MOODY'S ANALYTICS

Green Shoots and Climate Pathways

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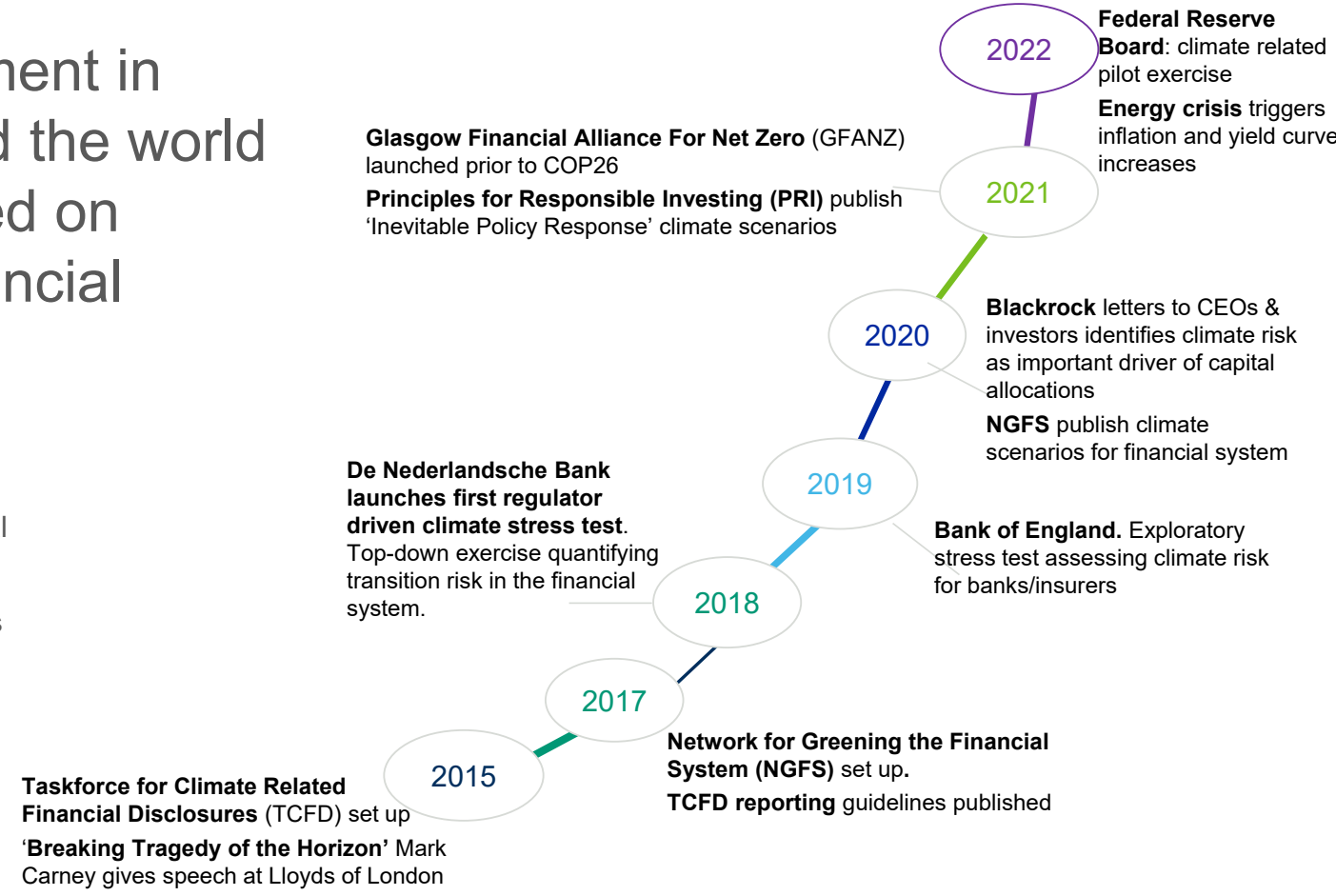
Emergence of Climate Risk as Focus for Finance

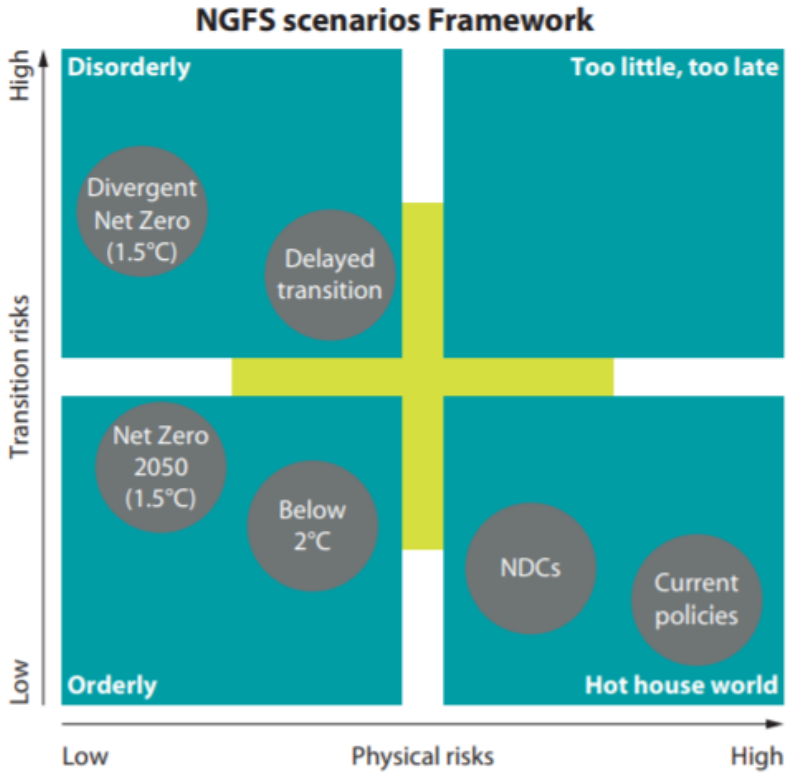
Since the Paris Agreement in 2015 regulators around the world have increasing focused on climate risk in their financial systems.

