Review of 1.5˚C and Other Newer Global Emissions Scenarios:

Insights for Company and Financial Climate Low-Carbon Transition Risk Assessment and Greenhouse Gas Goal Setting

Steven Rose (Energy Systems and Climate Analysis)
Morgan M. Scott (Sustainability and Ecosystem Stewardship)

Public Webcast
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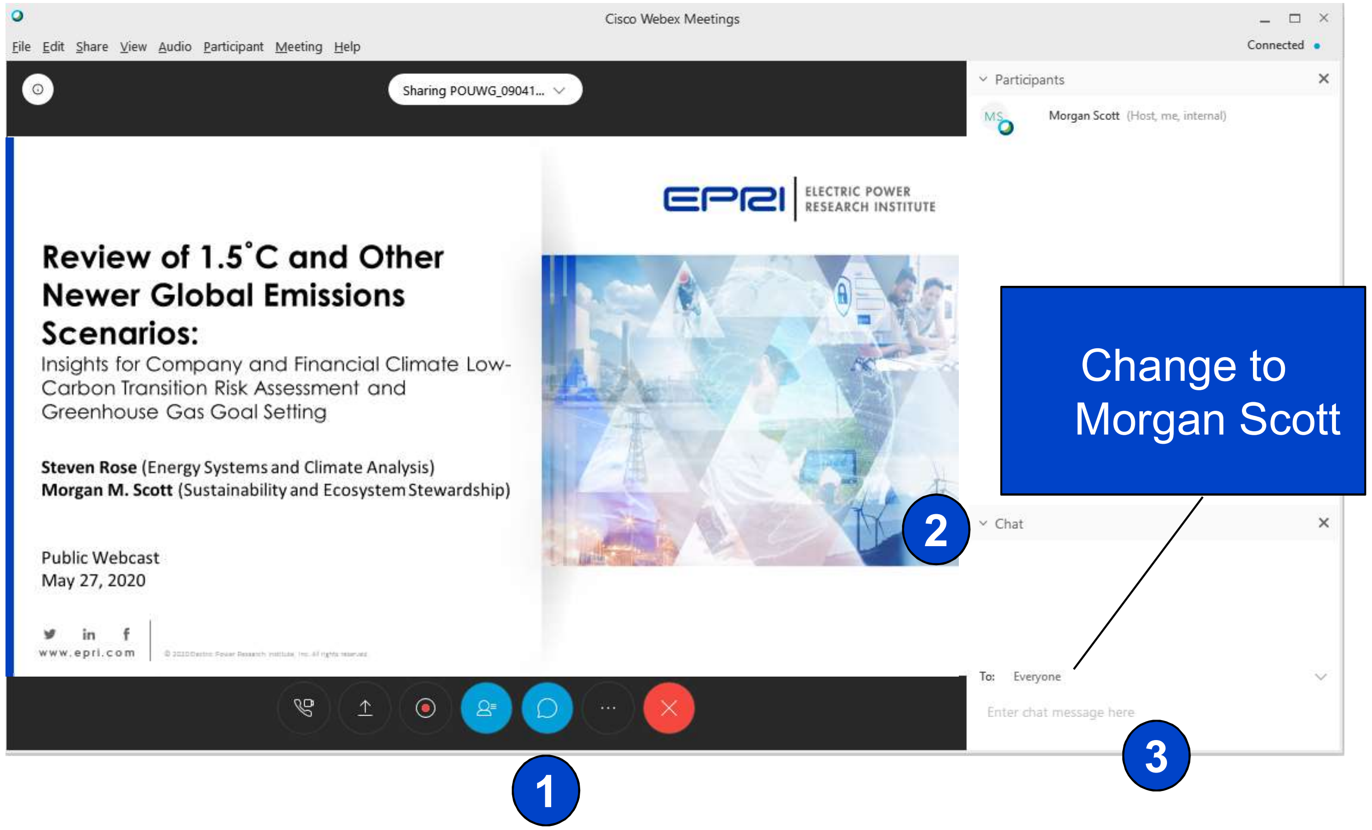
Housekeeping

- **Please PUT YOUR PHONE ON MUTE!**
  - And do not put your phone on hold
- Questions can be asked throughout the webcast – feel free to join in or you can use the chat feature.
- Please note today's webcast will be recorded. Your participation in this webcast provides your consent to the recording.
- The recorded webcast and a PDF of today's slide deck will be posted to www.epri.com/sustainability and www.eea.epri.com



About EPRI (the Electric Power Research Institute)

- A non-advocacy, nonprofit, scientific research organization with a public benefit mandate
- EPRI strives to advance knowledge and facilitate informed discussion and decision-making
- Recognized expertise in, among other things, climate scenarios, energy transformation, policy evaluation, and sustainability, as well as research community leadership and participation in, among other things, the Intergovernmental Panel on Climate Change (IPCC) and scenarios research community studies, and the Task Force on Climate-Related Financial Disclosures (TCFD) Advisory Group for Scenario Guidance

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Steven Rose

Energy Systems and Climate Analysis

Morgan Scott

Sustainability and Ecosystem Stewardship

Background

- Increasing interest in analyzing company and financial climate-related low-carbon transition risk and/or setting greenhouse gas (GHG) goals
- And, companies concerned about climate change—planning, engagement, and strategy (e.g., Scott and Rose, 2020, 2019)
- However, analyses technically challenging and general unfamiliarity with the science
- EPRI's initial study (2018) evaluated scientific understanding of the relationship between a company and a global temperature goal and derived insights and guidance for companies (evaluating ~1200 global emissions scenarios)
- New prominent global emissions scenarios data has become available (> 400 scenarios)
  - IPCC Special Report on 1.5 Degrees Celsius and IEA scenarios
  - These new scenarios already being considered by 3rd-party methodologies (e.g., Moody's, SBTi, 2° Investing Initiative, Carbon Tracker)
- Before moving forward, essential to understand and assess these scenario resources. In particular, to evaluate how they affect previous insights and guidance.

EPRI project helping to advance technical understanding, discussion, and decisions

Some EPRI products (initial study, flyer, EPRI journal article, public webcast, disclosure reporting survey, new study)

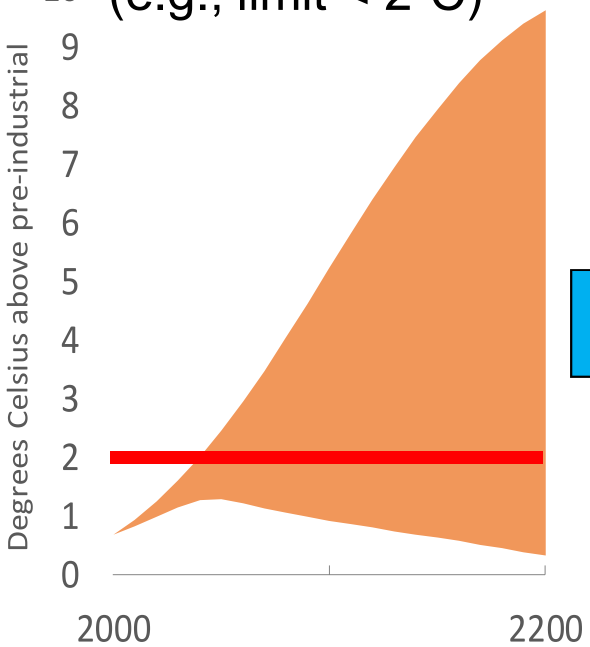
- Building a scientific foundation
- Educating companies & stakeholders
- Developing guidance
- Facilitating information exchange

Striving to enable grounded discussion and decisions by providing a scientific basis for risk assessment and goal setting

Global climate goals and the relationship to companies?

EPRI research evaluating the scientific relationship between a company and a global average temperature goal

Climate goals
(e.g., limit < 2˚C)



?

