Comment

Supplementary information to:

Why coalitions of wealthy nations should fund others to decarbonize

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Supplementary Information:

Why coalitions of wealthy nations should fund others to decarbonize

Climate Financing Paris-Aligned Conditional Nationally Determined Contributions (NDCs)

By Patrick Bolton, Ottmar Edenhofer, Alissa Kleinnijenhuis, Johan Rockström & Jeromin Zettelmeyer[1]

(Nature, March 2025)

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A1. Cost of Climate Finance and Economic Returns

In the Figure (entitled “Benefits of a Climate Finance Club”) of the main body of “Why Coalitions of Wealthy Nations Should Fund Others to Decarbonize” (Nature, March 2025), we report the climate finance fiscal costs, benefits and economic returns to an HIC financier coalition (i.e., the G7+EU (excl. USA), Norway, Switzerland, Australia, and South Korea) of providing grant-equivalent climate finance at scale – of $124bn a year – to developing countries (UNFCCC 1992 non-Annex I; excl. South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei, Darussalam and Kuwait). Here we show this Figure again, in form comparable with variations of this Figure that will follow in Supplementary Materials A2.

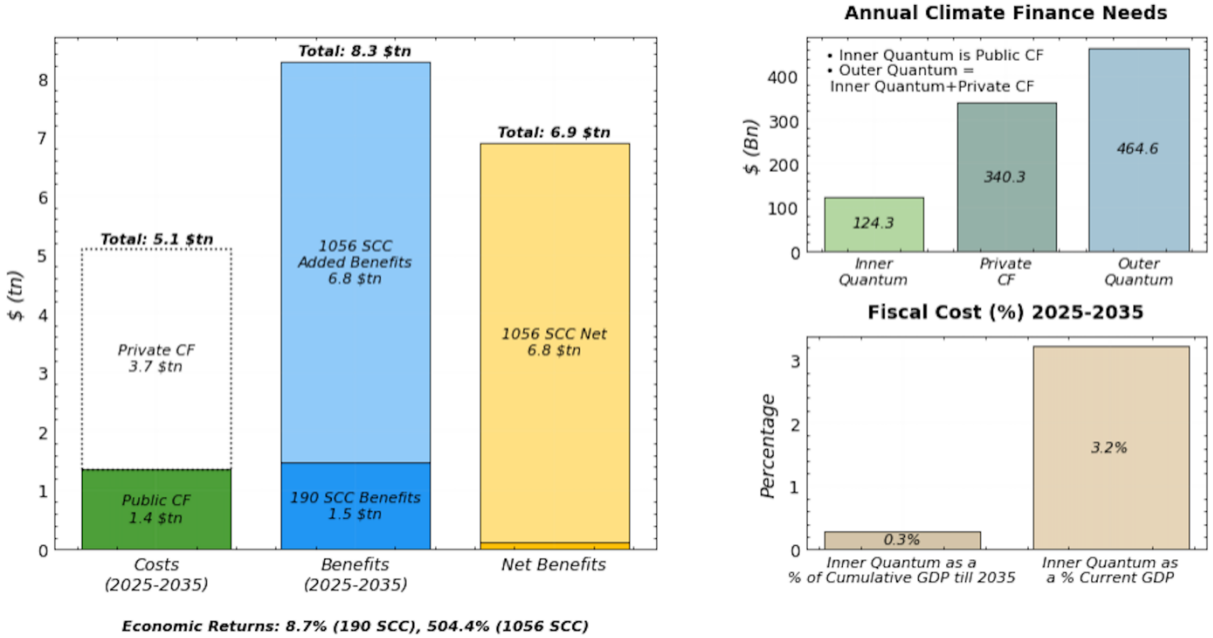


Figure note: Climate finance provided by a financier coalition (G7+EU (excl. USA), plus Norway, Switzerland, Australia, South Korea) to developing countries (i.e., UNFCCC 1992 non-Annex I, Developing Countries) excluding China and petroleum rich countries (i.e., South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei Darussalam and Kuwait) to implement their 1.5°C-Aligned NDCs. *This is the same figure as the main body figure entitled "Benefits of a Climate Finance Club," but now made comparable in form with the variations that will follow in Supplementary Materials A2.* The left plot shows total costs, benefits, and net benefits to financier to recipient countries. Total costs are broken down by the "inner quantum" of the provision public climate finance and an "outer quantum" that includes mobilized private finance. Total costs consist of: (i) the opportunity costs of phasing out fossil fuels; and (ii) and investment costs phasing in replacement renewables (i.e., including energy storage and grid extension). We assume that public climate finance (offered in grant-equivalent form) must cover 25 percent of the investment costs in renewables to be able to crowd the remaining 75 percent from private finance (via blended finance). A 100 percent of the opportunity costs of fossil fuels must be paid for with public climate finance (offered in the form of grants), as it does not generate a revenue stream and alternatives are not reliable. The benefits to financier countries (representing the avoided climate adaptation costs and avoided loss and damages to financier countries) are given by the multiplication of the recipients' emission reduction resulting from providing and mobilizing climate finance times the financiers' collective social cost of carbon (SSC). The share of the global SCC of financier countries is 21 percent (Ricke et al. (2018)). While the global SCC is uncertain, we take two estimates of the global SCC that represent a together a reasonable range: $190/tCO2 (Biden Administration Estimate; based on Rennert et al. (2022)) and $1056/tCO2 (just below the $1065/tCO2 estimate of Bilal & Känzig (2024)). The economic return on the climate finance investment by financier countries into recipient countries is given by the difference of financier countries' benefits (over 2025–2035) minus their public climate finance costs (over 2025–2035) expressed relative to their public climate finance costs (over 2025–2035). For a global SCC of $190/tCO2 the economic return to financier countries on the climate finance investment is 8.7% percent. For a global SCC of $1056/tCO2 their economic return is 504.4% percent. It is thus in the economic interest of the financier coalition to offer an "inner quantum" of public climate finance at scale – i.e., $124.3 billion annually ($1.4 trillion in total over 2025–2035) – to the developing country recipients. Right top plot shows the same cost as the left plot but

now expressed in annual terms. The right plot splits annual climate finance into the annual "inner quantum" of public climate finance (offered in grant-equivalent terms), the annual quantum of mobilized private finance, and the "outer quantum" of annual provided public climate finance and mobilized private climate finance. The bottom left plot shows the fiscal affordability to financier countries. The left bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of the financier countries' 2025–2035 cumulative GDP. The right bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of financier countries 2024 GDP. The latter estimates by how much sovereign debt of financier countries would rise as a percentage of their GDP if they would pay for the 2025–2035 climate finance fully at the beginning, in 2024, by issuing sovereign debt. The former expresses what the climate finance costs are to financier countries as a percentage of their GDP on an annual basis. It is not only in the economic interest of financier coalition countries to offer climate finance at scale to developing recipient countries, but also fiscally affordable; as financiers spend no more than 0.*3* percent of their annual GDP.

In Supplementary Table 1, we break down the fiscal costs to the HIC financier coalition of $124bn a year (2025-2035) – amounting to 0.3% of their annual GDP – into the annual grant-equivalent climate finance contribution that each HIC financier country must offer. The second column lists the 1992 United Nations Framework Convention on Climate Change (UNFCCC) development status of each HIC, as the baseline for who is expected to take the lead in providing climate finance and who are the recipients of climate finance up to today (both under the Paris Agreement (2015) and the COP29 New Common Quantified Goal of Climate Finance agreement (2024)).[2] The third column lists whether a country belongs to the G7 or EU. Column 6 shows what the annual climate finance contribution must be of each HIC financier country, assuming an "equal burden sharing agreement" where the total climate finance cost of $124 bn a year is shared among HIC financier countries in proportion to their GDP. Column 7 reports the climate finance multiplier, showing by what factor each HIC financier country's climate finance contribution must increase under the $124bn/y equal burden sharing agreement relative to their 2019-2020 reported annual climate finance contribution to developing countries (according to the Oxfam Shadow Climate Finance Report (2023)), reported in column 9. For the case of Europe and the USA we use more recent reported climate finance contributions, as shown in column 8. In column 10 (the last column), we list what percentage of each HIC country's 2019-2020 reported climate finance contribution was provided in grant-equivalent terms, when this information is publicly available.

We find in column 7 that for most HIC financier countries their annual climate finance contribution does not need to increase by more than a factor of 2. For instance, the European Union must increase its climate finance to $61bn/y from around $30bn/y today. There are also HIC countries whose climate finance contributions (under the $100bn/y goal agreed at COP15 2009 to be met by 2020) have been paltry relative to their GDP, and thus must increase their contributions under an equal burden sharing agreement to a greater extent, including Canada, Switzerland, and the United Kingdom. HIC countries with a low percentage of grant-equivalent climate finance will have to multiply their climate finance to a greater extent in grant-equivalent terms than our multiplier

[2] Throughout the main body and Supplementary Information, we interchangeably use HICs and developed countries (UNFCCC 1992 Annex II). We also interchangeably use LMICs and developing countries (UNFCCC 1992 non-Annex I). We often write HICs and LMICs for simplicity of exposition, but we are referring here to the UNFCCC 1992 classification of what counts as a developed and developing country, since the 1992 UNFCCC classification is the basis of the Paris Agreement (2015) and later climate finance negotiations.

reflects, as we use as the base of the multiplier the reported climate finance, irrespective of grant-equivalent amount.

For comparison, in column 4 we report the fiscal cost to the HIC financier coalition had the United States also contributed. In that case, the fiscal cost to the financier coalition would have been 0.2% of GDP (rather than 0.3% of GDP), and individual HIC contributions (under an equal burden sharing agreement) would have been slightly lower. The HIC coalition (i.e., the G7+EU (incl. USA), Norway, Switzerland, Australia, and South Korea) fiscal cost of column 4 corresponds to Supplementary Figure 2 (to be discussed). Supplementary Figure 2 is a variation of the cost-benefit analysis in Figure 1 in the main body, which includes the United States as financier.

In sum, Supplementary Table 1 gives a detailed recommendation of how much grant-equivalent climate finance each HIC in the financier coalition must provide to developing countries (excl. China and petroleum rich states) to finance their 1.5°C-aligned decarbonization of the power sector. The estimated climate finance amounts here (and throughout the Supplementary Information) provide a floor: LMICs need decarbonization beyond the power sector, and may also need climate finance for adaptation and loss and damage.