- Early regulatory stress tests focused on top-down analysis.
- Initially the exercises focused on physical or transition risk, but now cover both.
- Regulators have typically used scenarios inspired by the Network for Greening the Financial System (NGFS), tailored for their jurisdiction.
- Complexity is growing, increasing the burden on banks and insurers.



Growing Use of Climate Scenario Analysis in Finance

- Similar to existing Stress and Scenario Testing which is commonplace across the finance industry to quantify an entity's risk.
- Climate Scenario Analysis models a plausible future state of the world to assess the impact of climate-related risk on business operations.
- Network for Greening of Financial System Scenarios are emerging as a market standard - from the outset these were designed to be used specifically by financial institutions.

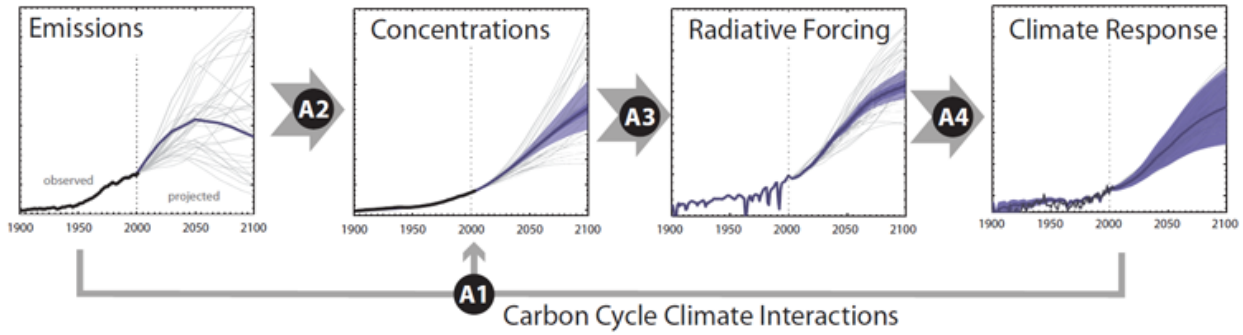


Positioning of scenarios is approximate, based on an assessment of physical and transition risks out to 2100.

Source: NGFS

Physical Climate Modelling & Uncertainty

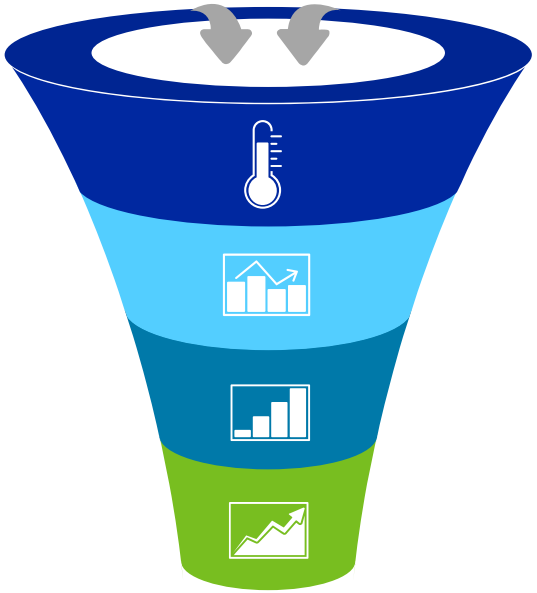
- Climate models/scenarios (for example CMIP 5 & 6) are used in some applications – for example insurance underwriting
- Emissions pathways from IAMs are often converted into climate and temperatures outputs using the reduced form model MAGICC.
- A single emissions path generates a distribution of temperatures due to uncertainties in climate sensitivity.
- Some feedback impacts are captured in in MAGICC 7, e.g.:
  - Water vapour levels
  - Albedo effects
  - Permafrost loss
  - CH4 cycle feedback effects



Schematic overview of MAGICC calculations showing the key steps from emissions to global and hemispheric climate responses.
Source: Fig A.1. in Meinshausen et al. 2011, ACP

Top-down Impact Analysis

How does it work?



