objectively, Competently, or Accurately.

29. The Technical Report falsely claimed that it "was funded by the County of San Diego," and that "[t]he authors declare no competing interests with relevant entities in the San Diego region." (Technical Report, p. 3.) In fact, Victor was paid with funds provided by GPS and remains intimately involved with the investor-owned-utility industry through EPRI and SDG&E. (*See* Contract No. 564557, p. 27; Contract 564557, Modification 1, Exhibit A, p. 6; EPRI Advisory Council Roster; SDG&E website [stating that its plan to "decarbonize California through 2045" was "conducted with technical support" from Victor].)

30. Chapter 2 of the Technical Report, entitled "Geospatial Analysis of Renewable Energy Production," reveals that GPS failed to perform the contract objectively, competently, or accurately, much less demonstrate any unique knowledge, skill, or ability.

31. In purporting to estimate the costs of new transmission line construction that would be necessary for development of remote, utility-scale renewable energy projects in San Diego County and Imperial County, the Technical Report arbitrarily ignored the $3.9 billion cost of and decade-long construction time necessary to develop the only transmission line project listed in the Technical Report that is capable of transporting 2,000 MW (the targeted transmission capacity) from the Greater Imperial CREZ[7] located in eastern San Diego County and Imperial County. (*See* Technical Report, p. 63 [New Imperial Valley-Serrano 500 kV line estimated to take 120 months at the cost of $3,680 million, plus New Imperial Valley 500/230 kV Bank at new substation estimated to take 105 months at the cost of $214 million].) Inexplicably and inconsistently, the Technical Report later admits to the exponentially higher costs and long construction timeframe necessary for transmission line development that it ignores in Chapter 2. (*Id.* at p. 267 [admitting in Chapter 7 that "CAISO estimates necessary transmission network upgrades for San Diego - Imperial - Baja – Arizona to be $3.9 billion and will take decades to complete"].)

32. Instead, the Technical Report arbitrarily utilized the costs of a project identified as "Non-CREZ" and described as an "Internal San Diego reconductoring" project (by definition a project not intended to transport electricity from remote areas and that can be developed on a much shorter timeframe than new transmission line construction) to erroneously account for only a tiny fraction of actual transmission costs. (*See* Technical Report, p. 63 [non-CREZ, internal San Diego reconductoring project estimated to take 18 months and cost $89 million].)

[7] CREZ is an acronym for Competitive Renewable Energy Zone: a specific area within California identified by state agencies as having high-value solar and/or wind resources. (*See e.g.* Brewster Birdsall et al., *Senate Bill 350 Study Volume IX: Environmental Study Prepared for California ISO* (July 8, 2016), p. 6 (Figure 1-1. Competitive Renewable Energy Zone (CREZ) Boundaries).

33. Had GPS utilized the cost of the relevant $3.9 billion transmission line project to estimate the costs of new transmission line construction necessary to support remote, utility-scale renewable energy projects, the Technical Report would have concluded that the transmission cost adder necessary to deliver remote solar and wind power to areas where the power is used equals approximately $127 per megawatt-hour (/MWh) and will take at least a decade to build. The cost adder of the new San Diego – Imperial Valley transmission line with transformer capacity project, in dollars per megawatt hour, is calculated first by ascertaining the annual cost of the project, and then by dividing the annual cost of the project by the annual potential generation of the line: $3.894 billion[8] [estimated project cost] x 0.1349[9] [new transmission line capital recovery factor] = $525 million/yr [annual cost]; $525 million/yr [annual cost] ÷ 4,119,351 MWh/yr [annual potential generation][10] = $127/MWh.[11]

34. The Technical Report identifies large rooftop solar potential citing to a GIS analysis conducted by the consultant(s) in two set of units, square footage and acres, but then arbitrarily assumes extraordinarily low rooftop solar potential for San Diego County with no supporting documentation. (Technical Report, p. 35.)

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[8] As identified in the Technical Report, the total cost of the transmission plus transformer project equals $3.894 billion, with a total increase of 1,812 MW. (*See* Technical Report, p. 63 (Table 2.F: identifying a $3,680 million transmission line with 1,412 MW increase, and a $214 million transformer bank with 400 MW increase); *see also* *id.*, at p. 267 (Table 7.1: "CAISO estimates necessary transmission network upgrades for San Diego - Imperial - Baja - Arizona to be $3.9 billion . .").

[9] The new transmission line capital recovery factor has been extrapolated from SDG&E's Sunrise Powerlink application before the California Public Utilities Commission: $254 million/yr [annualized cost] ÷ $1.883 billion [total cost] = 0.1349/yr, with $1.883 billion being the final Sunrise Power Link cost and $254 million/yr being the annualized cost of Sunrise Power Link: ($1.883 billion/$1.265 billion) x $164 million/yr] + $10 million/yr operations and maintenance = $254 million/yr. (*See* D.08-12-058, p. 293 [final Sunrise Power Link cost: $1.883 billion]; A.06-08-010, SDG&E Application Chapter IV (August 4, 2006), p. V-9 [original capital cost = $1.265 billion]; *id.* at p. V-11 [$164 million/yr annualized capital over 40 years + $10 million/yr operations & maintenance].)

[10] Extrapolated production of 1,812 MW of solar and wind generation interconnected to new San Diego – Imperial Valley transmission line: (1,812 MW [added generation identified in the Technical Report at p. 63] / 1,264 MW [actual renewables capacity connected to Sunrise Power Link]) x 2,873,543 MWh/yr [Sunrise Power Link annual production] = 4,119,351 MWh/yr. (R.20-08-020, Exhibit PCF-24 [Powers Rebuttal Testimony], p. 37; Exhibit PCF-60).

[11] *See also* Bill Powers, *Problems with RDF treatment of rooftop/parking lot solar* (January 25, 2023), p. 3, 18.

35. The 2.7 billion square feet of usable rooftop solar potential identified in the Technical Report converts to more than 21,000 MW DC[12] and about 19,500 MW AC,[13] but the Technical Report claims that "estimated region-wide rooftop solar potential capacity of approximately 3,360 MW AC" by citing to a footnote that does not in fact support the statement made. (Technical Report, p. 35). The Technical Report then utilizes this artificially low rooftop solar potential to erroneously conclude that rooftop solar could meet only "12% of estimated 2050 electricity demand." (Technical Report, p. 36.)

36. Google Project Sunroof, a software developed by Google utilizing Google's expansive mapping and computing data resources and relying only upon reliable rooftop surface area, estimates 14,700 MW DC of rooftop solar potential in San Diego County -- in the range of four times the output the Technical Report erroneously assumes -- with 9.5 million metric tons per year of avoided CO_2 emissions from the electricity sector in San Diego County.[14]

37. The Technical Report repeatedly recognized the benefits of customer-generated solar conceptually, but entirely and irrationally failed to quantify those benefits.

38. The Technical Report also arbitrarily reduced the potential contribution of rooftop and parking lot solar to decarbonization by arbitrarily using an exceptionally high – and unsupported – 2050 electricity demand estimate of 49,979 GWh, approximately 2.6 times the actual 2020 demand of 19,158 GWh. (Technical Report, p. 64). In contrast, California projects a statewide increase of only 1.76 times from 2022 to 2045. (*See* California Air Resources Board, *2022 Scoping Plan for Achieving Carbon Neutrality* (November 16, 2022), p. 202.)[15]

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[12] CPUC Docket Number A.08-03-015, Southern California Edison Solar Photovoltaic Program Testimony (March 27, 2008), p. 32 ["Generally, a 1 MW array employing crystalline modules will require 125,000 square feet of roof space."]. Therefore, 2.7 billion $ft^2 \div 125{,}000\ ft^2/MW$ DC = 21,600 MW DC.

[13] The direct current (DC) produced by the solar panel must be converted to alternating current (AC) in an inverter to be compatible with grid power. (*Id.* at p. 1 [DC to AC conversion ratio of 0.90].)

[14] Project Sunroof data explorer (June 2019), results available at https://sunroof.withgoogle.com/data-explorer/place/ChIJHWD_IzDr24ARKAeA6yv9DTU/ . Google Project Sunroof sets a rigorous solar exposure definition of usable roof area that reduces overall rooftop solar potential and identifies San Diego County rooftop solar potential as 1 billion square feet (ft^2), equivalent to 14,700 MW DC). The Google Project Sunroof 14,700 MW DC estimate equates to approximately 13,230 MW AC.

[15] Similarly, the Draft 2022 Scoping Plan Update stated that electricity demand will grow by "nearly 80 percent" by 2045. (*Draft 2022 Scoping Plan Update* (May 10, 2022), p. 161.)

39. Like residential rooftop and parking lot solar, commercial/industrial building solar does not require new transmission capacity to be deliverable. Rooftop and parking lot solar flow over the lower voltage distribution grid in the urban and suburban areas where the power is used.

40. The Technical Report assumes erroneously high commercial rooftop solar cost by using outdated estimates that do not purport to be production cost estimates from a geographically limited report (*see* Technical Report, p. 36), concluding only that further work should be done "to confirm distribution grid capability" to accommodate commercial rooftop solar. (Technical Report, p. 36.) The Technical Report irrationally ignores commercial solar costs in the reputable National Renewable Energy Laboratory (NREL) Annual Technology Baseline (ATB) database[16] that the Technical Report itself uses when estimating capital costs for remote utility-scale solar and wind costs elsewhere in the report (Technical Report, p. 25). The commercial rooftop solar cost should be approximately $48/MWh in 2022 as identified by in the same 2020 NREL ATB spreadsheet relied on in the Technical Report, not the $92/MWh commercial rooftop solar cost erroneously assumed in the Technical Report.

41. The Technical Report entirely ignores parking lot solar potential in the region, even though the County's own Office of Education has implemented a highly space efficient (60+ percent of parking area covered with solar panels) and successful parking lot solar project. See Figure 1.

42. San Diego County ground-level commercial parking area solar potential has been very conservatively estimated at 3,300 MW AC by Powers Engineering assuming only 25 percent of the parking area is covered with solar panels.[17] Commercial parking area solar potential estimates increase to about 7,900 MW AC utilizing average parking lot solar coverage estimates of 60 percent consistent with the County's Office of Education solar parking lot array as shown in Figure 1.

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[16] https://atb-archive.nrel.gov/electricity/2020/data.php

[17] *See* Bill Powers, *Roadmap to 100 Percent Local Solar Build-Out by 2030 in the City of San Diego* (May 2020), p. 21-24 (This report relies on very conservative rooftop solar and parking lot solar potential estimates to make the point that, even using very conservative estimates, the City of San Diego has sufficient local solar potential to achieve 100 percent clean electricity by 2030 relying only on a build-out of local solar capacity.).

Figure 1. San Diego County Office of Education Park Lot Solar Arrays[18]

43. The combined San Diego County rooftop and parking lot solar, assuming the approximately 13,200 MW AC Google Project Sunroof estimate for residential and commercial rooftops and the conservative 3,300 MW AC Powers Engineering estimate of 25 percent solar coverage for commercial parking areas, equals 16,500 MW AC: nearly five times greater than the unsupported RDF estimate of 3,360 MW AC.[19]

44. Rooftop and parking lot solar can meet the majority of the Technical Report's projected 2050 electricity demand, even using a very conservative parking lot solar utilization factor of 25 percent.

45. The tremendous potential of rooftop and parking lot solar is reflected by actual trends in renewable energy deployment in San Diego County, which has the highest concentration of rooftop and parking lot solar of any county in the state. San Diego has more than 1,850 MW AC of rooftop and parking lot solar in operation, having added 260 MW AC in 2022 alone,[20] compared to less than 300 MW of utility-scale remote solar and wind capacity.[21]

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[18] *See* Bill Powers, *Roadmap to 100 Percent Local Solar Build-Out by 2030 in the City of San Diego* (May 2020), p. 23 (Figure 3).

[19] The combined San Diego County estimate would increase to 21,100 MW AC if 60 percent solar coverage is assumed for parking lot solar: 13,200 MW AC + 7,900 MW AC = 21,100 MW AC.

[20] *See* California Distributed Generation Statistics [click on "Charts" and "SDGE"], available at https://www.californiadgstats.ca.gov/charts/.

[21] *See* https://www.eia.gov/electricity/data/eia860/.

46. The Technical Report thus failed to recognize the tremendous GHG emissions reduction and other benefits that could be quickly achieved by rooftop solar and parking lot solar, especially when combined with battery storage to enable 24/7 power, connected to the distribution grid.

E. The County Decides to Authorize Development of an Implementation Playbook Based on the Misleading and Erroneous Technical Report.

47. On August 31, 2022, the Board of Supervisors heard an item entitled "Receive an Update on the Integrated Regional Decarbonization Framework and Design of Implementation Playbook (Districts: All)." (August 31, 2022 Statement of Proceedings, p. 9 [Item 5].)

48. The County explained that the "the integrated RDF has three key components: the technical report, the workforce development study, and the Implementation Playbook;" and decided to turn its focus to "the development of the Implementation Playbook, which will translate the technical findings of the RDF so far into implementable actions for our region to decarbonize." (*Ibid.*) The County decided it would be "transitioning from the education phase of outreach to the implementation phase of the RDF" since "[t]he technical report and the workforce development study are now complete and available on our website." (*Ibid.*)

49. However, because the Technical Report failed to address the County's directive to achieve zero carbon by 2035, and because the Technical Report vastly understates both (1) the energy output available from the region's simplest, most straightforward renewable energy source (rooftop and parking lot solar), and (2) the true costs of remote, utility-scale renewable energy sources; developing implementing strategies using the Technical Report as a baseline is arbitrary and would fail to reduce GHG emissions to the extent possible and as quickly as possible and result in adverse climate change, land use, and human health impacts.

50. On August 31, 2022, the County announced that the Technical Report was "now complete and available on our website," and directed staff to "translate the technical findings of the RDF so far into implementable actions for our region to decarbonize" by developing an "Implementation Playbook" based on the Technical Report. (*Ibid.*)

51. The County Refuses to Address the Deficiencies in the Technical Report, Requiring Petitioner to File the Instant Petition.

52. Petitioner seeks review by and relief from this Court under Code of Civil Procedure section 1085, Public Resources Code section 21168.5, and other provisions of law.

53. The County has taken final agency action with respect to approving the Project. The County has a duty to comply with applicable state and local laws, including but not limited to CEQA, prior to undertaking the discretionary approvals at issue in this lawsuit. Petitioner possesses no effective remedy to challenge the approvals at issue in this action other than by means of this lawsuit.

54. Petitioner has performed any and all conditions precedent to filing the instant action.

55. Neither Public Resources Code section 21177 nor any other exhaustion-of-remedies requirement may be applied to Petitioner, because the County prevented any meaningful public comment under CEQA.

56. Nonetheless, Petitioner identified the flaws in Chapter 2 of the Technical Report and repeatedly requested that the County avoid relying on such flawed information. Petitioner and others provided comments orally, in writing, and in chats at every opportunity; and did their best, under the circumstances, to express their concerns to the County.

57. On February 24, 2023, Petitioner complied with Public Resources Code section 21167.5 by mailing to the County a letter stating that Petitioner planned to file a Petition for Writ of Mandate seeking to invalidate the County's approval of the Project. Attached hereto as Exhibit A is the true and correct copy of this letter and proof of service.

58. On or about February 27, 2023, Petitioner will comply with Public Resources Code section 21167.7 and Code of Civil Procedure section 388 by furnishing the Attorney General of the State of California with a copy of the Petition. Attached hereto as Exhibit B is the true and correct copy of the letter transmitting the Petition to the Attorney General.

59. Pursuant to Public Resources Code section 21167.6(b)(2), Petitioner elects to prepare the record of proceedings in this action. Concurrently with this Petition, Petitioner will file a notice of election to prepare the administrative record.

60. The County's conduct in approving the Project and in purporting to comply with CEQA constitutes a prejudicial abuse of discretion because, as is explained herein, the County failed to proceed in the manner required by law and it acted in excess of its jurisdiction.

61. Petitioner has no plain, speedy, or adequate remedy in the ordinary course of law, and Petitioner will suffer irreparable harm as a result of the County's violations of the laws referenced herein, including CEQA and the County's own competitive bidding requirements, unless this Court grants the requested writ of mandate to require the County to set aside its approval of the Project and related actions. In the absence of such remedies, the County's approvals will remain in effect in violation of State and local law, and Petitioner and its members will be irreparably harmed. No money damages or legal remedy could adequately compensate Petitioners and their members for that harm.

62. The County failed to satisfy its clear, present, ministerial duty to act in accordance with the laws and its own requirements as referenced herein. When the County is permitted or required by law to exercise discretion in setting policy, taking action, and approving projects under the aforementioned laws, the County remains under a clear, present, ministerial duty to exercise its discretion within the limits of, and in a manner consistent with, those laws and requirements. The County has failed and refused to do so, and instead has exercised its discretion beyond the limits and in violation of those laws.

63. Venue for this action properly lies in the Superior Court for the State of California in and for the County of San Diego pursuant to Code of Civil Procedure section 394. The County's main offices are located in and the activities authorized by the County will occur in San Diego County. Venue for this action properly lies in the Central division. The County's Board of Supervisors, which took action to approve this Project, does business at 1600 Pacific Highway, San Diego, CA 92101, which is assigned to the Central division. Similarly, the action that is challenged in this litigation--the approval of the Project—took place at the same location.

FIRST CAUSE OF ACTION

Violations of CEQA
Cal. Code Civ. Pro. § 1085
(Against All Respondents and Real Parties in Interest)

64. Paragraphs 1 through 63 are fully incorporated into this paragraph.

65. The County has a mandatory and ministerial duty to comply with CEQA whenever the County approves a non-exempt activity which has the potential for resulting in a direct or a foreseeable indirect physical change in the environment – a "project" as defined by CEQA. (*Union of Medical Marijuana Patients, Inc. v. County of San Diego ("Medical Marijuana Patients")* (2019) 7 Cal.5th 1171, 1191-1193; Pub. Res. Code, §§ 21065, 21080, subd. (a).)

66. Petitioner seeks to ensure the public receives the benefits to which it is entitled under the County's own ordinances and policies, and under CEQA, which "was enacted to (1) inform the government and public about a proposed activity's potential environmental impacts; (2) identify ways to reduce, or avoid, those impacts; (3) require project changes through alternatives or mitigation measures when feasible; and (4) disclose the government's rational for approving a project." (*Protecting Our Water & Environmental Resources v. County of Stanislaus ("POWER")* (2020) 10 Cal.5th 479, 488.)

67. The County's decision to implement the Technical Report constitutes an "activity directly undertaken by any public agency." (Pub. Res. Code, § 21065.)

68. Establishing strategies, policies, plans, or pathways with reference to an unrealistic and arbitrary baseline and timeframe -- one that does not adequately account for the GHG reduction potential and other benefits of rooftop and parking lot solar, and that dramatically overstates the benefits of remote, utility-scale renewable energy projects -- will not allow for GHG emissions reductions as quickly as possible and to the extent possible; and is the type of activity that "by its general nature" is "capable of causing a direct or reasonably foreseeable indirect physical change in the environment." (*Medical Marijuana Patients,* 7 Cal.5th at 1197).

69. The County misconstrued CEQA's definition of "project" and failed to apply the proper legal standard under CEQA and California law when it determined that implementing the Technical Report was not subject to CEQA because it was "administrative in nature and is not a project as defined in CEQA Guidelines Section 15378(b)(5)."

70. In fact, the County's decision to implement the Technical Report cannot be described as an administrative activity "that will not result in direct or indirect physical changes in the environment." (14 Cal. Code. Regs., § 15378, subd. (b)(5).) According to the County itself, the "Implementation Playbook" will "translate the technical findings of the RDF so far into implementable actions for our region to decarbonize." These implementable actions, by definition, will result in direct or indirect physical changes as detailed herein.

71. The County's decision to proceed with implementation plans based on the Technical Report committed the County to a definite course of action and precluded consideration of alternatives and mitigation measures.

72. Under CEQA, the County "cannot argue" that its decision to proceed with implementation based on the Technical Report "is not a project 'merely because further decisions must be made' before the activities directly causing environmental change will occur." (*Medical Marijuana Patients,* 7 Cal.5th at 1200 (citation omitted).) Environmental review must be "done early enough to serve, realistically, as a meaningful contribution to public decisions." (*Save Tara v. City of West Hollywood* (2008) 45 Cal.4th 116, 134-35.

73. The County itself admits that "to avert the worst impacts of climate change, the region needs to take a carbon neutral approach to climate action planning immediately." (Board Letter dated January 27, 2021, p. 3.)

74. Scientists agree that if global warming exceeds 1.5°C above preindustrial levels, "some impacts will cause release of additional greenhouse gases," including some that "will be irreversible, even if global warming is reduced."[22]

[22] IPCC, Contribution of Working Group II to the Sixth Assessment Report, p. 19.

75. In 2020, the average global temperature reached 1.2°C above preindustrial levels.[23] Without rapid emissions reductions, the 1.5° target will be passed by 2030.[24]

76. The Technical Report made no attempt to maximize GHG emissions reductions in the region sufficient to contribute its fair share of the emissions reductions required to avoid exceeding the 1.5° target and the associated climate change impacts.

77. The Technical Report even failed to reduce GHG emissions in the timeframe required by the County's initial authorization, which was "to achieve zero carbon in the region by 2035." (January 27, 2021 Statement of Proceedings, p. 4 [recommendation #2]; *id.* at p. 5 [taking action as recommended].)

78. Instead, while conceding that "aiming to decarbonize sooner may be desirable from the climate standpoint," the County explained that its consultants at GPS believed decarbonization should occur more slowly "to move in concert" with "national, State, and local governments." (Board Letter dated November 17, 2021, p. 4.)

79. The County's consultant's belief that decarbonization should move more slowly contradicts the consensus of climate scientists which establishes that reducing GHG emissions to the extent possible as quickly as possible is required to avoid devastating environmental impacts.

80. Climate science instructs that the more quickly GHG emissions are reduced in the near term, the more likely that the severity of impacts caused by climate change will be minimized: "It is virtually certain that global surface temperature rise and associated changes can be limited through rapid and substantial reductions in global GHG emissions" and "[c]continued GHG emissions greatly increase the likelihood of potentially irreversible changes in the global climate system."[25]

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[23] World Meteorological Organization, Press Release Number: 14012021: *2020 was one of the three warmest years on record* (January 15, 2021).

[24] Adam R. Aron, *The Climate Crisis – Science, Impacts, Policy, Psychology, Justice, Social Movements* (2023), p. 73-74 & Figure 3.3.

[25] IPCC, Working Group I Contribution to the Sixth Assessment Report, p. 63.

81. “The science is unequivocal, the changes are unprecedented, and there is no more time for delay.”[26] “With each additional increment of warming, these changes will become larger, resulting in long-lasting, irreversible implications, in particular for sea level rise.”[27]

82. Instead of decarbonizing within the 2030 timeframe necessary to avoid the severe climate change impacts anticipated by climate scientists, or even within the 2035 timeframe the County itself required of GPS, the Technical Report mapped a trajectory toward what it refers to as “an aspirational low-carbon 2050 future for the San Diego region.” (*See e.g.* Technical Report, p. 20.)

83. By proceeding with implementation plans based on an inaccurate report that used arbitrary data and failed to assess decarbonization on a timeframe necessary to mitigate or avoid the worst climate change impacts or the 2035 timeframe established by the County, and that failed to properly quantify and acknowledge available rooftop and parking lot solar in the San Diego region (the GHG emissions reduction strategy that for the San Diego region can be most quickly, efficiently, and effectively deployed), the County precluded implementation of alternatives and mitigation measures that can reduce GHG emissions to the greatest extent feasible in the most critical timeframe necessary to avoid the worse climate impacts.