To decarbonize their power sector, recipient countries of grant-equivalent climate finance must both be able to cover the cost of the *phase-out pipelin*e and the cost of the *phase-in pipeline*. The phase-in pipeline costs consist of the investment cost in renewables (and complementary energy storage technologies plus grid extension) and the phase-out pipeline costs consist of the opportunity costs of renouncing fossil fuels. The opportunity costs consist of the stranded asset value (expected discounted missed free cash flows from early closure) and any compensation of workers that lose their jobs and must be retrained. See Supplementary Table 4 (to be discussed).

The provided grant-equivalent climate finance can serve for the phase-in pipeline as catalytic capital to crowd in private finance (e.g., through blended finance). We assume that the HIC coalition covers 25% of the phase-in pipeline costs of recipients and is able to attract the remaining 75% from private sector finance. We assume that the HIC coalition must cover a 100% of the opportunity costs of closing fossil fuel operations early.[3] Since closing fossil fuel operations early does not generate a revenue stream, the private sector cannot be attracted to co-finance it. So grants must cover early closure costs.. Paying the polluter to stop polluting is sound economic logic if it makes the financier economically better off (Coase (1960)), as Figure 1 in the main body shows. Alternatively, carbon credits (under Article 6 of the Paris Agreement) could be used to pay for *early fossil fuel closure* –

[3] To the extent LMIC recipients can afford it and it is net beneficial to them (in terms of lower climate damages and adaptation costs, as well as air pollution, amongst others), they can pay part of the total costs.

which is *essential* to stay within the 1.5°C 50% carbon budget – but this is less foolproof in reducing emissions in absolute terms (needed to lower climate risks), as it is at best additional (offsetting a positive emission that would not otherwise be offset).

Supplementary Table 1. Climate Finance Contribution of Individual Financier Coalition Members (i.e., G7+EU, plus Norway, Switzerland, Australia, South Korea, excl. USA) to meet Climate Finance Mitigation needs ($124 Bn/y) of Developing Countries (excl. China, petroleum rich countries) to Implement 1.5°C-Aligned NDCs.

Table notes: A logical and simple way to form a "burden sharing agreement" among financier coalition countries to meet climate finance mitigation needs of developing country recipients (excl. China, petroleum rich countries) to implement 1.5°C-aligned NDCs is to require each financier country to contribute proportionally to their GDP (relative to the financier coalition's total GDP), as we do here.

			Contribution Breakdown by GDP for Developed Financiers to meet $ 124 Bn Goal [4] *(Financing Instrument: Grant Equivalent Climate Finance)*						
			EU + G7 + Norway + Switzerland + Australia + South Korea *(Fiscal Cost 0.2%)*		**EU + G7 + Norway + Switzerland + Australia + South Korea excl. USA** *(Fiscal Cost 0.3%)*		**Contribution (2023) ($ Bn)**	**Reported Climate Finance as per Oxfam Climate Finance Shadow Report 2023[6]**	
Financier	**UNFCCC 1992[5]**	**EU / G7**	**Required Annual Contribution ($ Bn)**	**Scaling Need: Multiplier**	**Required Annual Contribution ($ Bn)**	**Scaling Need: Multiplier**		**Annual Average Contribution (2019-2020) ($ Bn)**	**Grant Equiv. Clim. Fin.%**
Australia	DF		3.56		6.53			NA	
Canada	DF	G7	4.42	14.5	8.10	26.6		0.31	34%
Iceland	DF		NA		NA			NA	
Japan	DF	G7	8.70	1.0	15.95	1.8		8.81	9%
New Zealand	DF		NA		NA			NA	
Norway	DF		1.00	1.9	1.84	3.4		0.54	88%

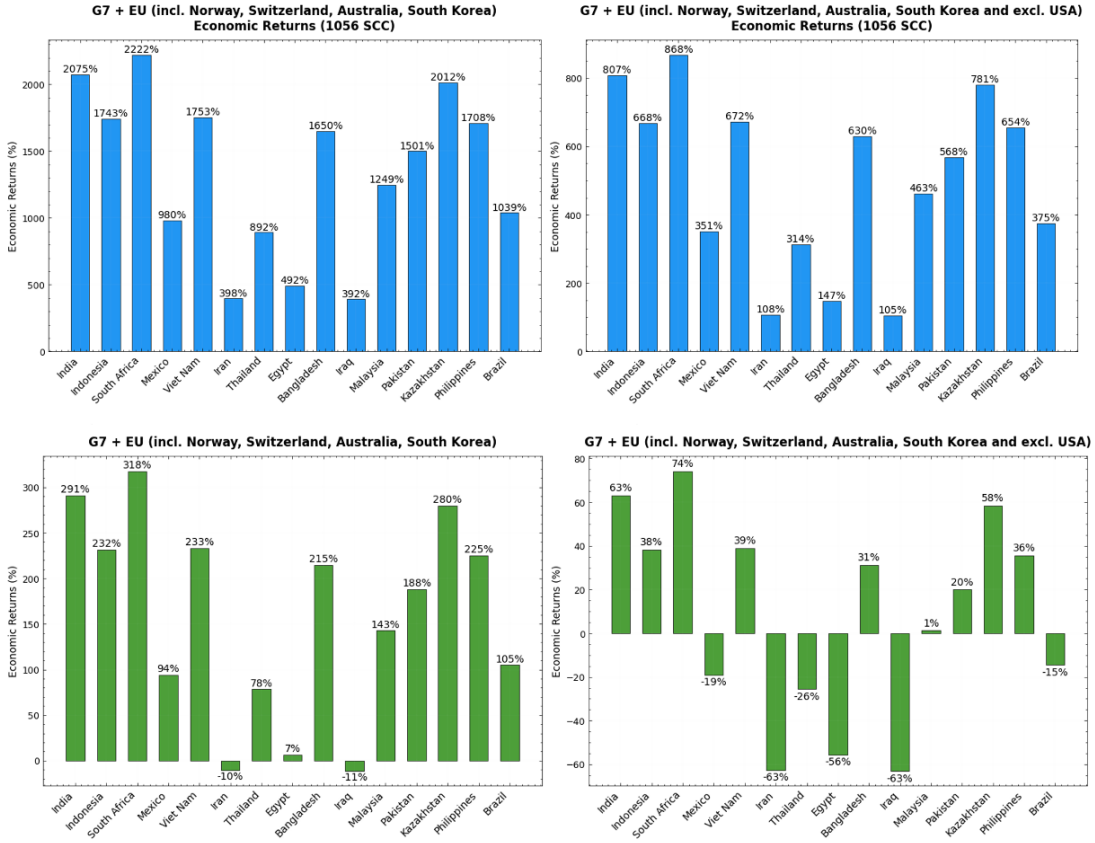
[4] The annual public climate finance mitigation need of developing recipients except for China and the petroleum countries to implement 1.5°C-Aligned NDCs is $ 124.3 Bn (see Figure 1).
[5] DF – Developed Financiers (i.e., UNFCCC 1992 Annex II, Developed Countries), EIT – Developed Economies In Transition (i.e., UNFCCC 1992 EIT, Developing Countries), DR – Developing Recipients (i.e., UNFCCC 1992 non-Annex I, Developing Countries).
[6] Oxfam Climate Finance Shadow Report 2023 Annex 1, Table A1.

Switzerland	DF		1.83	8.2	3.35	15.1		0.22	100%
United Kingdom of Great Britain and Northern Ireland	DF	G7	6.90	6.0	12.65	11.1		1.14	77%
United States of America	DF	G7	56.51	5.9	NA		9.5[7]	1.56	48%
Republic of Korea	DR		3.54		6.49			NA	
Other Developed Countries[8]						0.0		0.32	81%
EU Financiers	DF		33.13	1.2	60.75	2.1	28.6[9]	2.89	
Austria	DF	EU	1.07	5.6	1.95	10.3		0.19	29%
Belgium	DF	EU	1.31		2.39			NA	
Denmark	DF	EU	0.83	5.6	1.53	10.2		0.15	100%
Finland	DF	EU	0.62		1.14			NA	
France	DF	EU, G7	6.26	1.1	11.48	2.0		5.83	7%
Germany	DF	EU, G7	9.20	1.3	16.87	2.3		7.19	50%
Greece	DF	EU	0.49		0.90			NA	
Ireland	DF	EU	1.13		2.07			NA	
Italy	DF	EU, G7	4.66	16.9	8.54	31.1		0.27	70%
Luxembourg	DF	EU	0.18		0.32			NA	
Netherlands	DF	EU	2.31	5.0	4.23	9.2		0.46	100%
Portugal	DF	EU	0.59		1.09			NA	
Spain	DF	EU	3.26	7.6	5.99	13.9		0.43	12%
Sweden	DF	EU	1.23	2.5	2.25	4.5		0.49	99%

[7] Projections of 2023 climate finance reported in US Department of State, Progress Report on President Biden's Climate Finance Pledge.
[8] This is mentioned in the Oxfam Report however, not clearly defined what countries are part of this group.
[9] Europe's contribution to climate finance (in €bn) states 28.6 € Bn converted to USD using an exchange rate of 1.04 USD.

Poland	EIT	EU	1.68		3.07				
Romania	EIT	EU	0.72		1.33				
Czech Republic	EIT	EU	0.68		1.25				
Hungary	EIT	EU	0.44		0.80				
Slovakia	EIT	EU	0.27		0.50				
Bulgaria	EIT	EU	0.21		0.38				
Croatia	EIT	EU	0.17		0.31				
Lithuania	EIT	EU	0.16		0.29				
Slovenia	EIT	EU	0.14		0.26				
Latvia	EIT	EU	0.09		0.17				
Estonia	EIT	EU	0.08		0.15				
Cyprus		EU	0.07		0.12				
Total Contri-bution			**124.3**		**124.3**				

In the main body of Figure 1, we report the climate finance costs, benefits and economic return to the financier coalition from covering the decarbonization cost of the power sector of *all* developing countries (excl. China and petroleum rich states). In Supplementary Figure 1 below, we consider the case where the HIC financier coalition provides climate finance to *individual* LMICs that submit credible 1.5°C-aligned decarbonization plans. We observe that the economic return to the HIC coalition of providing climate finance to each of the largest 15 LMICs is always large and positive (typically far exceeding 100% and sometimes even 1000% for the higher end estimate of the global SCC of \$1056/tCO_2). We also observe that for the lower end estimate of the SCC (\$190/tCO_2), the economic return is sometimes negative if the US does not contribute. This is particularly so for the LMICs whose current power sector energy mix is heavily reliant on natural gas (Mexico, Egypt, Iraq and Iran) rather than coal. The economic return on paying for coal-phase outs is typically higher because more emissions are avoided per unit of energy supply.