Climate-conditioned financial variables (e.g. market valuations, yield curves, inflation rate)

Key steps

1. **Understand Climate Pathways**
   - » Understand the policy and climate change pathways (SSP/RCP, NGFS, PRI)
2. **Interpret Economic Implications**
   - » Interpreting macroeconomic variables including real capital investment, climate/energy inflation
3. **Determine Financial Basis Stresses**
   - » Calculate financial basis variable for each climate path
4. **Expand Scenario Variables**
   - » Translate climate-aligned scenarios into broader financial variables

Inputs into Risk Management models or Strategic Asset Allocation frameworks

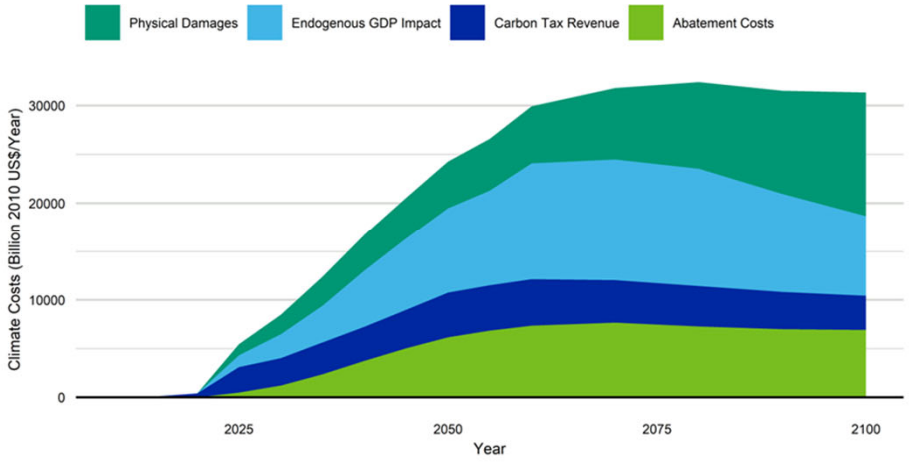
Applications

- **Impact assessment:** analyze financial impact from climate change from macroeconomic view
- **Regulatory compliance:** Incorporate climate scenarios into internal assessments and regulatory reporting

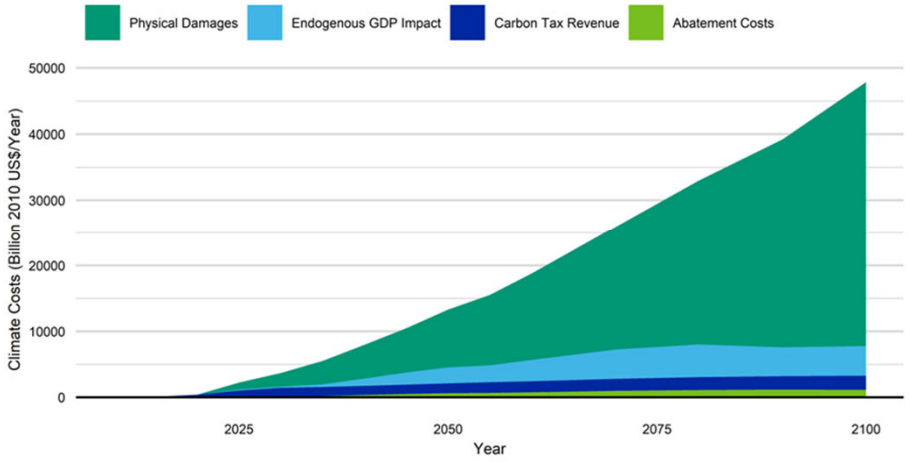
Three Waves of Real Economic Costs

- Carbon/emission pricing, abatement costs and physical damages/adaption costs
- Productivity impacts can also be significant and included as ‘fourth wave’
- Real costs will vary across regions and scenarios
- Combined, they become a significant proportion of ongoing gross capital formation/investment

Orderly Transition – Net Zero 2050



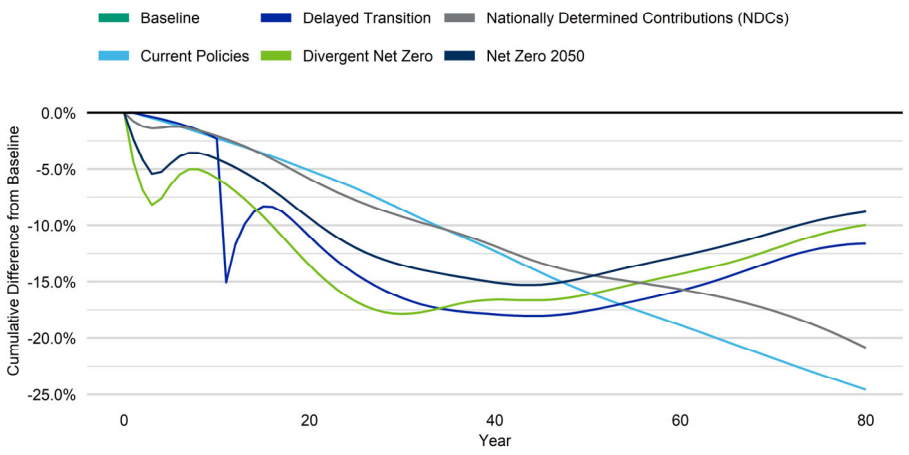
Hot House Scenario – Nationally Determined Contributions