84. The cumulatively significant GHG emissions impact of the County’s decision to proceed with implementation based on the Technical Report alone constitutes a significant environmental effect. (Pub. Res. Code § 21083, subd. (b)(2); Pub. Res. Code, § 21084, subd. (b); Cal. Code Regs., tit. 14, § 15064, subd. (h)(1); Cal. Code Regs., tit. 14, § 15183.5.)

85. The County’s decision to proceed with implementation based on the Technical Report precludes alternatives and mitigation measures that could lead to adoption of an implementation plan that would minimize pollution and human health impacts in disadvantaged communities by maximizing replacement of polluting fossil fuels with rooftop and parking lot solar in disadvantaged communities.

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[26] IPCC, Working Group I Contribution to the Sixth Assessment Report, p. v.
[27] IPCC, Working Group I Contribution to the Sixth Assessment Report, p. v.

86. As the Legislature has recognized, "[c]ontinuing to reduce greenhouse gas emissions is critical for the protection of all areas of the state, but especially for the state's most disadvantaged communities, as those communities are affected first, and, most frequently, by the adverse impacts of climate change, including an increased frequency of extreme weather events, such as drought, heat, and flooding. The state's most disadvantaged communities also are disproportionately impacted by the deleterious effects of climate change on public health." (Stats. 2016, Ch. 249, § 1, subd. (c).)

87. The County's decision to proceed with implementation based on the Technical Report precludes alternatives and mitigation measures that would avoid or minimize significant land use impacts caused by developing large, utility-scale solar in the backcountry and potentially in Imperial County instead of maximizing rooftop and parking lot solar in already developed areas of the County.

88. The County was required by law to complete CEQA review before deciding to proceed with development of implementation plans based on the arbitrary Technical Report. (Cal. Code Regs., tit. 14, § 15004.) By failing to conduct any CEQA review, the County violated CEQA.

89. The County violated the fundamental CEQA principle "that before conducting CEQA review, agencies must not 'take any action' that significantly furthers a project 'in a manner that forecloses alternatives or mitigation measures that would ordinarily be part of CEQA review.'" (*Save Tara*, 45 Cal.4th at 138.)

<u>SECOND CAUSE OF ACTION</u>
Violations of Competitive Bidding Mandates
Cal. Code Civ. Pro. § 1085
(Against All Respondents and Real Parties in Interest)

90. Paragraphs 1 through 89 are fully incorporated into this paragraph.

91. The County has a clear, present, and ministerial duty under Policy A-87 to ensure all contracts are competitively bid, unless a specific exemption applies and has been properly documented.

92. Petitioner is informed and believes and thereon alleges that the contracts with GPS violated the public bidding requirements because they were awarded on a single source basis without documenting or meeting the requirements for single source contracts; and without acknowledging that GPS - through Victor's involvement with the investor-owned-utility industry and SDG&E, had a conflict of interest and could not represent the public's interest in the simplest and quickest GHG emissions reduction strategies – regional saturation of rooftop and parking lot solar with battery systems.

93. Petitioner seeks to enforce the public duties established by the County's competitive bidding requirements, which "are for the purposes of inviting competition, to guard against favoritism, improvidence, extravagance, fraud and corruption, and to secure the best work or supplies at the lowest price practicable, and they are enacted for the benefit of property holders and taxpayers, and not for the benefit or enrichment of bidders, and should be so construed and administered as to accomplish such purpose fairly and reasonably with sole reference to the public interests." (*Domar Electric, Inc. v. County of Los Angeles* (1994) 9 Cal.4th 161, 173 [quoting 10 McQuillan, Municipal Corporations (3d rev. ed. 1990) § 29.29, p. 375].)

PRAYER FOR RELIEF

WHEREFORE, Petitioner respectfully prays for relief as follows:

On the First Cause of Action

1. For a peremptory writ of mandate directing that:

(a) The County void its decision to proceed with implementation plans based on the Technical Report, and any and all subsequent decisions based on the Technical Report;

(b) The County and Real Parties (and any and all persons acting at the request of, in concert with, or for the benefit of one or more of them) suspend any action authorized by the ordinances, resolutions, and associated agreement(s) approved by the County that could result in any change or alteration to the physical environment unless and until the County complies with CEQA and the Judgment of this Court; and

On the Second Cause of Action

2. For a peremptory writ of mandate directing that:

(a) The County refrain from violating competitive bidding mandates;

(b) The County rescind its approval of the contract with GPS and any and all amendments thereto; and

(c) The County refrain from relying on the Technical Report without first complying with competitive bidding mandates.

On All Causes of Action

3. For costs of suit;

4. For reasonable attorneys' fees; and

5. For such other and further relief as the Court deems just and proper.

DATED: February 27, 2023

SHUTE, MIHALY & WEINBERGER LLP

By: ______________________

WINTER KING

Attorneys for Petitioner The Protect Our Communities Foundation

Verification

I, Bill Powers, declare:

I am a member of the Board and Board Secretary of Petitioner The Protect Our Communities Foundation. I am authorized by Petitioner to make this verification on its behalf. I have read the foregoing Petition and know the contents thereof, and the facts therein stated are true to my own knowledge, except as to those matters stated on information and belief, and as to those matters, I believe them to be true.

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

Executed on February 27, 2023 at San Diego, California.

By: Bill Powers

Bill Powers, Secretary
The Protect Our Communities Foundation

1621031.1

EXHIBIT A

SHUTE, MIHALY & WEINBERGER LLP

396 HAYES STREET, SAN FRANCISCO, CA 94102
T: (415) 552-7272 F: (415) 552-5816
www.smwlaw.com

WINTER KING
Attorney
King@smwlaw.com

February 24, 2023

U.S. Mail

San Diego County Board of Supervisors
c/o Clerk of the Board
County of San Diego
County Administration Center, Room 402
1600 Pacific Highway
San Diego, CA 92101

Re: *The Protect Our Communities Foundation v. County of San Diego, et al.*: Notice pursuant to PRC § 21167.5

Dear Chair Vargas and Members of the Board:

This letter is to notify you that The Protect Our Communities Foundation will file suit against San Diego County for failure to comply with the requirements of the California Environmental Quality Act (CEQA), Public Resources Code section 21000 et seq., the CEQA Guidelines, California Code of Regulations title 14, section 15000 et seq., and other state and local laws in the administrative process that culminated in the County's decision to proceed with the County's Regional Decarbonization Framework (RDF) by developing an "Implementation Playbook" based on a document entitled San Diego Regional Decarbonization Framework Technical Report (Technical Report). The lawsuit will also challenge the County's decision to contract with a consultant to prepare the Technical Report even though the consultant had a conflict of interest in the substance of that document due to its close ties with the investor-owned-utility industry, and specifically with San Diego Gas & Electric Company (SDG&E), in violation of the County's public bidding requirements. This notice is given pursuant to Public Resources Code section 21167.5.

Very truly yours,

SHUTE, MIHALY & WEINBERGER LLP

Winter King

1621021.2

PROOF OF SERVICE

At the time of service, I was over 18 years of age and **not a party to this action**. I am employed in the County of San Francisco, State of California. My business address is 396 Hayes Street, San Francisco, CA 94102.

On February 24, 2023, I served true copies of the following document(s) described as:

NOTICE OF INTENT TO SUE

on the parties in this action as follows:

San Diego County Board of Supervisors
c/o Clerk of the Board
County of San Diego
County Administration Center, Room 402
1600 Pacific Highway
San Diego, CA 92101

BY MAIL: I enclosed the document(s) in a sealed envelope or package addressed to the persons at the addresses listed in the Service List and placed the envelope for collection and mailing, following our ordinary business practices. I am readily familiar with Shute, Mihaly & Weinberger LLP's practice for collecting and processing correspondence for mailing. On the same day that the correspondence is placed for collection and mailing, it is deposited in the ordinary course of business with the United States Postal Service, in a sealed envelope with postage fully prepaid.

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

Executed on February 24, 2023, at San Francisco, California.

Jenn

____
Jennifer K Miao

EXHIBIT B

SHUTE, MIHALY & WEINBERGER LLP

396 HAYES STREET, SAN FRANCISCO, CA 94102
T: (415) 552-7272 F: (415) 552-5816
www.smwlaw.com

WINTER KING
Attorney
King@smwlaw.com

February 27, 2023

Via U.S. Mail

Attorney General Rob Bonta
Office of the Attorney General
1300 I Street
Sacramento, CA 95814-2919

Re: *The Protect Our Communities Foundation v. County of San Diego, et al.*

Dear Attorney General Bonta:

Enclosed please find a copy of the Verified Petition for Writ of Mandate ("Petition") in the above case.

This Petition is provided to you in accordance with Public Resources Code section 21167.7 and Code of Civil Procedure section 388. Please acknowledge receipt in the enclosed prepaid, self-addressed envelope. Thank you.

Very truly yours,

SHUTE, MIHALY & WEINBERGER LLP

Winter King

Enclosure

1621472.1

ROOFTOP-SOLAR JUSTICE

WHY NET METERING IS GOOD FOR PEOPLE AND THE PLANET AND WHY MONOPOLY UTILITIES WANT TO KILL IT

MARCH 2023

CENTER *for* BIOLOGICAL DIVERSITY

ROOFTOP-SOLAR JUSTICE

WHY NET METERING IS GOOD FOR PEOPLE AND THE PLANET AND WHY MONOPOLY UTILITIES WANT TO KILL IT

Howard Crystal

Roger Lin

Jean Su

MARCH 2023

The authors would like to thank Karl Rabago, Greer Ryan, Mary K. Reinhart, and the Energy Justice Program at the Center for Biological Diversity for their review and contributions.

CENTER *for* BIOLOGICAL DIVERSITY

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INTRODUCTION

A war over the nation's energy future is raging across the United States. On one side are everyday people who can benefit from clean, renewable energy through distributed-solar projects like rooftop and community solar. On the other side are for-profit electric utilities threatened by distributed solar's impact on their lucrative, guaranteed profits. These companies are using their influence with regulators and legislators in a coordinated effort to undermine the expansion of distributed solar. They recently succeeded in California.

This report addresses the environmental and economic justice of net energy metering, or NEM, and the utility industry's false and self-serving claims against distributed-solar growth.

To combat the climate emergency and pervasive energy inequity, we need to maximize distributed solar development. NEM already exists in many states and is a key policy driver to expand distributed solar. Customers pay only for the net electricity they use each month, considering both the power going to the grid when rooftop-solar systems generate excess electricity and the power coming in from the grid (particularly at night). Net metering substantially reduces electricity bills, allowing people to recoup their distributed-solar investments.

For-profit utilities are fighting NEM on multiple fronts and in many states. In California, for example, they recently convinced regulators to gut net metering for new customers. In Florida a utility-backed bill to gut net metering passed the legislature. Utility companies fight NEM because it undermines their business model, which assumes that centralized utilities are the only legitimate makers and sellers of electricity.

As this report shows, anti-net-metering talking points are based on an outdated version of the grid, where for-profit utilities control everything. Utilities want to gut net metering to maintain control and use the proceeds to pay for rising utility costs, including the growing costs of addressing climate-fueled catastrophes and stranded assets in fossil fuel infrastructure.

EXECUTIVE SUMMARY

The climate emergency demands a rapid and just transition to a fossil-free energy grid. This should include millions of rooftop and similar solar installations on homes, buildings and other available areas.[1] As electric car and all-electric building growth maintain demand for electricity, distributed solar will be vital for a stronger and more affordable grid.[2] It will reduce the need for utility infrastructure by bringing more pollution-free renewables online, while also improving resiliency and reliability and adding jobs and value to communities.[3] These benefits are particularly relevant for environmental justice communities, which face both higher energy burdens and disproportionate harms from the fossil fuel economy.[4]

Net energy metering (NEM) drives distributed solar expansion by catalyzing private investment in new projects. Corporate electric utilities make their profits building infrastructure like power plants and transmission lines. The more their customers can rely on self-generation, the less money utilities make.

This report outlines the benefits of distributed solar to people, the grid and the planet. It shows:

- Net metering's critical role in expanding distributed solar to low-income communities, lowering other utility costs, improving grid resilience and reliability, and bringing jobs to communities harmed first and worst by the climate crisis.
- Why for-profit utilities fight distributed solar and net metering, and what's at stake if they win.
- How utilities' false claims about net metering put shareholders first and ratepayers last.
- The best policy options to protect all consumers during the clean energy transition.

Billions of dollars are available for renewable energy investment under the Inflation Reduction Act,[5] and utilities are trying to prevent those funds from flowing to distributed energy. These companies use their influence to advance regulations and legislation that will protect their profits; they especially fight initiatives that would help people generate their own electricity.[6]

Utilities earn enormous guaranteed profits and also disconnect millions of customers who cannot afford to pay their electric bills.[7] The same companies claim to be concerned with the wellbeing of their customers when they argue, falsely, that net metering lets distributed solar customers pay less than their fair share for the grid.[8]

Numerous studies disprove this claim.[9] A recent report from the Department of Energy shows that most of the top states for distributed-solar adoption among disadvantaged communities are states with NEM policies.[10] In addition, many environmental justice organizations support net metering because of the benefits of self-generated electricity.[11]

Bringing those benefits to as many people as possible, as quickly as possible, is critical to creating a just, resilient, and 100% renewable energy grid. Moderate to high-income households have been more likely to install distributed solar because it frequently requires upfront capital.[12] We need policies that make distributed solar and net metering more accessible to renters and low-income communities through community solar and direct assistance programs.

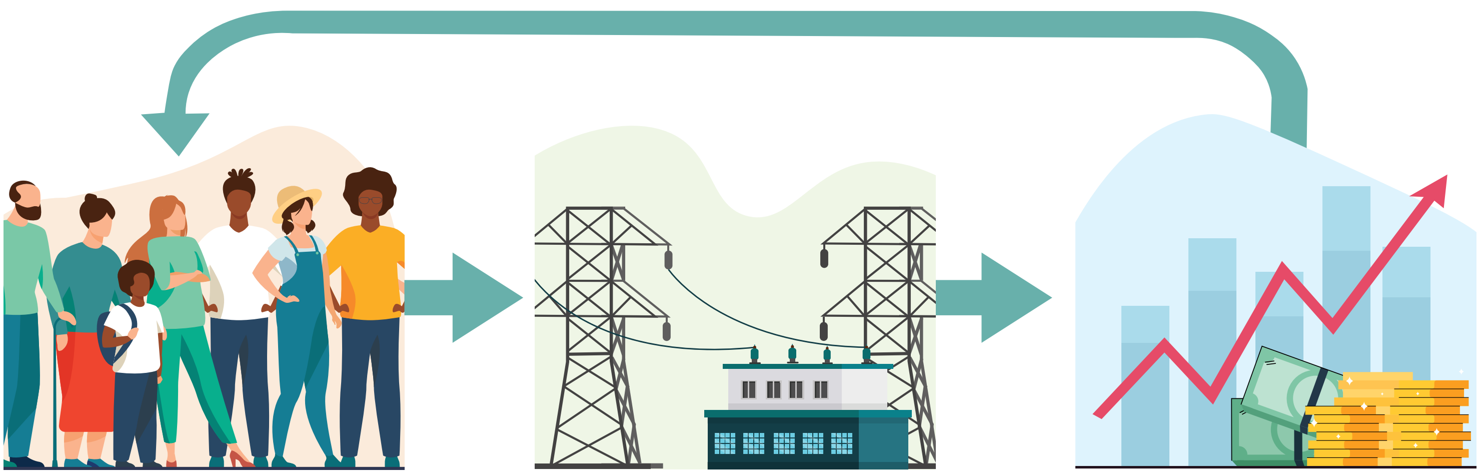
Policymakers should expand NEM, rein in utility costs, and develop properly sited utility-scale renewable energy projects.[13] These larger projects are necessary to fully replace the destructive, polluting fossil fuel economy, but they must not be a substitute for distributed-solar development. Pairing net metering with the Inflation Reduction Act's rooftop-solar tax credits and community solar project incentives will encourage more of these investments in cities and towns across the country.

HOW UTILITIES MAKE MONEY AND HOW NEM FITS IN

Many of us think of electricity as a government service, and in some areas it is. About 25% of electricity in the United States is generated by "public power" providers — not-for-profit entities owned by municipal governments or the local community.

However, in much of the country, an electric utility is a private company — or, more likely, a subsidiary of a private mega-company — seeking profits for investors. Unlike other for-profit companies, these utilities generally have state-approved monopolies preventing competition, and their rates must be approved by state regulators. Under this system, a utility's profits come from its customers and are tied to its capital investments. The regulator sets rates to guarantee a profit on capital investments on the grounds that the company would have made those profits another way had it directly invested those funds in another for-profit enterprise.[14]

This means utilities always want to build new infrastructure: That's how they make money.



Customers pay utilities for the companies' costs, and they pay a profit on capital investments.

Utility companies provide electricity and build new facilities like power plants and transmission lines. They can receive as much as 10% or more profit from their customers for those investments.[15]

Utilities are allowed to profit from ratepayers based on the premise that the company would have received a market-based profit if it invested in some other for-profit business.

As demand for centralized utility power grew, and utilities continued building new things, they also continued to profit handsomely. Less demand for the utility's electricity means fewer new things for them to build, which translates to less profit.

Self-generated electricity, like rooftop solar, and net metering directly threaten corporate utility profits. Utilities want customers to remain dependent on utility-generated power so their investors will continue to receive guaranteed profits from new capital investments.

CORPORATE UTILITIES FIGHT NET METERING

Corporate utilities and their allies have been fighting net metering for years.

- Georgia: Expanding net metering was rejected, limiting participation in rooftop solar.[16]
- Nevada: The utility-backed decision to phase out net metering caused such a backlash that the legislature reinstated most of it, reinvigorating the distributed solar industry.[17]
- Federal Energy Regulatory Commission: An industry-backed group tried and failed to gut net metering across the country.[18]

Today's battles include:[19]

- California: State regulators have gutted net metering for new customers.[20]
- Florida: A Florida Light and Power-backed bill to gut net metering passed the legislature but was vetoed by the governor.[21]
- Arkansas: Newly proposed legislation would end net metering.[22]
- North Carolina: The utilities are urging the commission to gut net metering.[23]

EXPANDING DISTRIBUTED SOLAR FOR A JUST FUTURE

Generating electricity through distributed-solar development saves customers money. Just like adjusting the thermostat, buying a more efficient appliance or installing insulation, distributed solar lowers utility bills. Net metering adds to this benefit, allowing customers to pay for only the net electricity they use each month.

Self-generated electricity also saves money by lowering other utility costs. As we transition to all-electric buildings, and from traditional cars to electric vehicles, electricity demand will remain strong.[24] More reliance on distributed solar will lessen the need for new transmission lines and other centralized power infrastructure. Savings will also come from fewer wildfires and other grid-related accidents.[25]

Distributed solar, especially when paired with battery storage or micro-grids, is vital to creating a resilient and reliable energy system. Lack of access to air conditioning during heat waves or heat during winter storms, or the inability to run medical equipment or refrigerate medication, can be life-threatening. Communities of color, elderly, disabled and low-income residents are the most vulnerable.[26] Widespread power outages are killing customers[27] and will only become more frequent as climate change-fueled extreme weather puts ever-greater strains on the grid. Distributed energy can provide essential power even when the centralized grid fails.[28]

Distributed solar also reduces power plant emissions, which pollute the air and water. This means healthier communities, particularly among disadvantaged communities where fossil fuel plants are often located.[29] We'll need fewer central power plants, which means less climate pollution. This is the same pollution fueling the climate emergency and disproportionately harming these same low-income communities and communities of color.[30]

In planning for the renewable energy future, policymakers tend to focus on massive solar or wind projects in remote locations, which require new transmission lines to bring this power to population centers.[31] Self-generation through distributed solar can be a force multiplier, fulfilling energy demand that would otherwise come from large-scale projects that can harm biodiversity and wipe out natural carbon sinks.[32]

Distributed solar also brings jobs and other economic benefits to the communities where the projects are built — significantly more jobs than utility-scale clean energy and fossil fuel projects.[33] This is one way to help environmental justice communities harmed first and worst by the climate crisis. Bringing jobs and energy resilience to these communities helps begin to redress historical inequities while also replacing the fossil fuel infrastructure that has caused so much harm.

HOW SOLAR AND NET METERING ADVANCE EQUITY

Marginalized communities are most often served by monopoly electric utilities with long histories of harming these communities through polluting facilities, unreliable service, shutoff policies, and climate-harming emissions.[34]

Self-generation through distributed solar can mitigate all these harms, reducing polluting emissions, lowering costs, and providing resilient backup power in emergencies, particularly when paired with battery-storage technologies.

Distributed-solar projects bring clean energy installation jobs and other local economic opportunities.

Net metering adds to these benefits by increasing savings and incentivizing more distributed-solar projects, including in these marginalized communities that will benefit most from them. This is why the California Energy Commission found net metering instrumental in the success of low-income solar programs.[35] It is also why many environmental justice groups support self-generation and net metering.[36]

The approaches and infrastructure developed in the fossil fuel era no longer work. Centralized power generation is not the best option in the clean energy era. Policymakers need to encourage self-generation of electricity, which NEM helps to do. They should not be discouraging distributed-solar investments by trying to gut net metering.

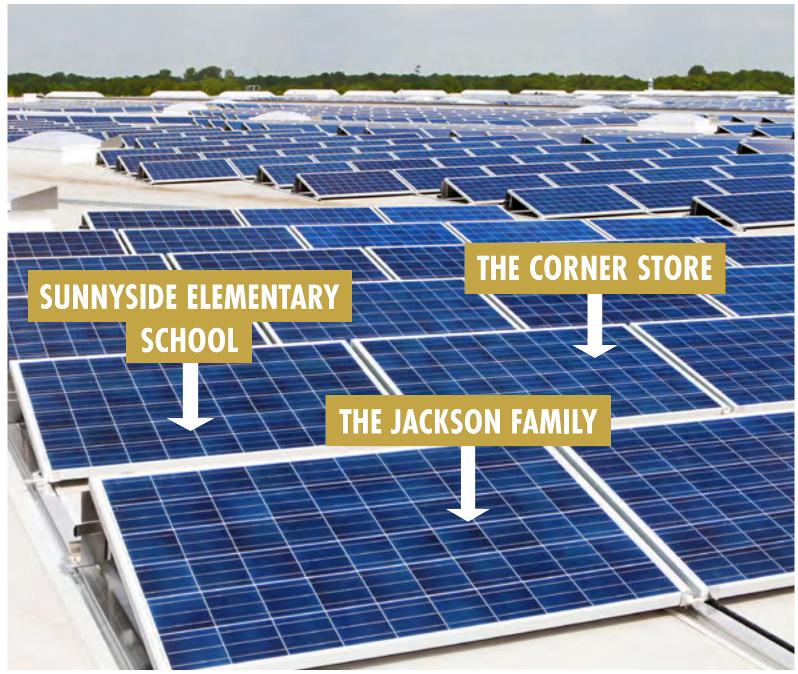
ADDRESSING THE DISTRIBUTED ENERGY EQUITY CHALLENGE

Distributed solar has been more accessible to homeowners than renters — and to those with the means to invest. They can use a home improvement loan to invest in solar panels and apply net-metered savings, where net metering exists, along with other incentives to recoup their investment. In many places they can team up with a solar company that pays for the system in exchange for a portion of the benefits.[37]

We need smart public policies to make self-generation more broadly accessible. In addition to the incentives in the Inflation Reduction Act,[38] this must include state and local government investments in community solar and related projects, so more homeowners and renters can take advantage of distributed solar near their homes. The California Solar on Multifamily Affordable Housing Program is a great example.[39] Policies also should include financial assistance to expand distributed solar to low-income communities that are unable to make these investments, such as the District of Columbia's Solar For All Program.[40]

COMMUNITY SOLAR AND VIRTUAL NET METERING

Net metering is vital for community-solar project participants, who acquire part of a project's solar generation.[41] With virtual net metering, people receive credit on their electricity bills for the power generated by their portion of the community-solar project. This provides the same incentive that makes distributed solar attractive to homeowners.[42]



Net metering should continue to be a key driver in expanding distributed solar to new communities. As the Department of Energy recently found, most of the top states for distributed-solar adoption among disadvantaged communities have full retail net metering.[43] This demonstrates the importance of this policy for bringing distributed-solar benefits to these areas.