Company

Emissions, as well as energy systems, economic activity, and policy?

Rose and Scott (2018)

EPRI research on company transition risk – deriving methodological guidance from a foundation of scientific assessment & understanding

Scientific assessment of the relationship between a company & climate goals

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Key insights for companies & stakeholders

Technical principles for methodologies

Key observations from assessment

Scientific assessment of the relationship between a company & climate goals

EPRI research on company transition risk – deriving methodological guidance from a foundation of scientific assessment & understanding

Methodological guidance

- For company low-carbon transition risk assessment
- For company GHG goal setting
- For evaluating 3rd-party methodologies
- For evaluation of company risk assessments

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Key insights for companies & stakeholders | **Technical principles for methodologies**

↑ ↑

Key observations from assessment

↑ ↑ ↑

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Methodological guidance

- For company low-carbon transition risk assessme
- For company GHG goal setting
- For evaluating 3rd-party methodologies
- For evaluation of company risk assessments

Are the initial study technical observations, company-level insights and principles robust?

Key insights for companies & stakeholders | **Technical principles for methodologies**

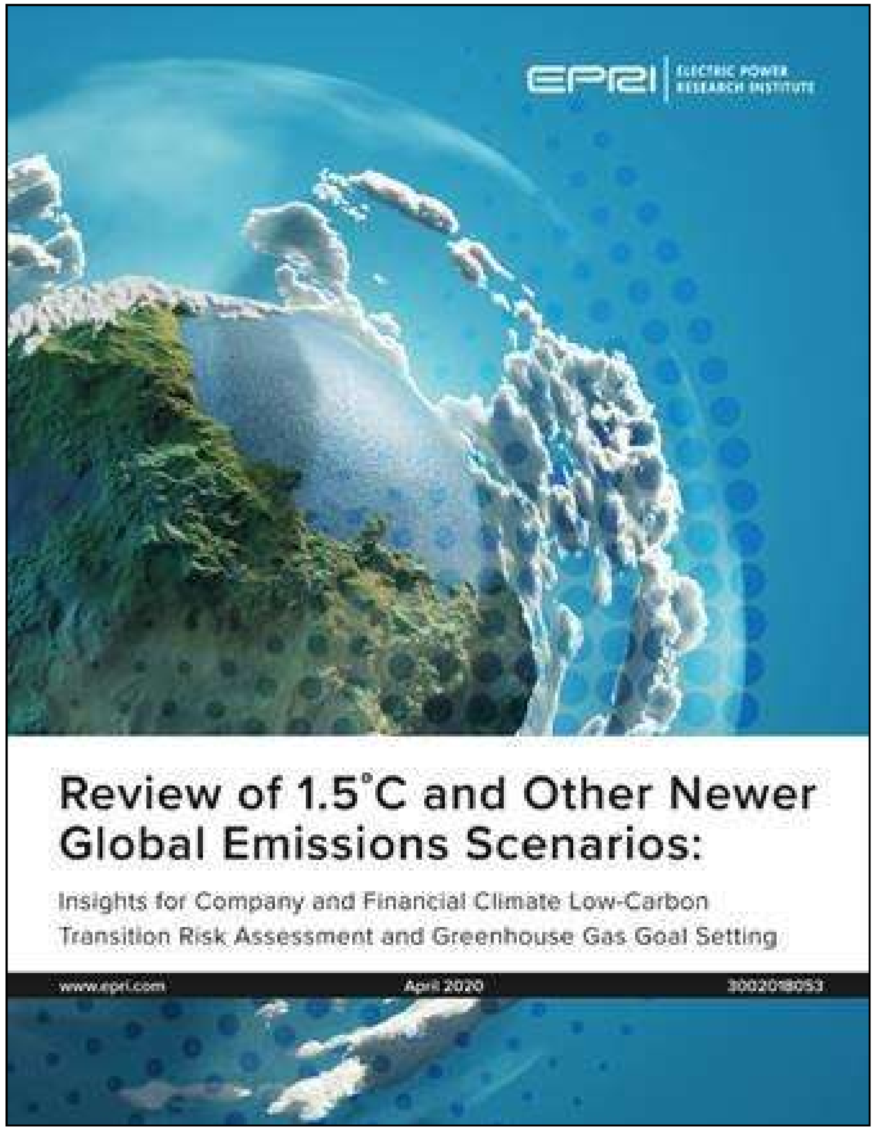
Key observations from assessment

Scientific assessment of the relationship between a company & climate goals

New study

Study outline

- Summary – Background and Key Insights
- Analysis
  - Assessment Approach
  - Results
    - Data Overview
    - Emissions Pathways
    - CO_2 Removal Deployment (i.e., negative emissions technology deployment)
    - Energy Systems
    - Pathway Attainability
    - Policy Design
    - Evaluation of New Scenarios in Terms of EPRI's Initial Study Issues and Insights
- How Can a Company Use the 1.5˚C Pathways?
- Conclusion
- References



Assessment approach

- **Assesses prominent newer global emissions scenarios**
  - IPCC Special Report on 1.5 Degrees Celsius scenario dataset (IPCC SR1.5)
  - International Energy Agency scenarios (energy system)
    - World Energy Outlook SDS (WEO; 2017; 2019)
    - Energy Transformation Pathways B2DS (ETP; 2017)
- **Approach**
  - Similar to that implemented in our initial study (Rose and Scott, 2018)
  - Specifically…
    - Inventory the data
    - Identify pathways consistent with temperature outcomes
    - Assess characteristics of pathways
    - Evaluate pathways in terms of the issues and insights identified in the initial study

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Appropriate use of scenario data

Initial study database issues and insights hold here as well, resulting in scenario interpretation guidance:

- ***A single scenario is misleading.*** Not a prediction or prescription. A projection contingent on the model and assumptions, which are uncertainties to consider.
- ***Sets of scenarios across models ("ensembles") are appropriate and useful.*** Reflects uncertainty. Helps identify robust insights. Provides useful ranges, *but not* defensible distributions and statistics (e.g., medians, percentiles).
- ***Scenario ranges capture only part of the uncertainty.*** Full uncertainty larger. What is represented is ad hoc.
- ***Results represent aggregate sectors and markets.*** Individual companies and their circumstances are not modeled. Results should not be interpreted as implying all companies should behave alike.

Data biases to consider!

IPCC SR1.5 scenario inventory by model (total number of scenarios followed by number of scenarios after SR1.5 exclusions*)

			Distribution of Scenarios Used				
Model	Total in database	1.5°C & 2°C scenarios	Below 1.5	1.5 Low Overshoot	1.5 High Overshoot	Lower 2.0	Higher 2.0
AIM	90 / 90	41 / 41	0 / 0	6 / 6	1 / 1	24 / 24	10 / 10
C-ROADS	6 / 6	5 / 5	2 / 2	1 / 1	2 / 2	0 / 0	0 / 0
GCAM	23 / 23	7 / 7	0 / 0	1 / 1	2 / 2	1 / 1	3 / 3
GENeSYS	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
IEA	2 / 2	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1
IMAGE	61 / 61	26 / 26	0 / 0	7 / 7	4 / 4	6 / 6	9 / 9
MERGE-ETL*	3 / 0	2 / 0	0 / 0	1 / 0	0 / 0	0 / 0	1 / 0
MESSAGE	58 / 58	36 / 36	0 / 0	6 / 6	6 / 6	11 / 11	13 / 13
POLES	37 / 10	28 / 7	4 / 0	7 / 1	5 / 4	9 / 2	3 / 0
REMIND	93 / 93	62 / 62	2 / 2	11 / 11	17 / 17	16 / 16	16 / 16
WITCH	39 / 39	14 / 14	1 / 1	4 / 4	0 / 0	7 / 7	2 / 2
Total	413 / 383	222 / 199	9 / 5	44 / 37	37 / 36	74 / 67	58 / 54