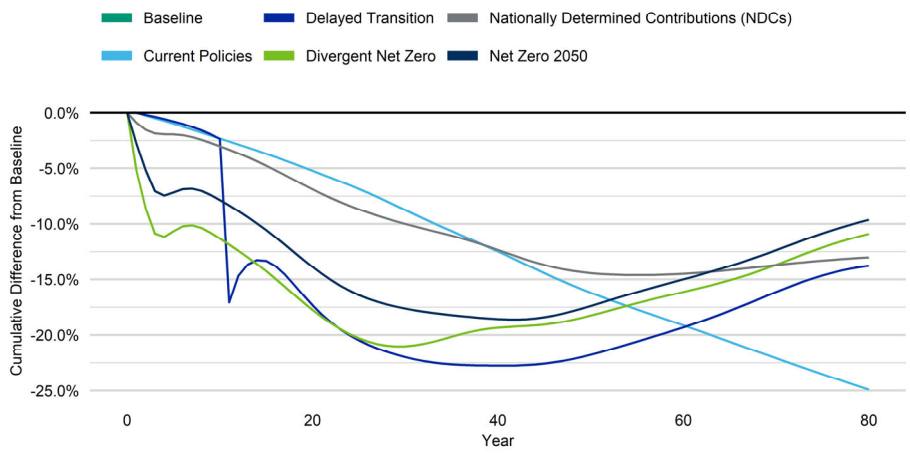
Source: NGFS, Moody’s Analytics

Cumulative Return Impact

Impact on Equity Total Return Index Relative to Baseline



GBP, Nominal Returns



GBP, Real Returns

Source: Moody's Analytics

Investment Outcomes

Retirement Impacts for UK Living Wage Workers

- Pension funds and asset managers don't 'own' investments, they are custodians of public's savings/wealth
- Strongly skewed to wealthier deciles of populations (eg the main owners)
- However, in the UK following 'auto enrollment' 80% of workers have private pension
- Significant focus for financial regulation is protecting customers/consumers

Table 6 Summary of the projected outcomes for the representative Generation Z investor

Climate Pathway	Percentile Outcome (%)	Final Fund Value (£)	Real Final Fund Value (2020 £)	No Years Wages (Years)	Income @5% pa (£)	Real Income @5% pa (2020 £)	Income @7% pa (£)	Real Income @7% pa (2020 £)
Counterfactual Baseline	10th	96435	35905	2.07	4822	1795	6750	2513
Counterfactual Baseline	50th	203612	69621	4.01	10181	3481	14253	4873
Counterfactual Baseline	90th	549133	146948	8.46	27457	7347	38439	10286
Counterfactual Baseline	Average	298632	83059	4.78	14932	4153	20904	5814
Current Policies	Average	284403	79003	4.55	14220	3950	19908	5530
Below 2C	Average	283422	78707	4.53	14171	3935	19840	5510
Net Zero 2050	Average	278579	77298	4.45	13929	3865	19501	5411
Delayed Transition	Average	264931	73396	4.22	13247	3670	18545	5138

All results show the average outcome except for the first two columns which show percentiles of the baseline projection.

Table 7 Comparison of the impact of climate pathways on retirement income levels for the representative investors using different Integrated Assessment Models outcomes.

Pathway	Remind	GCAM	Message
Current Policies	-1.2%	-1.0%	-1.0%
Below 2C	-2.7%	-3.0%	-2.6%
Net Zero 2050	-6.8%	-3.5%	-6.3%
Delayed	-3.5%	-2.3%	-4.0%

a). Generation X. Expected Damages. NICE Asset Allocation.

Pathway	Remind	GCAM	Message
Current Policies	-3.1%	-2.3%	-2.6%
Below 2C	-5.7%	-7.2%	-4.5%
Net Zero 2050	-11.5%	-8.6%	-8.5%
Delayed	-15.2%	-11.1%	-17.7%

b). Millennial. Expected Damages. NICE Asset Allocation.

Pathway	Remind	GCAM	Message
Current Policies	-4.9%	-3.6%	-4.2%
Below 2C	-5.2%	-10.5%	-4.9%
Net Zero 2050	-6.9%	-11.9%	-5.1%
Delayed	-11.6%	-21.2%	-19.4%

c). Generation Z. Expected Damages. NICE Asset Allocation.