Another key element of NEM is its simplicity. Customers pay only for the net electricity used, accounting for both what they have taken from the grid and what they have contributed to it. Other approaches where excess energy is compensated at a lower rate unnecessarily complicate distributed solar, discourage adoption, and undervalue the worth of the electricity sent to the grid.

With the right policies, a broad array of customers will reap the benefits of distributed solar and net metering. This will help people, the grid and the planet.

Photo of solar panels by AleSpa/ Wikimedia CC BY-SA

THE TRUTH ABOUT BIG UTILITIES' 'COST-SHIFT' MYTH

Utilities fight self-generation and NEM for a reason. As net metering and other policies lead to more distributed-solar development, customers will need less utility-provided infrastructure, and for-profit corporate utilities will make less money.

UTILITIES FIGHTING NET METERING ARE DISCONNECTING CUSTOMERS, OBSTRUCTING CLEAN ENERGY, AND MAKING ENORMOUS PROFITS

Utilities claim they oppose net metering because it harms less affluent customers. But as the Center for Biological Diversity, Energy and Policy Institute and BailOut Watch have documented, utilities are disconnecting low-income customers while earning record profits.[44] Access to electricity is a basic human right, and the United States has given private companies the social license to take away this human right from poor families. These companies also actively fight clean energy initiatives, including through their membership in controversial trade associations.[45]

FLORIDA

- Nearly 1.5 million customers were disconnected in 2020 and 2021.[46]
- Next Era, owner of Florida Power and Light (FPL), paid shareholders more than $8 billion in 2020-2022.[47]
- FPL used a political consulting firm to oppose a state senator who had been pushing pro-rooftop solar legislation, according to news reports.[48]

NORTH CAROLINA

- More than 150,000 customers were disconnected in 2020 and 2021.[49]
- Duke Energy paid shareholders more than $8 billion 2020-22.[50]
- Duke has lobbied against clean energy initiatives.[51]
- Duke is working to end net metering in North Carolina.[52]

GEORGIA

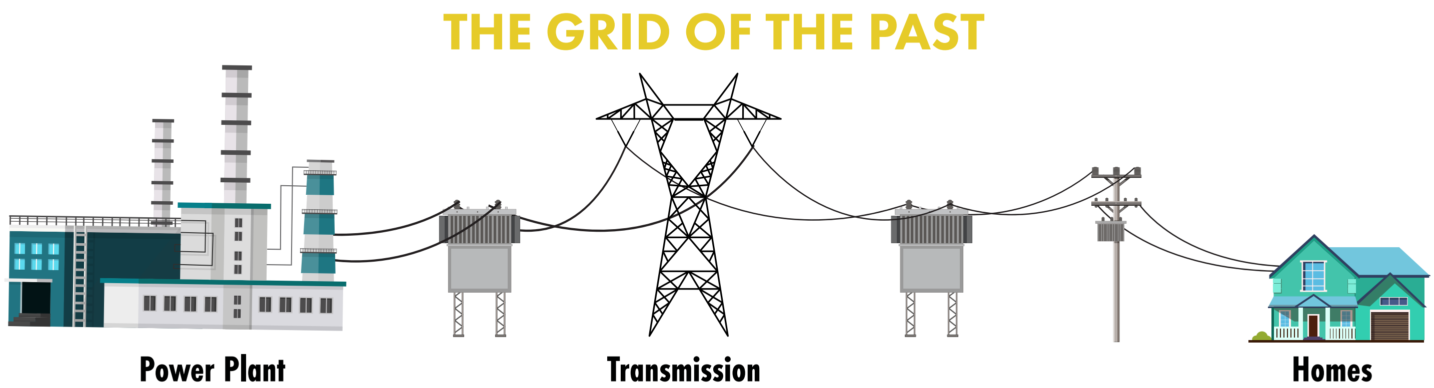
- More than 388,000 customers were disconnected in 2021 and 2022.[53]
- Southern Company (Georgia Power's owner) paid shareholders more than $7.5 billion in 2020-22.[54]
- Southern Company has reportedly paid more than $62 million to special interest groups and outside firms involved in campaigns against climate science.[55]
- Georgia Power opposes lifting the Georgia cap on net-metering systems.[56]

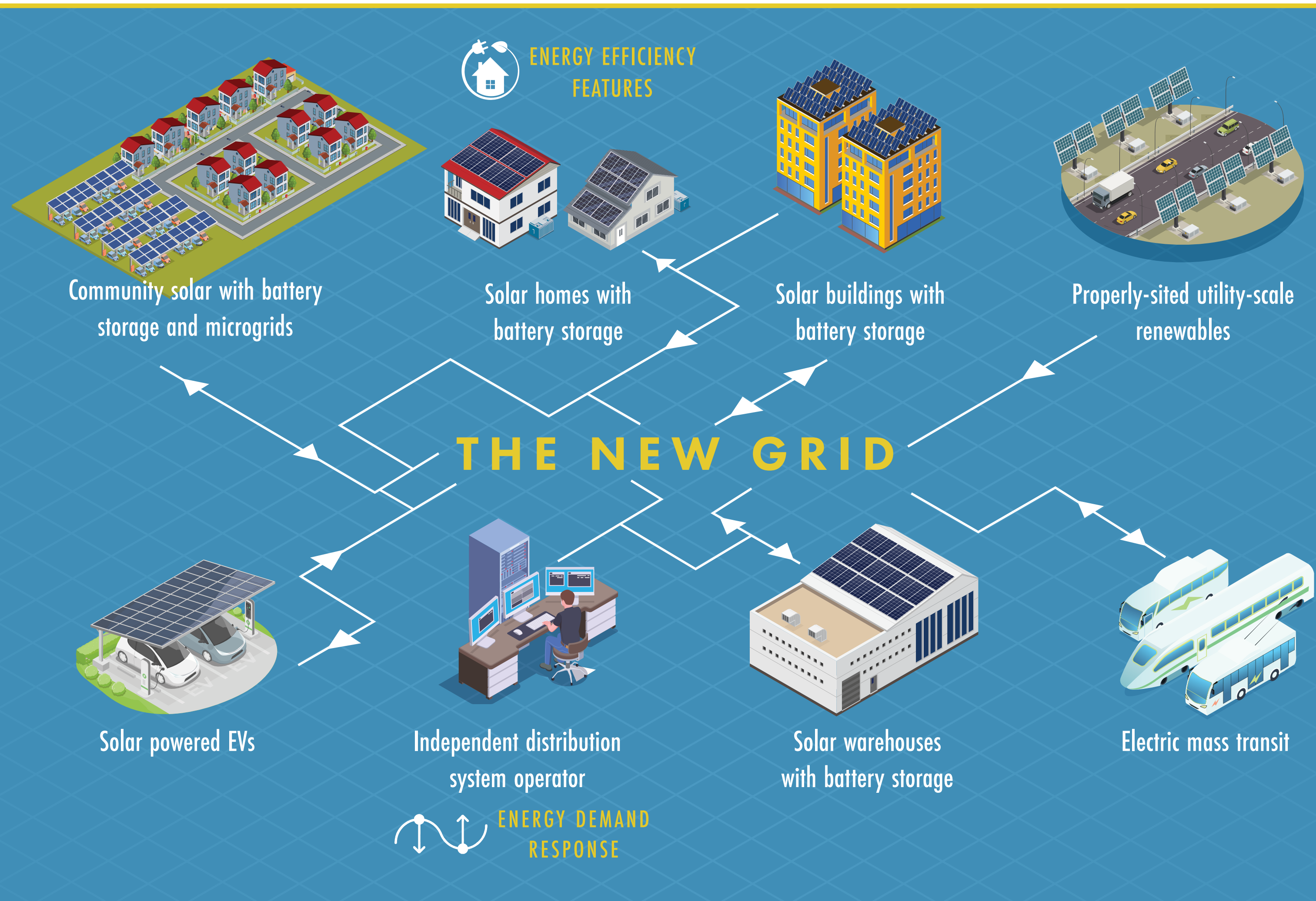
Utilities need a way to undermine net metering, so they've falsely claimed that it creates a "cost-shift" whereby solar owners don't pay their fair share to maintain the grid. The principal problem with this bogus cost-shift theory is that it is premised on the grid of the past, rather than the grid of today and tomorrow.

The grid of the past was a closed system. Only utilities were building electricity infrastructure and providing electricity, and customers were dependent on utilities for everything. In the grid of the past, regulators wanted to spread those utility-only costs among customers.

If you reduced your electricity bill by using energy-efficient insulation, windows or appliances, no one accused you of cheating. Paying your fair share just meant paying for the electricity you used, which the utility supplied.

The cost-shift argument only makes sense in that old world, where the same costs are reallocated among all customers.





The grid of today — and the grid transformation we urgently need — looks entirely different. It lets everyone contribute to the grid. Now homeowners, businesses and communities can generate their own electricity through distributed solar and related technologies, with all the benefits discussed earlier.

We no longer have a hermetically sealed system that requires a growing utility infrastructure that serves all customers and that all customers must pay for. As we generate more electricity independent of corporate utilities, we'll need less from the utility, which will save everyone money. With more distributed solar we'll need fewer power plants, including dirty fossil fuel plants, and utility-owned and large-scale solar and wind projects. We'll need fewer transmission lines, which will mean fewer wildfires and less damage to communities and ecosystems, as well as fewer costly efforts to put these lines underground.[57] Fewer transmission lines also means avoiding permitting battles over these projects and losing power from bringing electricity over long distances.[58] Private-utility executives should be paid less for the smaller system they will manage.

In this new grid, net metering makes perfect sense and is perfectly equitable. It incentivizes more local solar, which benefits everyone with lower costs, more resilience, more jobs and healthier communities. Like the customers of the past who paid less when they invested in home energy efficiency, NEM customers fairly pay for the net electricity they use over the month. The only ones who don't benefit are for-profit utilities addicted to a business model where they only profit by selling us more and more.

The cost-shift myth ignores all this. Relying on the grid of the past, the myth claims solar customers' net-metering savings means they don't pay their fair share of utility costs, shifting costs to benefit the wealthy.

Net-metering opponents argue that self-generated electricity should be compensated at the same wholesale rate utilities pay for centralized power generation.[59] But this ignores all the benefits of self-generated electricity, which studies show is much more valuable than centralized utility power.[60] One recent analysis in California showed the lower demand for more transmission lines because of distributed solar was enough to offset the customers' lower utility payments. The study didn't even account for the other benefits of distributed solar.[61]

Numerous studies have found that self-generated electricity is worth far more than the electricity that comes from centralized utility systems.[62]

These studies are confirmed by real-world experience. Net metering has been around for decades, and utilities have long threatened it will explode other customers' bills. That hasn't happened. Most of the states with the highest percentage of solar adoption among disadvantaged communities have full retail net metering.[63]

The grid of the past only served as our power-delivery system, but the new grid is also vital to addressing the climate emergency. The urgency of transitioning away from fossil fuels will bring new electricity demand as electric car sales increase and homes and buildings become all-electric, including with energy-efficient heat pumps.[64]

If there's a gap between utility costs and funding during the transition away from the utility-owned, fossil fuel-reliant energy system, additional public investment can keep utility prices in check. Utilities should shoulder the costs of their misplaced investments in fossil fuel infrastructure. We must maximize the speed and growth of clean energy. That could require targeted public financing and funding to deploy distributed solar. This is much better public policy than weakening or eliminating net metering, which would increase customer dependence by giving utilities more control and more customer money.

POLICY RECOMMENDATIONS

Regulators should preserve net-metering policies to make distributed solar more affordable and speed the transition to 100% clean, renewable energy. The utility narrative focuses on who is going to pay for their new infrastructure, but policymakers have a duty to ask whether that infrastructure is needed.

State regulators and lawmakers should:

- Preserve and expand net metering programs.
- Provide targeted public financing and funding for distributed energy and community solar.
- Require performance-based ratemaking that rewards utilities for their performance in key metrics, rather than providing them handsome profits for infrastructure investments.[65]
- Mandate integrated resource planning to determine whether and when utilities should build new things and whether there are better alternatives to meet community energy needs.[66]
- Implement energy-efficiency programs, often the most cost-effective energy solution[67] but frequently undermined by utilities.[68]
- Account for all relevant social costs, including the value of self-generated renewable energy.

To build our clean energy future, distributed-solar projects should be prioritized and maximized, while any utility-scale projects should be properly sited.

Distributed solar brings local jobs and resilient technologies to new communities. Most utility-scale renewable energy generation in remote locations needs to be paired with new transmission lines and loses up to 10% of its power over long distances.[69] Its costs also often include environmental harms to animals and habitats, along with conflicts with local communities where those lines are sited.[70]

The best way to maximize community benefits and minimize environmental harms is building out as much self-generation as feasible through distributed energy. Net metering is one of the most important tools to make that happen. We need to bring self-generated and affordable electricity to as many homes and communities as possible through rooftop solar and net metering. Doing so will shrink the size of corporate utilities and put the benefits of local renewable energy where they belong — with all of us.

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SYNTHESIS REPORT
OF THE IPCC SIXTH ASSESSMENT REPORT (AR6)

Summary for Policymakers

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Other IPCC reports cited in this Synthesis Report:
AR5 Fifth Assessment Report

Introduction

This Synthesis Report (SYR) of the IPCC Sixth Assessment Report (AR6) summarises the state of knowledge of climate change, its widespread impacts and risks, and climate change mitigation and adaptation. It integrates the main findings of the Sixth Assessment Report (AR6) based on contributions from the three Working Groups[1], and the three Special Reports[2]. The summary for Policymakers (SPM) is structured in three parts: SPM.A Current Status and Trends, SPM.B Future Climate Change, Risks, and Long-Term Responses, and SPM.C Responses in the Near Term[3].

This report recognizes the interdependence of climate, ecosystems and biodiversity, and human societies; the value of diverse forms of knowledge; and the close linkages between climate change adaptation, mitigation, ecosystem health, human well-being and sustainable development, and reflects the increasing diversity of actors involved in climate action.

Based on scientific understanding, key findings can be formulated as statements of fact or associated with an assessed level of confidence using the IPCC calibrated language[4].

[1] The three Working Group contributions to AR6 are: AR6 Climate Change 2021: The Physical Science Basis; AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability; and AR6 Climate Change 2022: Mitigation of Climate Change. Their assessments cover scientific literature accepted for publication respectively by 31 January 2021, 1 September 2021 and 11 October 2021.

[2] The three Special Reports are: Global Warming of 1.5°C (2018): an IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (SR1.5); Climate Change and Land (2019): an IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (SRCCL); and The Ocean and Cryosphere in a Changing Climate (2019) (SROCC). The Special Reports cover scientific literature accepted for publication respectively by 15 May 2018, 7 April 2019 and 15 May 2019.

[3] In this report, the near term is defined as the period until 2040. The long term is defined as the period beyond 2040.

[4] Each finding is grounded in an evaluation of underlying evidence and agreement. The IPCC calibrated language uses five qualifiers to express a level of confidence: very low, low, medium, high and very high, and typeset in italics, for example, *medium confidence*. The following terms are used to indicate the assessed likelihood of an outcome or a result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, more likely than not >50–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely 95–100%; more likely than not >50–100%; and extremely unlikely 0–5%) are also used when appropriate. Assessed likelihood is typeset in italics, e.g., *very likely*. This is consistent with AR5 and the other AR6 Reports.

A. Current Status and Trends

Observed Warming and its Causes

A.1 Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850–1900 in 2011–2020. Global greenhouse gas emissions have continued to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries, and among individuals (*high confidence*). {2.1, Figure 2.1, Figure 2.2}

A.1.1 Global surface temperature was 1.09°C [0.95°C–1.20°C][5] higher in 2011–2020 than 1850–1900[6], with larger increases over land (1.59°C [1.34°C–1.83°C]) than over the ocean (0.88°C [0.68°C–1.01°C]). Global surface temperature in the first two decades of the 21st century (2001-2020) was 0.99 [0.84 to 1.10]°C higher than 1850-1900. Global surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2000 years (*high confidence*). {2.1.1, Figure 2.1}

A.1.2 The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019[7] is 0.8°C–1.3°C, with a best estimate of 1.07°C. Over this period, it is *likely* that well-mixed greenhouse gases (GHGs) contributed a warming of 1.0°C–2.0°C[8], and other human drivers (principally aerosols) contributed a cooling of 0.0°C–0.8°C, natural (solar and volcanic) drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. {2.1.1, Figure 2.1}

A.1.3 Observed increases in well-mixed GHG concentrations since around 1750 are unequivocally caused by GHG emissions from human activities over this period. Historical cumulative net CO_2 emissions from 1850 to 2019 were 2400±240 $GtCO_2$ of which more than half (58%) occurred between 1850 and 1989, and about 42% occurred between 1990 and 2019 (*high confidence*). In 2019, atmospheric CO_2 concentrations (410 parts per million) were higher than at any time in at least 2 million years (*high confidence*), and concentrations of methane (1866 parts per billion) and nitrous oxide (332 parts per billion) were higher than at any time in at least 800,000 years (*very high confidence*). {2.1.1, Figure 2.1}

A.1.4 Global net anthropogenic GHG emissions have been estimated to be 59±6.6 $GtCO_2$-eq[9] in 2019, about 12% (6.5 $GtCO_2$-eq) higher than in 2010 and 54% (21 $GtCO_2$-eq) higher than in 1990, with the largest share and growth in gross GHG emissions occurring in CO_2 from fossil fuels combustion and industrial processes (CO_2-FFI) followed by methane, whereas the highest relative growth occurred in fluorinated gases (F-gases), starting from low levels in 1990. Average annual GHG emissions during 2010-2019 were higher than in any previous decade on record, while the rate of growth between 2010 and 2019 (1.3% $year^{-1}$) was lower than that between 2000 and 2009 (2.1% $year^{-1}$). In 2019, approximately 79% of global GHG emissions came from the sectors of energy, industry, transport and buildings together and 22%[10] from agriculture, forestry and other land use (AFOLU). Emissions reductions in CO_2-FFI due to improvements in energy intensity of GDP and carbon intensity of energy, have been less than emissions increases from rising global activity levels in industry, energy supply, transport, agriculture and buildings. (*high confidence*) {2.1.1}

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[5] Ranges given throughout the SPM represent *very likely* ranges (5–95% range) unless otherwise stated.

[6] The estimated increase in global surface temperature since AR5 is principally due to further warming since 2003–2012 (+0.19°C [0.16°C–0.22°C]). Additionally, methodological advances and new datasets have provided a more complete spatial representation of changes in surface temperature, including in the Arctic. These and other improvements have also increased the estimate of global surface temperature change by approximately 0.1°C, but this increase does not represent additional physical warming since AR5.

[7] The period distinction with A.1.1 arises because the attribution studies consider this slightly earlier period. The observed warming to 2010–2019 is 1.06°C [0.88°C–1.21°C].

[8] Contributions from emissions to the 2010-2019 warming relative to 1850-1900 assessed from radiative forcing studies are: CO_2 0.8 [0.5 to 1.2]°C; methane 0.5 [0.3 to 0.8]°C; nitrous oxide 0.1 [0.0 to 0.2]°C and fluorinated gases 0.1 [0.0 to 0.2]°C. {2.1.1}

[9] GHG emission metrics are used to express emissions of different greenhouse gases in a common unit. Aggregated GHG emissions in this report are stated in CO_2-equivalents (CO_2-eq) using the Global Warming Potential with a time horizon of 100 years (GWP100) with values based on the contribution of Working Group I to the AR6. The AR6 WGI and WGIII reports contain updated emission metric values, evaluations of different metrics with regard to mitigation objectives, and assess new approaches to aggregating gases. The choice of metric depends on the purpose of the analysis and all GHG emission metrics have limitations and uncertainties, given that they simplify the complexity of the physical climate system and its response to past and future GHG emissions. {2.1.1}

[10] GHG emission levels are rounded to two significant digits; as a consequence, small differences in sums due to rounding may occur. {2.1.1}

A.1.5 Historical contributions of CO_2 emissions vary substantially across regions in terms of total magnitude, but also in terms of contributions to CO_2-FFI and net CO_2 emissions from land use, land-use change and forestry (CO_2-LULUCF). In 2019, around 35% of the global population live in countries emitting more than 9 tCO_2-eq per capita[11] (excluding CO_2-LULUCF) while 41% live in countries emitting less than 3 tCO_2-eq per capita; of the latter a substantial share lacks access to modern energy services. Least developed countries (LDCs) and Small Island Developing States (SIDS) have much lower per capita emissions (1.7 tCO_2-eq and 4.6 tCO_2-eq, respectively) than the global average (6.9 tCO_2-eq), excluding CO_2-LULUCF. The 10% of households with the highest per capita emissions contribute 34–45% of global consumption-based household GHG emissions, while the bottom 50% contribute 13–15%. *(high confidence)* {2.1.1, Figure 2.2}

Observed Changes and Impacts

A.2 Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. Human-caused climate change is already affecting many weather and climate extremes in every region across the globe. This has led to widespread adverse impacts and related losses and damages to nature and people (*high confidence*). Vulnerable communities who have historically contributed the least to current climate change are disproportionately affected (*high confidence*). {2.1, Table 2.1, Figure 2.2 and 2.3} (Figure SPM.1)

A.2.1 It is unequivocal that human influence has warmed the atmosphere, ocean and land. Global mean sea level increased by 0.20 [0.15–0.25] m between 1901 and 2018. The average rate of sea level rise was 1.3 [0.6 to 2.1]mm yr^{-1} between 1901 and 1971, increasing to 1.9 [0.8 to 2.9] mm yr^{-1} between 1971 and 2006, and further increasing to 3.7 [3.2 to 4.2] mm yr^{-1} between 2006 and 2018 (*high confidence*). Human influence was *very likely* the main driver of these increases since at least 1971. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has further strengthened since AR5. Human influence has *likely* increased the chance of compound extreme events since the 1950s, including increases in the frequency of concurrent heatwaves and droughts (*high confidence*). {2.1.2, Table 2.1, Figure 2.3, Figure 3.4} (Figure SPM.1)

A.2.2 Approximately 3.3–3.6 billion people live in contexts that are highly vulnerable to climate change. Human and ecosystem vulnerability are interdependent. Regions and people with considerable development constraints have high vulnerability to climatic hazards. Increasing weather and climate extreme events have exposed millions of people to acute food insecurity[12] and reduced water security, with the largest adverse impacts observed in many locations and/or communities in Africa, Asia, Central and South America, LDCs, Small Islands and the Arctic, and globally for Indigenous Peoples, small-scale food producers and low-income households. Between 2010 and 2020, human mortality from floods, droughts and storms was 15 times higher in highly vulnerable regions, compared to regions with very low vulnerability. (*high confidence*) {2.1.2, 4.4} (Figure SPM.1)