Supplementary Figure 1: Economic Return to Financier Coalition (i.e., G7+EU, plus Norway, Switzerland, Australia, South Korea, excl. USA) of Providing Climate Finance to meet Mitigation Needs to Implement 1.5°C-Aligned NDCs of individual Top 15 Developing Countries by Emissions

Figure notes: The economic return (%) is defined as: ([economic benefits (F)] – [public climate finance costs (F→R)]) / [public climate finance costs (F→R)]x100, where F is the financier coalition and R is the recipient. Left plots: incl. US; right plots: excl. US; top plots: $1056/tCO2 global SCC; bottom plots: $190/tCO2 global SCC.

In Supplementary Table 2, we report the annual climate finance costs to the HIC coalition to decarbonize the top-15 individual developing countries by power sector emissions (excl. China and petroleum states) over 2025-2035. We break down the annual climate finance cost by what the public sector must cover ("Annual Inner Quantum of Public Climate Finance") and what the crowded-in private sector can cover ("Annual Climate Finance"). We again assume that HICs cover 25% of investment costs in renewables (and complementary technologies) and 100% of fossil fuel early closure costs. The fiscal cost to the HIC coalition (irrespective of whether the US contributes) is very small as a percentage of their 2024 GDP (and even smaller as a percentage of their annual GDP over 2025-2035). Financing decarbonization of individual LMICs (and LMICs as a whole; see Supplementary Table 1) is thus fiscally affordable to HICs, and gives them a large economic return (see Supplementary Figure 1).

Supplementary Table 2: Climate Finance and Fiscal Costs to Financier Coalition (i.e., G7+EU, plus Norway, Switzerland, Australia, South Korea, excl. USA) of Providing Climate Finance to meet Mitigation Needs to Implement 1.5°C-Aligned NDCs for individual Top 15 Developing Countries by Emissions

	Climate Finance Costs		**Fiscal Costs in %** *(Annual Inner Quantum / 2024 GDP of Financier Group) * 100*	
Country	Annual Inner Quantum of Public Climate Finance ($Bn)	Annual Private Climate Finance ($Bn)	G7 + EU (incl. Norway, Switzerland, Australia, South Korea)	G7 + EU (incl. Norway, Switzerland, Australia, South Korea and excl. USA)
India	27.7	76.0	0.04%	0.07%
Indonesia	8.2	23.1	0.01%	0.02%
South Africa	5.3	14.5	0.01%	0.01%
Mexico	6.0	16.2	0.01%	0.01%
Viet Nam	5.5	15.1	0.01%	0.01%
Iran	9.9	27.9	0.01%	0.02%
Thailand	4.5	13.1	0.01%	0.01%
Egypt	9.2	27.6	0.01%	0.02%
Bangladesh	3.2	78.0	0.00%	0.01%
Iraq	7.4	20.3	0.01%	0.02%

Malaysia	3.4	9.4	0.00%	0.01%
Pakistan	2.0	5.2	0.00%	0.00%
Kazakhstan	1.8	5.1	0.00%	0.00%
Philippines	1.8	4.7	0.00%	0.00%
Brazil	4.9	10.5	0.01%	0.01%

In Supplementary Table 3, we break down the total climate finance costs over 2025-2035 to decarbonize LMICs (excl. China and petroleum rich states), as well as the annual climate finance costs, and their annual public sector and private sector split – all displayed in main body Figure 1 – into these amounts for the individual LMICs. Supplementary Table 3 provides a foundation for the coalition of HIC financiers to determine how much climate finance LMICs need (as a floor) for 1.5°C-aligned decarbonization. Supplementary Table 3 also provides a foundation for developing countries to cost their 1.5°C-aligned decarbonization plans. It can inform their *conditional* nationally determined contributions (NDCs), which are the Paris pledges that developed countries pledge to execute *contingent* on receiving external climate finance (from HICs).

Supplementary Table 3: Climate finance Needs of each Developing Country (UNFCCC 1992 non-Annex I), excl. China and petroleum rich countries, to Implement 1.5°C-Aligned NDCs over 2025-2035, and Annual and Public-Private Sector Breakdown

Table notes: The third row presents the empirical estimates of the climate finance (CF) needs of each Developing Country (UNFCCC 1992 non-Annex I), excl. China and petroleum rich countries (i.e., South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei Darussalam and Kuwait), to implement 1.5°C-Aligned NDCs over 2025-2035. The fourth row breaks down the total climate finance need 2025-2035 (of row 3) into the annual climate finance need; this is also referred to as the "outer quantum" of the total annual climate finance need for each country. The fifth and sixth row breaks down the annual climate finance need (of row 4) into the part that the public sector pays and the part the private sector pays. We refer to the annual public climate finance provision as the "inner quantum." The inner quantum of public climate finance must be met as *grant-equivalent climate finance*. The inner quantum of public climate finance must cover a 100% of the opportunity costs of phasing out fossil fuels (see Appendix Table 2 for more details) and cover sufficiently much of the costs of phasing in renewables and supporting energy storage and grid technologies that it can attract private finance to pay the remainder. We assume the public sector pays 25% of the renewable investment costs and can attract covering the remaining 75% of the investment costs from the private sector. Illustratively, of the total "outer quantum" annual climate finance need of $464.6 Bn, 25% of investment costs and 100% of opportunity costs equals the annual "inner quantum" public climate finance need of $124.3 Bn, and 75% of investment costs equals the annual private climate finance need of $340.3 Bn.

	Country	**Total CF Need ($ Bn) (2024-2035)**	**Annual CF Need ($ Bn) (Outer Quantum)**	**Annual Public CF Need ($ Bn) (Inner Quantum)**	**Annual Private CF Need ($ Bn)**

	Developing Recipients excl. China & Petroleum rich countries	**5110.794**	**464.618**	**124.310**	**340.307**
1	India	1141.254	103.750	27.690	76.060
2	Iran	416.406	37.855	9.924	27.931
3	Egypt	404.967	36.815	9.231	27.585
4	Indonesia	344.055	31.278	8.184	23.094
5	Iraq	305.303	27.755	7.419	20.335
6	Mexico	244.692	22.245	6.031	16.214
7	Viet Nam	226.342	20.577	5.521	15.055
8	South Africa	217.984	19.817	5.313	14.504
9	Thailand	194.155	17.650	4.530	13.120
10	Brazil	169.050	15.368	4.907	10.462
11	Malaysia	140.565	12.779	3.352	9.427
12	Bangladesh	122.600	11.145	3.195	7.951
13	Nigeria	79.428	7.221	1.848	5.372
14	Pakistan	78.507	7.137	1.975	5.162
15	Algeria	76.662	6.969	1.773	5.197
16	Kazakhstan	75.961	6.906	1.803	5.103
17	Argentina	72.688	6.608	1.687	4.921
18	Philippines	71.120	6.465	1.803	4.663
19	Syrian Arab Republic	54.216	4.929	1.329	3.600
20	Uzbekistan	49.407	4.492	1.201	3.291
21	Ghana	43.228	3.930	0.992	2.938
22	Morocco	42.551	3.868	0.989	2.880
23	Chile	41.461	3.769	1.016	2.753
24	Turkmenistan	41.081	3.735	0.977	2.757
25	Israel	38.893	3.536	0.944	2.591
26	Colombia	30.619	2.784	0.767	2.017
27	Libya	27.830	2.530	0.681	1.849
28	Azerbaijan	25.284	2.299	0.606	1.692
29	Oman	25.134	2.285	0.631	1.654
30	Peru	21.281	1.935	0.500	1.434
31	Serbia	19.491	1.772	0.464	1.308

32	Venezuela, Bolivarian Republic of	19.485	1.771	0.519	1.252
33	Singapore	17.458	1.587	0.447	1.140
34	Dominican Republic	15.293	1.390	0.390	1.001
35	Tunisia	15.159	1.378	0.353	1.025
36	Lebanon	13.062	1.187	0.340	0.847
37	Zimbabwe	11.242	1.022	0.352	0.670
38	Jordan	10.272	0.934	0.267	0.667
39	Yemen	10.105	0.919	0.247	0.671
40	South Sudan	9.378	0.853	0.261	0.592
41	Democratic People's Republic of Korea	8.929	0.812	0.211	0.601
42	Trinidad and Tobago	7.888	0.717	0.200	0.517
43	Bosnia and Herzegovina	7.601	0.691	0.188	0.503
44	Sri Lanka	7.275	0.661	0.191	0.471
45	Lao People's Democratic Republic	7.206	0.655	0.187	0.468
46	Myanmar	6.714	0.610	0.229	0.381
47	Cambodia	6.217	0.565	0.163	0.402
48	El Salvador	6.142	0.558	0.144	0.415
49	Cuba	5.948	0.541	0.144	0.396
50	United Republic of Tanzania	5.736	0.521	0.131	0.391
51	Bolivia (Plurinational State of)	5.232	0.476	0.138	0.338
52	Panama	4.771	0.434	0.120	0.313
53	Honduras	4.613	0.419	0.116	0.303
54	Montenegro	4.308	0.392	0.103	0.289
55	Republic of Moldova	4.048	0.368	0.103	0.265
56	Senegal	3.942	0.358	0.093	0.266
57	Angola	3.805	0.346	0.087	0.259
58	Jamaica	3.644	0.331	0.086	0.245
59	Botswana	3.523	0.320	0.119	0.201
60	Ecuador	3.282	0.298	0.079	0.220
61	Guatemala	3.029	0.275	0.074	0.202
62	Uruguay	2.971	0.270	0.073	0.197