Source: Author's Own Calcs

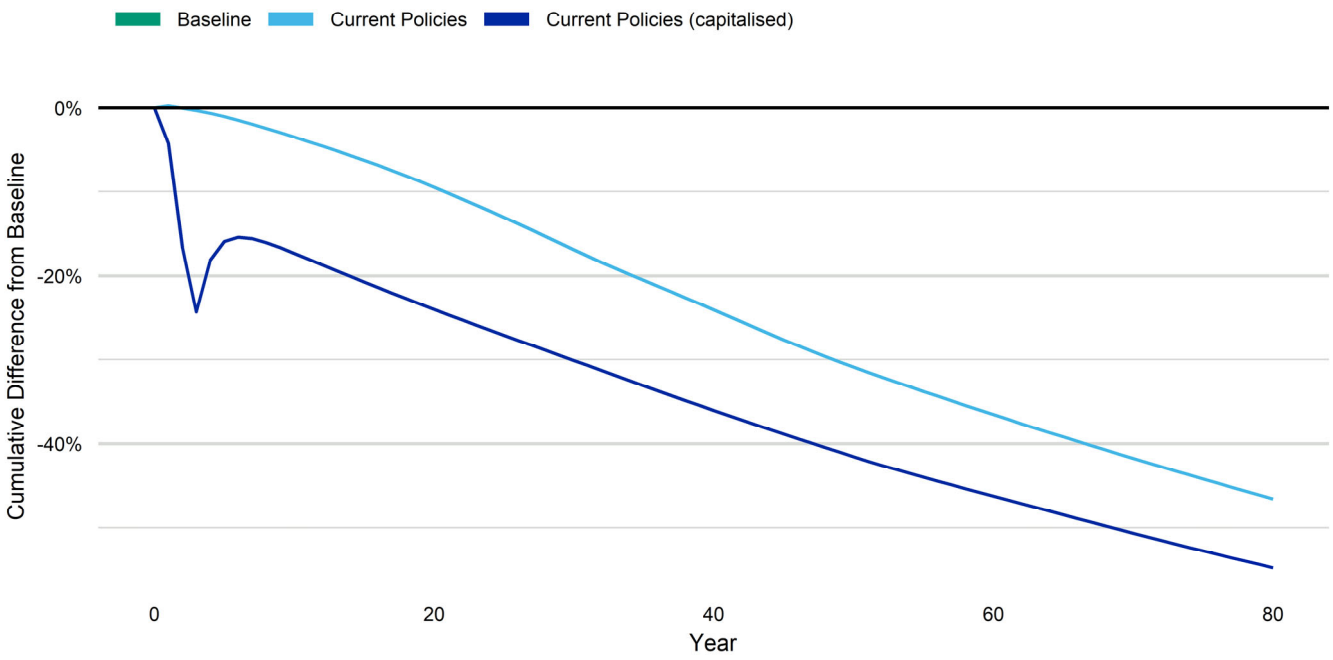
Short term scenarios

Capitalizing changes in expectations

Long term drag on returns can be brought forward by capitalisation.

Climate scenarios are often considered as slow-onset, long-term effects, which exert a drag on growth and returns over decades, but short-term scenarios are also possible to create.

- Simulate a “Minsky moment” via a change in expectations and pricing in future losses.
- This is particularly relevant for physical risk and hot house scenarios where direct effects take time to impact the economy



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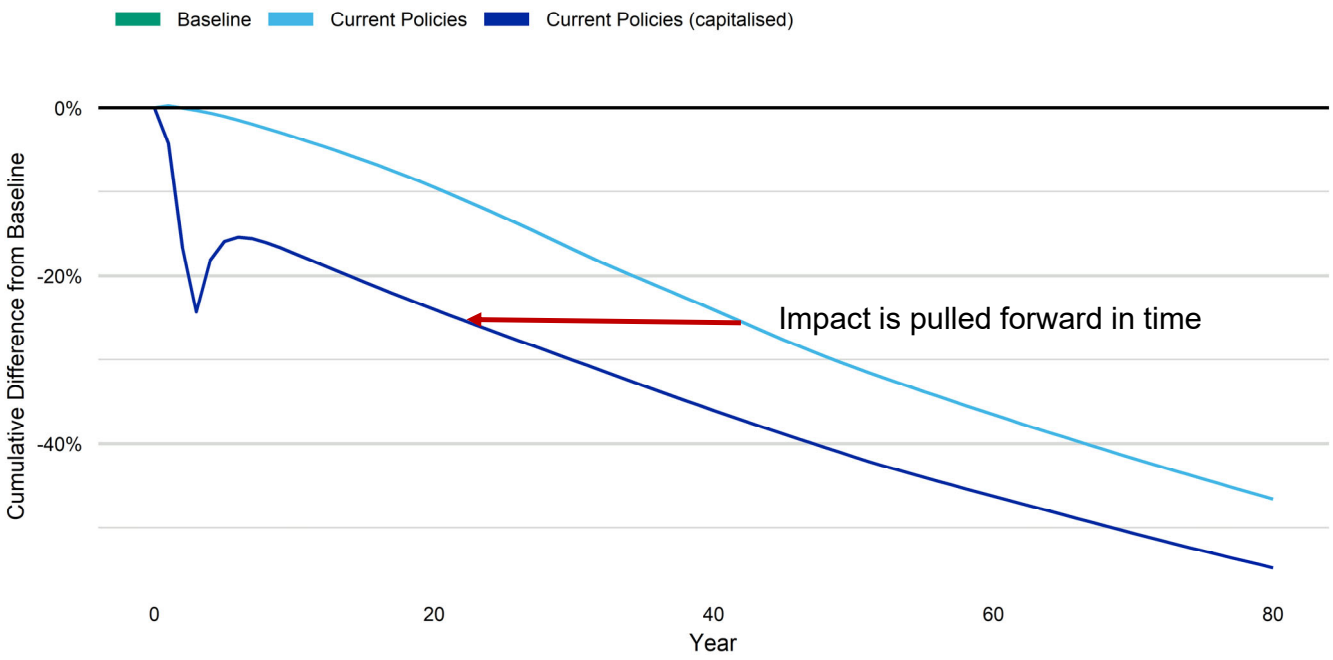