A.2.3 Climate change has caused substantial damages, and increasingly irreversible losses, in terrestrial, freshwater, cryospheric, and coastal and open ocean ecosystems (*high confidence*). Hundreds of local losses of species have been driven by increases in the magnitude of heat extremes (*high confidence*) with mass mortality events recorded on land and in the ocean (*very high confidence*). Impacts on some ecosystems are approaching irreversibility such as the impacts of hydrological changes resulting from the retreat of glaciers, or the changes in some mountain (*medium confidence*) and Arctic ecosystems driven by permafrost thaw (*high confidence*). {2.1.2, Figure 2.3} (Figure SPM.1)

A.2.4 Climate change has reduced food security and affected water security, hindering efforts to meet Sustainable Development Goals (*high confidence*). Although overall agricultural productivity has increased, climate change has slowed this growth over the past 50 years globally (*medium confidence*), with related negative impacts mainly in mid- and low latitude regions but positive impacts in some high latitude regions (*high confidence*). Ocean warming and ocean acidification have adversely affected food production from

[11] Territorial emissions.
[12] Acute food insecurity can occur at any time with a severity that threatens lives, livelihoods or both, regardless of the causes, context or duration, as a result of shocks risking determinants of food security and nutrition, and is used to assess the need for humanitarian action {2.1}.

fisheries and shellfish aquaculture in some oceanic regions (*high confidence*). Roughly half of the world's population currently experience severe water scarcity for at least part of the year due to a combination of climatic and non-climatic drivers (*medium confidence*). {2.1.2, Figure 2.3} (Figure SPM.1)

A.2.5 In all regions increases in extreme heat events have resulted in human mortality and morbidity (*very high confidence*). The occurrence of climate-related food-borne and water-borne diseases (*very high confidence*) and the incidence of vector-borne diseases (*high confidence*) have increased. In assessed regions, some mental health challenges are associated with increasing temperatures (*high confidence*), trauma from extreme events (*very high confidence*), and loss of livelihoods and culture (*high confidence*). Climate and weather extremes are increasingly driving displacement in Africa, Asia, North America (*high confidence*), and Central and South America (*medium confidence*), with small island states in the Caribbean and South Pacific being disproportionately affected relative to their small population size (*high confidence*). {2.1.2, Figure 2.3} (Figure SPM.1)

A.2.6 Climate change has caused widespread adverse impacts and related losses and damages[13] to nature and people that are unequally distributed across systems, regions and sectors. Economic damages from climate change have been detected in climate-exposed sectors, such as agriculture, forestry, fishery, energy, and tourism. Individual livelihoods have been affected through, for example, destruction of homes and infrastructure, and loss of property and income, human health and food security, with adverse effects on gender and social equity. (*high confidence*) {2.1.2} (Figure SPM.1)

A.2.7 In urban areas, observed climate change has caused adverse impacts on human health, livelihoods and key infrastructure. Hot extremes have intensified in cities. Urban infrastructure, including transportation, water, sanitation and energy systems have been compromised by extreme and slow-onset events[14], with resulting economic losses, disruptions of services and negative impacts to well-being. Observed adverse impacts are concentrated amongst economically and socially marginalised urban residents. (*high confidence*) {2.1.2}

[START FIGURE SPM.1 HERE]

[13] In this report, the term 'losses and damages' refer to adverse observed impacts and/or projected risks and can be economic and/or non-economic. (See Annex I: Glossary)

[14] Slow-onset events are described among the climatic-impact drivers of the WGI AR6 and refer to the risks and impacts associated with e.g., increasing temperature means, desertification, decreasing precipitation, loss of biodiversity, land and forest degradation, glacial retreat and related impacts, ocean acidification, sea level rise and salinization. {2.1.2}

Adverse impacts from human-caused climate change will continue to intensify

a) Observed widespread and substantial impacts and related losses and damages attributed to climate change

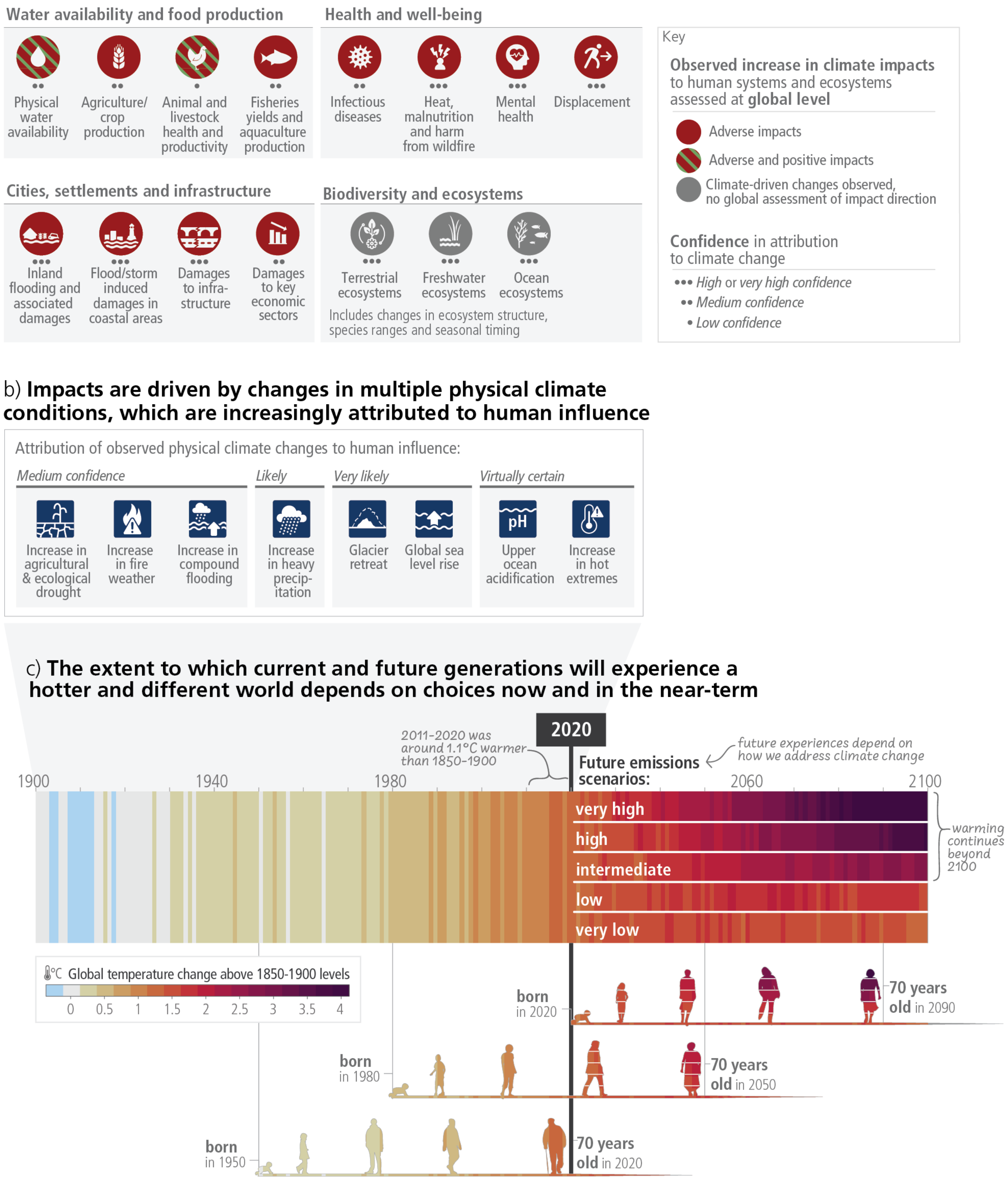

Figure SPM.1: (a) Climate change has already caused widespread impacts and related losses and damages on human systems and altered terrestrial, freshwater and ocean ecosystems worldwide. Physical water availability includes balance of water available from various sources including ground water, water quality and demand for water. Global mental health and displacement assessments reflect only assessed regions. Confidence levels reflect the assessment of attribution of the observed impact to climate change. **(b)** Observed impacts are connected to physical climate changes including many that have been attributed to human influence such as the selected climatic impact-drivers shown. Confidence and likelihood levels reflect the assessment of attribution of the observed climatic impact-driver to human influence. **(c)** Observed (1900–2020) and projected (2021–2100) changes in global surface temperature (relative to 1850–1900), which are linked to changes in climate conditions and impacts, illustrate how the climate has already changed and will change along the lifespan of three representative generations (born in 1950, 1980 and 2020). Future projections (2021–2100) of changes in global surface temperature are shown for very low (SSP1-1.9), low (SSP1-2.6), intermediate (SSP2-4.5), high (SSP3-7.0) and very high (SSP5-8.5) GHG emissions scenarios. Changes in annual global surface temperatures are presented as 'climate stripes', with future projections showing the human-caused long-term trends and continuing modulation by natural variability (represented here using observed levels of past natural variability). Colours on the generational icons correspond to the global surface temperature stripes for each year, with segments on future icons differentiating possible future experiences. {2.1, 2.1.2, Figure 2.1, Table 2.1, Figure 2.3, Cross-Section Box.2, 3.1, Figure 3.3, 4.1, 4.3} (Box SPM.1)

[END FIGURE SPM.1 HERE]

Current Progress in Adaptation and Gaps and Challenges

A.3 Adaptation planning and implementation has progressed across all sectors and regions, with documented benefits and varying effectiveness. Despite progress, adaptation gaps exist, and will continue to grow at current rates of implementation. Hard and soft limits to adaptation have been reached in some ecosystems and regions. Maladaptation is happening in some sectors and regions. Current global financial flows for adaptation are insufficient for, and constrain implementation of, adaptation options, especially in developing countries (*high confidence*). {2.2, 2.3}

A.3.1 Progress in adaptation planning and implementation has been observed across all sectors and regions, generating multiple benefits (*very high confidence*). Growing public and political awareness of climate impacts and risks has resulted in at least 170 countries and many cities including adaptation in their climate policies and planning processes (*high confidence*). {2.2.3}

A.3.2 Effectiveness[15] of adaptation in reducing climate risks[16] is documented for specific contexts, sectors and regions (*high confidence*). Examples of effective adaptation options include: cultivar improvements, on-farm water management and storage, soil moisture conservation, irrigation, agroforestry, community-based adaptation, farm and landscape level diversification in agriculture, sustainable land management approaches, use of agroecological principles and practices and other approaches that work with natural processes (*high confidence*). Ecosystem-based adaptation[17] approaches such as urban greening, restoration of wetlands and upstream forest ecosystems have been effective in reducing flood risks and urban heat (*high confidence*). Combinations of non-structural measures like early warning systems and structural measures like levees have reduced loss of lives in case of inland flooding (*medium confidence*). Adaptation options such as disaster risk management, early warning systems, climate services and social safety nets have broad applicability across multiple sectors (*high confidence*). {2.2.3}

A.3.3 Most observed adaptation responses are fragmented, incremental[18], sector-specific and unequally distributed across regions. Despite progress, adaptation gaps exist across sectors and regions, and will continue to grow under current levels of implementation, with the largest adaptation gaps among lower income groups. (*high confidence*) {2.3.2}

A.3.4 There is increased evidence of maladaptation in various sectors and regions (*high confidence*). Maladaptation especially affects marginalised and vulnerable groups adversely (*high confidence*). {2.3.2}

A.3.5 Soft limits to adaptation are currently being experienced by small-scale farmers and households along some low-lying coastal areas (*medium confidence*) resulting from financial, governance, institutional and policy constraints (*high confidence*). Some tropical, coastal, polar and mountain ecosystems have reached hard

[15] Effectiveness refers here to the extent to which an adaptation option is anticipated or observed to reduce climate-related risk. {2.2.3}
[16] See Annex I: Glossary {2.2.3}
[17] Ecosystem based Adaptation (EbA) is recognized internationally under the Convention on Biological Diversity (CBD14/5). A related concept is Nature-based Solutions (NbS), see Annex I: Glossary.
[18] Incremental adaptations to change in climate are understood as extensions of actions and behaviours that already reduce the losses or enhance the benefits of natural variations in extreme weather/climate events. {2.3.2}

adaptation limits (*high confidence*). Adaptation does not prevent all losses and damages, even with effective adaptation and before reaching soft and hard limits (*high confidence*). {2.3.2}

A.3.6 Key barriers to adaptation are limited resources, lack of private sector and citizen engagement, insufficient mobilization of finance (including for research), low climate literacy, lack of political commitment, limited research and/or slow and low uptake of adaptation science, and low sense of urgency. There are widening disparities between the estimated costs of adaptation and the finance allocated to adaptation (*high confidence*). Adaptation finance has come predominantly from public sources, and a small proportion of global tracked climate finance was targeted to adaptation and an overwhelming majority to mitigation (*very high confidence*). Although global tracked climate finance has shown an upward trend since AR5, current global financial flows for adaptation, including from public and private finance sources, are insufficient and constrain implementation of adaptation options, especially in developing countries (*high confidence*). Adverse climate impacts can reduce the availability of financial resources by incurring losses and damages and through impeding national economic growth, thereby further increasing financial constraints for adaptation, particularly for developing and least developed countries (*medium confidence*). {2.3.2; 2.3.3}

[START BOX SPM.1 HERE]

Box SPM.1 The use of scenarios and modelled pathways in the AR6 Synthesis Report

Modelled scenarios and pathways[19] are used to explore future emissions, climate change, related impacts and risks, and possible mitigation and adaptation strategies and are based on a range of assumptions, including socio-economic variables and mitigation options. These are quantitative projections and are neither predictions nor forecasts. Global modelled emission pathways, including those based on cost effective approaches contain regionally differentiated assumptions and outcomes, and have to be assessed with the careful recognition of these assumptions. Most do not make explicit assumptions about global equity, environmental justice or intra-regional income distribution. IPCC is neutral with regard to the assumptions underlying the scenarios in the literature assessed in this report, which do not cover all possible futures.[20] {Cross-Section Box.2}

WGI assessed the climate response to five illustrative scenarios based on Shared Socio-economic Pathways (SSPs)[21] that cover the range of possible future development of anthropogenic drivers of climate change found in the literature. High and very high GHG emissions scenarios (SSP3-7.0 and SSP5-8.5[22]) have CO_2 emissions that roughly double from current levels by 2100 and 2050, respectively. The intermediate GHG emissions scenario (SSP2-4.5) has CO_2 emissions remaining around current levels until the middle of the century. The very low and low GHG emissions scenarios (SSP1-1.9 and SSP1-2.6) have CO_2 emissions declining to net zero around 2050 and 2070, respectively, followed by varying levels of net negative CO_2 emissions. In addition, Representative Concentration Pathways (RCPs)[23] were used by WGI and WGII to assess regional climate changes, impacts and risks. In WGIII, a large number of global modelled emissions pathways were assessed, of which 1202 pathways were categorised based on their assessed global warming over the 21st century; categories range from pathways that limit warming to 1.5°C with more than 50% likelihood (noted >50% in this report) with no or limited overshoot (C1) to pathways that exceed 4°C (C8). (Box SPM.1, Table 1). {Cross-Section Box.2}

[19] In the literature, the terms pathways and scenarios are used interchangeably, with the former more frequently used in relation to climate goals. WGI primarily used the term scenarios and WGIII mostly used the term modelled emission and mitigation pathways. The SYR primarily uses scenarios when referring to WGI and modelled emission and mitigation pathways when referring to WGIII.

[20] Around half of all modelled global emission pathways assume cost-effective approaches that rely on least-cost mitigation/abatement options globally. The other half looks at existing policies and regionally and sectorally differentiated actions.

[21] SSP-based scenarios are referred to as SSPx-y, where 'SSPx' refers to the Shared Socioeconomic Pathway describing the socioeconomic trends underlying the scenarios, and 'y' refers to the level of radiative forcing (in watts per square metre, or Wm^{-2}) resulting from the scenario in the year 2100. {Cross-Section Box.2}

[22] Very high emissions scenarios have become less likely but cannot be ruled out. Warming levels >4°C may result from very high emissions scenarios, but can also occur from lower emission scenarios if climate sensitivity or carbon cycle feedbacks are higher than the best estimate. {3.1.1}

[23] RCP-based scenarios are referred to as RCPy, where 'y' refers to the level of radiative forcing (in watts per square metre, or Wm^{-2}) resulting from the scenario in the year 2100. The SSP scenarios cover a broader range of greenhouse gas and air pollutant futures than the RCPs. They are similar but not identical, with differences in concentration trajectories. The overall effective radiative forcing tends to be higher for the SSPs compared to the RCPs with the same label (*medium confidence*). {Cross-Section Box.2}

Global warming levels (GWLs) relative to 1850–1900 are used to integrate the assessment of climate change and related impacts and risks since patterns of changes for many variables at a given GWL are common to all scenarios considered and independent of timing when that level is reached. {Cross-Section Box.2}

[START BOX SPM.1, TABLE 1 HERE]

Box SPM.1, Table 1: Description and relationship of scenarios and modelled pathways considered across AR6 Working Group reports. {Cross-Section Box.2, Figure 1}

Category in WGIII	Category description	GHG emissions scenarios (SSPx-y*) in WGI & WGII	RCPy** in WGI & WGII
C1	limit warming to 1.5°C (>50%) with no or limited overshoot***	Very low (SSP1-1.9)	
C2	return warming to 1.5°C (>50%) after a high overshoot***		
C3	limit warming to 2°C (>67%)	Low (SSP1-2.6)	RCP2.6
C4	limit warming to 2°C (>50%)		
C5	limit warming to 2.5°C (>50%)		
C6	limit warming to 3°C (>50%)	Intermediate (SSP2-4.5)	RCP 4.5
C7	limit warming to 4°C (>50%)	High (SSP3-7.0)	
C8	exceed warming of 4°C (>50%)	Very high (SSP5-8.5)	RCP 8.5

* See footnote 27 for the SSPx-y terminology.
** See footnote 28 for the RCPy terminology.
*** Limited overshoot refers to exceeding 1.5°C global warming by up to about 0.1°C, high overshoot by 0.1°C-0.3°C, in both cases for up to several decades.

[END BOX SPM.1, TABLE 1 HERE]

[END BOX SPM.1 HERE]

Current Mitigation Progress, Gaps and Challenges

A.4 Policies and laws addressing mitigation have consistently expanded since AR5. Global GHG emissions in 2030 implied by nationally determined contributions (NDCs) announced by October 2021 make it *likely* that warming will exceed 1.5°C during the 21st century and make it harder to limit warming below 2°C. There are gaps between projected emissions from implemented policies and those from NDCs and finance flows fall short of the levels needed to meet climate goals across all sectors and regions. (*high confidence*) {2.2, 2.3, Figure 2.5, Table 2.2}

A.4.1 The UNFCCC, Kyoto Protocol, and the Paris Agreement are supporting rising levels of national ambition. The Paris Agreement, adopted under the UNFCCC, with near universal participation, has led to policy development and target-setting at national and sub-national levels, in particular in relation to mitigation, as well as enhanced transparency of climate action and support (*medium confidence*). Many regulatory and economic instruments have already been deployed successfully (*high confidence*). In many countries, policies have enhanced energy efficiency, reduced rates of deforestation and accelerated technology deployment, leading to avoided and in some cases reduced or removed emissions (*high confidence*). Multiple lines of evidence suggest that mitigation policies have led to several[24] Gt CO_2-eq yr^{-1} of avoided global emissions *(medium confidence).* At least 18 countries have sustained absolute production-based GHG and consumption-based CO_2 reductions[25] for longer than 10 years. These reductions have only partly offset global emissions growth (*high confidence*). {2.2.1, 2.2.2}

[24]At least 1.8 $GtCO_2$-eq yr^{-1} can be accounted for by aggregating separate estimates for the effects of economic and regulatory instruments. Growing numbers of laws and executive orders have impacted global emissions and were estimated to result in 5.9 $GtCO_2$-eq yr^{-1} less emissions in 2016 than they otherwise would have been. (*medium confidence*) {2.2.2}
[25] Reductions were linked to energy supply decarbonisation, energy efficiency gains, and energy demand reduction, which resulted from both policies and changes in economic structure (*high confidence*). {2.2.2}

A.4.2 Several mitigation options, notably solar energy, wind energy, electrification of urban systems, urban green infrastructure, energy efficiency, demand-side management, improved forest- and crop/grassland management, and reduced food waste and loss, are technically viable, are becoming increasingly cost effective and are generally supported by the public. From 2010– 2019 there have been sustained decreases in the unit costs of solar energy (85%), wind energy (55%), and lithium ion batteries (85%), and large increases in their deployment, e.g., >10x for solar and >100x for electric vehicles (EVs), varying widely across regions. The mix of policy instruments that reduced costs and stimulated adoption includes public R&D, funding for demonstration and pilot projects, and demand pull instruments such as deployment subsidies to attain scale. Maintaining emission-intensive systems may, in some regions and sectors, be more expensive than transitioning to low emission systems. (*high confidence*) {2.2.2, Figure 2.4}

A.4.3 A substantial 'emissions gap' exists between global GHG emissions in 2030 associated with the implementation of NDCs announced prior to COP26[26] and those associated with modelled mitigation pathways that limit warming to 1.5°C (>50%) with no or limited overshoot or limit warming to 2°C (>67%) assuming immediate action (*high confidence*). This would make it *likely* that warming will exceed 1.5°C during the 21st century (*high confidence*). Global modelled mitigation pathways that limit warming to 1.5°C (>50%) with no or limited overshoot or limit warming to 2°C (>67%) assuming immediate action imply deep global GHG emissions reductions this decade (*high confidence*) (see SPM Box 1, Table 1, B.6)[27]. Modelled pathways that are consistent with NDCs announced prior to COP26 until 2030 and assume no increase in ambition thereafter have higher emissions, leading to a median global warming of 2.8 [2.1–3.4]°C by 2100 (*medium confidence*). Many countries have signalled an intention to achieve net-zero GHG or net-zero CO_2 by around mid-century but pledges differ across countries in terms of scope and specificity, and limited policies are to date in place to deliver on them. {2.3.1, Table 2.2, Figure 2.5; Table 3.1; 4.1}

A.4.4 Policy coverage is uneven across sectors (*high confidence*). Policies implemented by the end of 2020 are projected to result in higher global GHG emissions in 2030 than emissions implied by NDCs, indicating an 'implementation gap' (*high confidence*). Without a strengthening of policies, global warming of 3.2 [2.2–3.5]°C is projected by 2100 (*medium confidence*). {2.2.2, 2.3.1, 3.1.1, Figure 2.5} (Box SPM.1, Figure SPM.5)

A.4.5 The adoption of low-emission technologies lags in most developing countries, particularly least developed ones, due in part to limited finance, technology development and transfer, and capacity (*medium confidenc*e). The magnitude of climate finance flows has increased over the last decade and financing channels have broadened but growth has slowed since 2018 *(high confidence).* Financial flows have developed heterogeneously across regions and sectors (*high confidence*). Public and private finance flows for fossil fuels are still greater than those for climate adaptation and mitigation (*high confidence*). The overwhelming majority of tracked climate finance is directed towards mitigation, but nevertheless falls short of the levels needed to limit warming to below 2°C or to 1.5°C across all sectors and regions (see C7.2) (*very high confidence*). In 2018, public and publicly mobilised private climate finance flows from developed to developing countries were below the collective goal under the UNFCCC and Paris Agreement to mobilise USD100 billion per year by 2020 in the context of meaningful mitigation action and transparency on implementation (*medium confidence*). {2.2.2, 2.3.1, 2.3.3}