* SR1.5 excluded scenarios have a notable impact

Summary of key insights

Detailed Key Insights

- A broad range of global emissions pathways are consistent with limiting global warming to 1.5°C
- 1.5˚C pathways are even more challenging, and less attainable, than the already challenging 2˚C pathways
- All IPCC Special Report 1.5˚C and 2˚C pathways use negative emissions technologies
- Significant additional electrification is consistent with limiting global warming to 1.5°C and 2°C under certain assumptions
- Fossil energy use through 2030 and 2050 could be consistent with limiting warming to 1.5˚C and 2°C
- Neither the new IEA scenarios nor illustrative IPCC emissions pathways are capturing uncertainty relevant to companies

Overall Key insights

- This assessment of newer scenarios validates and strengthens the technical observations, insights, and methodological guidance from EPRI's initial study
- If considering using 1.5°C pathways, it will be important to consider attainability, uncertainty, and global scenario issues
- The 1.5°C pathway considerations above provide methodological guidance for company assessment and goal setting
- To more fully capture scientific understanding, the newer scenario data should be combined with other scenario data and pathway attainability (plausibility) taken into account

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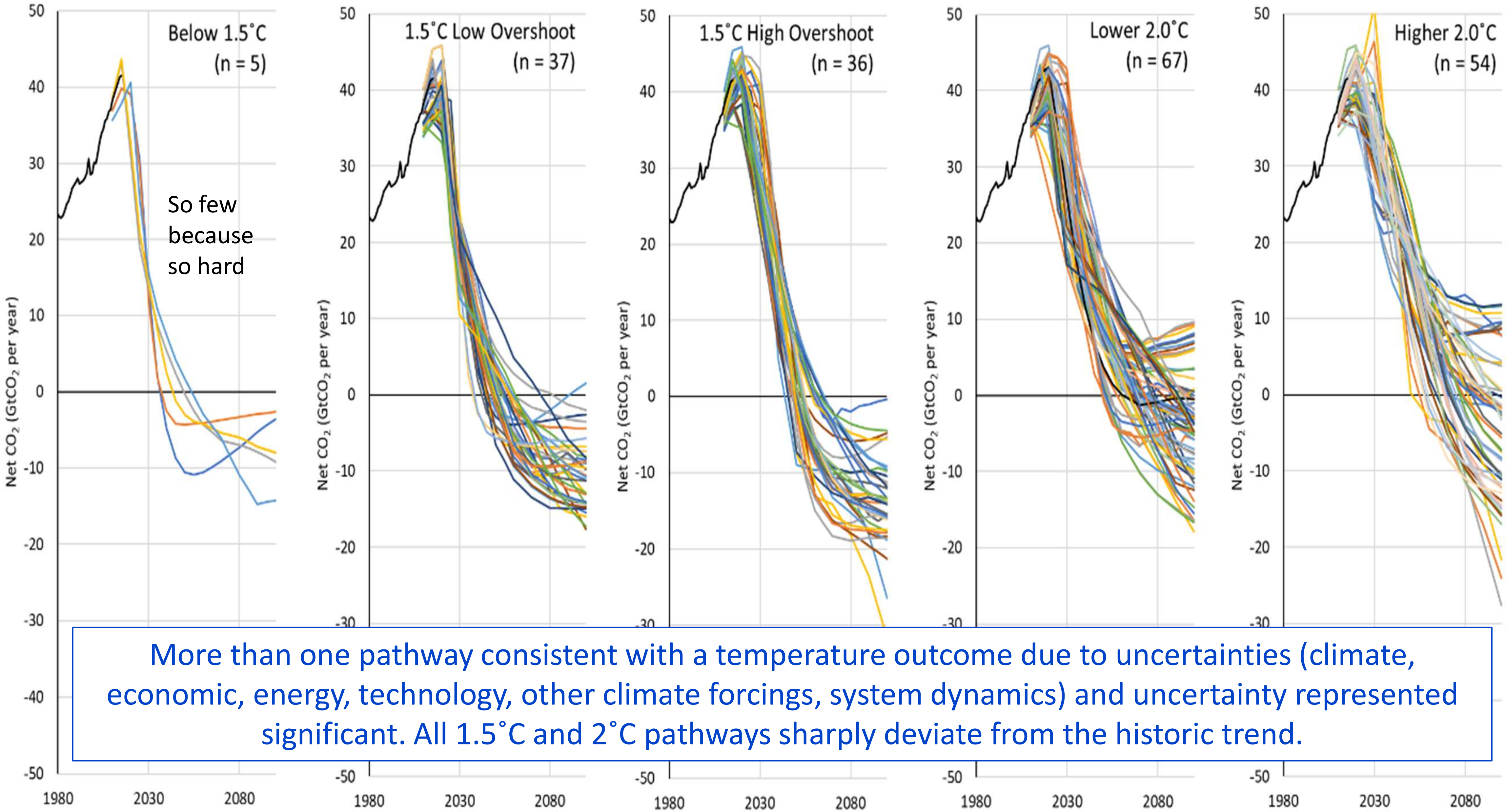
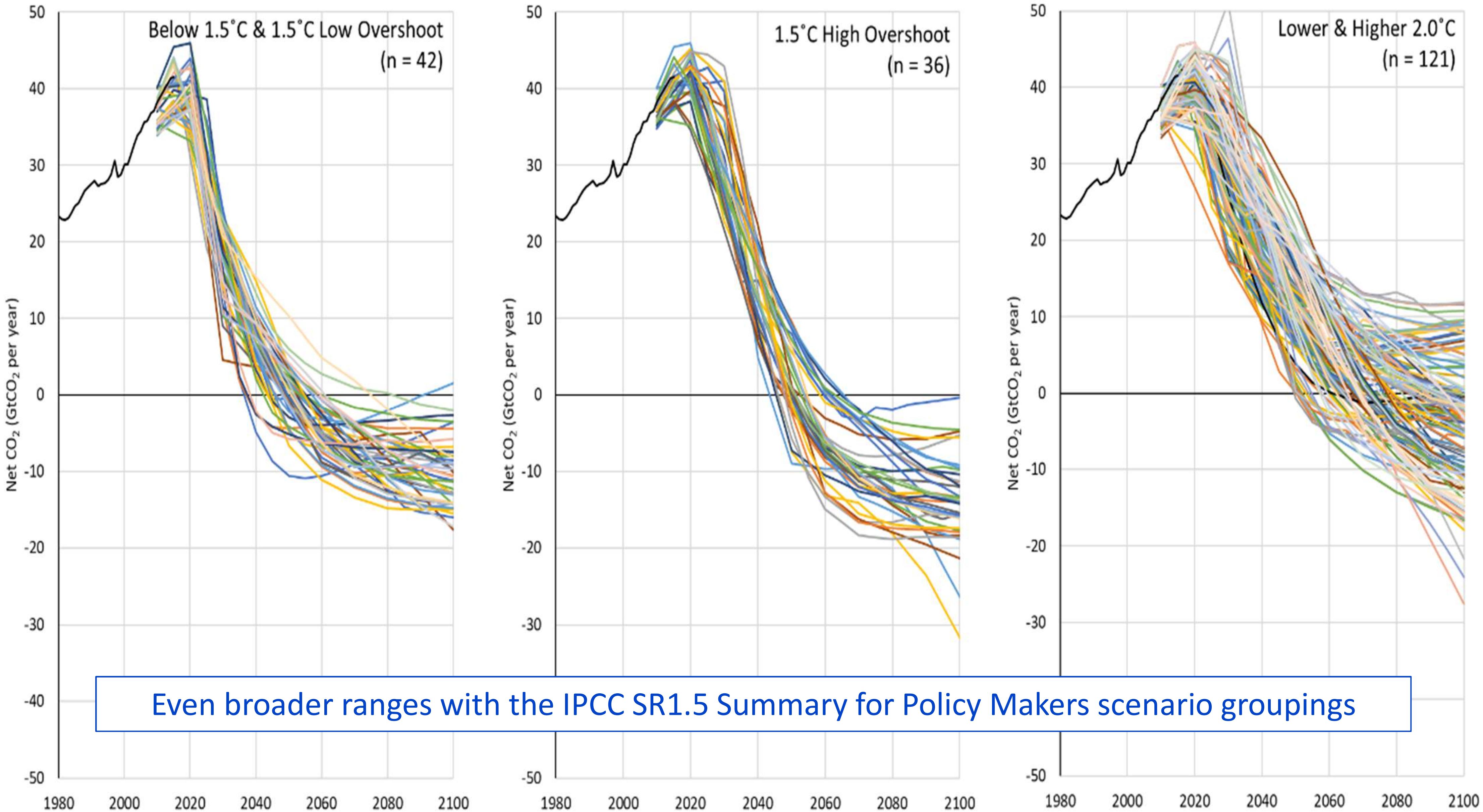
Global net CO_2 pathways