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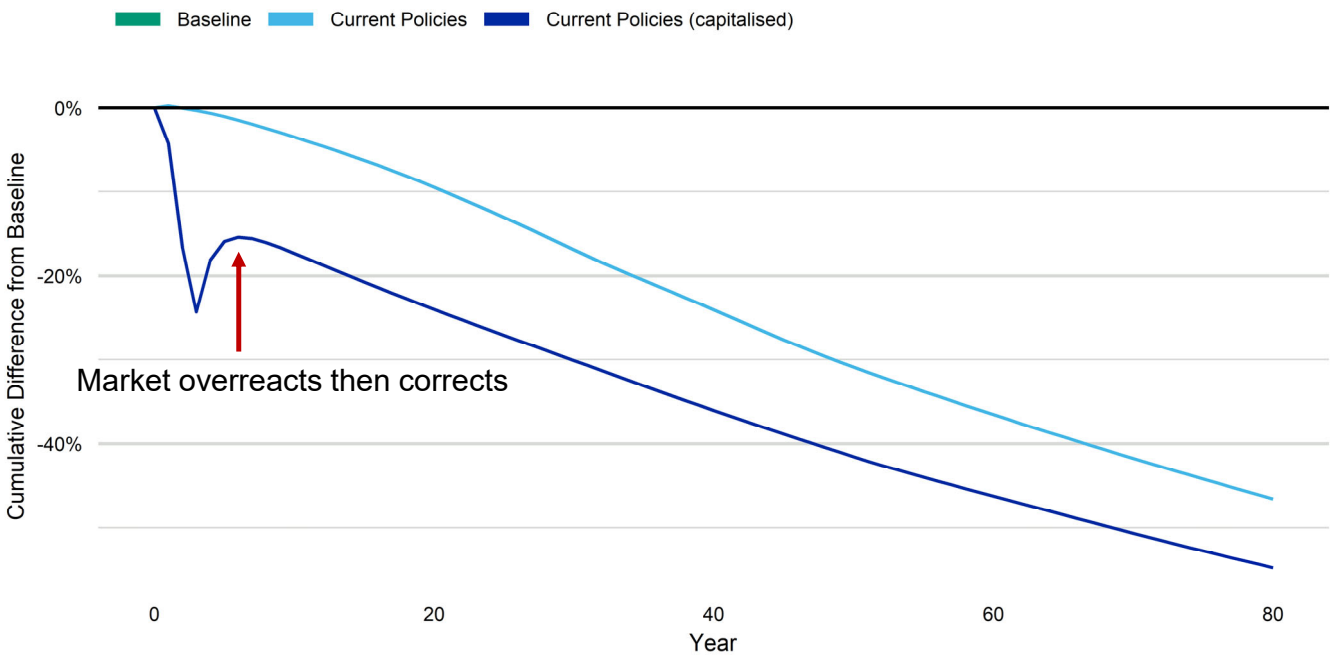
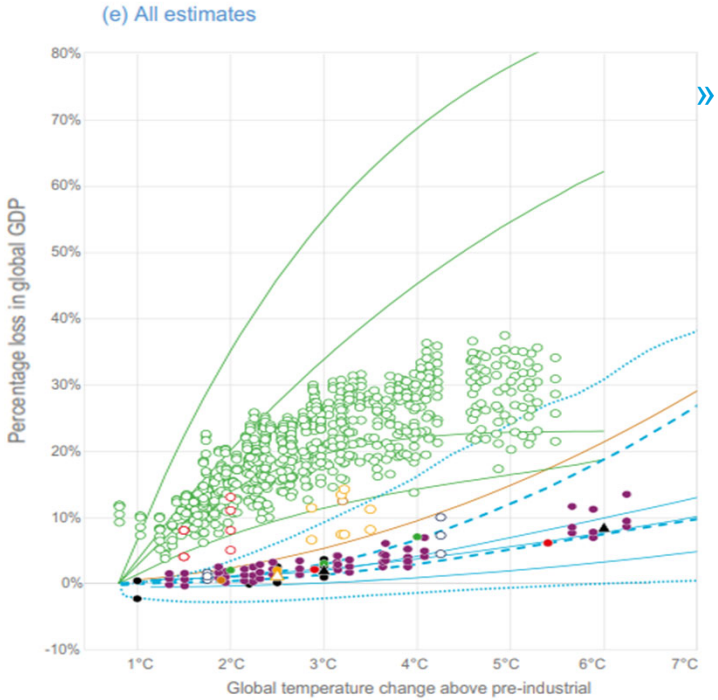


Putting the ‘Climate Risk’ Trade Off Into Context

» Highly uncertain economics….



Source: IPCC, 2022, Cross-Working Group Box ECONOMIC.1

» ……leads to marginal trade offs in global (financial) wealth….

Scenario	Present value of consumption [Trillions of 2019 US international $]	Difference from base
Base	6,266	0.0
C/B optimal	6,373	106.8
T ≤ 2°C	6,349	82.8
Paris, updated 2022	6,342	76.4

Table 6. Total global wealth (present value of consumption), 2019 US$.

Source: Barrage, L., & Nordhaus, W. D. (2023). Policies, Projections and the Social Cost of Carbon: Results from the DICE-2023 Model. *NBER Working Paper Series*.

Code	RKR	Scope
RKR-A	Risk to low-lying coastal socioecological systems	Risks to ecosystem services, people, livelihoods and key infrastructure in low-lying coastal areas and associated with a wide range of hazards, including sea level change, ocean warming and acidification, weather extremes (storms, cyclones) and sea ice loss, for example
RKR-B	Risk to terrestrial and ocean ecosystems	Transformation of terrestrial and ocean/coastal ecosystems, including change in structure and/or functioning and/or loss of biodiversity
RKR-C	Risks associated with critical physical infrastructure, networks and services	Systemic risks due to extreme events leading to the breakdown of physical infrastructure and networks providing critical goods and services
RKR-D	Risk to living standards	Economic impacts across scales, including impacts on GDP, poverty and livelihoods, as well as the exacerbating effects of impacts on socioeconomic inequality between and within countries
RKR-E	Risk to human health	Human mortality and morbidity, including heat-related impacts and vector-borne and water-borne diseases
RKR-F	Risk to food security	Food insecurity and the breakdown of food systems due to climate change effects on land or ocean resources
RKR-G	Risk to water security	Risk from water-related hazards (floods and droughts) and water quality deterioration; focus on water scarcity, water-related disasters and risk to Indigenous and traditional cultures and ways of life
RKR-H	Risks to peace and to human mobility	Risks to peace within and among societies from armed conflict as well as risks to low-agency human mobility within and across state borders, including the potential for involuntarily immobile populations