63	Kyrgyzstan	2.889	0.263	0.070	0.193
64	Cameroon	2.419	0.220	0.056	0.164
65	North Macedonia	2.272	0.207	0.058	0.149
66	Mongolia	1.849	0.168	0.067	0.101
67	Zambia	1.830	0.166	0.053	0.114
68	Gabon	1.772	0.161	0.041	0.120
69	Armenia	1.670	0.152	0.044	0.108
70	Georgia	1.555	0.141	0.040	0.101
71	Kenya	1.442	0.131	0.063	0.068
72	Mauritania	1.331	0.121	0.045	0.076
73	Nicaragua	1.190	0.108	0.032	0.077
74	Bahamas	1.060	0.096	0.029	0.067
75	Mauritius	0.744	0.068	0.019	0.048
76	Mozambique	0.716	0.065	0.020	0.045
77	Tajikistan	0.690	0.063	0.020	0.042
78	Madagascar	0.676	0.061	0.021	0.041
79	Mali	0.560	0.051	0.013	0.038
80	Congo	0.512	0.047	0.013	0.033
81	Equatorial Guinea	0.481	0.044	0.014	0.030
82	Burkina Faso	0.460	0.042	0.015	0.026
83	Djibouti	0.440	0.040	0.015	0.025
84	Chad	0.393	0.036	0.013	0.022
85	Sierra Leone	0.388	0.035	0.014	0.022
86	Uganda	0.383	0.035	0.016	0.018
87	Somalia	0.268	0.024	0.008	0.016
88	Niger	0.260	0.024	0.016	0.008
89	Barbados	0.244	0.022	0.007	0.015
90	Papua New Guinea	0.218	0.020	0.005	0.015
91	Antigua and Barbuda	0.207	0.019	0.005	0.014
92	Benin	0.199	0.018	0.005	0.013
93	Seychelles	0.194	0.018	0.006	0.012
94	Afghanistan	0.180	0.016	0.005	0.012
95	Maldives	0.142	0.013	0.003	0.009
96	Suriname	0.127	0.012	0.004	0.008

97	Eritrea	0.116	0.011	0.007	0.003
98	Togo	0.112	0.010	0.003	0.008
99	Rwanda	0.107	0.010	0.003	0.007
100	Costa Rica	0.092	0.008	0.003	0.005
101	Central African Republic	0.061	0.006	0.003	0.003
102	Namibia	0.052	0.005	0.001	0.004

In Supplementary Table 4, we break down the total climate finance needs of LMICs (excl. China and petroleum rich states) over 2025-2035 (for the power sector as a floor) – as shown in the main body of Figure 1 – into its *investment costs* and *opportunity costs* constituents. Of the around $5.1 trillion climate finance need over 2025-2035, the lion share consists of the investment costs in renewables (around $5 trillion), and only $120bn consists of the opportunity costs of closing fossil fuels early. For the renewable investment costs, the majority are the costs to replace fossil fuel energy with renewables and keep up with any growth in energy demand (around $4 trillion), and the remaining $1 trillion are the complementary investment costs in storage capacity (short and long term) and grid extension. For the opportunity costs estimated around $120bn, $83 billion is for compensating workers for lost wages (we assume 5 years of wage compensation at their current levels until they either find a new job or retire), $1.6bn for retraining, and $35.2 billion for compensating fossil fuel owners for their expected discounted missed free cash flows (stranded asset value). Paying for early fossil fuel closure is a bargain given the enormous economic benefits (see main body Figure 1) from avoided emissions it delivers. Renewable addition to meet growing energy demand is not enough: climate finance for renewables must be tied to early phase out of fossil fuel.[10] Compensating for early fossil fuel phase out also helps alleviate political opposition to the green transition.

Supplementary Table 4 also breaks-down the detailed decomposition of investment costs and opportunity costs for LMICs (excl. China and petroleum rich states) into investment costs and opportunity costs for each LMICs. Supplementary Table 4 can be used by both HICs and LMICs to cost climate finance needs (as a floor).

[10] The climate mitigation finance strategy of compensating for early fossil fuel power plants to implement a country's net-zero plan has successfully been executed before in Germany. The German Coal Exit Act (2020) allowed coal power plants to voluntarily exit between 2020 and 2026 and compete in auctions for compensation payments. These plants voluntarily participated because their financial incentives were aligned with the phase-out, as the compensation offered through coal auctions exceeded what they would have earned under a business-as-usual scenario. Simultaneously, the German government also provided subsidies for renewables. Together the coal phase-out auctions, and renewable subsidies enabled Germany to phase-out coal while meeting energy demand through phased-in renewables.

Supplementary Table 4: Climate finance Needs of each Developing Country (UNFCCC 1992 non-Annex I), excl. China and petroleum rich countries, to Implement 1.5°C-Aligned NDCs over 2025-2035, and Breakdown into Investment Costs and Opportunity Costs, and their Subcomponents

Table notes: Column 3 reports the climate finance needs of each developing country (UNFCCC 1992 non-Annex I), excl. China and petroleum rich countries, to implement 1.5°C-Aligned NDCs over 2025-2035, and Breakdown into investment costs (column 4) and opportunity costs (column 10), and their subcomponents. The investment costs consist of the investment costs in: renewables to replace fossil fuels and keep up with any growth in energy demand (column 5), short-term energy storage via li-ion batteries (column 6; in line with Way et al. (2022) we conservatively assume that 20% of daily generated renewable energy must be able to be stored short-term); long-term energy storage via green hydrogen produced with electrolysers (column 7; in line with Way et al. (2022) we conservatively assume that one month worth of annual generated renewable energy must be able to be stored long-term); renewables to power electrolysers so that the hydrogen produced is green (column 8); grid extension (column 9). The opportunity costs consist of the opportunity costs of: fossil fuel owners (column 11; i.e., their expected discounted missed free cash flow from early closure; in other words, their stranded asset value); fossil fuel workers (column 12; i.e., compensation for lost wages for the duration of 5 years); fossil fuel worker retraining for employment elsewhere, particularly in the renewable industry (column 13). Appendix Table 2 relates to Appendix Table 1. By taking a 100% of the opportunity costs and 25% of the investment costs you get the total "inner quantum" public climate finance need over 2025-2035; and by dividing that by the number of years you get the annual "inner quantum" public climate finance need. By taking 75% of the investment costs, you get the total private climate finance need over 2025-2035; and by dividing that by the number of years you get the annual private climate finance need. For 45 countries, estimates are not available due to data limitations. Detailed methodology is presented in Section 9.5 of "The Economic Case for a New Common Quantified Goal of Climate Finance at Scale."

	Country	Total CF Need ($ Bn) (2024-2035)	Renewables Investment Costs ($ Bn) (2024-2035)						Opportunity Costs ($ Bn) (2024-2035)			
			Total RE Invt.	Renewable energy	Short-term storage	Long-term storage	Renewables to power electrolysers	Grid extension	Total OC	Owners	Workers 5 year wages	Workers retraining
	Developing Recipients excl. China & Petroleum rich countries	**5110.794**	**4991.171**	**3950.269**	**547.753**	**72.797**	**73.974**	**346.374**	**119.617**	**35.160**	**82.839**	**1.615**
1	India	1141.254	1115.553	835.864	144.964	19.245	21.953	93.527	25.700	1.061	24.165	0.475
2	Iran	416.406	409.659	365.095	25.174	3.405	0.873	15.111	6.748	2.617	4.050	0.080
3	Egypt	404.967	404.574	344.463	27.601	3.603	12.238	16.668	0.393	0.155	0.233	0.005
4	Indonesia	344.055	338.706	268.173	39.359	5.164	0.746	25.264	5.349	2.255	3.034	0.060
5	Iraq	305.303	298.252	268.333	16.613	2.133	0.000	11.173	7.051	1.767	5.184	0.100
6	Mexico	244.692	237.804	189.833	24.926	3.271	4.731	15.042	6.888	5.550	1.312	0.026
7	Viet Nam	226.342	220.812	166.343	27.593	3.552	5.153	18.170	5.530	0.451	4.981	0.098
8	South Africa	217.984	212.729	158.112	28.464	3.786	3.623	18.743	5.256	0.016	5.138	0.101

9	Thailand	194.155	192.432	160.175	17.355	2.320	2.589	9.994	1.723	0.026	1.664	0.033
10	Brazil	169.050	153.437	115.503	20.436	2.676	2.214	12.608	15.613	12.474	3.078	0.061
11	Malaysia	140.565	138.259	108.714	15.567	2.044	1.716	10.218	2.307	0.953	1.328	0.026
12	Bangladesh	122.600	116.610	82.748	17.642	2.311	2.429	11.481	5.990	0.902	4.991	0.097
13	Nigeria	79.428	78.794	67.058	6.937	0.938	0.075	3.786	0.633	0.036	0.585	0.012
14	Pakistan	78.507	75.705	54.836	11.110	1.539	0.734	7.487	2.802	0.271	2.483	0.048
15	Algeria	76.662	76.218	62.804	6.897	0.904	1.260	4.352	0.443	0.040	0.396	0.008
16	Kazakhstan	75.961	74.842	57.277	8.847	1.178	1.634	5.906	1.119	0.194	0.908	0.018
17	Argentina	72.688	72.171	54.918	9.245	1.198	1.040	5.770	0.517	0.030	0.477	0.009
18	Philippines	71.120	68.390	51.238	8.747	1.406	1.172	5.827	2.730	0.252	2.430	0.047
19	Syrian Arab Republic	54.216	52.794	45.058	4.302	0.544	0.091	2.799	1.422	0.455	0.949	0.018
20	Uzbekistan	49.407	48.263	36.304	6.360	0.909	0.432	4.257	1.144	0.526	0.607	0.012
21	Ghana	43.228	43.088	32.582	5.701	0.745	0.556	3.504	0.140	0.038	0.100	0.002
22	Morocco	42.551	42.233	34.812	3.869	0.508	0.488	2.555	0.319	0.035	0.279	0.006
23	Chile	41.461	40.380	28.927	6.191	0.823	0.701	3.737	1.081	0.176	0.888	0.017
24	Turkmenistan	41.081	40.442	31.768	4.563	0.608	0.778	2.725	0.639	0.474	0.162	0.003
25	Israel	38.893	38.007	26.511	5.986	0.778	0.765	3.968	0.886	0.017	0.852	0.017
26	Colombia	30.619	29.581	22.434	3.706	0.485	0.643	2.312	1.039	0.751	0.281	0.006
27	Libya	27.830	27.121	18.466	4.671	0.614	0.567	2.803	0.709	0.028	0.668	0.013
28	Azerbaijan	25.284	24.818	20.841	2.056	0.286	0.228	1.407	0.466	0.231	0.231	0.005
29	Oman	25.134	24.260	17.843	3.893	0.494	0.574	1.456	0.875	0.042	0.817	0.016
30	Peru	21.281	21.039	15.740	2.904	0.396	0.380	1.618	0.242	0.155	0.085	0.002
31	Serbia	19.491	19.186	13.695	2.708	0.374	0.495	1.914	0.305	0.040	0.260	0.005
32	Venezuela, Bolivarian Republic of	19.485	18.367	13.792	2.633	0.343	0.000	1.599	1.118	0.726	0.384	0.008
33	Singapore	17.458	16.716	11.132	2.943	0.416	0.349	1.876	0.741	0.328	0.405	0.008
34	Dominican Republic	15.293	14.674	10.857	2.025	0.275	0.273	1.243	0.620	0.348	0.267	0.005
35	Tunisia	15.159	15.029	10.262	2.527	0.327	0.328	1.586	0.129	0.015	0.113	0.002
36	Lebanon	13.062	12.428	10.776	0.970	0.134	0.000	0.548	0.633	0.068	0.555	0.011
37	Zimbabwe	11.242	9.829	7.112	1.431	0.186	0.218	0.882	1.413	0.000	1.386	0.027
38	Jordan	10.272	9.782	6.257	1.844	0.242	0.203	1.236	0.490	0.181	0.303	0.006
39	Yemen	10.105	9.847	7.849	1.072	0.149	0.182	0.595	0.259	0.094	0.161	0.003