More than one pathway consistent with a temperature outcome due to uncertainties (climate, economic, energy, technology, other climate forcings, system dynamics) and uncertainty represented significant. All 1.5˚C and 2˚C pathways sharply deviate from the historic trend.

Global net CO_2 pathways – 3 groupings



Characteristics of global net CO_2 pathways

	Peaking year	Peak CO_2 range (Gt CO_2/yr)		Years to 10 Gt CO_2/yr	Net zero year	2050 % change (from 2010)		2100 net CO_2 range (Gt CO_2/yr)	
Below 1.5°C	≤ 2020	39.9	43.7	10-15	2035 - 2055	-95%	-129%	-2.6	-14.2
1.5°C low overshoot	≤ 2020	35.5	45.9	10-30	2040 - 2085	-71%	-118%	1.5	-17.7
1.5°C high overshoot	≤ 2030	36.3	45.9	20-30	2045 - 2065	-74%	-125%	-0.3	-31.7
Lower 2.0˚C	≤ 2030	35.8	45.9	20-55	2050 - never	-49%	-102%	9.6	-17.9
Higher 2.0˚C	≤ 2030	35.9	51.1	30-not < 2100	2050 - never	-35%	-99%	11.9	-27.5

Pathway characteristics inform thinking about uncertainty and attainability.

Overlap in ranges highlights importance of non-CO_2 factors.

* Including IPCC SR1.5 excluded scenarios changes the ranges, e.g., the combined Below 1.5˚C & 1.5˚C low overshoot net zero year range becomes 2035 to not before 2100

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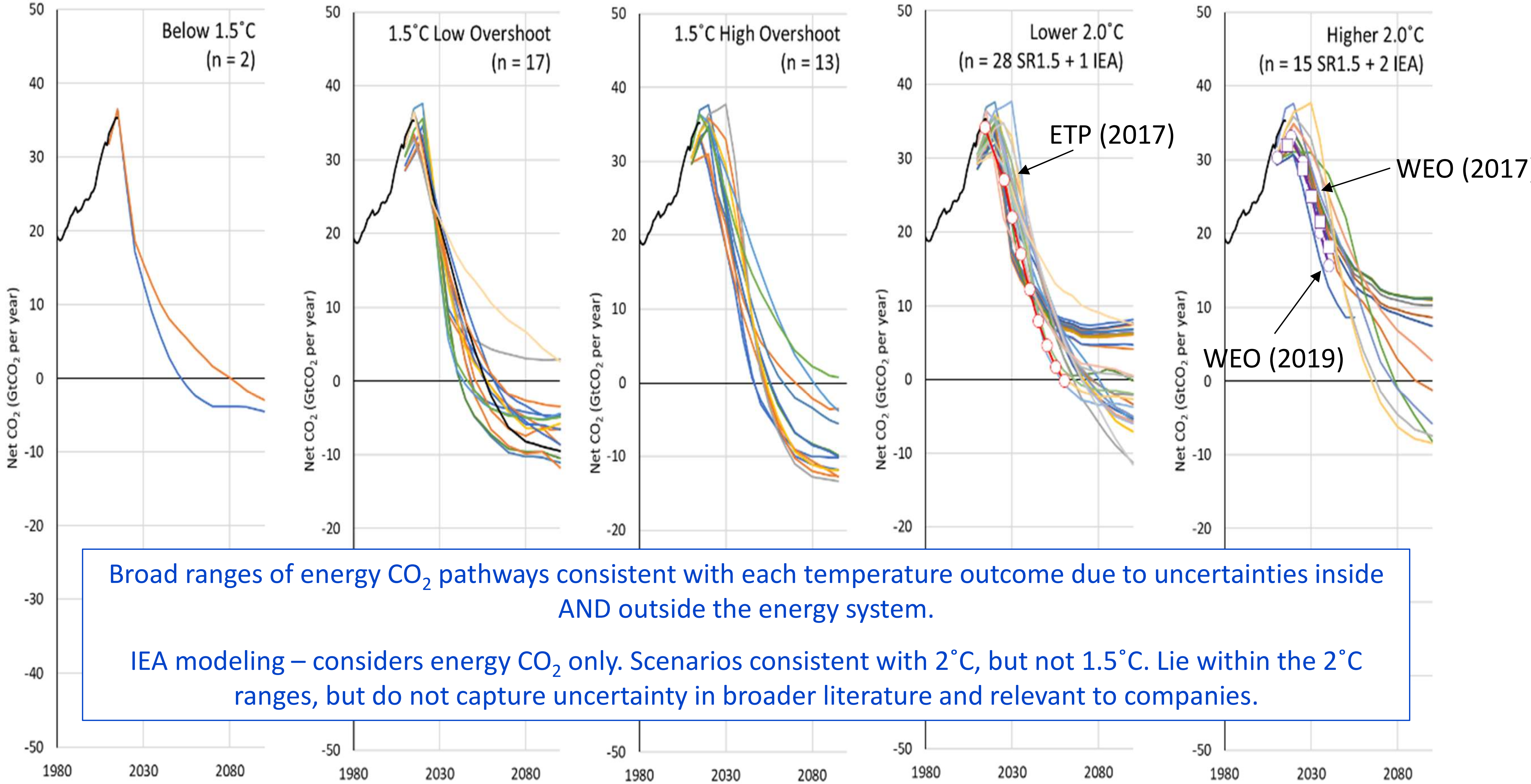
Global energy CO_2 pathways



Broad ranges of energy CO_2 pathways consistent with each temperature outcome due to uncertainties inside AND outside the energy system.

IEA modeling – considers energy CO_2 only. Scenarios consistent with 2˚C, but not 1.5˚C. Lie within the 2˚C ranges, but do not capture uncertainty in broader literature and relevant to companies.