Source: IPCC, 2022, Table TS.AII.1

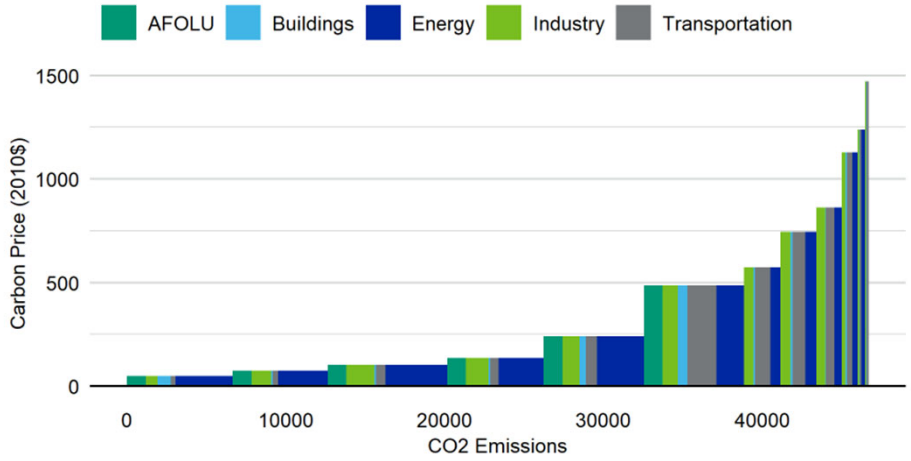
» ……at significant ecological and socio-economic cost.

The Stairway to Net Zero

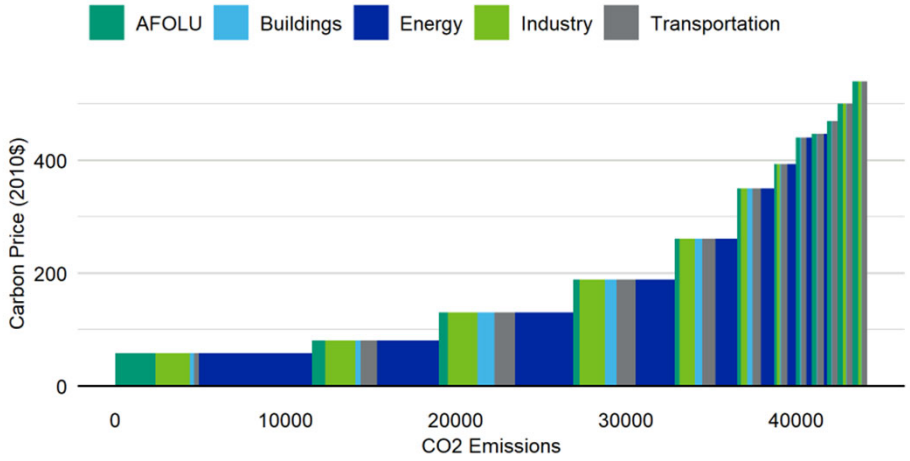
Communicating What Needs to Be Done

- Marginal abatement cost curves can illustrate what needs to be done across the whole economy to achieve net zero
- The stairway to net zero is a series of 5 year timesteps – each requiring a certain level of emission cuts and investment
- Some sectors can decarbonise earlier than others. IAMs/scenarios can differ significantly on sectoral impacts and energy mix