40	South Sudan	9.378	8.681	6.959	0.975	0.131	0.003	0.613	0.696	0.011	0.673	0.012
41	Democratic People's Republic of Korea	8.929	8.814	7.372	0.809	0.105	0.000	0.529	0.115	0.006	0.108	0.002
42	Trinidad and Tobago	7.888	7.577	5.840	0.898	0.117	0.152	0.569	0.311	0.257	0.054	0.001
43	Bosnia and Herzegovina	7.601	7.383	6.207	0.810	0.133	0.013	0.220	0.219	0.000	0.214	0.004
44	Sri Lanka	7.275	6.901	5.596	0.693	0.101	0.078	0.432	0.374	0.041	0.327	0.006
45	Lao People's Democratic Republic	7.206	6.864	5.151	0.961	0.125	0.000	0.628	0.342	0.007	0.329	0.006
46	Myanmar	6.714	5.587	4.320	0.701	0.096	0.021	0.449	1.126	0.001	1.104	0.021
47	Cambodia	6.217	5.903	4.584	0.658	0.118	0.097	0.446	0.315	0.007	0.302	0.006
48	El Salvador	6.142	6.080	4.730	0.716	0.095	0.117	0.423	0.062	0.015	0.046	0.001
49	Cuba	5.948	5.815	4.120	0.879	0.120	0.131	0.564	0.133	0.133	0.000	0.000
50	United Republic of Tanzania	5.736	5.728	4.758	0.589	0.082	0.000	0.298	0.008	0.006	0.002	0.000
51	Bolivia (Plurinational State of)	5.232	4.953	3.508	0.754	0.103	0.092	0.496	0.278	0.219	0.058	0.001
52	Panama	4.771	4.596	3.457	0.598	0.079	0.090	0.372	0.174	0.095	0.078	0.001
53	Honduras	4.613	4.449	3.313	0.618	0.081	0.055	0.382	0.163	0.077	0.085	0.001
54	Montenegro	4.308	4.237	3.485	0.386	0.048	0.068	0.250	0.070	0.000	0.069	0.001
55	Republic of Moldova	4.048	3.890	2.565	0.722	0.101	0.078	0.424	0.158	0.117	0.040	0.001
56	Senegal	3.942	3.898	2.827	0.588	0.084	0.084	0.315	0.045	0.003	0.041	0.001
57	Angola	3.805	3.794	3.099	0.411	0.058	0.017	0.209	0.011	0.003	0.008	0.000
58	Jamaica	3.644	3.595	2.806	0.386	0.050	0.091	0.262	0.049	0.010	0.039	0.000
59	Botswana	3.523	2.945	2.227	0.381	0.048	0.060	0.229	0.578	0.000	0.566	0.011
60	Ecuador	3.282	3.224	2.571	0.379	0.052	0.003	0.219	0.058	0.054	0.004	0.000
61	Guatemala	3.029	2.958	2.273	0.377	0.051	0.036	0.222	0.070	0.019	0.050	0.001
62	Uruguay	2.971	2.889	2.278	0.338	0.052	0.062	0.159	0.082	0.068	0.014	0.000
63	Kyrgyzstan	2.889	2.830	2.205	0.357	0.045	0.000	0.223	0.060	0.002	0.056	0.001
64	Cameroon	2.419	2.408	1.834	0.338	0.046	0.000	0.190	0.011	0.003	0.008	0.000
65	North Macedonia	2.272	2.185	1.956	0.148	0.022	0.014	0.045	0.087	0.012	0.073	0.001
66	Mongolia	1.849	1.479	1.479	0.000	0.000	0.000	0.000	0.370	0.002	0.361	0.007

67	Zambia	1.830	1.668	1.288	0.225	0.032	0.006	0.117	0.162	0.001	0.158	0.003
68	Gabon	1.772	1.759	1.309	0.251	0.032	0.000	0.168	0.013	0.001	0.011	0.000
69	Armenia	1.670	1.580	1.580	0.000	0.000	0.000	0.000	0.090	0.016	0.073	0.001
70	Georgia	1.555	1.480	1.199	0.153	0.025	0.001	0.101	0.075	0.017	0.057	0.001
71	Kenya	1.442	0.998	0.650	0.182	0.026	0.018	0.122	0.444	0.001	0.434	0.008
72	Mauritania	1.331	1.112	0.728	0.205	0.028	0.023	0.129	0.218	0.113	0.104	0.002
73	Nicaragua	1.190	1.124	0.820	0.162	0.022	0.014	0.105	0.066	0.019	0.047	0.001
74	Bahamas	1.060	0.986	0.770	0.113	0.015	0.019	0.069	0.074	0.013	0.060	0.001
75	Mauritius	0.744	0.709	0.481	0.137	0.021	0.015	0.054	0.035	0.000	0.034	0.001
76	Mozambique	0.716	0.666	0.491	0.099	0.015	0.008	0.053	0.050	0.001	0.048	0.001
77	Tajikistan	0.690	0.620	0.477	0.079	0.010	0.000	0.053	0.069	0.005	0.063	0.001
78	Madagascar	0.676	0.594	0.410	0.100	0.013	0.009	0.063	0.082	0.001	0.079	0.001
79	Mali	0.560	0.559	0.446	0.062	0.008	0.007	0.036	0.001	0.001	0.000	0.000
80	Congo	0.512	0.490	0.378	0.076	0.011	0.000	0.024	0.022	0.000	0.021	0.000
81	Equatorial Guinea	0.481	0.435	0.349	0.048	0.007	0.000	0.031	0.046	0.000	0.045	0.001
82	Burkina Faso	0.460	0.388	0.266	0.066	0.009	0.008	0.040	0.071	0.001	0.069	0.001
83	Djibouti	0.440	0.372	0.291	0.043	0.006	0.007	0.026	0.068	0.001	0.066	0.001
84	Chad	0.393	0.329	0.257	0.038	0.005	0.006	0.023	0.064	0.001	0.062	0.001
85	Sierra Leone	0.388	0.318	0.209	0.059	0.008	0.006	0.036	0.070	0.001	0.067	0.001
86	Uganda	0.383	0.270	0.193	0.042	0.006	0.001	0.028	0.112	0.001	0.110	0.002
87	Somalia	0.268	0.240	0.157	0.045	0.006	0.005	0.027	0.028	0.001	0.027	0.001
88	Niger	0.260	0.115	0.115	0.000	0.000	0.000	0.000	0.145	0.000	0.142	0.003
89	Barbados	0.244	0.226	0.148	0.042	0.006	0.005	0.026	0.018	0.005	0.013	0.000
90	Papua New Guinea	0.218	0.218	0.159	0.033	0.005	0.000	0.022	0.000	0.000	0.000	0.000
91	Antigua and Barbuda	0.207	0.199	0.149	0.025	0.004	0.004	0.017	0.008	0.007	0.001	0.000
92	Benin	0.199	0.193	0.154	0.020	0.003	0.005	0.011	0.006	0.000	0.005	0.000
93	Seychelles	0.194	0.169	0.111	0.031	0.004	0.003	0.019	0.025	0.000	0.024	0.000
94	Afghanistan	0.180	0.174	0.146	0.015	0.002	0.001	0.010	0.006	0.002	0.004	0.000
95	Maldives	0.142	0.139	0.104	0.018	0.002	0.003	0.012	0.003	0.002	0.001	0.000
96	Suriname	0.127	0.110	0.080	0.023	0.005	0.000	0.002	0.017	0.002	0.015	0.000
97	Eritrea	0.116	0.049	0.049	0.000	0.000	0.000	0.000	0.067	0.000	0.066	0.001
98	Togo	0.112	0.112	0.087	0.015	0.002	0.002	0.006	0.000	0.000	0.000	0.000

99	Rwanda	0.107	0.105	0.066	0.020	0.003	0.002	0.014	0.002	0.000	0.002	0.000
100	Costa Rica	0.092	0.080	0.060	0.011	0.002	0.001	0.007	0.012	0.001	0.011	0.000
101	Central African Republic	0.061	0.039	0.026	0.007	0.001	0.001	0.004	0.021	0.000	0.021	0.000
102	Namibia	0.052	0.052	0.041	0.006	0.001	0.001	0.004	0.000	0.000	0.000	0.000

In Supplementary Table 5, we break down the global social cost of carbon (SCC) into the country-level SCC shares, as estimated by Ricke et al. (2018); see column 3. In columns 4 and 5, we report the absolute country-level SCC for a global SCC of $190/tCO2 and $1056/tCO2, respectively (obtained by multiplying the country-level SCC shares of column 3 with either $190/tCO2 or $1056/tCO2). Supplementary Table 5 also reports the collective SCC share of the HIC financier coalition (21%) in main body Figure 1; as well as the collective SCC of variations of HIC financier coalitions (considered in Supplementary Figures 2-5). We observe that the collective SCC share of all developed countries (UNFCCC 1992) is 48%. Excluding the United States from the HIC financier coalition substantially reduces the coalition SCC share.