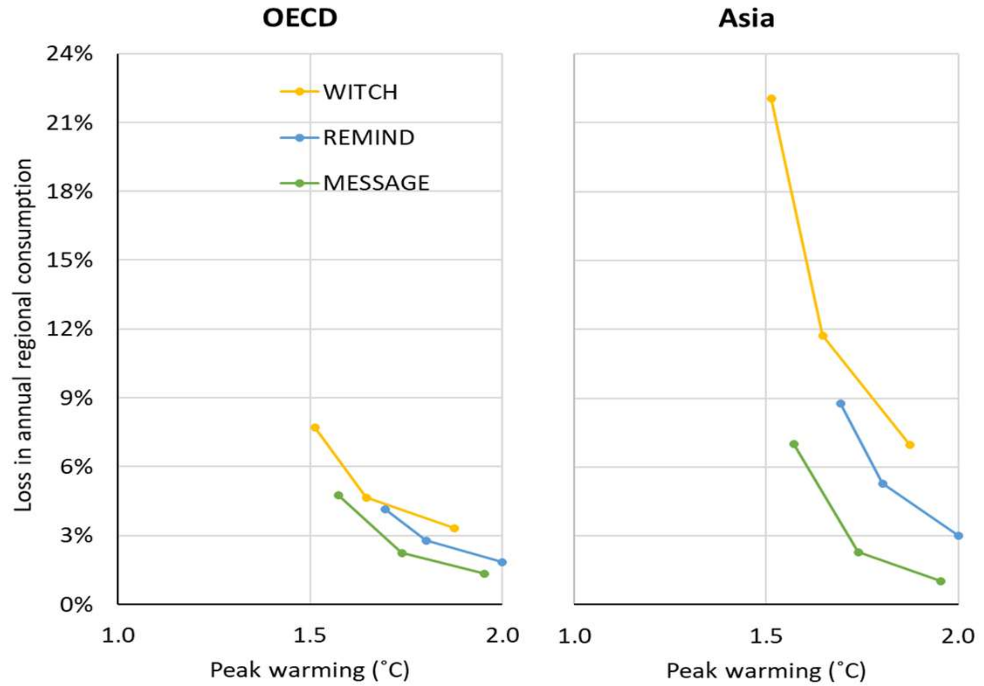
Pathway attainability

- Initial study found pathway attainability to be an uncertainty for companies
- 1.5˚C pathways even more challenging than already challenging 2˚C pathways
  - Pathway characteristics (e.g., peak ≤ 2020, rate of decline, CDR deployment, electricity growth)
  - Model infeasibilities (e.g., many models cannot solve)
  - Economic cost (e.g., increase non-linearly w/ ambition)
  - Policy assumptions (e.g., idealized global economy-wide cooperation assumed)
- New 2˚C pathways also challenging (e.g., energy CO_2 peak ≤ 2020, global cooperation)
- Conclusion
  - A broader set of pathways relevant in terms of plausible potential futures
  - Also appropriate to consider the likelihood of pathways (those less likely given lower weight)

Example of model infeasibilities

Cumulative energy CO_2 budget through 2100 ($GtCO_2$)	1600	1000	400
Corresponding global average temperature	> 2˚C	< 2˚C	< 1.5˚C
	Number of models able to produce the scenario out of the number that tried		
Full set of default technologies available	11 of 11	11 of 11	6 of 10
100% higher advanced bioenergy costs	10 of 10	8 of 10	6 of 10
Advanced bioenergy technology unavailable until 2050	10 of 10	7 of 9	5 of 10
Ligno-cellulosic biofuel unavailable	11 of 11	10 of 11	5 of 10
Bioenergy with CCS unavailable	10 of 11	6 of 11	0 of 10
All advanced bioenergy technologies unavailable	10 of 11	5 of 11	0 of 10
Modern biomass supply limited to 100 EJ/year	9 of 9	8 of 9	2 of 10*

Example of regional costs increasing non-linearly



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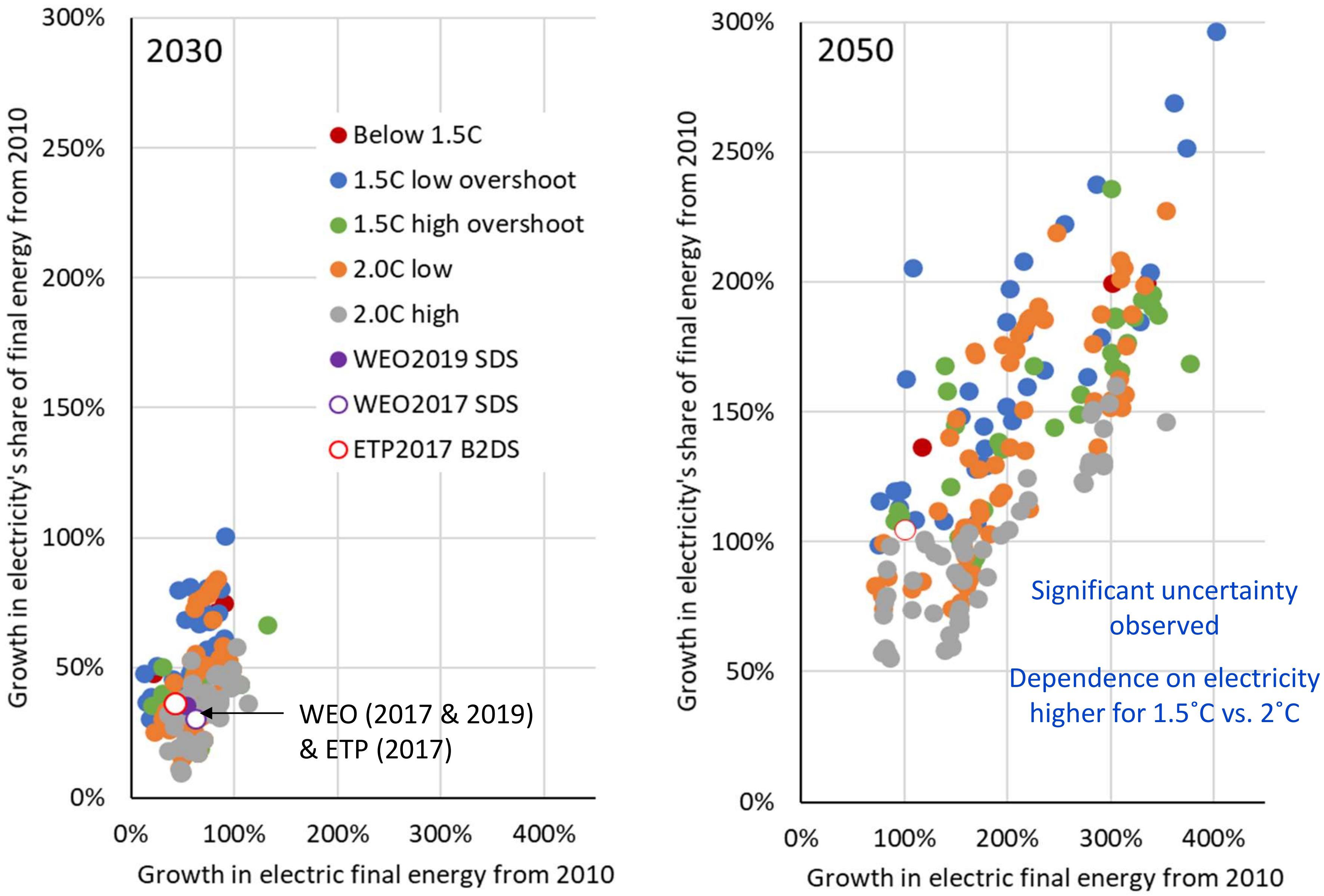
Global electrification – assumptions matter

Significant increased electrification in global scenarios, but key assumptions contribute to the outcome – **global economy-wide cooperation and cost-effective low-carbon electricity technologies**

Policy design and technology availability key uncertainties to evaluate!