World, Net Zero 2050 Scenario



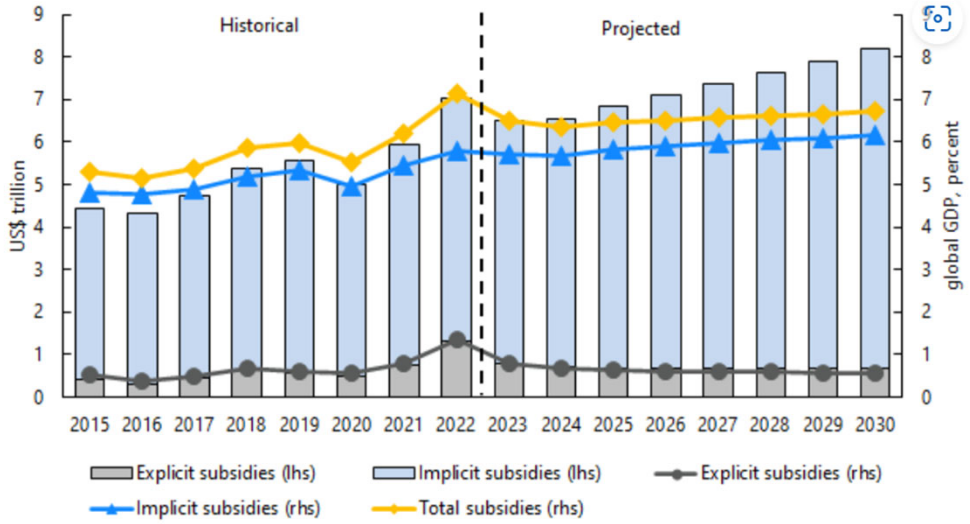
GCAM 5.3



REMIND-MAgPIE 3.0-4.4

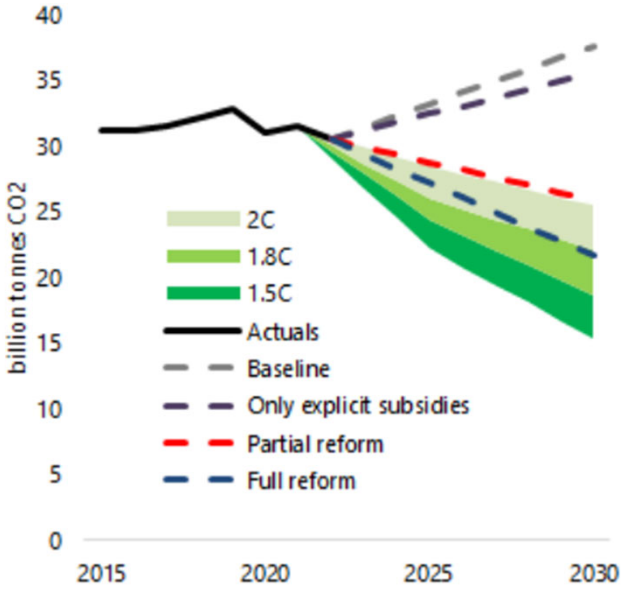
See McKinsey *Pathways to A Low Carbon Economy* and Goldman Sachs *Carbonomics* for similar bottom-up abatement curves split by sector and technology

Subsidies and Policies Will Drive Outcomes



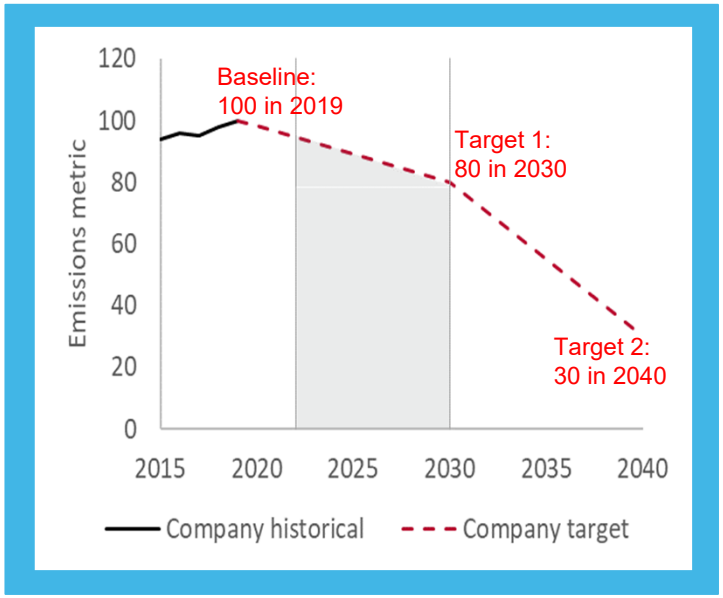
- The key drivers of outcomes will be future subsidies and polices
- A key focus for finance/investments is keeping aligned with those changes/pathways

Source: https://www.imf.org/en/Topics/climate-change/energy-subsidies



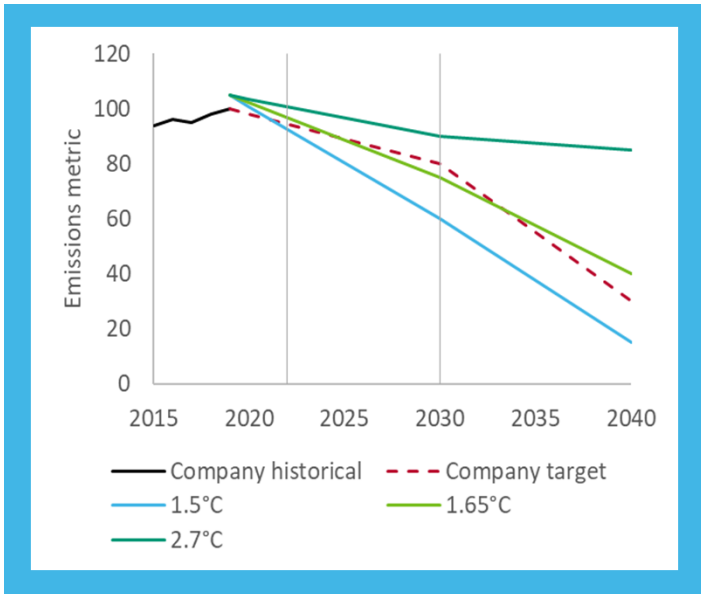
Temperature Alignment Data & Methodologies

Company targeted emissions are quantified over the period 2022-2030…



- Hypothetical company target has a base year of 2019
- Emissions projected from this point assuming target is met
- Cumulative emissions metric calculated

… and compared to IEA* temperature rise benchmarks, to understand level of near-term ambition.



- Aggregate emissions fall between 1.65°C and 2.7°C benchmarks
- Company implied temperature rise of 1.8°C via interpolation

*International Energy Agency

Source: Moody's Temperature Alignment Data

Conclusions

- Clear alignment/similarities in approach being taken in finance
  - Strong focus on downsides, for ‘burning embers’ cf ‘climate risk’
  - Significant and growing use of climate scenarios/models in finance – based on ‘the science’
- Economic/Financial climate impacts are significant but highly uncertain
  - Uncertainties in fundamental climate science (climate sensitivities, geospatial impacts) are significant, but small compared to broader socio-economic uncertainty
  - Can lead to ‘factionalisation’ - difficulty building mainstream consensus around uncertain exposures/controversial impact analysis
  - Significance of financial/economic trade-off is often overstated
- Growing Focus on Solutions
  - Firm and portfolio alignment metrics cf ‘Green Shoots/Safe Landings’
- Speed of transition will ultimately be driven by policies & subsidies