Supplementary Table 5 matters because it provides the basis to compute the economic benefits to HIC financiers of providing climate finance for LMIC decarbonization. In particular, for a given estimation of the country-level SCCs, the economic benefits to the HIC financier coalition of providing climate finance for LMIC decarbonization is estimated to be given by the avoided emissions of LMICs implied by the provided climate finance times the financier coalitions' collective SCC.

Supplementary Table 5: Country and Financier Coalition Social Cost of Carbon (SCC)

Table notes: While the global SCC is uncertain, we take two estimates of the global SCC that represent a together a reasonable range: $190/tCO2 (Biden Administration Estimate; Rennert et al. (2022)) and $1056/tCO2 (in line with Bilal & Känzig (2024)). The country SCC is a share (%) of the global SCC. The equality holds that the sum across country-level SCCs adds up to the global SCC. We take the country SCC shares (%) from Ricke et al. (2018). The SCC of a financier coalition is the sum of the SCC of its country members. We use the country-level SCC to estimate what the economic benefits are of emission reductions. The economic benefits of climate finance provision of a financier coalition to a recipient country group are at a minimum given by the emission reductions that climate finance provision and mobilization achieves in the recipient country (group) times the financier coalition SCC. Column 1 lists countries and financier coalitions. Column 2 gives the UNFCCC 1992 development status category (Developed (DF), In Economic Transition (EIT), Developing (DR)). Column 3 gives the (financial coalition) country (group) share (%) of the global SCC, obtained from Ricke et al. (2018). Column 4 and 5 give the absolute SCC value of the (financial coalition) country (group), given share (%) of the global SCC, and the global SCC range ($190/tCO2, $1056/tCO2). For instance, for a lower end global SCC estimate of $190/tCO2, the developed country SCC is $91/tCO2, since its SCC share is 48.0%.

Country Name	Party Category (UNFCCC, 1992)	SCC Share (%)	Absolute Share (190 SCC)	Absolute Share (1056 SCC)
Developed Financiers		**47.99**	**91.18**	**506.75**

Developed Financiers (excl. US)		**18.63**	**35.39**	**196.68**
G7 + EU		**47.25**	**89.78**	**498.96**
G7 + EU (excl. US)		**17.89**	**33.99**	**188.89**
G7 + EU (incl. Norway, Switzerland, Australia, South Korea)		**50.36**	**95.69**	**531.83**
G7 + EU (incl. Norway, Switzerland, Australia, South Korea and excl. USA)		**21.00**	**39.90**	**221.76**
G7 + EU (incl. China, Norway, Switzerland, Australia, South Korea and excl. USA)		**23.19**	**61.16**	**339.90**
Developed EIT		**3.90**	**7.41**	**41.18**
Developing Recipients		**46.66**	**88.66**	**492.76**
Developing Recipients (excl. China and Petroleum rich countries i.e. South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei Darussalam and Kuwait		**27.46**	**52.18**	**290.00**
United States of America	DF	29.36	55.79	310.07
China	DR	11.19	21.26	118.14
India	DR	6.51	12.37	68.77
Saudi Arabia	DR	3.44	6.53	36.30
Japan	DF	2.83	5.37	29.83
Brazil	DR	2.71	5.15	28.64
Canada	DF	2.23	4.23	23.50
Russian Federation	EIT	2.21	4.20	23.36
France	DF	2.19	4.16	23.10
Germany	DF	2.11	4.01	22.31
Mexico	DR	2.09	3.97	22.04
United Kingdom of Great Britain and Northern Ireland	DF	1.68	3.18	17.69
United Arab Emirates	DR	1.68	3.18	17.69
Italy	DF	1.54	2.92	16.24
Australia	DF	1.43	2.71	15.05
Spain	DF	1.43	2.71	15.05
Turkey		1.40	2.66	14.78
Iran	DR	1.09	2.07	11.48
Republic of Korea	DR	1.05	2.00	11.09
Qatar	DR	0.98	1.85	10.30
Nigeria	DR	0.94	1.78	9.90
Indonesia	DR	0.86	1.64	9.11

Pakistan	DR	0.85	1.62	8.98
Kuwait	DR	0.84	1.59	8.84
Iraq	DR	0.79	1.50	8.32
Egypt	DR	0.73	1.38	7.66
Israel	DR	0.71	1.35	7.52
South Africa	DR	0.71	1.35	7.52
Malaysia	DR	0.64	1.21	6.73
Venezuela, Bolivarian Republic of	DR	0.61	1.16	6.47
Argentina	DR	0.59	1.12	6.20
Colombia	DR	0.59	1.12	6.20
Thailand	DR	0.55	1.05	5.81
Poland	EIT	0.53	1.00	5.54
Netherlands	DF	0.48	0.90	5.02
Sweden	DF	0.44	0.83	4.62
Algeria	DR	0.43	0.81	4.49
Angola	DR	0.40	0.76	4.22
Philippines	DR	0.38	0.71	3.96
Kazakhstan	DR	0.34	0.64	3.56
Belgium	DF	0.33	0.62	3.43
Norway	DF	0.33	0.62	3.43
Switzerland	DF	0.31	0.59	3.30
Austria	DF	0.30	0.57	3.17
Peru	DR	0.29	0.55	3.04
Oman	DR	0.25	0.48	2.64
Greece	DF	0.24	0.45	2.51
Viet Nam	DR	0.24	0.45	2.51
Czech Republic	EIT	0.23	0.43	2.38
Sudan	DR	0.23	0.43	2.38
Finland	DF	0.21	0.40	2.24
Bangladesh	DR	0.21	0.40	2.24
Libya	DR	0.21	0.40	2.24
Ukraine	EIT	0.19	0.36	1.98
Denmark	DF	0.16	0.31	1.72
Portugal	DF	0.16	0.31	1.72

Chile	DR	0.16	0.31	1.72
Syrian Arab Republic	DR	0.16	0.31	1.72
Romania	EIT	0.15	0.29	1.58
Hungary	EIT	0.13	0.24	1.32
Morocco	DR	0.13	0.24	1.32
Dominican Republic	DR	0.11	0.21	1.19
Uzbekistan	DR	0.11	0.21	1.19
Yemen	DR	0.11	0.21	1.19
Ireland	DF	0.10	0.19	1.06
Belarus	EIT	0.10	0.19	1.06
Slovakia	EIT	0.10	0.19	1.06
Azerbaijan	DR	0.10	0.19	1.06
Ecuador	DR	0.10	0.19	1.06
Ethiopia	DR	0.10	0.19	1.06
Sri Lanka	DR	0.10	0.19	1.06
Tunisia	DR	0.10	0.19	1.06
United Republic of Tanzania	DR	0.10	0.19	1.06
New Zealand	DF	0.09	0.17	0.92
Afghanistan	DR	0.09	0.17	0.92
Guatemala	DR	0.09	0.17	0.92
Panama	DR	0.09	0.17	0.92
Turkmenistan	DR	0.09	0.17	0.92
Uganda	DR	0.09	0.17	0.92
Bulgaria	EIT	0.08	0.14	0.79
Botswana	DR	0.08	0.14	0.79
Costa Rica	DR	0.08	0.14	0.79
Ghana	DR	0.08	0.14	0.79
Kenya	DR	0.08	0.14	0.79
Myanmar	DR	0.08	0.14	0.79
Luxembourg	DF	0.06	0.12	0.66
Croatia	EIT	0.06	0.12	0.66
Bolivia (Plurinational State of)	DR	0.06	0.12	0.66
Jordan	DR	0.06	0.12	0.66
Serbia	DR	0.06	0.12	0.66

Slovenia	EIT	0.05	0.10	0.53
Burkina Faso	DR	0.05	0.10	0.53
Cameroon	DR	0.05	0.10	0.53
Equatorial Guinea	DR	0.05	0.10	0.53
Lebanon	DR	0.05	0.10	0.53
Lithuania	EIT	0.04	0.07	0.40
Brunei Darussalam	DR	0.04	0.07	0.40
Cambodia	DR	0.04	0.07	0.40
Congo	DR	0.04	0.07	0.40
Côte d'Ivoire	DR	0.04	0.07	0.40
Cuba	DR	0.04	0.07	0.40
Gabon	DR	0.04	0.07	0.40
Honduras	DR	0.04	0.07	0.40
Mali	DR	0.04	0.07	0.40
Nepal	DR	0.04	0.07	0.40
Niger	DR	0.04	0.07	0.40
Paraguay	DR	0.04	0.07	0.40
Zambia	DR	0.04	0.07	0.40
Estonia	EIT	0.03	0.05	0.26
Latvia	EIT	0.03	0.05	0.26
Albania	DR	0.03	0.05	0.26
Chad	DR	0.03	0.05	0.26
Democratic Republic of the Congo	DR	0.03	0.05	0.26
El Salvador	DR	0.03	0.05	0.26
Lao People's Democratic Republic	DR	0.03	0.05	0.26
Malawi	DR	0.03	0.05	0.26
Mauritania	DR	0.03	0.05	0.26
Mozambique	DR	0.03	0.05	0.26
North Macedonia	DR	0.03	0.05	0.26
Rwanda	DR	0.03	0.05	0.26
Senegal	DR	0.03	0.05	0.26
Trinidad and Tobago	DR	0.03	0.05	0.26
Uruguay	DR	0.03	0.05	0.26
Cyprus		0.03	0.05	0.26