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Newer scenarios validate and strengthen the initial study technical observations, insights, and guidance

Technical observations ✓

1. Significant global emissions scenario resources are available (including model infeasibility results data), but appropriate interpretation is critical.
2. Broad ranges of CO_2 pathways, budgets (cumulative emissions over time), and annual emissions reductions are consistent with any global temperature outcome.
3. Assumptions matter for properly using results. In particular, optimistic assumptions regarding policy design (idealized global cooperation) and technology availability are influencing existing results. However, these are important uncertainties for companies to evaluate.
4. Policy design is a key additional uncertainty for companies absent from global scenarios.
5. Applying uniform targets (GHG, technology, other) across companies is unlikely to be cost-effective for society (e.g., 80% or 100% CO_2 reductions in 2050).
6. Emissions pathways consistent with limiting global warming to 2°C and below are extremely challenging to realize—geophysically, technologically, economically, and politically. As a result, it is uncertain whether the pathways are attainable, which implies that the likelihood of pathways matters and higher global emissions pathways are possible, relevant, and potentially more likely.
7. Other non-climate-policy related risks, such as with input and output markets, economic growth, and technology matter, as does current company strategy, for assessing the relative importance of climate risks and assessing risk management strategies.
8. GHG emissions are only one part of an asset's or portfolio's value, and the full value should be considered for proper risk assessment and risk management.
9. Despite broad ranges for global emissions scenario results, there are robust insights that hold regardless of the model and assumptions that provide a foundation for analysis and decisions. For instance, global emissions must peak and decline for limiting global average warming to a 50% chance of 3°C or lower, an emissions pathway cost-effective for society for one future is not cost-effective for every plausible future, and the cost-effective emissions reduction level for an economic sector is highly uncertain.

Company-level insights ✓

- Individual company perspective is essential for defining uncertainties relevant to a company and current company-specific context.
- A scientific basis is necessary for grounded decisions. Approaches and strategies should be based on scientific understanding to characterize uncertainties and identify robust insights.
- The cost-effective societal role of a company in reducing GHG emissions at the lowest cost to customers and society is highly uncertain.
- It is difficult to identify a unique company-level GHG pathway or target that is cost-effective in all plausible futures; and, if choosing a pathway or target, uncertainties are important to communicate.
- The cost-effective pathway or target for a company will likely differ from what is cost-effective at the global, country, and sector level, as well as from what is cost-effective for other companies.
- It is important for a company to characterize and incorporate the numerous uncertainties relevant to the company, have flexibility in emissions reduction levels and how they are met to contain societal costs, and identify a robust strategy that makes sense in different future contexts and can respond appropriately, where a strategy is more than a target or pathway.

Guidance ✓

Issues methodologies need to consider

- Uncertainties
  - Temperature-emissions relationship
  - Global emissions pathway attainability
  - Policy design features
  - Non-climate-related reference conditions (e.g., markets, technology)
- Global scenarios data problematic for guiding and assessing companies
- Company-specific context
- Uniform vs. varied targets across companies
- Flexibility options
- Quantitative comparison of alternative strategies
- Evaluation of strategy robustness for alternative futures
- Full (system) value of company assets and investments

Global scenario limitations

- Finding data to be poor quantitative benchmarks for guiding or assessing company risk and strategy
  1. Many consistent pathways for a climate goal,
  2. Some pathways unlikely and others plausible,
  3. Results do not represent companies,
  4. Some companies operate in more than one sector,
  5. Pathways contingent on assumptions and missing uncertainties that affect companies,
  6. Companies pursuing same emissions effort costly for society,
  7. Sub-global results problematic (e.g., region, country, sector emissions, technologies, or markets) – assumption contingent, aggregate sectors, uniform action implied, key uncertainties missing, uncertainty increases with resolution

Validation means that the technical observations, company-level insights, and technical principles provide a

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Company-level insights for companies and stakeholders

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Technical principles and guidance for methodologies

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Qualitative insights very useful – guide company analysis and assessment with principles for methodologies and analytical design guidance

Technical principles for evaluating and developing methodologies

A technical checklist for methodologies

Technical issues for company methodologies

- Are the following relevant uncertainties considered and how?
  - Temperature-emissions relationship?
  - Global emissions pathway attainability?
  - Policy design features?
  - Non-climate-related reference conditions (e.g., markets, technology)?
- Are global scenario results used and how are problematic issues addressed?
- How is company-specific context considered?
- Is a uniform goal explicitly or implicitly imposed across companies or are goals allowed to vary from one company to the next?
- Given uncertainties, does the approach provide flexibility?
- Is quantitative comparison of alternative strategies possible?
- What is the approach for evaluating strategy robustness?
- Is the full (system) value of company assets and investments considered?

Rose and Scott (2018)

Table ES-3
How different approaches address company analysis issues identified by this study

Sources: Developed from this study, SBTi (2015, 2017), IEA (2016), Ceres (2018), and UNEP FI (2018)

Issue to consider	This study		SBTi	Ceres	UNEP FI pilot
Scenarios used	1000+ (a)		1 (b)	See note (c)	See note (d)
Uncertainties					
Global temperature-CO_2 relationship for 2°C (cumulative 2011-2050 $GtCO_2$)	Global net	465 to 1692	--	--	1139
	Global energy	324 to 1636	1085	--	1022
	Global electric	94 to 642	335	--	261
Global temperature-CO_2 relationship for 2°C (annual changes in 2050 relative to 2010)	Global net	14% to -96%	--	--	-72%
	Global energy	9% to -99%	-52%	--	-58%
	Global electric	-2% to -163%	-89%	--	-94%
	U.S. net CO_2eq	-58% to -110%	--	-81% (80% relative to 1990)	--
	U.S. electric	-44% to -170%	--	-92% (90% relative to 1990)	--
Attainability of 2°C global emissions pathways	(1) Consider uncertainty about attainability, and (2) Potentially assign probabilities Example of (1) – all pathways peaking before mid-century 2011-2050 cumulative CO_2 ranges ($GtCO_2$): Global net: 465 to 1999 Global energy: 323 to 1883 Global electric: 94 to 894 2050 CO_2 reduction ranges: Global net: 52% to -96% Global energy: 83% to -99% Global electric: 53% to -163% U.S. net CO_2eq: -28% to -110% U.S. electric: -29% to -170%		Not considered	Not considered	Not considered
Uncertainty about climate policy design	Important but not currently reflected in global scenarios		Not considered	Not considered	Not considered
Non-climate-related uncertainties	Consider (e.g., service demand, fuel markets, technology costs)		Not considered	Some discussion	Some discussion
Company-specific context	Important, varies from company-to-company (e.g., current assets, markets, systems, and policy & strategy)		Limited consideration (base year activity and emissions, target year activity)	Some discussion	Some discussion
Uniform vs. varied GHG targets across companies	Uniform targets found unlikely to be cost-effective		Proposes globally uniform sectoral targets	Proposes uniform target for all utilities	Implies uniform targets within sector segments
Company flexibility	Consider flexibility in GHG reduction levels and how achieved		Constrained to single GHG target without coordination	Constrained to single GHG target (coordination not considered)	Not considered
Quantitative comparison of company alternatives	Compare cost, environmental effectiveness, cost risk, and sensitivity of results		No method	Various potential comparisons noted (e.g., technology, cost)	Not discussed
Company strategy robustness	Evaluate by considering uncertainties and risk management		Not considered	Not considered	Not considered

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Global temperature-CO_2 relationship for 2°C (cumulative 2011-2050 $GtCO_2$)	Global net	465 to 1692	--	--	1139
	Global energy	324 to 1636	1085	--	1022
	Global electric	94 to 642	335	--	[illegible]
Global temperature-CO_2 relationship for 2°C (annual changes in 2050 relative to 2010)	Global net	14% to -96%	--	[illegible]	[illegible]
	Global energy	9% to -99%	-52%[illegible]	[illegible]	[illegible]
	Global electric	-2% to -163%	[illegible]	[illegible]	[illegible]
	U.S. net CO_2eq	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]	[illegible] in global		Not considered	Not considered	Not considered
[illegible]	[illegible] (e.g., service demand, fuel markets, technology costs)		Not considered	Some discussion	Some discussion
Company-specific context	Important, varies from company-to-company (e.g., current assets, markets, systems, and policy & strategy)		Limited consideration (base year activity and emissions, target year activity)	Some discussion	Some discussion
Uniform vs. varied GHG targets across companies	Uniform targets found unlikely to be cost-effective		Proposes globally uniform sectoral targets	Proposes uniform target for all utilities	Implies uniform targets within sector segments
Company flexibility	Consider flexibility in GHG reduction levels and how achieved		Constrained to single GHG target without coordination	Constrained to single GHG target (coordination not considered)	Not considered
Quantitative comparison of company alternatives	Compare cost, environmental effectiveness, cost risk, and sensitivity of results		No method	Various potential comparisons noted (e.g., technology, cost)	Not discussed
Company strategy robustness	Evaluate by considering uncertainties and risk management		Not considered	Not considered	Not considered

Recent methodologies do not reflect scientific understanding!
For instance, …
- Do not represent uncertainty evident in the literature
- Are missing uncertainties relevant to companies
- Propose applying uniform targets across companies

How can a company use the 1.5˚C pathways?