[26] Due to the literature cutoff date of WGIII, the additional NDCs submitted after 11 October 2021 are not assessed here. {Footnote 32 in Longer Report}

[27] Projected 2030 GHG emissions are 50 (47–55) $GtCO_2$-eq if all conditional NDC elements are taken into account. Without conditional elements, the global emissions are projected to be approximately similar to modelled 2019 levels at 53 (50–57) $GtCO_2$-eq. {2.3.1, Table 2.2}

B. Future Climate Change, Risks, and Long-Term Responses

Future Climate Change

B.1 Continued greenhouse gas emissions will lead to increasing global warming, with the best estimate of reaching 1.5°C in the near term in considered scenarios and modelled pathways. Every increment of global warming will intensify multiple and concurrent hazards (*high confidence*). Deep, rapid, and sustained reductions in greenhouse gas emissions would lead to a discernible slowdown in global warming within around two decades, and also to discernible changes in atmospheric composition within a few years (*high confidence*). {Cross-Section Boxes 1 and 2, 3.1, 3.3, Table 3.1, Figure 3.1, 4.3} (Figure SPM.2, Box SPM.1)

B.1.1 Global warming[28] will continue to increase in the near term (2021-2040) mainly due to increased cumulative CO_2 emissions in nearly all considered scenarios and modelled pathways. In the near term, global warming is *more likely than not* to reach 1.5°C even under the very low GHG emission scenario (SSP1-1.9) and *likely* or *very likely* to exceed 1.5°C under higher emissions scenarios. In the considered scenarios and modelled pathways, the best estimates of the time when the level of global warming of 1.5°C is reached lie in the near term[29]. Global warming declines back to below 1.5°C by the end of the 21st century in some scenarios and modelled pathways (see B.7). The assessed climate response to GHG emissions scenarios results in a best estimate of warming for 2081–2100 that spans a range from 1.4°C for a very low GHG emissions scenario (SSP1-1.9) to 2.7°C for an intermediate GHG emissions scenario (SSP2-4.5) and 4.4°C for a very high GHG emissions scenario (SSP5-8.5)[30], with narrower uncertainty ranges[31] than for corresponding scenarios in AR5. {Cross-Section Boxes 1 and 2, 3.1.1, 3.3.4, Table 3.1, 4.3} (Box SPM.1)

B.1.2 Discernible differences in trends of global surface temperature between contrasting GHG emissions scenarios (SSP1-1.9 and SSP1-2.6 vs. SSP3-7.0 and SSP5-8.5) would begin to emerge from natural variability[32] within around 20 years. Under these contrasting scenarios, discernible effects would emerge within years for GHG concentrations, and sooner for air quality improvements, due to the combined targeted air pollution controls and strong and sustained methane emissions reductions. Targeted reductions of air pollutant emissions lead to more rapid improvements in air quality within years compared to reductions in GHG emissions only, but in the long term, further improvements are projected in scenarios that combine efforts to reduce air pollutants as well as GHG emissions[33]. (*high confidence*) {3.1.1} (Box SPM.1)

B.1.3 Continued emissions will further affect all major climate system components. With every additional increment of global warming, changes in extremes continue to become larger. Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation, and very wet and very dry weather and climate events and seasons (*high confidence*). In scenarios with increasing CO_2 emissions, natural land and ocean carbon sinks are projected to take up a decreasing proportion of these emissions (*high confidence*). Other projected changes include further reduced extents and/or volumes of almost

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[28] Global warming (see Annex I: Glossary) is here reported as running 20-year averages, unless stated otherwise, relative to 1850–1900. Global surface temperature in any single year can vary above or below the long-term human-caused trend, due to natural variability. The internal variability of global surface temperature in a single year is estimated to be about ±0.25°C (5–95% range, *high confidence*). The occurrence of individual years with global surface temperature change above a certain level does not imply that this global warming level has been reached. {4.3, Cross-Section Box.2}

[29] Median five-year interval at which a 1.5°C global warming level is reached (50% probability) in categories of modelled pathways considered in WGIII is 2030-2035. By 2030, global surface temperature in any individual year could exceed 1.5°C relative to 1850-1900 with a probability between 40% and 60%, across the five scenarios assessed in WGI (*medium confidence*). In all scenarios considered in WGI except the very high emissions scenario (SSP5-8.5), the midpoint of the first 20-year running average period during which the assessed average global surface temperature change reaches 1.5°C lies in the first half of the 2030s. In the very high GHG emissions scenario, the midpoint is in the late 2020s. {3.1.1, 3.3.1, 4.3} (Box SPM.1)

[30] The best estimates [and *very likely* ranges] for the different scenarios are: 1.4°C [1.0°C–1.8°C] (SSP1-1.9); 1.8°C [1.3°C–2.4°C] (SSP1-2.6); 2.7°C [2.1°C–3.5°C] (SSP2-4.5)); 3.6°C [2.8°C–4.6°C] (SSP3-7.0); and 4.4°C [3.3°C–5.7°C] (SSP5-8.5). {3.1.1} (Box SPM.1)

[31] Assessed future changes in global surface temperature have been constructed, for the first time, by combining multi-model projections with observational constraints and the assessed equilibrium climate sensitivity and transient climate response. The uncertainty range is narrower than in the AR5 thanks to improved knowledge of climate processes, paleoclimate evidence and model-based emergent constraints. {3.1.1}

[32] See Annex I: Glossary. Natural variability includes natural drivers and internal variability. The main internal variability phenomena include El Niño-Southern Oscillation, Pacific Decadal Variability and Atlantic Multi-decadal Variability. {4.3}

[33] Based on additional scenarios.

all cryospheric elements[34] (*high confidence*), further global mean sea level rise (*virtually certain*), and increased ocean acidification (*virtually certain*) and deoxygenation (*high confidence*). {3.1.1, 3.3.1, Figure 3.4} (Figure SPM.2)

B.1.4 With further warming, every region is projected to increasingly experience concurrent and multiple changes in climatic impact-drivers. Compound heatwaves and droughts are projected to become more frequent, including concurrent events across multiple locations (*high confidence*). Due to relative sea level rise, current 1-in-100 year extreme sea level events are projected to occur at least annually in more than half of all tide gauge locations by 2100 under all considered scenarios (*high confidence*). Other projected regional changes include intensification of tropical cyclones and/or extratropical storms (*medium confidence*), and increases in aridity and fire weather (*medium* to *high confidence*) {3.1.1, 3.1.3}

B.1.5 Natural variability will continue to modulate human-caused climate changes, either attenuating or amplifying projected changes, with little effect on centennial-scale global warming (*high confidence*). These modulations are important to consider in adaptation planning, especially at the regional scale and in the near term. If a large explosive volcanic eruption were to occur[35], it would temporarily and partially mask human-caused climate change by reducing global surface temperature and precipitation for one to three years (*medium confidence*). {4.3}

[START FIGURE SPM.2 HERE]

[34] Permafrost, seasonal snow cover, glaciers, the Greenland and Antarctic Ice Sheets, and Arctic Sea ice.
[35] Based on 2500-year reconstructions, eruptions with a radiative forcing more negative than -1 Wm-2, related to the radiative effect of volcanic stratospheric aerosols in the literature assessed in this report, occur on average twice per century. {4.3}

With every increment of global warming, regional changes in mean climate and extremes become more widespread and pronounced

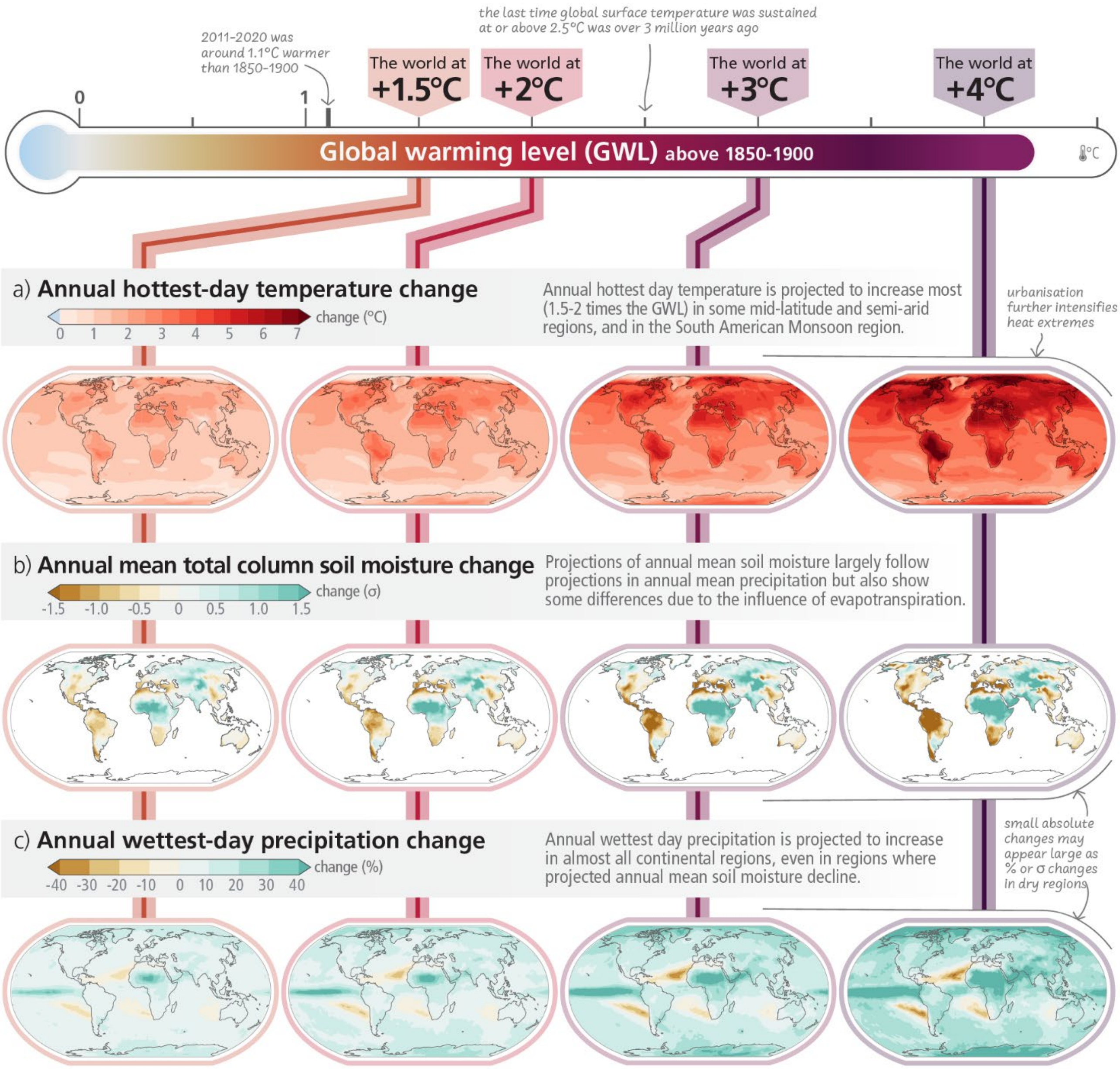

Figure SPM.2: Projected changes of annual maximum daily maximum temperature, annual mean total column soil moisture and annual maximum 1-day precipitation at global warming levels of 1.5°C, 2°C, 3°C, and 4°C relative to 1850–1900. Projected **(a)** annual maximum daily temperature change (°C), **(b)** annual mean total column soil moisture (standard deviation), **(c)** annual maximum 1-day precipitation change (%). The panels show CMIP6 multi-model median changes. In panels (b) and (c), large positive relative changes in dry regions may correspond to small absolute changes. In panel (b), the unit is the standard deviation of interannual variability in soil moisture during 1850–1900. Standard deviation is a widely used metric in characterising drought severity. A projected reduction in mean soil moisture by one standard deviation corresponds to soil moisture conditions typical of droughts that occurred about once every six years during 1850–1900. The WGI Interactive Atlas (https://interactive-atlas.ipcc.ch/) can be used to explore additional changes in the climate system across the range of global warming levels presented in this figure. {Figure 3.1, Cross-Section Box.2}

[END FIGURE SPM.2 HERE]

Climate Change Impacts and Climate-Related Risks

B.2 For any given future warming level, many climate-related risks are higher than assessed in AR5, and projected long-term impacts are up to multiple times higher than currently observed (*high confidence*). Risks and projected adverse impacts and related losses and damages from climate change escalate with every increment of global warming (*very high confidence*). Climatic and non-climatic risks will increasingly interact, creating compound and cascading risks that are more complex and difficult to manage (*high confidence*). {Cross-Section Box.2, 3.1, 4.3, Figure 3.3, Figure 4.3} (Figure SPM.3, Figure SPM.4)

B.2.1 In the near term, every region in the world is projected to face further increases in climate hazards (*medium to high confidence*, depending on region and hazard), increasing multiple risks to ecosystems and humans (*very high confidence*). Hazards and associated risks expected in the near-term include an increase in heat-related human mortality and morbidity (*high confidence*), food-borne, water-borne, and vector-borne diseases (*high confidence*), and mental health challenges[36] (*very high confidence*), flooding in coastal and other low-lying cities and regions (*high confidence*), biodiversity loss in land, freshwater and ocean ecosystems (*medium to very high confidence*, depending on ecosystem), and a decrease in food production in some regions (*high confidence*). Cryosphere-related changes in floods, landslides, and water availability have the potential to lead to severe consequences for people, infrastructure and the economy in most mountain regions (*high confidence*). The projected increase in frequency and intensity of heavy precipitation (*high confidence*) will increase rain-generated local flooding (*medium confidence*). {Figure 3.2, Figure 3.3, 4.3, Figure 4.3} (Figure SPM.3, Figure SPM.4)

B.2.2 Risks and projected adverse impacts and related losses and damages from climate change will escalate with every increment of global warming (*very high confidence*). They are higher for global warming of 1.5°C than at present, and even higher at 2°C (*high confidence*). Compared to the AR5, global aggregated risk levels[37] (Reasons for Concern[38]) are assessed to become high to very high at lower levels of global warming due to recent evidence of observed impacts, improved process understanding, and new knowledge on exposure and vulnerability of human and natural systems, including limits to adaptation (*high confidence*). Due to unavoidable sea level rise (see also B.3), risks for coastal ecosystems, people and infrastructure will continue to increase beyond 2100 (*high confidence*). {3.1.2, 3.1.3, Figure 3.4, Figure 4.3} (Figures SPM.3, Figure SPM.4)

B.2.3 With further warming, climate change risks will become increasingly complex and more difficult to manage. Multiple climatic and non-climatic risk drivers will interact, resulting in compounding overall risk and risks cascading across sectors and regions. Climate-driven food insecurity and supply instability, for example, are projected to increase with increasing global warming, interacting with non-climatic risk drivers such as competition for land between urban expansion and food production, pandemics and conflict. (*high confidence*) {3.1.2, 4.3, Figure 4.3}

B.2.4 For any given warming level, the level of risk will also depend on trends in vulnerability and exposure of humans and ecosystems. Future exposure to climatic hazards is increasing globally due to socio-economic development trends including migration, growing inequality and urbanisation. Human vulnerability will concentrate in informal settlements and rapidly growing smaller settlements. In rural areas vulnerability will be heightened by high reliance on climate-sensitive livelihoods. Vulnerability of ecosystems will be strongly influenced by past, present, and future patterns of unsustainable consumption and production, increasing

[36] In all assessed regions.
[37] Undetectable risk level indicates no associated impacts are detectable and attributable to climate change; moderate risk indicates associated impacts are both detectable and attributable to climate change with at least *medium confidence*, also accounting for the other specific criteria for key risks; high risk indicates severe and widespread impacts that are judged to be high on one or more criteria for assessing key risks; and very high risk level indicates very high risk of severe impacts and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks. {3.1.2}
[38] The Reasons for Concern (RFC) framework communicates scientific understanding about accrual of risk for five broad categories. RFC1: Unique and threatened systems: ecological and human systems that have restricted geographic ranges constrained by climate-related conditions and have high endemism or other distinctive properties. RFC2: Extreme weather events: risks/impacts to human health, livelihoods, assets and ecosystems from extreme weather events. RFC3: Distribution of impacts: risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability. RFC4: Global aggregate impacts: impacts to socio-ecological systems that can be aggregated globally into a single metric. RFC5: Large-scale singular events: relatively large, abrupt and sometimes irreversible changes in systems caused by global warming. See also Annex I: Glossary. {3.1.2, Cross-Section Box.2}

demographic pressures, and persistent unsustainable use and management of land, ocean, and water. Loss of ecosystems and their services has cascading and long-term impacts on people globally, especially for Indigenous Peoples and local communities who are directly dependent on ecosystems, to meet basic needs. (*high confidence*) {Cross-Section Box.2, Figure 1c, 3.1.2, 4.3}

[START FIGURE SPM.3 HERE]

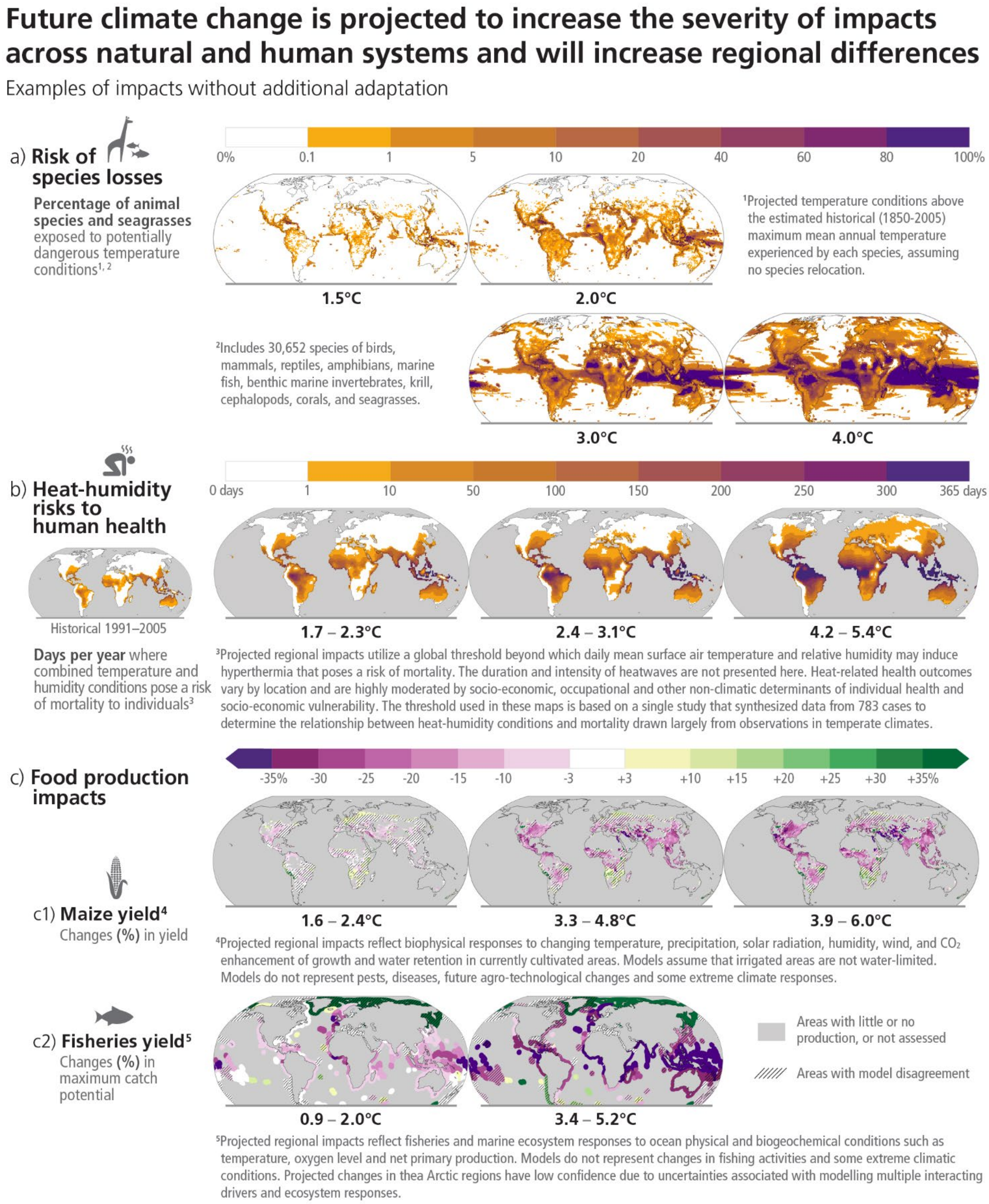

Figure SPM.3: Projected risks and impacts of climate change on natural and human systems at different global warming levels (GWLs) relative to 1850-1900 levels. Projected risks and impacts shown on the maps are based on outputs from different subsets of Earth system and impact models that were used to project each impact indicator without additional adaptation. WGII provides further assessment of the impacts on human and natural systems using these projections and additional lines of evidence. **(a)** Risks of species losses as indicated by the percentage of assessed species exposed to potentially dangerous temperature conditions, as defined by conditions beyond the estimated historical (1850-2005) maximum mean annual temperature experienced by each species, at GWLs of 1.5ºC, 2ºC,3ºC and 4ºC. Underpinning projections of temperature are from 21 Earth system models and do not consider extreme events impacting ecosystems such as the Arctic. **(b)** Risks to human health as indicated by the days per year of population exposure to hyperthermic conditions that pose a risk of mortality from surface air temperature and humidity conditions for historical period (1991-2005) and at GWLs of 1.7°C–2.3°C (mean = 1.9°C; 13 climate models), 2.4°C–3.1°C (2.7°C; 16 climate models) and 4.2°C–5.4°C (4.7°C; 15 climate models). Interquartile ranges of GWLs by 2081–2100 under RCP2.6, RCP4.5 and RCP8.5. The presented index is consistent with common features found in many indices included within WGI and WGII assessments **(c)** Impacts on food production: (c1) Changes in maize yield by 2080–2099 relative to 1986–2005 at projected GWLs of 1.6°C–2.4ºC (2.0°C), 3.3°C–4.8ºC (4.1°C) and 3.9°C–6.0ºC (4.9°C). Median yield changes from an ensemble of 12 crop models, each driven by bias-adjusted outputs from 5 Earth system models, from the Agricultural Model Intercomparison and Improvement Project (AgMIP) and the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP). Maps depict 2080–2099 compared to 1986–2005 for current growing regions (>10 ha), with the corresponding range of future global warming levels shown under SSP1-2.6, SSP3-7.0 and SSP5-8.5, respectively. Hatching indicates areas where <70% of the climate-crop model combinations agree on the sign of impact. (c2) Change in maximum fisheries catch potential by 2081–2099 relative to 1986–2005 at projected GWLs of 0.9°C–2.0°C (1.5°C) and 3.4°C–5.2°C (4.3°C). GWLs by 2081–2100 under RCP2.6 and RCP8.5. Hatching indicates where the two climate-fisheries models disagree in the direction of change. Large relative changes in low yielding regions may correspond to small absolute changes. Biodiversity and fisheries in Antarctica were not analysed due to data limitations. Food security is also affected by crop and fishery failures not presented here.{3.1.2, Figure 3.2, Cross-Section Box.2} (Box SPM.1)

[END FIGURE SPM.3 HERE]

[START FIGURE SPM.4 HERE]