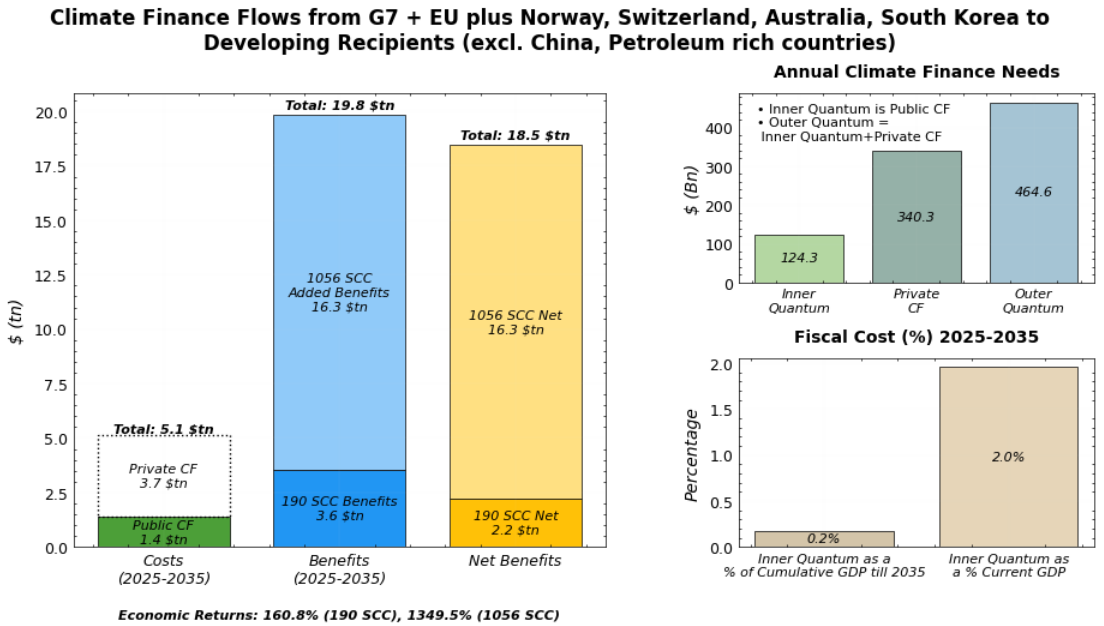
Iceland	DF	0.01	0.02	0.13
Armenia	DR	0.01	0.02	0.13
Bahamas	DR	0.01	0.02	0.13
Benin	DR	0.01	0.02	0.13
Bhutan	DR	0.01	0.02	0.13
Bosnia and Herzegovina	DR	0.01	0.02	0.13
Georgia	DR	0.01	0.02	0.13
Guinea	DR	0.01	0.02	0.13
Jamaica	DR	0.01	0.02	0.13
Kyrgyzstan	DR	0.01	0.02	0.13
Madagascar	DR	0.01	0.02	0.13
Mauritius	DR	0.01	0.02	0.13
Mongolia	DR	0.01	0.02	0.13
Nicaragua	DR	0.01	0.02	0.13
Papua New Guinea	DR	0.01	0.02	0.13
Sierra Leone	DR	0.01	0.02	0.13
Tajikistan	DR	0.01	0.02	0.13
Togo	DR	0.01	0.02	0.13
Andorra	DR	0.00	0.00	0.00
Antigua and Barbuda	DR	0.00	0.00	0.00
Bahrain	DR	0.00	0.00	0.00
Barbados	DR	0.00	0.00	0.00
Belize	DR	0.00	0.00	0.00
Burundi	DR	0.00	0.00	0.00
Cabo Verde	DR	0.00	0.00	0.00
Central African Republic	DR	0.00	0.00	0.00
Comoros	DR	0.00	0.00	0.00
Cook Islands	DR	0.00	0.00	0.00
Democratic People's Republic of Korea	DR	0.00	0.00	0.00
Djibouti	DR	0.00	0.00	0.00
Dominica	DR	0.00	0.00	0.00
Eritrea	DR	0.00	0.00	0.00
Eswatini	DR	0.00	0.00	0.00
Fiji	DR	0.00	0.00	0.00

Gambia	DR	0.00	0.00	0.00
Grenada	DR	0.00	0.00	0.00
Guinea-Bissau	DR	0.00	0.00	0.00
Guyana	DR	0.00	0.00	0.00
Haiti	DR	0.00	0.00	0.00
Holy See	DR	0.00	0.00	0.00
Kiribati	DR	0.00	0.00	0.00
Lesotho	DR	0.00	0.00	0.00
Liberia	DR	0.00	0.00	0.00
Maldives	DR	0.00	0.00	0.00
Marshall Islands	DR	0.00	0.00	0.00
Micronesia	DR	0.00	0.00	0.00
Montenegro	DR	0.00	0.00	0.00
Namibia	DR	0.00	0.00	0.00
Nauru	DR	0.00	0.00	0.00
Niue	DR	0.00	0.00	0.00
Palau	DR	0.00	0.00	0.00
Republic of Moldova	DR	0.00	0.00	0.00
Saint Kitts and Nevis	DR	0.00	0.00	0.00
Saint Lucia	DR	0.00	0.00	0.00
Saint Vincent and the Grenadines	DR	0.00	0.00	0.00
Samoa	DR	0.00	0.00	0.00
San Marino	DR	0.00	0.00	0.00
Sao Tome and Principe	DR	0.00	0.00	0.00
Seychelles	DR	0.00	0.00	0.00
Singapore	DR	0.00	0.00	0.00
Solomon Islands	DR	0.00	0.00	0.00
Somalia	DR	0.00	0.00	0.00
South Sudan	DR	0.00	0.00	0.00
State of Palestine	DR	0.00	0.00	0.00
Suriname	DR	0.00	0.00	0.00
Timor-Leste	DR	0.00	0.00	0.00
Tonga	DR	0.00	0.00	0.00
Tuvalu	DR	0.00	0.00	0.00

Vanuatu	DR	0.00	0.00	0.00
Zimbabwe	DR	0.00	0.00	0.00
Ivory Coast		0.00	0.00	0.00
Lichtenstein		0.00	0.00	0.00
Monaco		0.00	0.00	0.00

A2. Variations in Financier Coalitions meet Climate Finance Mitigation needs of Developing Countries to Implement 1.5°C-Aligned NDCs

Supplementary Figure 2 provides a variation of the cost-benefit analysis in Figure 1 in the main body; now including (rather than excluding) the United States as financier. Since the LMIC recipients have not changed, the climate finance costs have remained unchanged (at $124bn/y); but since the financier coalition has expanded to include the United States, the fiscal cost to each HIC financier have dropped from 0.3% of annual GDP to 0.2%. The economic return to the HIC financier coalition increases with the inclusion of the United States as financier as they hold a significant share of the global SCC, and thus the benefits from avoided emissions in LMICs.



Supplementary Figure 2: Climate Finance Mitigation needs of Developing Countries (excl. China and petroleum rich countries) to Implement 1.5°C-Aligned NDCs, and Fiscal costs and Benefits to a Financier Coalition (G7+EU, plus Norway, Switzerland, Australia, South Korea).

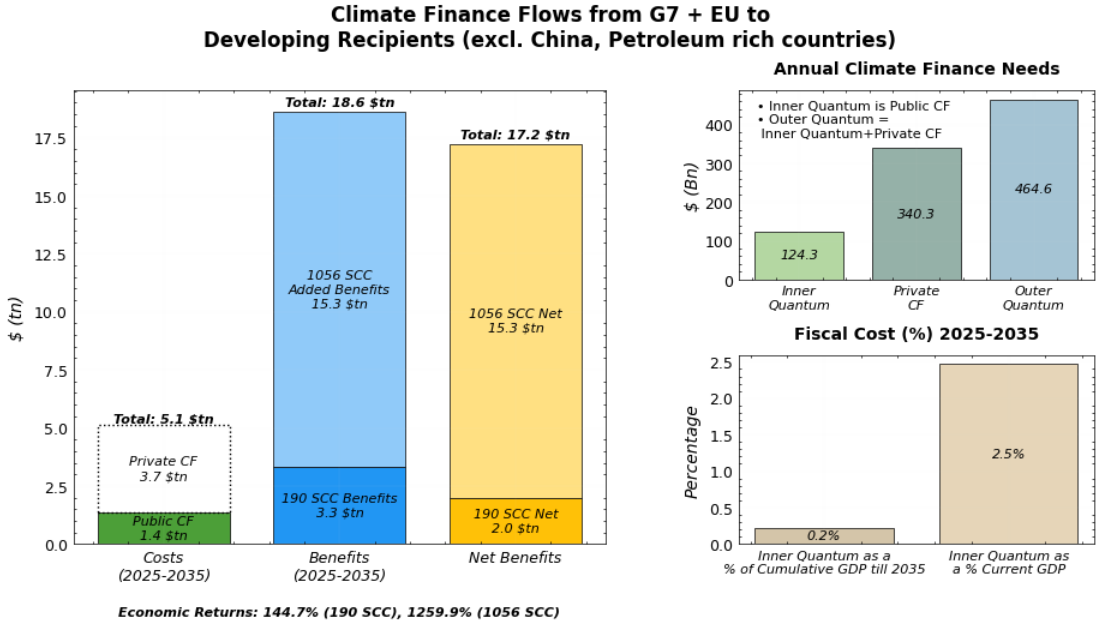
Figure note: Climate finance provided by a financier coalition (G7+EU, plus Norway, Switzerland, Australia, South Korea) to developing countries (i.e., UNFCCC 1992 non-Annex I, Developing Countries) excluding China and petroleum rich countries (i.e., South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei Darussalam and Kuwait) to implement their 1.5°C-Aligned NDCs. *Compared to Figure 1, Appendix Figure 1 includes the USA in the financier coalition. The l*eft plot shows total costs, benefits, and net benefits to financier to recipient countries. Total costs are broken down by the "inner quantum" of the provision public climate finance and an "outer quantum" that includes mobilized private finance. Total costs consist of: (i) the opportunity costs of phasing out fossil fuels; and (ii) and investment costs phasing in replacement renewables (i.e., including energy storage and grid extension). We assume that public climate finance (offered in grant-equivalent form) must cover 25 percent of the investment costs in renewables to be able to crowd the remaining 75 percent from private finance (via blended finance). A 100 percent of the opportunity costs of fossil fuels must be paid for with public climate finance (offered in the form of grants), as it does not generate a revenue stream and alternatives are not reliable. The benefits to financier countries (representing the avoided climate adaptation costs and avoided loss and damages to financier countries) are given by the multiplication of the recipients' emission reduction resulting from providing and mobilizing climate finance times the financiers' collective social cost of carbon (SSC). The share of the global SCC of financier countries is 50.4 percent (Ricke et al. (2018)). While the global SCC is uncertain, we take two estimates of the global SCC that represent a together a reasonable range: $190/tCO2 (Biden Administration Estimate; Rennert et al. (2022)) and $1056/tCO2 (in line with Bilal & Känzig (2024)). The economic return on the climate finance investment by financier countries into recipient

countries is given by the difference of financier countries' benefits (over 2025–2035) minus their public climate finance costs (over 2025–2035) expressed relative to their public climate finance costs (over 2025–2035). For a global SCC of $190/tCO2 the economic return to financier countries on the climate finance investment is *160.8* percent. For a global SCC of $1056/tCO2 their economic return is *1349.5* percent. It is thus in the economic interest of the financier coalition to offer an "inner quantum" of public climate finance at scale – i.e., $124.3 billion annually ($1.4 trillion in total over 2025–2035) – to the developing country recipients. Right top plot shows the same cost as the left plot but now expressed in annual terms. The right plot splits annual climate finance into the annual "inner quantum" of public climate finance (offered in grant-equivalent terms), the annual quantum of mobilized private finance, and the "outer quantum" of annual provided public climate finance and mobilized private climate finance. The bottom left plot shows the fiscal affordability to financier countries. The left bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of the financier countries' 2025–2035 cumulative GDP. The right bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of financier countries 2024 GDP. The latter estimates by how much sovereign debt of financier countries would rise as a percentage of their GDP if they would pay for the 2025–2035 climate finance fully at the beginning, in 2024, by issuing sovereign debt. The former expresses what the climate finance costs are to financier countries as a percentage of their GDP on an annual basis. It is not only in the economic interest of financier coalition countries to offer climate finance at scale to developing recipient countries, but also fiscally affordable; as financiers spend no more than 0.*2* percent of their annual GDP.