- Companies and stakeholders understandably asking whether and how they might use 1.5˚C pathways
- Based on this analysis, there are a few considerations that suggest caution
  - Pathway attainability, pathway uncertainty, and global scenario limitations
- These considerations also provide guidance to companies
  - And identify candidates for uncertainties, risks, and opportunities companies might consider

	Insight from 1.5°C pathways	How a company can apply insight
Attainability	From the attainability assessment of 1.5°C pathways, we find that pathway plausibility is relevant.	Develop a risk management strategy for the *set of plausible futures*.
Uncertainty	From the range of 1.5°C pathways, we find that uncertainties should to be considered.	Evaluate plausible futures that represent company relevant uncertainties, risks, and opportunities.
Global scenario limitations	From the global scenarios issues, we find that comparing to global scenario results is of limited value to characterizing a company's risk or assessing its strategy.	Develop an assessment and strategy that recognizes company-specific circumstances and communicates the limitations of global scenario results as benchmarks.

Concluding remarks

- Going forward, we need to flesh out more comprehensive operationalization guidance, fill gaps in knowledge, and develop science tailored to the purpose
  - Stay tuned for forthcoming EPRI company technical guidance and policy design analysis
- We find that our technical observations, insights, and guidance are robust to new scenarios and therefore represent a reliable basis for evaluating and developing company methodologies now and into the future
  - Among other things,
    - Company-specific circumstances are unique and global scenarios do not capture them
    - The future is uncertain and strategies will need to be flexible
    - There is no "right" pathway/goal for a company, nor should we expect them all to have the same pathway/goal, nor want them to
    - If a company chooses a pathway/goal, there are uncertainties and risks to communicate
- New scenarios will continue to become available, and they should be assessed similar to what we have done

Thank you!

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EPRI resources

- Rose, S and M Scott, 2020. *Review of 1.5˚C and Other Newer Global Emissions Scenarios: Insights for Company and Financial Climate Low-Carbon Transition Risk Assessment and Greenhouse Gas Goal Setting*. EPRI, Palo Alto, CA: 2020. Report #3002018053.

- Rose, S and M Scott, 2018. *Grounding Decisions: A Scientific Foundation for Companies Considering Global Climate Scenarios and Greenhouse Gas Goals*. EPRI, Palo Alto, CA: 2018. Report #3002014510.

- Rose, S and M Scott, 2018b. *A Technical Foundation for Company Climate Scenarios and Emissions Goals*. EPRI, Palo Alto, CA: 2018. Report #3002014515.

- Scott, M and S Rose, 2019. *Climate Disclosure and Voluntary Reporting Trends: 2018 Survey Results*. EPRI, Palo Alto, CA: 2019. Report #3002016948.

- **Forthcoming**

  - Scott, M and S Rose, 2020. *Climate Disclosure and Voluntary Reporting Trends: 2019 Survey Results*. EPRI, Palo Alto, CA, forthcoming. 3002018052.

  - Rose, S and M Scott, 2020. *Guiding Decisions: Scientific Guidance for Evaluating and Developing Company Climate Transition Risk Assessment Methodologies and Informing Greenhouse Gas Goal Setting*, EPRI, Palo Alto, CA, forthcoming. Report #3002018051.

Appendix

Data overview and appropriate use

Assess emissions scenarios data

↓

Identify appropriate use

↓

Derive insights

IPCC SR1.5 – we focus on 1.5˚C and 2˚C scenarios

Pathway Group	Pathway Group Description (see specific selection criteria below table)	#	#	# after exclusions	# after exclusions
Below 1.5˚C	Limit global average temperature to 1.5°C	9	53	5	42
1.5˚C Low Overshoot	Result in global average temperature below 1.5°C by 2100 after exceeding it by less than 0.1˚C	44		37	
1.5˚C High Overshoot	Result in global average temperature below 1.5°C by 2100 after exceeding it by 0.1˚C to 0.4˚C	37	37	36	36
Lower 2˚C	Limit global average temperature to 2°C with a higher likelihood	74	132	67	121
Higher 2˚C	Limit global average temperature to 2°C with a lower likelihood	58		54	
Total (1.5˚C and 2˚C)		222		199	
Other	Pathways not in groupings above	191		184	
Total		413		383	

IEA Scenarios

- World Energy Outlook Sustainable Development Scenario (2017)
- World Energy Outlook Sustainable Development Scenario (2019)
- Energy Technology Perspectives Beyond 2-Degrees Scenario (2017)

* IPCC SR1.5 excluded scenarios with 2010 global CO_2eq emissions outside the 2010 range assessed in the IPCC 5th Assessment Report

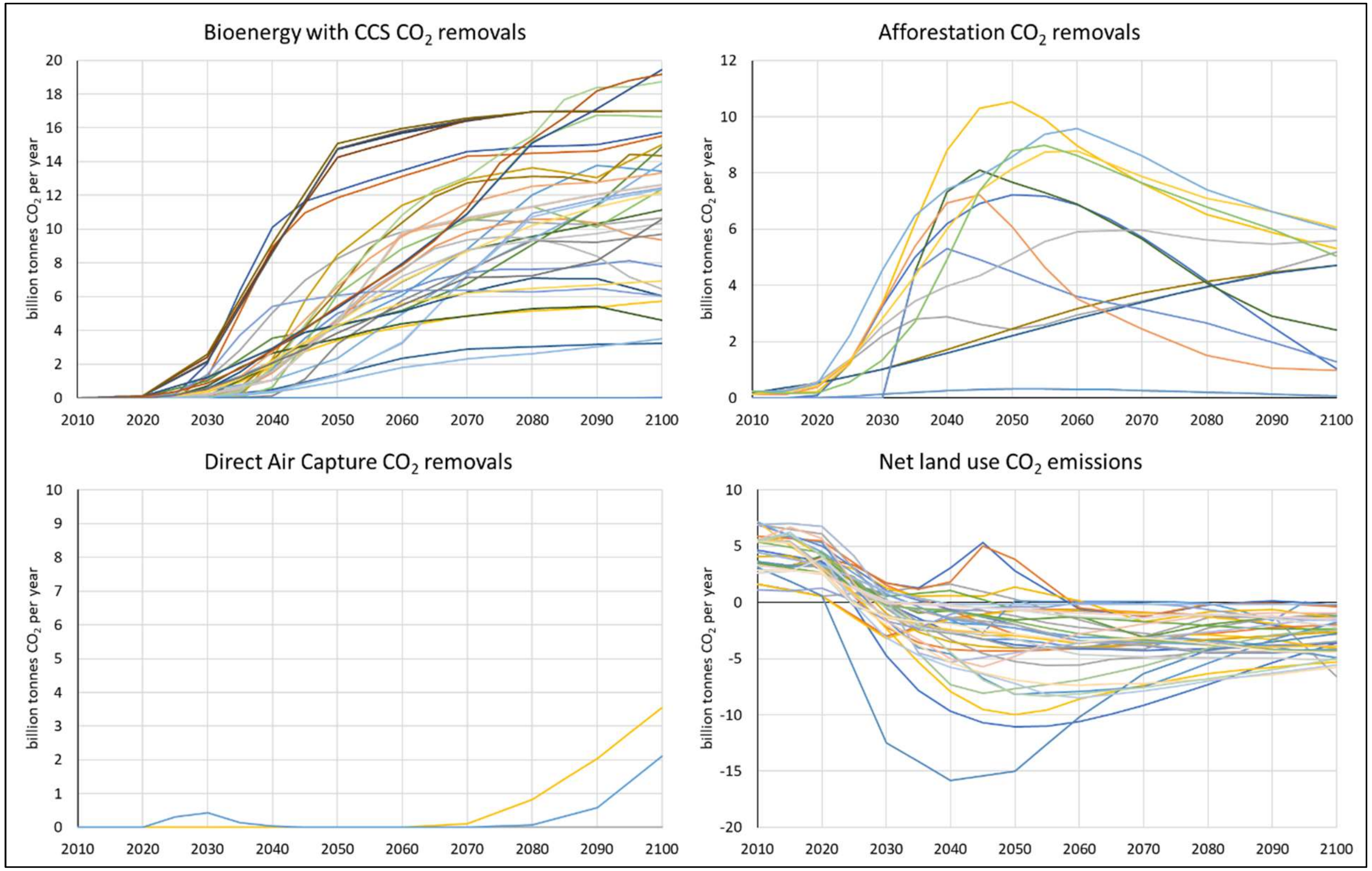
CO_2 removal (CDR) technology deployment