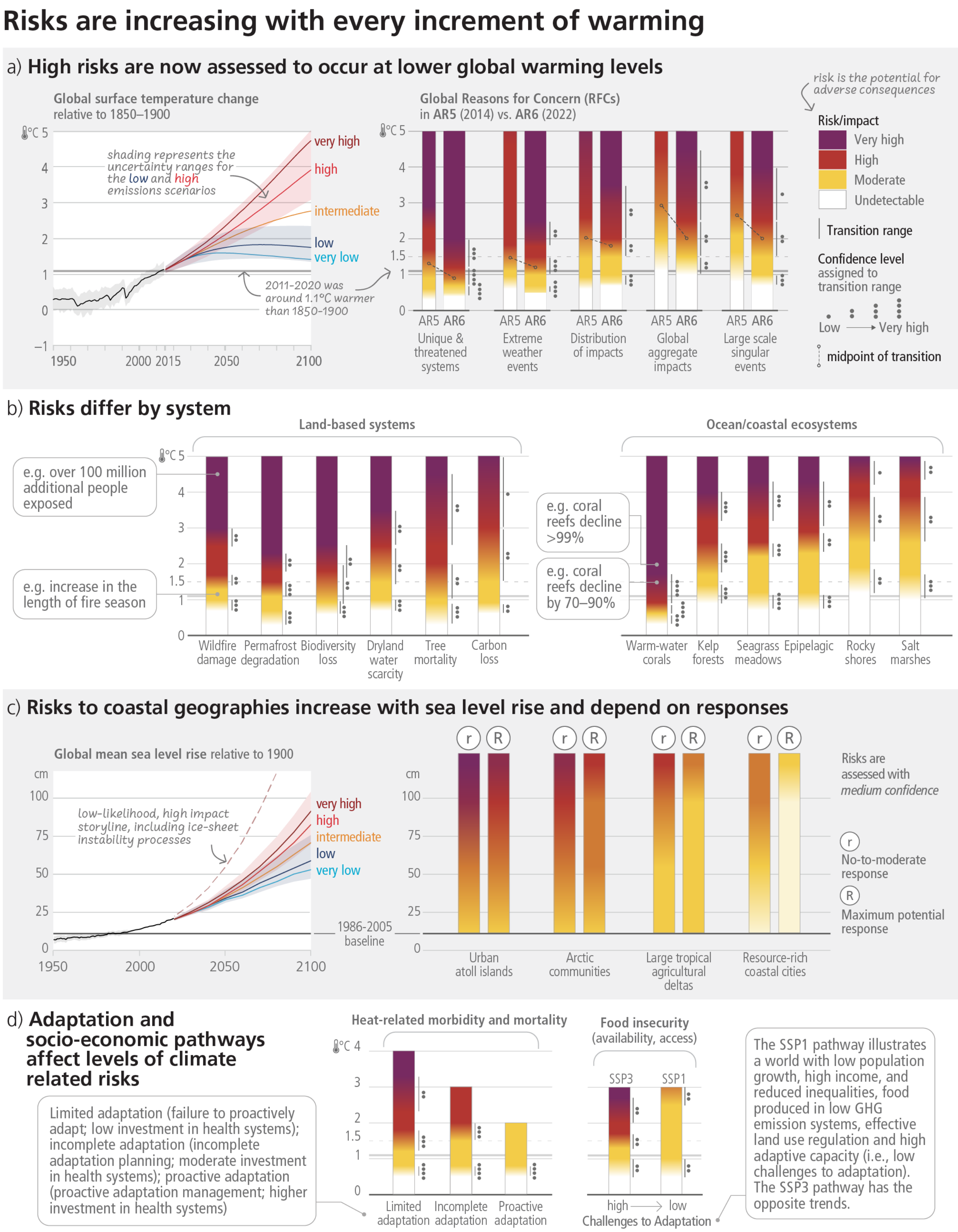

Figure SPM.4: Subset of assessed climate outcomes and associated global and regional climate risks. The burning embers result from a literature based expert elicitation. **Panel (a): Left** – Global surface temperature changes in °C relative to 1850–1900. These changes were obtained by combining CMIP6 model simulations with observational constraints based on past simulated warming, as well as an updated assessment of equilibrium climate sensitivity. *Very likely* ranges are shown for the low and high GHG emissions scenarios (SSP1-2.6 and SSP3-7.0) (Cross-Section Box 2); **Right** – Global Reasons for Concern (RFC), comparing AR6 (thick embers) and AR5 (thin embers) assessments. Risk transitions have generally shifted towards lower temperatures with updated scientific understanding. Diagrams are shown for each RFC, assuming low to no adaptation. Lines connect the midpoints of the transitions from moderate to high risk across AR5 and AR6. **Panel (b)**: Selected global risks for land and ocean ecosystems, illustrating general increase of risk with global warming levels with low to no adaptation. **Panel (c)**: **Left** - Global mean sea level change in centimetres, relative to 1900.

The historical changes (black) are observed by tide gauges before 1992 and altimeters afterwards. The future changes to 2100 (coloured lines and shading) are assessed consistently with observational constraints based on emulation of CMIP, ice-sheet, and glacier models, and *likely* ranges are shown for SSP1-2.6 and SSP3-7.0. **Right** - Assessment of the combined risk of coastal flooding, erosion and salinization for four illustrative coastal geographies in 2100, due to changing mean and extreme sea levels, under two response scenarios, with respect to the SROCC baseline period (1986-2005). The assessment does not account for changes in extreme sea level beyond those directly induced by mean sea level rise; risk levels could increase if other changes in extreme sea levels were considered (e.g., due to changes in cyclone intensity). "No-to-moderate response" describes efforts as of today (i.e. no further significant action or new types of actions). "Maximum potential response" represent a combination of responses implemented to their full extent and thus significant additional efforts compared to today, assuming minimal financial, social and political barriers. (In this context, 'today' refers to 2019.) The assessment criteria include exposure and vulnerability, coastal hazards, in-situ responses and planned relocation. Planned relocation refers to managed retreat or resettlements. The term response is used here instead of adaptation because some responses, such as retreat, may or may not be considered to be adaptation. **Panel (d):** Selected risks under different socio-economic pathways, illustrating how development strategies and challenges to adaptation influence risk. **Left** - Heat-sensitive human health outcomes under three scenarios of adaptation effectiveness. The diagrams are truncated at the nearest whole ºC within the range of temperature change in 2100 under three SSP scenarios. **Right** - Risks associated with food security due to climate change and patterns of socio-economic development. Risks to food security include availability and access to food, including population at risk of hunger, food price increases and increases in disability adjusted life years attributable to childhood underweight. Risks are assessed for two contrasted socio-economic pathways (SSP1 and SSP3) excluding the effects of targeted mitigation and adaptation policies. {Figure 3.3} (Box SPM.1)

[END FIGURE SPM.4 HERE]

Likelihood and Risks of Unavoidable, Irreversible or Abrupt Changes

B.3 Some future changes are unavoidable and/or irreversible but can be limited by deep, rapid and sustained global greenhouse gas emissions reduction. The likelihood of abrupt and/or irreversible changes increases with higher global warming levels. Similarly, the probability of low-likelihood outcomes associated with potentially very large adverse impacts increases with higher global warming levels. (*high confidence*) {3.1}

B.3.1 Limiting global surface temperature does not prevent continued changes in climate system components that have multi-decadal or longer timescales of response (*high confidence*). Sea level rise is unavoidable for centuries to millennia due to continuing deep ocean warming and ice sheet melt, and sea levels will remain elevated for thousands of years (*high confidence*). However, deep, rapid and sustained GHG emissions reductions would limit further sea level rise acceleration and projected long-term sea level rise commitment. Relative to 1995–2014, the *likely* global mean sea level rise under the SSP1-1.9 GHG emissions scenario is 0.15–0.23 m by 2050 and 0.28–0.55 m by 2100; while for the SSP5-8.5 GHG emissions scenario it is 0.20–0.29 m by 2050 and 0.63–1.01 m by 2100 (*medium confidence*). Over the next 2000 years, global mean sea level will rise by about 2–3 m if warming is limited to 1.5°C and 2–6 m if limited to 2°C (*low confidence*). {3.1.3, Figure 3.4} (Box SPM.1)

B.3.2 The likelihood and impacts of abrupt and/or irreversible changes in the climate system, including changes triggered when tipping points are reached, increase with further global warming (*high confidence*). As warming levels increase, so do the risks of species extinction or irreversible loss of biodiversity in ecosystems including forests (*medium confidence*), coral reefs (*very high confidence*) and in Arctic regions (*high confidence*). At sustained warming levels between 2°C and 3°C, the Greenland and West Antarctic ice sheets will be lost almost completely and irreversibly over multiple millennia, causing several metres of sea level rise (*limited evidence*). The probability and rate of ice mass loss increase with higher global surface temperatures (*high confidence*). {3.1.2, 3.1.3}

B.3.3 The probability of low-likelihood outcomes associated with potentially very large impacts increases with higher global warming levels (*high confidence*). Due to deep uncertainty linked to ice-sheet processes, global mean sea level rise above the *likely* range – approaching 2 m by 2100 and in excess of 15 m by 2300 under the very high GHG emissions scenario (SSP5-8.5) (*low confidence*) – cannot be excluded. There is *medium confidence* that the Atlantic Meridional Overturning Circulation will not collapse abruptly before 2100, but if it were to occur, it would *very likely* cause abrupt shifts in regional weather patterns, and large impacts on ecosystems and human activities. {3.1.3} (Box SPM.1)

Adaptation Options and their Limits in a Warmer World

B.4 Adaptation options that are feasible and effective today will become constrained and less effective with increasing global warming. With increasing global warming, losses and damages will increase and additional human and natural systems will reach adaptation limits. Maladaptation can be avoided by flexible, multi-sectoral, inclusive, long-term planning and implementation of adaptation actions, with co-benefits to many sectors and systems. (*high confidence*) {3.2, 4.1, 4.2, 4.3}

B.4.1 The effectiveness of adaptation, including ecosystem-based and most water-related options, will decrease with increasing warming. The feasibility and effectiveness of options increase with integrated, multi-sectoral solutions that differentiate responses based on climate risk, cut across systems and address social inequities. As adaptation options often have long implementation times, long-term planning increases their efficiency. (*high confidence*) {3.2, Figure 3.4, 4.1, 4.2}

B.4.2 With additional global warming, limits to adaptation and losses and damages, strongly concentrated among vulnerable populations, will become increasingly difficult to avoid (*high confidence*). Above 1.5°C of global warming, limited freshwater resources pose potential hard adaptation limits for small islands and for regions dependent on glacier and snow melt (*medium confidence*). Above that level, ecosystems such as some warm-water coral reefs, coastal wetlands, rainforests, and polar and mountain ecosystems will have reached or surpassed hard adaptation limits and as a consequence, some Ecosystem-based Adaptation measures will also lose their effectiveness (*high confidence*). {2.3.2, 3.2, 4.3}

B.4.3 Actions that focus on sectors and risks in isolation and on short-term gains often lead to maladaptation over the long-term, creating lock-ins of vulnerability, exposure and risks that are difficult to change. For example, seawalls effectively reduce impacts to people and assets in the short-term but can also result in lock-ins and increase exposure to climate risks in the long-term unless they are integrated into a long-term adaptive plan. Maladaptive responses can worsen existing inequities especially for Indigenous Peoples and marginalised groups and decrease ecosystem and biodiversity resilience. Maladaptation can be avoided by flexible, multi-sectoral, inclusive, long-term planning and implementation of adaptation actions, with co-benefits to many sectors and systems. (*high confidence*) {2.3.2, 3.2}

Carbon Budgets and Net Zero Emissions

B.5 Limiting human-caused global warming requires net zero CO_2 emissions. Cumulative carbon emissions until the time of reaching net-zero CO_2 emissions and the level of greenhouse gas emission reductions this decade largely determine whether warming can be limited to 1.5°C or 2°C (*high confidence*). Projected CO_2 emissions from existing fossil fuel infrastructure without additional abatement would exceed the remaining carbon budget for 1.5°C (50%) (*high confidence*). {2.3, 3.1, 3.3, Table 3.1}

B.5.1 From a physical science perspective, limiting human-caused global warming to a specific level requires limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions, along with strong reductions in other greenhouse gas emissions. Reaching net zero GHG emissions primarily requires deep reductions in CO_2, methane, and other GHG emissions, and implies net-negative CO_2 emissions[39]. Carbon dioxide removal (CDR) will be necessary to achieve net-negative CO2 emissions (see B.6). Net zero GHG emissions, if sustained, are projected to result in a gradual decline in global surface temperatures after an earlier peak. (*high confidence*) {3.1.1, 3.3.1, 3.3.2, 3.3.3, Table 3.1, Cross-Section Box 1}

B.5.2 For every 1000 $GtCO_2$ emitted by human activity, global surface temperature rises by 0.45°C (best estimate, with a *likely* range from 0.27 to 0.63°C). The best estimates of the remaining carbon budgetsfrom the

[39] Net zero GHG emissions defined by the 100-year global warming potential. See footnote 9.

beginning of 2020 are 500 $GtCO_2$ for a 50% likelihood of limiting global warming to 1.5°C and 1150 $GtCO_2$ for a 67% likelihood of limiting warming to 2°C[40]. The stronger the reductions in non-CO_2 emissions the lower the resulting temperatures are for a given remaining carbon budget or the larger remaining carbon budget for the same level of temperature change[41]. {3.3.1}

B.5.3 If the annual CO_2 emissions between 2020–2030 stayed, on average, at the same level as 2019, the resulting cumulative emissions would almost exhaust the remaining carbon budget for 1.5°C (50%), and deplete more than a third of the remaining carbon budget for 2°C (67%). Estimates of future CO_2 emissions from existing fossil fuel infrastructures without additional abatement[42] already exceed the remaining carbon budget for limiting warming to 1.5°C (50%) (*high confidence*). Projected cumulative future CO_2 emissions over the lifetime of existing and planned fossil fuel infrastructure, if historical operating patterns are maintained and without additional abatement[43], are approximately equal to the remaining carbon budget for limiting warming to 2°C with a likelihood of 83%[44] (*high confidence*). {2.3.1, 3.3.1, Figure 3.5}

B.5.4 Based on central estimates only, historical cumulative net CO_2 emissions between 1850 and 2019 amount to about four-fifths[45] of the total carbon budget for a 50% probability of limiting global warming to 1.5°C (central estimate about 2900 $GtCO_2$), and to about two thirds[46] of the total carbon budget for a 67% probability to limit global warming to 2°C (central estimate about 3550 $GtCO_2$). {3.3.1, Figure 3.5}

Mitigation Pathways

B.6 All global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot, and those that limit warming to 2°C (>67%), involve rapid and deep and, in most cases, immediate greenhouse gas emissions reductions in all sectors this decade. Global net zero CO_2 emissions are reached for these pathway categories, in the early 2050s and around the early 2070s, respectively. (*high confidence*) {3.3, 3.4, 4.1, 4.5, Table 3.1} (Figure SPM.5, Box SPM.1)

B.6.1 Global modelled pathways provide information on limiting warming to different levels; these pathways, particularly their sectoral and regional aspects, depend on the assumptions described in Box SPM.1. Global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot or limit warming to 2°C (>67%) are characterized by deep, rapid and, in most cases, immediate GHG emissions reductions. Pathways that limit warming to 1.5C (>50%) with no or limited overshoot reach net zero CO_2 in the early 2050s, followed by net negative CO_2 emissions. Those pathways that reach net zero GHG emissions do so around the 2070s. Pathways that limit warming to 2C (>67%) reach net zero CO2 emissions in the early 2070s. Global GHG emissions are projected to peak between 2020 and at the latest before 2025 in global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot and in those that limit warming to 2°C (>67%) and assume immediate action. (*high confidence*) {3.3.2, 3.3.4, 4.1, Table 3.1, Figure 3.6} (Table XX)

[START TABLE XX]

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[40] Global databases make different choices about which emissions and removals occurring on land are considered anthropogenic. Most countries report their anthropogenic land CO_2 fluxes including fluxes due to human-caused environmental change (e.g., CO_2 fertilisation) on 'managed' land in their national GHG inventories. Using emissions estimates based on these inventories, the remaining carbon budgets must be correspondingly reduced. {3.3.1}

[41] For example, remaining carbon budgets could be 300 or 600 $GtCO_2$ for 1.5°C (50%), respectively for high and low non-CO_2 emissions, compared to 500 $GtCO_2$ in the central case. {3.3.1}

[42] Abatement here refers to human interventions that reduce the amount of greenhouse gases that are released from fossil fuel infrastructure to the atmosphere.

[43] Ibid.

[44] WGI provides carbon budgets that are in line with limiting global warming to temperature limits with different likelihoods, such as 50%, 67% or 83%. {3.3.1}

[45] Uncertainties for total carbon budgets have not been assessed and could affect the specific calculated fractions.

[46] Ibid.

Table XX: Greenhouse gas and CO_2 emission reductions from 2019, median and 5-95 percentiles {3.3.1; 4.1; Table 3.1; Figure 2.5; Box SPM1}

		Reductions from 2019 emission levels (%)			
		2030	2035	2040	2050
Limit warming to1.5°C (>50%) with no or limited overshoot	GHG	43 [34-60]	60 [49-77]	69 [58-90]	84 [73-98]
	CO_2	48 [36-69]	65 [50-96]	80 [61-109]	99 [79-119]
Limit warming to 2°C (>67%)	GHG	21 [1-42]	35 [22-55]	46 [34-63]	64 [53-77]
	CO_2	22 [1-44]	37 [21-59]	51 [36-70]	73 [55-90]

[END TABLE XX]

B.6.2 Reaching net zero CO_2 or GHG emissions primarily requires deep and rapid reductions in gross emissions of CO_2, as well as substantial reductions of non-CO_2 GHG emissions (*high confidence*). For example, in modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot, global methane emissions are reduced by 34 [21–57]% by 2030 relative to 2019. However, some hard-to-abate residual GHG emissions (e.g., some emissions from agriculture, aviation, shipping, and industrial processes) remain and would need to be counterbalanced by deployment of carbon dioxide removal (CDR) methods to achieve net zero CO_2 or GHG emissions (*high confidence*). As a result, net zero CO_2 is reached earlier than net zero GHGs (*high confidence*). {3.3.2, 3.3.3, Table 3.1, Figure 3.5} (Figure SPM.5)

B.6.3 Global modelled mitigation pathways reaching net zero CO_2 and GHG emissions include transitioning from fossil fuels without carbon capture and storage (CCS) to very low- or zero-carbon energy sources, such as renewables or fossil fuels with CCS, demand-side measures and improving efficiency, reducing non-CO_2 GHG emissions, and CDR[47]. In most global modelled pathways, land-use change and forestry (via reforestation and reduced deforestation) and the energy supply sector reach net zero CO_2 emissions earlier than the buildings, industry and transport sectors. (*high confidence*) {3.3.3, 4.1, 4.5, Figure 4.1} (Figure SPM.5, Box SPM.1)

B.6.4 Mitigation options often have synergies with other aspects of sustainable development, but some options can also have trade-offs. There are potential synergies between sustainable development and, for instance, energy efficiency and renewable energy. Similarly, depending on the context[48], biological CDR methods like reforestation, improved forest management, soil carbon sequestration, peatland restoration and coastal blue carbon management can enhance biodiversity and ecosystem functions, employment and local livelihoods. However, afforestation or production of biomass crops can have adverse socio-economic and environmental impacts, including on biodiversity, food and water security, local livelihoods and the rights of Indigenous Peoples, especially if implemented at large scales and where land tenure is insecure. Modelled pathways that assume using resources more efficiently or that shift global development towards sustainability include fewer challenges, such as less dependence on CDR and pressure on land and biodiversity. (*high confidence*) {3.4.1}

[START FIGURE SPM.5 HERE]

[47] CCS is an option to reduce emissions from large-scale fossil-based energy and industry sources provided geological storage is available. When CO_2 is captured directly from the atmosphere (DACCS), or from biomass (BECCS), CCS provides the storage component of these CDR methods. CO_2 capture and subsurface injection is a mature technology for gas processing and enhanced oil recovery. In contrast to the oil and gas sector, CCS is less mature in the power sector, as well as in cement and chemicals production, where it is a critical mitigation option. The technical geological storage capacity is estimated to be on the order of 1000 $GtCO_2$, which is more than the CO_2 storage requirements through 2100 to limit global warming to 1.5°C, although the regional availability of geological storage could be a limiting factor. If the geological storage site is appropriately selected and managed, it is estimated that the CO_2 can be permanently isolated from the atmosphere. Implementation of CCS currently faces technological, economic, institutional, ecological-environmental and socio-cultural barriers. Currently, global rates of CCS deployment are far below those in modelled pathways limiting global warming to 1.5°C to 2°C. Enabling conditions such as policy instruments, greater public support and technological innovation could reduce these barriers. (*high confidence*) {3.3.3}

[48] The impacts, risks, and co-benefits of CDR deployment for ecosystems, biodiversity and people will be highly variable depending on the method, site-specific context, implementation and scale (*high confidence*).

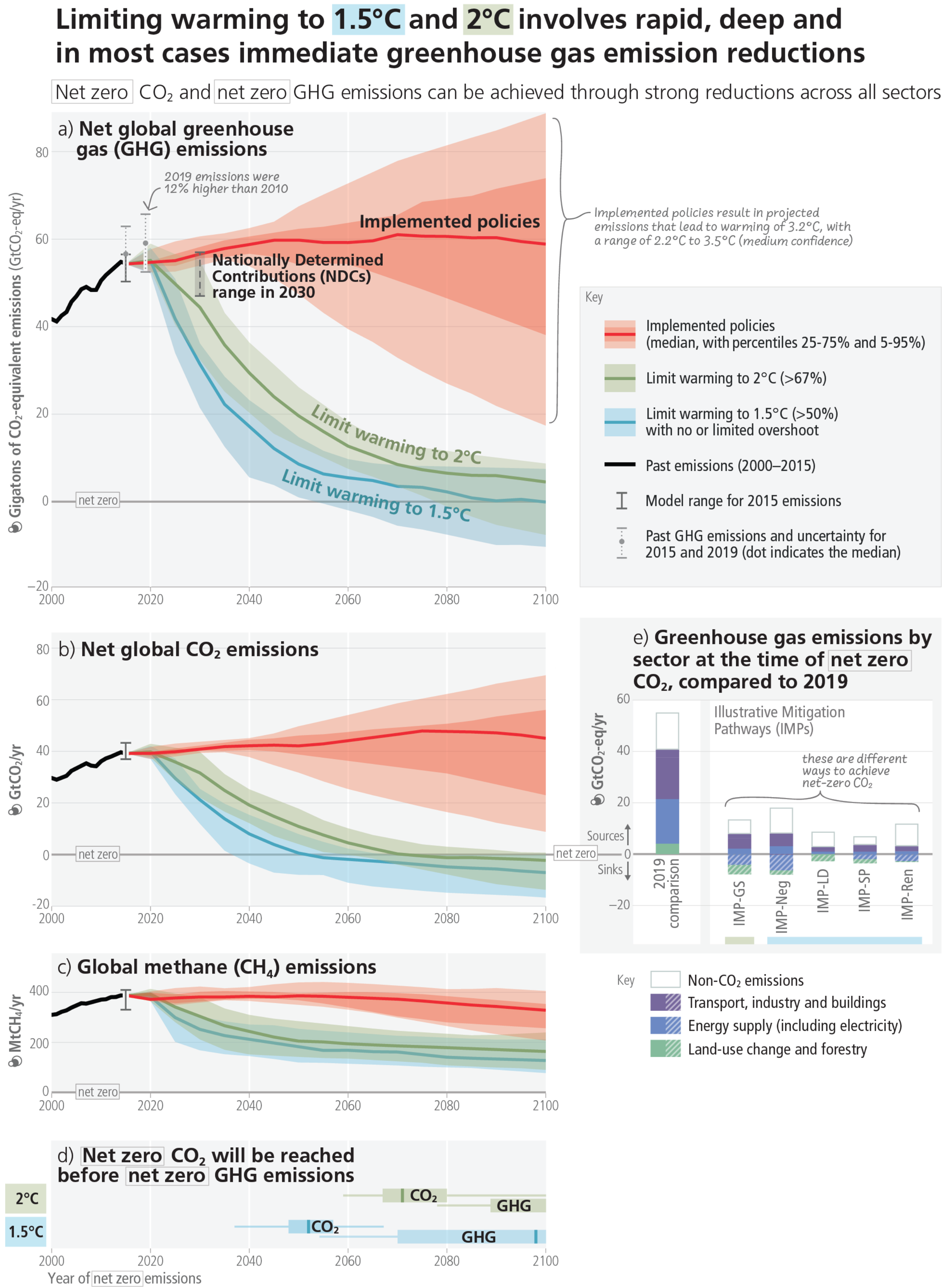

Figure SPM.5: Global emissions pathways consistent with implemented policies and mitigation strategies. Panel (a), (b) and **(c)** show the development of global GHG, CO_2 and methane emissions in modelled pathways, while **panel (d)** shows the associated timing of when GHG and CO_2 emissions reach net zero. Coloured ranges denote the 5th to 95th percentile across the global modelled pathways falling within a given category as described in Box SPM.1. The red ranges depict emissions pathways assuming policies that were implemented by the end of 2020. Ranges of modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot are shown in light blue (category C1) and pathways that limit warming to 2°C (>67%) are shown in green (category C3). Global emission pathways that would limit warming to 1.5°C (>50%) with no or limited overshoot and also reach net zero GHG in the second half of the century do so between 2070-2075. **Panel (e)** shows the sectoral contributions of CO_2 and non-CO_2 emissions sources and sinks at the time when net zero CO_2 emissions are reached in illustrative mitigation pathways (IMPs) consistent with limiting warming to 1.5°C with a high reliance on net negative emissions (IMP-Neg) ("high overshoot"), high resource efficiency (IMP-LD), a focus on sustainable development (IMP-SP), renewables (IMP-Ren) and limiting warming to 2°C with less rapid mitigation initially followed by a gradual strengthening (IMP-GS). Positive and negative emissions for different IMPs are compared to GHG emissions from the year 2019. Energy supply (including electricity) includes bioenergy with carbon dioxide capture and storage and direct air carbon dioxide capture and storage. CO_2 emissions from land-use change and forestry can only be shown as a net number as many models do not report emissions and sinks of this category separately. {Figure 3.6, 4.1} (Box SPM.1)

[END FIGURE SPM.5 HERE]

Overshoot: Exceeding a Warming Level and Returning

B.7 If warming exceeds a specified level such as 1.5°C, it could gradually be reduced again by achieving and sustaining net negative global CO_2 emissions. This would require additional deployment of carbon dioxide removal, compared to pathways without overshoot, leading to greater feasibility and sustainability concerns. Overshoot entails adverse impacts, some irreversible, and additional risks for human and natural systems, all growing with the magnitude and duration of overshoot. (*high confidence*) {3.1, 3.3, 3.4, Table 3.1, Figure 3.6}

B.7.1 Only a small number of the most ambitious global modelled pathways limit global warming to 1.5°C (>50%) by 2100 without exceeding this level temporarily. Achieving and sustaining net negative global CO_2 emissions, with annual rates of CDR greater than residual CO_2 emissions, would gradually reduce the warming level again (*high confidence*). Adverse impacts that occur during this period of overshoot and cause additional warming via feedback mechanisms, such as increased wildfires, mass mortality of trees, drying of peatlands, and permafrost thawing, weakening natural land carbon sinks and increasing releases of GHGs would make the return more challenging (*medium confidence*). {3.3.2, 3.3.4, Table 3.1, Figure 3.6} (Box SPM.1)

B.7.2 The higher the magnitude and the longer the duration of overshoot, the more ecosystems and societies are exposed to greater and more widespread changes in climatic impact-drivers, increasing risks for many natural and human systems. Compared to pathways without overshoot, societies would face higher risks to infrastructure, low-lying coastal settlements, and associated livelihoods. Overshooting 1.5°C will result in irreversible adverse impacts on certain ecosystems with low resilience, such as polar, mountain, and coastal ecosystems, impacted by ice-sheet, glacier melt, or by accelerating and higher committed sea level rise. (*high confidence*) {3.1.2, 3.3.4}

B.7.3 The larger the overshoot, the more net negative CO_2 emissions would be needed to return to 1.5°C by 2100. Transitioning towards net zero CO_2 emissions faster and reducing non-CO_2 emissions such as methane more rapidly would limit peak warming levels and reduce the requirement for net negative CO_2 emissions, thereby reducing feasibility and sustainability concerns, and social and environmental risks associated with CDR deployment at large scales. (*high confidence*) {3.3.3, 3.3.4, 3.4.1, Table 3.1}

C. Responses in the Near Term

Urgency of Near-Term Integrated Climate Action

C.1 Climate change is a threat to human well-being and planetary health (*very high confidence*). There is a rapidly closing window of opportunity to secure a liveable and sustainable future for all (*very high confidence*). Climate resilient development integrates adaptation and mitigation to advance sustainable development for all, and is enabled by increased international cooperation including improved access to adequate financial resources, particularly for vulnerable regions, sectors and groups, and inclusive governance and coordinated policies (*high confidence*). The choices and actions implemented in this decade will have impacts now and for thousands of years (*high confidence*). {3.1, 3.3, 4.1, 4.2, 4.3, 4.4, 4.7, 4.8, 4.9, Figure 3.1, Figure 3.3, Figure 4.2} (Figure SPM.1; Figure SPM.6)

C.1.1 Evidence of observed adverse impacts and related losses and damages, projected risks, levels and trends in vulnerability and adaptation limits, demonstrate that worldwide climate resilient development action is more urgent than previously assessed in AR5. Climate resilient development integrates adaptation and GHG mitigation to advance sustainable development for all. Climate resilient development pathways have been constrained by past development, emissions and climate change and are progressively constrained by every increment of warming, in particular beyond 1.5°C. (*very high confidence*) {3.4; 3.4.2; 4.1}

C.1.2 Government actions at sub-national, national and international levels, with civil society and the private sector, play a crucial role in enabling and accelerating shifts in development pathways towards sustainability and climate resilient development (*very high confidence*). Climate resilient development is enabled when governments, civil society and the private sector make inclusive development choices that prioritize risk reduction, equity and justice, and when decision-making processes, finance and actions are integrated across governance levels, sectors, and timeframes (*very high confidence*). Enabling conditions are differentiated by national, regional and local circumstances and geographies, according to capabilities, and include: political commitment and follow-through, coordinated policies, social and international cooperation, ecosystem stewardship, inclusive governance, knowledge diversity, technological innovation, monitoring and evaluation, and improved access to adequate financial resources, especially for vulnerable regions, sectors and communities (*high confidence*). {3.4; 4.2, 4.4, 4.5, 4.7, 4.8} (Figure SPM.6)

C.1.3 Continued emissions will further affect all major climate system components, and many changes will be irreversible on centennial to millennial time scales and become larger with increasing global warming. Without urgent, effective, and equitable mitigation and adaptation actions, climate change increasingly threatens ecosystems, biodiversity, and the livelihoods, health and wellbeing of current and future generations. (*high confidence*) {3.1.3; 3.3.3; 3.4.1, Figure 3.4; 4.1, 4.2, 4.3, 4.4} (Figure SPM.1, Figure SPM.6).

[START FIGURE SPM.6 HERE]

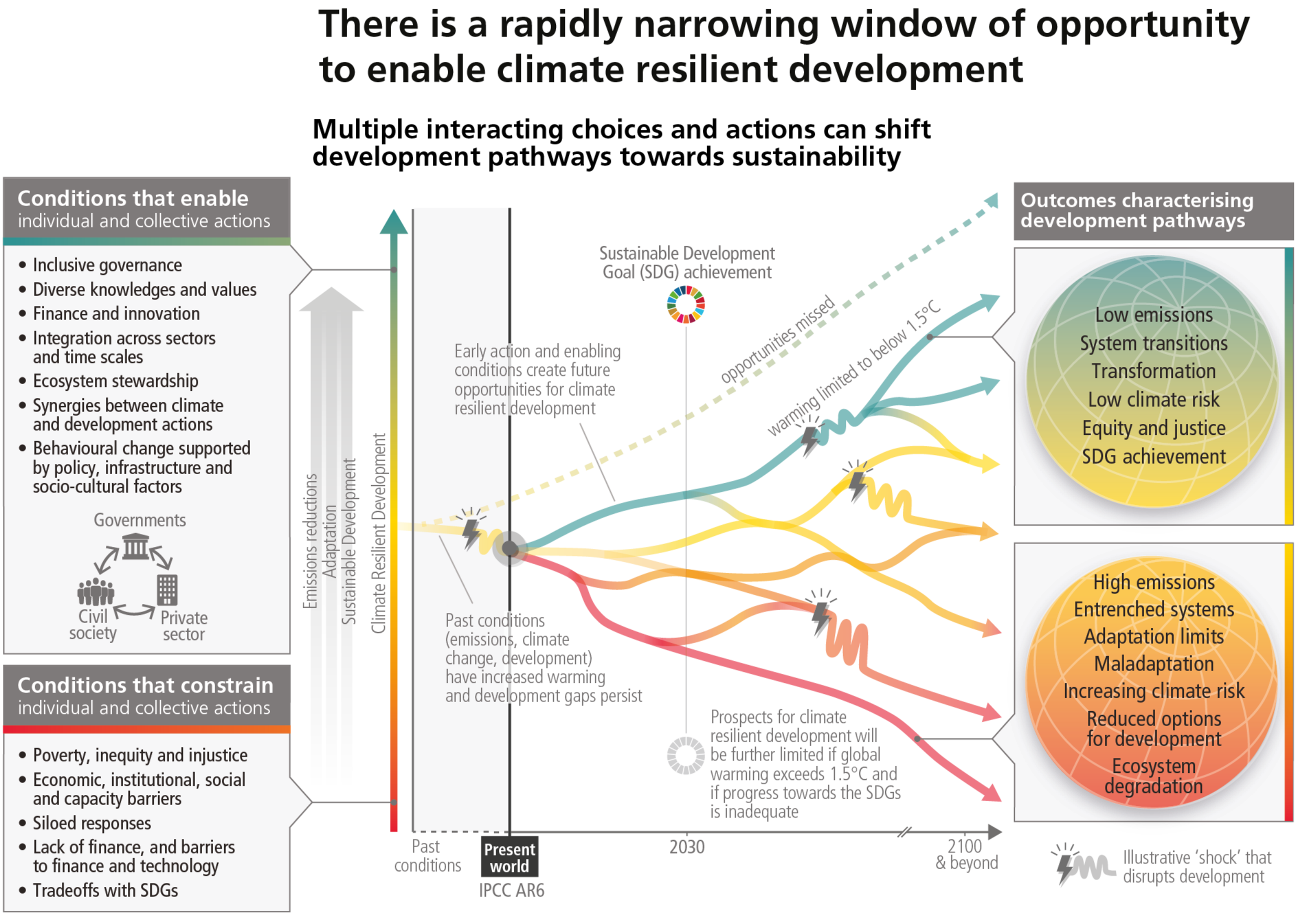

Figure SPM.6: The illustrative development pathways (red to green) and associated outcomes (right panel) show that there is a rapidly narrowing window of opportunity to secure a liveable and sustainable future for all. Climate resilient development is the process of implementing greenhouse gas mitigation and adaptation measures to support sustainable development. Diverging pathways illustrate that interacting choices and actions made by diverse government, private sector and civil society actors can advance climate resilient development, shift pathways towards sustainability, and enable lower emissions and adaptation. Diverse knowledge and values include cultural values, Indigenous Knowledge, local knowledge, and scientific knowledge. Climatic and non-climatic events, such as droughts, floods or pandemics, pose more severe shocks to pathways with lower climate resilient development (red to yellow) than to pathways with higher climate resilient development (green). There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5°C, and with every increment of warming, losses and damages will increase. The development pathways taken by countries at all stages of economic development impact GHG emissions and mitigation challenges and opportunities, which vary across countries and regions. Pathways and opportunities for action are shaped by previous actions (or inactions and opportunities missed; dashed pathway) and enabling and constraining conditions (left panel), and take place in the context of climate risks, adaptation limits and development gaps. The longer emissions reductions are delayed, the fewer effective adaptation options. {Figure 4.2; 3.1; 3.2; 3.4; 4.2; 4.4; 4.5; 4.6; 4.9}

[END FIGURE SPM.6 HERE]

The Benefits of Near-Term Action

C.2 Deep, rapid and sustained mitigation and accelerated implementation of adaptation actions in this decade would reduce projected losses and damages for humans and ecosystems (*very high confidence*), and deliver many co-benefits, especially for air quality and health (*high confidence*). Delayed mitigation and adaptation action would lock-in high-emissions infrastructure, raise risks of stranded assets and cost-escalation, reduce feasibility, and increase losses and damages (*high confidence*). Near-term actions involve high up-front investments and potentially disruptive changes that can be lessened by a range of enabling policies (*high confidence*). {2.1, 2.2, 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8}

C.2.1 Deep, rapid, and sustained mitigation and accelerated implementation of adaptation actions in this decade would reduce future losses and damages related to climate change for humans and ecosystems (*very high confidence*). As adaptation options often have long implementation times, accelerated implementation of adaptation in this decade is important to close adaptation gaps (*high confidence*). Comprehensive, effective, and innovative responses integrating adaptation and mitigation can harness synergies and reduce trade-offs between adaptation and mitigation (*high confidence*). {4.1, 4.2, 4.3}.

C.2.2 Delayed mitigation action will further increase global warming and losses and damages will rise and additional human and natural systems will reach adaptation limits (*high confidence*). Challenges from delayed adaptation and mitigation actions include the risk of cost escalation, lock-in of infrastructure, stranded assets, and reduced feasibility and effectiveness of adaptation and mitigation options (*high confidence*). Without rapid, deep and sustained mitigation and accelerated adaptation actions, losses and damages will continue to increase, including projected adverse impacts in Africa, LDCs, SIDS, Central and South America[49], Asia and the Arctic, and will disproportionately affect the most vulnerable populations (*high confidence*). {2.1.2; 3.1.2, 3.2, 3.3.1, 3.3.3; 4.1, 4.2, 4.3} (Figure SPM.3, Figure SPM.4)

C.2.3 Accelerated climate action can also provide co-benefits (see also C.4). Many mitigation actions would have benefits for health through lower air pollution, active mobility (e.g., walking, cycling), and shifts to sustainable healthy diets. Strong, rapid and sustained reductions in methane emissions can limit near-term warming and improve air quality by reducing global surface ozone. (*high confidence*) Adaptation can generate multiple additional benefits such as improving agricultural productivity, innovation, health and wellbeing, food security, livelihood, and biodiversity conservation (*very high confidence*). {4.2, 4.5.4, 4.5.5, 4.6}

C.2.4 Cost-benefit analysis remains limited in its ability to represent all avoided damages from climate change (*high confidence*). The economic benefits for human health from air quality improvement arising from mitigation action can be of the same order of magnitude as mitigation costs, and potentially even larger (*medium confidence*). Even without accounting for all the benefits of avoiding potential damages the global economic and social benefit of limiting global warming to 2°C exceeds the cost of mitigation in most of the assessed literature (*medium confidence*).[50] More rapid climate change mitigation, with emissions peaking earlier, increases co-benefits and reduces feasibility risks and costs in the long-term, but requires higher up-front investments (*high confidence*). {3.4.1, 4.2}

C.2.5 Ambitious mitigation pathways imply large and sometimes disruptive changes in existing economic structures, with significant distributional consequences within and between countries. To accelerate climate action, the adverse consequences of these changes can be moderated by fiscal, financial, institutional and regulatory reforms and by integrating climate actions with macroeconomic policies through (i) economy-wide packages, consistent with national circumstances, supporting sustainable low-emission growth paths; (ii) climate resilient safety nets and social protection; and (iii) improved access to finance for low-emissions infrastructure and technologies, especially in developing countries. (*high confidence*) {4.2, 4.4, 4.7, 4.8.1}

[49] The southern part of Mexico is included in the climactic subregion South Central America (SCA) for WGI. Mexico is assessed as part of North America for WGII. The climate change literature for the SCA region occasionally includes Mexico, and in those cases WGII assessment makes reference to Latin America. Mexico is considered part of Latin America and the Caribbean for WGIII.

[50] The evidence is too limited to make a similar robust conclusion for limiting warming to 1.5°C. Limiting global warming to 1.5°C instead of 2°C would increase the costs of mitigation, but also increase the benefits in terms of reduced impacts and related risks, and reduced adaptation needs (*high confidence*).

[START FIGURE SPM.7 HERE]

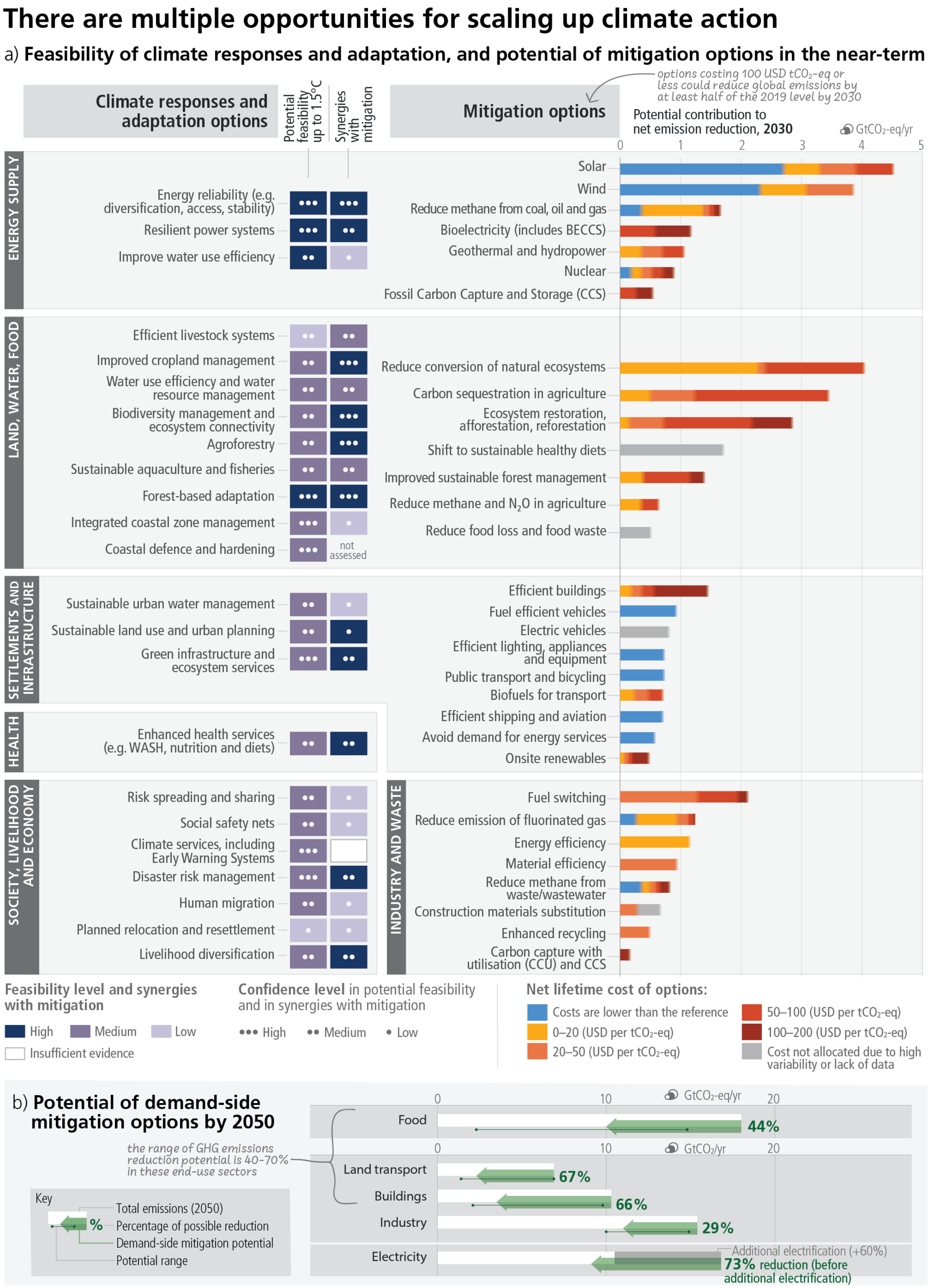

Figure SPM.7: Multiple Opportunities for scaling up climate action. **Panel (a)** presents selected mitigation and adaptation options across different systems. The left hand side of panel a shows climate responses and adaptation options assessed for their multidimensional feasibility at global scale, in the near term and up to 1.5°C global warming. As literature above 1.5°C is limited, feasibility at higher levels of warming may change, which is currently not possible to assess robustly. The term response is used here in addition to adaptation because some responses, such as migration, relocation and resettlement may or may not be considered to be adaptation. Forest based adaptation includes sustainable forest management, forest conservation and restoration, reforestation and afforestation. WASH refers to water, sanitation and hygiene. Six feasibility dimensions (economic, technological, institutional, social, environmental and geophysical) were used to calculate the potential feasibility of climate responses and adaptation options, along with their synergies with mitigation. For potential feasibility and feasibility dimensions, the figure shows high, medium, or low feasibility. Synergies with mitigation are identified as high, medium, and low.

The right hand side of Panel a provides an overview of selected mitigation options and their estimated costs and potentials in 2030. Costs are net lifetime discounted monetary costs of avoided GHG emissions calculated relative to a reference technology. Relative potentials and costs will vary by place, context and time and in the longer term compared to 2030. The potential (horizontal axis) is the net GHG emission reduction (sum of reduced emissions and/or enhanced sinks) broken down into cost categories (coloured bar segments) relative to an emission baseline consisting of current policy (around 2019) reference scenarios from the AR6 scenarios database. The potentials are assessed independently for each option and are not additive. Health system mitigation options are included mostly in settlement and infrastructure (e.g., efficient healthcare buildings) and cannot be identified separately. Fuel switching in industry refers to switching to electricity, hydrogen, bioenergy and natural gas. Gradual colour transitions indicate uncertain breakdown into cost categories due to uncertainty or heavy context dependency. The uncertainty in the total potential is typically 25–50%.