Early and significant annual CDR deployment in 1.5°C and 2°C pathways – as early as 2020 and ramping up to 45% of today's annual emissions levels.

All IPCC SR1.5 1.5˚C and 2˚C pathways use negative emissions technologies.

Likely required to limit warming to 1.5˚C, and potentially 2˚C.

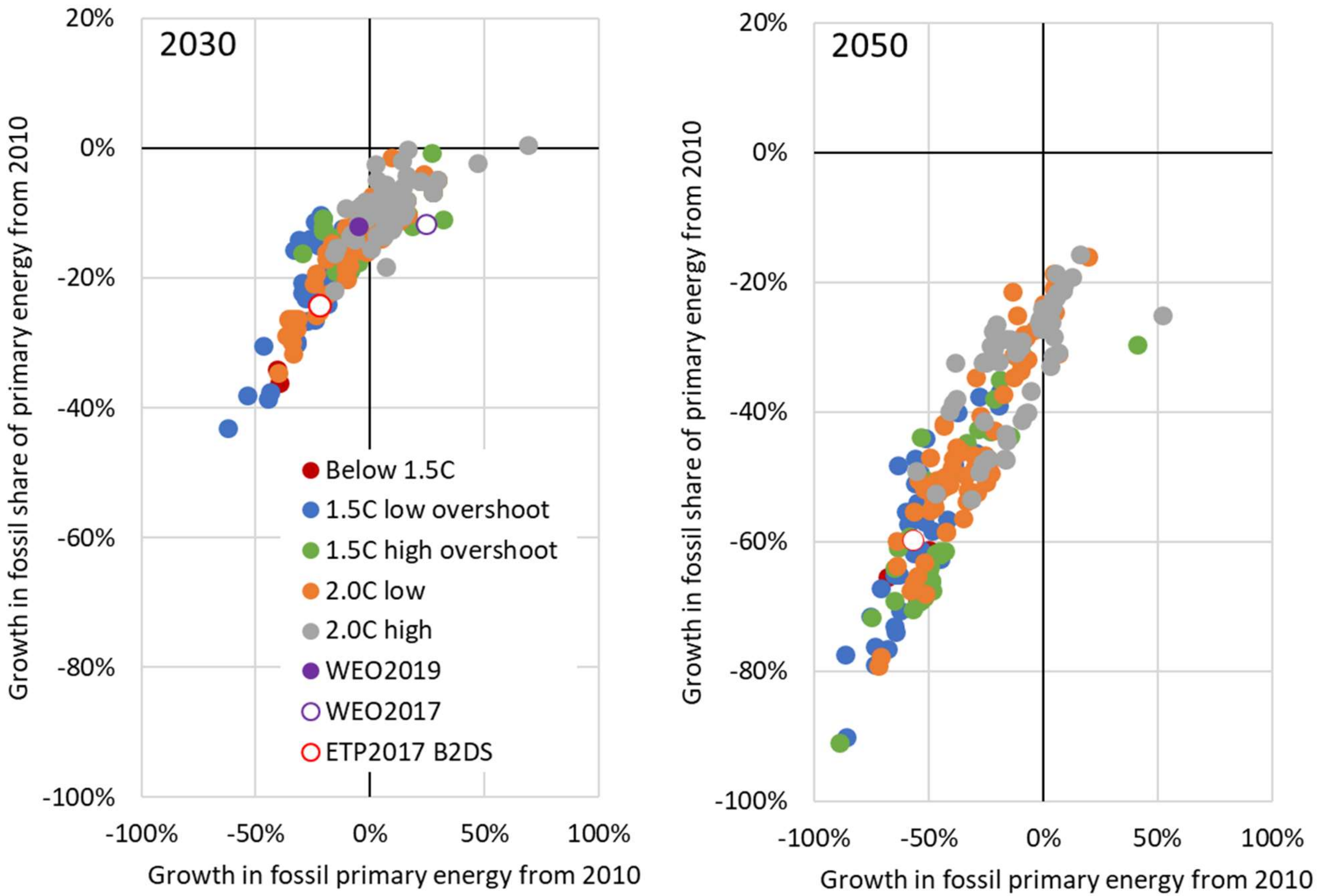
CDR annual deployments for Below 1.5C and 1.5C Low Overshoot pathways (without excluded scenarios)



Global fossil energy

Fossil energy declines but is still in use in 2050 in the 1.5˚C and 2˚C scenarios.

Near-term growth is less consistent with 1.5˚C.



Technical observations

1. Significant global emissions scenario resources are available (including model infeasibility results data), but appropriate interpretation is critical.
2. Broad ranges of CO_2 pathways, budgets (cumulative emissions over time), and annual emissions reductions are consistent with any global temperature outcome.
3. Assumptions matter for properly using results. In particular, optimistic assumptions regarding policy design (idealized global cooperation) and technology availability are influencing existing results. However, these are important uncertainties for companies to evaluate.
4. Policy design is a key additional uncertainty for companies absent from global scenarios.
5. Applying uniform targets (GHG, technology, other) across companies is unlikely to be cost-effective for society (e.g., 80% or 100% CO_2 reductions in 2050).
6. Emissions pathways consistent with limiting global warming to 2˚C and below are extremely challenging to realize—geophysically, technologically, economically, and politically. As a result, it is uncertain whether the pathways are attainable, which implies that the likelihood of pathways matters and higher global emissions pathways are possible, relevant, and potentially more likely.
7. Other non-climate-policy related risks, such as with input and output markets, economic growth, and technology matter, as does current company strategy, for assessing the relative importance of climate risks and assessing risk management strategies.
8. GHG emissions are only one part of an asset's or portfolio's value, and the full value should be considered for proper risk assessment and risk management.
9. Despite broad ranges for global emissions scenario results, there are robust insights that hold regardless of the model and assumptions that provide a foundation for analysis and decisions. For instance, global emissions must peak and decline for limiting global average warming to a 50% chance of 3˚C or lower, an emissions pathway cost-effective for society for one future is not cost-effective for every plausible future, and the cost-effective emissions reduction level for an economic sector is highly uncertain.