Panel (b) displays the indicative potential of demand-side mitigation options for 2050. Potentials are estimated based on approximately 500 bottom-up studies representing all global regions. The baseline (white bar) is provided by the sectoral mean GHG emissions in 2050 of the two scenarios (IEA-STEPS and IP_ModAct) consistent with policies announced by national governments until 2020. The green arrow represents the demand-side emissions reductions potentials. The range in potential is shown by a line connecting dots displaying the highest and the lowest potentials reported in the literature. Food shows demand-side potential of socio-cultural factors and infrastructure use, and changes in land-use patterns enabled by change in food demand. Demand-side measures and new ways of end-use service provision can reduce global GHG emissions in end-use sectors (buildings, land transport, food) by 40–70% by 2050 compared to baseline scenarios, while some regions and socioeconomic groups require additional energy and resources. The last row shows how demand-side mitigation options in other sectors can influence overall electricity demand. The dark grey bar shows the projected increase in electricity demand above the 2050 baseline due to increasing electrification in the other sectors. Based on a bottom-up assessment, this projected increase in electricity demand can be avoided through demand-side mitigation options in the domains of infrastructure use and socio-cultural factors that influence electricity usage in industry, land transport, and buildings (green arrow). {Figure 4.4}

[END FIGURE SPM.7 HERE]

Mitigation and Adaptation Options across Systems

C.3 Rapid and far-reaching transitions across all sectors and systems are necessary to achieve deep and sustained emissions reductions and secure a liveable and sustainable future for all. These system transitions involve a significant upscaling of a wide portfolio of mitigation and adaptation options. Feasible, effective, and low-cost options for mitigation and adaptation are already available, with differences across systems and regions. (*high confidence*) {4.1, 4.5, 4.6} (Figure SPM.7)

C.3.1 The systemic change required to achieve rapid and deep emissions reductions and transformative adaptation to climate change is unprecedented in terms of scale, but not necessarily in terms of speed (*medium confidence*). Systems transitions include: deployment of low- or zero-emission technologies; reducing and changing demand through infrastructure design and access, socio-cultural and behavioural changes, and increased technological efficiency and adoption; social protection, climate services or other services; and protecting and restoring ecosystems (*high confidence*). Feasible, effective, and low-cost options for mitigation and adaptation are already available (*high confidence*). The availability, feasibility and potential of mitigation and adaptation options in the near-term differs across systems and regions (*very high confidence*). {4.1, 4.5.1–4.5.6}(Figure SPM.7)

Energy Systems

C.3.2 Net zero CO_2 energy systems entail: a substantial reduction in overall fossil fuel use, minimal use of unabated fossil fuels[51], and use of carbon capture and storage in the remaining fossil fuel systems; electricity systems that emit no net CO_2; widespread electrification; alternative energy carriers in applications less amenable to electrification; energy conservation and efficiency; and greater integration across the energy system (*high confidence*). Large contributions to emissions reductions with costs less than USD 20 tCO_2-eq^{-1} come from solar and wind energy, energy efficiency improvements, and methane emissions reductions (coal mining, oil and gas, waste) (*medium confidence*). There are feasible adaptation options that support infrastructure resilience, reliable power systems and efficient water use for existing and new energy generation systems (*very high confidence*). Energy generation diversification (e.g., via wind, solar, small scale hydropower) and demand side management (e.g., storage and energy efficiency improvements) can increase energy reliability and reduce vulnerabilities to climate change (*high confidence*). Climate responsive energy markets, updated design standards on energy assets according to current and projected climate change, smart-grid technologies, robust transmission systems and improved capacity to respond to supply deficits have high feasibility in the medium- to long-term, with mitigation co-benefits (*very high confidence*). {4.5.1} (Figure SPM.7)

Industry and Transport

C.3.3 Reducing industry GHG emissions entails coordinated action throughout value chains to promote all mitigation options, including demand management, energy and materials efficiency, circular material flows, as well as abatement technologies and transformational changes in production processes (*high confidence*). In transport, sustainable biofuels, low-emissions hydrogen, and derivatives (including ammonia and synthetic fuels) can support mitigation of CO_2 emissions from shipping, aviation, and heavy-duty land transport but require production process improvements and cost reductions (*medium confidence*). Sustainable biofuels can offer additional mitigation benefits in land-based transport in the short and medium term (*medium confidence*). Electric vehicles powered by low-GHG emissions electricity have large potential to reduce land-based transport GHG emissions, on a life cycle basis (*high confidence*). Advances in battery technologies could facilitate the electrification of heavy-duty trucks and compliment conventional electric rail systems (*medium confidence*). The environmental footprint of battery production and growing concerns about critical minerals can be addressed by material and supply diversification strategies, energy and material efficiency improvements, and circular material flows (*medium confidence*). 4.5.2, 4.5.3} (Figure SPM.7)

[51] In this context, 'unabated fossil fuels' refers to fossil fuels produced and used without interventions that substantially reduce the amount of GHG emitted throughout the life cycle; for example, capturing 90% or more CO2 from power plants, or 50–80% of fugitive methane emissions from energy supply.

Cities, Settlements and Infrastructure

C.3.4 Urban systems are critical for achieving deep emissions reductions and advancing climate resilient development (*high confidence*). Key adaptation and mitigation elements in cities include considering climate change impacts and risks (e.g. through climate services) in the design and planning of settlements and infrastructure; land use planning to achieve compact urban form, co-location of jobs and housing; supporting public transport and active mobility (e.g., walking and cycling); the efficient design, construction, retrofit, and use of buildings; reducing and changing energy and material consumption; sufficiency[52]; material substitution; and electrification in combination with low emissions sources (*high confidence*). Urban transitions that offer benefits for mitigation, adaptation, human health and well-being, ecosystem services, and vulnerability reduction for low-income communities are fostered by inclusive long-term planning that takes an integrated approach to physical, natural and social infrastructure (*high confidence*). Green/natural and blue infrastructure supports carbon uptake and storage and either singly or when combined with grey infrastructure can reduce energy use and risk from extreme events such as heatwaves, flooding, heavy precipitation and droughts, while generating co-benefits for health, well-being and livelihoods (*medium confidence*). {4.5.3}

Land, Ocean, Food, and Water

C.3.5 Many agriculture, forestry, and other land use (AFOLU) options provide adaptation and mitigation benefits that could be upscaled in the near-term across most regions. Conservation, improved management, and restoration of forests and other ecosystems offer the largest share of economic mitigation potential, with reduced deforestation in tropical regions having the highest total mitigation potential. Ecosystem restoration, reforestation, and afforestation can lead to trade-offs due to competing demands on land. Minimizing trade-offs requires integrated approaches to meet multiple objectives including food security. Demand-side measures (shifting to sustainable healthy diets[53] and reducing food loss/waste) and sustainable agricultural intensification can reduce ecosystem conversion, and methane and nitrous oxide emissions, and free up land for reforestation and ecosystem restoration. Sustainably sourced agricultural and forest products, including long-lived wood products, can be used instead of more GHG-intensive products in other sectors. Effective adaptation options include cultivar improvements, agroforestry, community-based adaptation, farm and landscape diversification, and urban agriculture. These AFOLU response options require integration of biophysical, socioeconomic and other enabling factors. Some options, such as conservation of high-carbon ecosystems (e.g., peatlands, wetlands, rangelands, mangroves and forests), deliver immediate benefits, while others, such as restoration of high-carbon ecosystems, take decades to deliver measurable results. {4.5.4} (Figure SPM.7)

C.3.6 Maintaining the resilience of biodiversity and ecosystem services at a global scale depends on effective and equitable conservation of approximately 30% to 50% of Earth's land, freshwater and ocean areas, including currently near-natural ecosystems (*high confidence*). Conservation, protection and restoration of terrestrial, freshwater, coastal and ocean ecosystems, together with targeted management to adapt to unavoidable impacts of climate change reduces the vulnerability of biodiversity and ecosystem services to climate change (*high confidence*), reduces coastal erosion and flooding (*high confidence*), and could increase carbon uptake and storage if global warming is limited (*medium confidence*). Rebuilding overexploited or depleted fisheries reduces negative climate change impacts on fisheries (*medium confidence*) and supports food security, biodiversity, human health and well-being (*high confidence*). Land restoration contributes to climate change mitigation and adaptation with synergies via enhanced ecosystem services and with economically positive returns and co-benefits for poverty reduction and improved livelihoods (*high confidence*). Cooperation, and inclusive decision making, with Indigenous Peoples and local communities, as well as recognition of inherent rights of Indigenous Peoples, is integral to successful adaptation and mitigation across forests and other ecosystems (*high confidence*). {4.5.4, 4.6} (Figure SPM.7)

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[52] A set of measures and daily practices that avoid demand for energy, materials, land, and water while delivering human well-being for all within planetary boundaries {4.5.3}

[53] 'Sustainable healthy diets' promote all dimensions of individuals' health and well-being; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable, as described in FAO and WHO. The related concept of 'balanced diets' refers to diets that feature plant-based foods, such as those based on coarse grains, legumes, fruits and vegetables, nuts and seeds, and animal-sourced food produced in resilient, sustainable and low-GHG emission systems, as described in SRCCL.

Health and Nutrition

C.3.7 Human health will benefit from integrated mitigation and adaptation options that mainstream health into food, infrastructure, social protection, and water policies (*very high confidence*). Effective adaptation options exist to help protect human health and wellbeing, including: strengthening public health programs related to climate-sensitive diseases, increasing health systems resilience, improving ecosystem health, improving access to potable water, reducing exposure of water and sanitation systems to flooding, improving surveillance and early warning systems, vaccine development (*very high confidence*), improving access to mental healthcare, and Heat Health Action Plans that include early warning and response systems (*high confidence*). Adaptation strategies which reduce food loss and waste or support balanced, sustainable healthy diets contribute to nutrition, health, biodiversity and other environmental benefits (*high confidence*). {4.5.5} (Figure SPM.7)

Society, Livelihoods, and Economies

C.3.8 Policy mixes that include weather and health insurance, social protection and adaptive social safety nets, contingent finance and reserve funds, and universal access to early warning systems combined with effective contingency plans, can reduce vulnerability and exposure of human systems. Disaster risk management, early warning systems, climate services and risk spreading and sharing approaches have broad applicability across sectors. Increasing education including capacity building, climate literacy, and information provided through climate services and community approaches can facilitate heightened risk perception and accelerate behavioural changes and planning. (*high confidence*) {4.5.6}

Synergies and Trade-Offs with Sustainable Development

C.4 Accelerated and equitable action in mitigating and adapting to climate change impacts is critical to sustainable development. Mitigation and adaptation actions have more synergies than trade-offs with Sustainable Development Goals. Synergies and trade-offs depend on context and scale of implementation. (*high confidence*) {3.4, 4.2, 4.4, 4.5, 4.6, 4.9, Figure 4.5}

C.4.1 Mitigation efforts embedded within the wider development context can increase the pace, depth and breadth of emission reductions (*medium confidence*). Countries at all stages of economic development seek to improve the well-being of people, and their development priorities reflect different starting points and contexts. Different contexts include but are not limited to social, economic, environmental, cultural, political circumstances, resource endowment, capabilities, international environment, and prior development (*high confidence*). In regions with high dependency on fossil fuels for, among other things, revenue and employment generation, mitigating risk for sustainable development requires policies that promote economic and energy sector diversification and considerations of just transitions principles, processes and practices (*high confidence*). Eradicating extreme poverty, energy poverty, and providing decent living standards in low-emitting countries / regions in the context of achieving sustainable development objectives, in the near term, can be achieved without significant global emissions growth (*high confidence*). {4.4, 4.6, Annex I: Glossary}

C.4.2 Many mitigation and adaptation actions have multiple synergies with Sustainable Development Goals (SDGs) and sustainable development generally, but some actions can also have trade-offs. Potential synergies with SDGs exceed potential trade-offs; synergies and trade-offs depend on the pace and magnitude of change and the development context including inequalities with consideration of climate justice. Trade-offs can be evaluated and minimised by giving emphasis to capacity building, finance, governance, technology transfer, investments, development, context specific gender-based and other social equity considerations with meaningful participation of Indigenous Peoples, local communities and vulnerable populations. (*high confidence*) {3.4.1, 4.6, Figure 4.5, 4.9}

C.4.3 Implementing both mitigation and adaptation actions together and taking trade-offs into account supports co-benefits and synergies for human health and well-being. For example, improved access to clean energy sources and technologies generate health benefits especially for women and children; electrification combined with low-GHG energy, and shifts to active mobility and public transport can enhance air quality, health, employment, and can elicit energy security and deliver equity. (*high confidence*) {4.2, 4.5.3, 4.5.5, 4.6, 4.9}

Equity and Inclusion

C.5 Prioritising equity, climate justice, social justice, inclusion and just transition processes can enable adaptation and ambitious mitigation actions and climate resilient development. Adaptation outcomes are enhanced by increased support to regions and people with the highest vulnerability to climatic hazards. Integrating climate adaptation into social protection programs improves resilience. Many options are available for reducing emission-intensive consumption, including through behavioural and lifestyle changes, with co-benefits for societal well-being. (*high confidence*) {4.4, 4.5}

C.5.1 Equity remains a central element in the UN climate regime, notwithstanding shifts in differentiation between states over time and challenges in assessing fair shares. Ambitious mitigation pathways imply large and sometimes disruptive changes in economic structure, with significant distributional consequences, within and between countries. Distributional consequences within and between countries include shifting of income and employment during the transition from high- to low-emissions activities. (*high confidence*) {4.4}

C.5.2 Adaptation and mitigation actions, that prioritise equity, social justice, climate justice, rights-based approaches, and inclusivity, lead to more sustainable outcomes, reduce trade-offs, support transformative change and advance climate resilient development. Redistributive policies across sectors and regions that shield the poor and vulnerable, social safety nets, equity, inclusion and just transitions, at all scales can enable deeper societal ambitions and resolve trade-offs with sustainable development goals. Attention to equity and broad and meaningful participation of all relevant actors in decision making at all scales can build social trust which builds on equitable sharing of benefits and burdens of mitigation that deepen and widen support for transformative changes. (*high confidence*) {4.4}

C.5.3 Regions and people (3.3 to 3.6 billion in number) with considerable development constraints have high vulnerability to climatic hazards (see A.2.2). Adaptation outcomes for the most vulnerable within and across countries and regions are enhanced through approaches focusing on equity, inclusivity and rights-based approaches. Vulnerability is exacerbated by inequity and marginalisation linked to e.g., gender, ethnicity, low incomes, informal settlements, disability, age, and historical and ongoing patterns of inequity such as colonialism, especially for many Indigenous Peoples and local communities. Integrating climate adaptation into social protection programs, including cash transfers and public works programs, is highly feasible and increases resilience to climate change, especially when supported by basic services and infrastructure. The greatest gains in well-being in urban areas can be achieved by prioritising access to finance to reduce climate risk for low-income and marginalised communities including people living in informal settlements. (*high confidence*). {4.4, 4.5.3, 4.5.5, 4.5.6}

C.5.4 The design of regulatory instruments and economic instruments and consumption-based approaches, can advance equity. Individuals with high socio-economic status contribute disproportionately to emissions, and have the highest potential for emissions reductions. Many options are available for reducing emission-intensive consumption while improving societal well-being. Socio-cultural options, behaviour and lifestyle changes supported by policies, infrastructure, and technology can help end-users shift to low-emissions-intensive consumption, with multiple co-benefits. A substantial share of the population in low-emitting countries lack access to modern energy services. Technology development, transfer, capacity building and financing can support developing countries/ regions leapfrogging or transitioning to low-emissions transport systems thereby providing multiple co-benefits. Climate resilient development is advanced when actors work in equitable, just and inclusive ways to reconcile divergent interests, values and worldviews, toward equitable and just outcomes. (*high confidence*) {2.1, 4.4}

Governance and Policies

C.6 Effective climate action is enabled by political commitment, well-aligned multilevel governance, institutional frameworks, laws, policies and strategies and enhanced access to finance and technology. Clear goals, coordination across multiple policy domains, and inclusive governance processes facilitate effective climate action. Regulatory and economic instruments can support deep emissions reductions and climate resilience if scaled up and applied widely. Climate resilient development benefits from drawing on diverse knowledge. (*high confidence*) {2.2, 4.4, 4.5, 4.7}

C.6.1 Effective climate governance enables mitigation and adaptation. Effective governance provides overall direction on setting targets and priorities and mainstreaming climate action across policy domains and levels, based on national circumstances and in the context of international cooperation. It enhances monitoring and evaluation and regulatory certainty, prioritising inclusive, transparent and equitable decision-making, and improves access to finance and technology (see C.7). (*high confidence)* {2.2.2, 4.7}

C.6.2 Effective local, municipal, national and subnational institutions build consensus for climate action among diverse interests, enable coordination and inform strategy setting but require adequate institutional capacity. Policy support is influenced by actors in civil society, including businesses, youth, women, labour, media, Indigenous Peoples, and local communities. Effectiveness is enhanced by political commitment and partnerships between different groups in society. (*high confidence*) {2.2; 4.7}

C.6.3 Effective multilevel governance for mitigation, adaptation, risk management, and climate resilient development is enabled by inclusive decision processes that prioritise equity and justice in planning and implementation, allocation of appropriate resources, institutional review, and monitoring and evaluation. Vulnerabilities and climate risks are often reduced through carefully designed and implemented laws, policies, participatory processes, and interventions that address context specific inequities such as those based on gender, ethnicity, disability, age, location and income. (*high confidence*) {4.4, 4.7}

C.6.4 Regulatory and economic instruments could support deep emissions reductions if scaled up and applied more widely (*high confidence*). Scaling up and enhancing the use of regulatory instruments can improve mitigation outcomes in sectoral applications, consistent with national circumstances (*high confidence*). Where implemented, carbon pricing instruments have incentivized low-cost emissions reduction measures but have been less effective, on their own and at prevailing prices during the assessment period, to promote higher-cost measures necessary for further reductions (*medium confidence*). Equity and distributional impacts of such carbon pricing instruments, e.g., carbon taxes and emissions trading, can be addressed by using revenue to support low-income households, among other approaches. Removing fossil fuel subsidies would reduce emissions[54] and yield benefits such as improved public revenue, macroeconomic and sustainability performance; subsidy removal can have adverse distributional impacts, especially on the most economically vulnerable groups which, in some cases can be mitigated by measures such as redistributing revenue saved, all of which depend on national circumstances (*high confidence*). Economy-wide policy packages, such as public spending commitments, pricing reforms, can meet short-term economic goals while reducing emissions and shifting development pathways towards sustainability (*medium confidence*). Effective policy packages would be comprehensive, consistent, balanced across objectives, and tailored to national circumstances *(high confidence)*. {2.2.2, 4.7}

C.6.5 Drawing on diverse knowledges and cultural values, meaningful participation and inclusive engagement processes—including Indigenous Knowledge, local knowledge, and scientific knowledge—facilitates climate resilient development, builds capacity and allows locally appropriate and socially acceptable solutions. (*high confidence*) {4.4, 4.5.6, 4.7}

[54] Fossil fuel subsidy removal is projected by various studies to reduce global CO_2 emission by 1-4%, and GHG emissions by up to 10% by 2030, varying across regions (*medium confidence*).

Finance, Technology and International Cooperation

C.7 Finance, technology and international cooperation are critical enablers for accelerated climate action. If climate goals are to be achieved, both adaptation and mitigation financing would need to increase many-fold. There is sufficient global capital to close the global investment gaps but there are barriers to redirect capital to climate action. Enhancing technology innovation systems is key to accelerate the widespread adoption of technologies and practices. Enhancing international cooperation is possible through multiple channels. *(high confidence)* {2.3, 4.8}

C.7.1 Improved availability of and access to finance[55] would enable accelerated climate action (*very high confidence*). Addressing needs and gaps and broadening equitable access to domestic and international finance, when combined with other supportive actions, can act as a catalyst for accelerating adaptation and mitigation, and enabling climate resilient development *(high confidence)*. If climate goals are to be achieved, and to address rising risks and accelerate investments in emissions reductions, both adaptation and mitigation finance would need to increase many-fold (*high confidence)*. {4.8.1}

C.7.2 Increased access to finance can build capacity and address soft limits to adaptation and avert rising risks, especially for developing countries, vulnerable groups, regions and sectors (*high confidence*). Public finance is an important enabler of adaptation and mitigation, and can also leverage private finance *(high confidence)*. Average annual modelled mitigation investment requirements for 2020 to 2030 in scenarios that limit warming to 2°C or 1.5°C are a factor of three to six greater than current levels[56], and total mitigation investments (public, private, domestic and international) would need to increase across all sectors and regions (*medium confidence*). Even if extensive global mitigation efforts are implemented, there will be a need for financial, technical, and human resources for adaptation *(high confidence*). {4.3, 4.8.1}

C.7.3 There is sufficient global capital and liquidity to close global investment gaps, given the size of the global financial system, but there are barriers to redirect capital to climate action both within and outside the global financial sector and in the context of economic vulnerabilities and indebtedness facing developing countries. Reducing financing barriers for scaling up financial flows would require clear signalling and support by governments, including a stronger alignment of public finances in order to lower real and perceived regulatory, cost and market barriers and risks and improving the risk-return profile of investments. At the same time, depending on national contexts, financial actors, including investors, financial intermediaries, central banks and financial regulators can shift the systemic underpricing of climate-related risks, and reduce sectoral and regional mismatches between available capital and investment needs. (*high confidence*) {4.8.1}

C.7.4 Tracked financial flows fall short of the levels needed for adaptation and to achieve mitigation goals across all sectors and regions. These gaps create many opportunities and the challenge of closing gaps is largest in developing countries. Accelerated financial support for developing countries from developed countries and other sources is a critical enabler to enhance adaptation and mitigation actions and address inequities in access to finance, including its costs, terms and conditions, and economic vulnerability to climate change for developing countries. Scaled-up public grants for mitigation and adaptation funding for vulnerable regions, especially in Sub-Saharan Africa, would be cost-effective and have high social returns in terms of access to basic energy. Options for scaling up mitigation in developing countries include: increased levels of public finance and publicly mobilised private finance flows from developed to developing countries in the context of the USD 100 billion-a-year goal; increased use of public guarantees to reduce risks and leverage private flows at lower cost; local capital markets development; and building greater trust in international cooperation processes. A coordinated effort to make the post-pandemic recovery sustainable over the longer-term can accelerate climate action, including in developing regions and countries facing high debt costs, debt distress and macroeconomic uncertainty. (*high confidence*) {4.8.1}

[55] Finance originates from diverse sources: public or private, local, national or international, bilateral or multilateral, and alternative sources. It can take the form of grants, technical assistance, loans (concessional and non-concessional), bonds, equity, risk insurance and financial guarantees (of different types).
[56] These estimates rely on scenario assumptions.

C.7.5 Enhancing technology innovation systems can provide opportunities to lower emissions growth, create social and environmental co-benefits, and achieve other SDGs. Policy packages tailored to national contexts and technological characteristics have been effective in supporting low-emission innovation and technology diffusion. Public policies can support training and R&D, complemented by both regulatory and market-based instruments that create incentives and market opportunities. Technological innovation can have trade-offs such as new and greater environmental impacts, social inequalities, overdependence on foreign knowledge and providers, distributional impacts and rebound effects[57], requiring appropriate governance and policies to enhance potential and reduce trade-offs. Innovation and adoption of low-emission technologies lags in most developing countries, particularly least developed ones, due in part to weaker enabling conditions, including limited finance, technology development and transfer, and capacity building. (*high confidence*) {4.8.3}

C.7.6 International cooperation is a critical enabler for achieving ambitious climate change mitigation, adaptation, and climate resilient development (*high confidence*). Climate resilient development is enabled by increased international cooperation including mobilising and enhancing access to finance, particularly for developing countries, vulnerable regions, sectors and groups and aligning finance flows for climate action to be consistent with ambition levels and funding needs (*high confidence*). Enhancing international cooperation on finance, technology and capacity building can enable greater ambition and can act as a catalyst for accelerating mitigation and adaptation, and shifting development pathways towards sustainability (*high confidence*). This includes support to NDCs and accelerating technology development and deployment (*high confidence*). Transnational partnerships can stimulate policy development, technology diffusion, adaptation and mitigation, though uncertainties remain over their costs, feasibility and effectiveness (*medium confidence*). International environmental and sectoral agreements, institutions and initiatives are helping, and in some cases may help, to stimulate low GHG emissions investments and reduce emissions (*medium confidence*). {2.2.2, 4.8.2}

[57] Leading to lower net emission reductions or even emission increases.