Supplementary Figure 3 provides a variation of the cost-benefit analysis in Figure 1 in the main body, this time assuming that the HIC financier coalition consists of the EU+G7. In Supplementary Figure 4, we provide the same variation of the cost-benefit analysis in main body Figure 1, but now assuming that the HIC financier coalition consists of the EU+G7 (excl. USA). In neither of these two variations the absolute climate finance cost ($124bn/y) is unaltered, but the fiscal costs and economic return do change. In supplementary Figure 4 the gross benefits and thus economic return are negative for the lower estimate of the global SCC ($190/tCO2) – of which the EU+G7 excl. US holds 18% (see Supplementary Table 5). The fiscal cost to the HIC financier coalition consisting of the EU+G7 (excl. US) is also higher (at 0.4% of their annual GDP) than in the main body Figure 1. The reason the return turns negative for the lower SCC estimate is that without Norway, Switzerland, Australia, and South Korea also contributing, the collective SCC of the financier coalition is not large enough that their economic benefits of providing climate finance to LMICs exceed their cost.

For climate financing LMICs as a whole it is important that the net of HIC financiers is cast as wide as possible to reduce fiscal costs and increase the economic return. As shown in Supplementary Figure 1, whenever HIC financiers provide climate finance to individual LMICs a smaller HIC coalition can typically generate positive economic returns, and do so at very small fiscal costs, even if the net of HIC coalition contributors is not cast as wide.

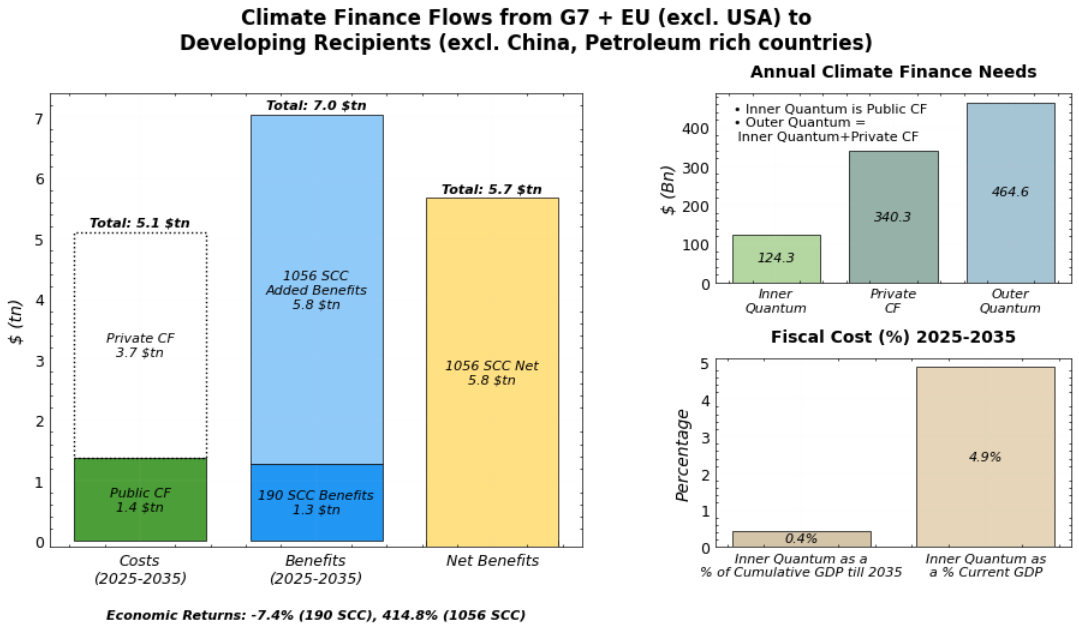
Whenever the United States contributes, the economic return to the HIC coalition are positive (between 145%-1260%) and fiscal costs are small (0.2% of GDP), even if the HIC coalition only consists of the EU+G7; see Supplementary Figure 3.



Supplementary Figure 3: Climate Finance Mitigation needs of Developing Countries (excl. China and petroleum rich countries) to Implement 1.5°C-Aligned NDCs, and Fiscal costs and Benefits to a Financier Coalition (G7+EU).

Figure note: Climate finance provided by a financier coalition (G7+EU) to developing countries (i.e., UNFCCC 1992 non-Annex I, Developing Countries) excluding China and petroleum rich countries (i.e., South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei Darussalam and Kuwait) to implement their 1.5°C-Aligned NDCs. Compared to Appendix Figure 1, Appendix Figure 2 excludes Norway, Switzerland, Australia, South Korea from the financier coalition. The left plot shows total costs, benefits, and net benefits to financier to recipient countries. Total costs are broken down by the "inner quantum" of the provision public climate finance and an "outer quantum" that includes mobilized private finance. Total costs consist of: (i) the opportunity costs of phasing out fossil fuels; and (ii) and investment costs phasing in replacement renewables (i.e., including energy storage and grid extension). We assume that public climate finance (offered in grant-equivalent form) must cover 25 percent of the investment costs in renewables to be able to crowd the remaining 75 percent from private finance (via blended finance). A 100 percent of the opportunity costs of fossil fuels must be paid for with public climate finance (offered in the form of grants), as it does not generate a revenue stream and alternatives are not reliable. The benefits to financier countries (representing the avoided climate adaptation costs and avoided loss and damages to financier countries) are given by the multiplication of the recipients' emission reduction resulting from providing and mobilizing climate finance times the financiers' collective social cost of carbon (SSC). The share of the global SCC of financier countries is 47.3 percent (Ricke et al. (2018)). While the global SCC is uncertain, we take two estimates of the global SCC that represent a together a reasonable range: $190/tCO2 (Biden Administration Estimate; Rennert et al. (2022)) and $1056/tCO2 (in line with Bilal & Känzig (2024)). The economic return on the climate finance investment by financier countries into recipient

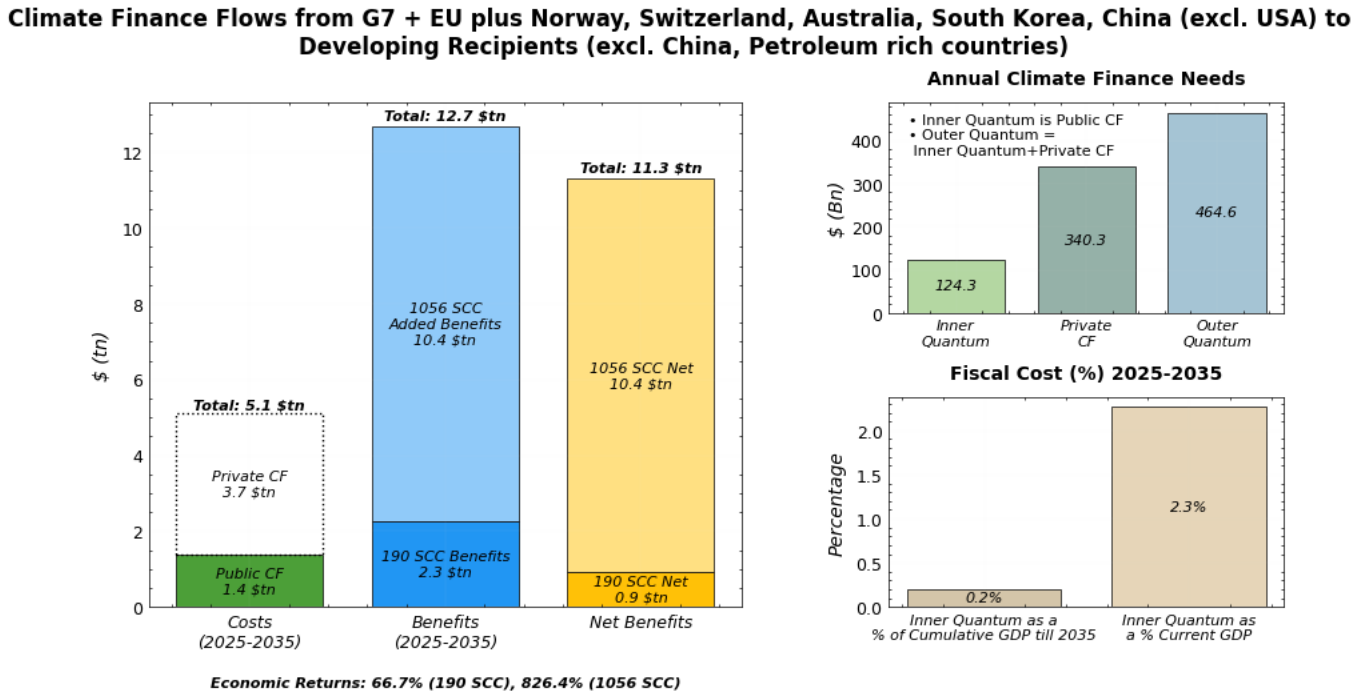
countries is given by the difference of financier countries' benefits (over 2025–2035) minus their public climate finance costs (over 2025–2035) expressed relative to their public climate finance costs (over 2025–2035). For a global SCC of $190/tCO2 the economic return to financier countries on the climate finance investment is 144.7 percent. For a global SCC of $1056/tCO2 their economic return is 1259.9 percent. It is thus in the economic interest of the financier coalition to offer an "inner quantum" of public climate finance at scale – i.e., $124.3 billion annually ($1.4 trillion in total over 2025–2035) – to the developing country recipients. Right top plot shows the same cost as the left plot but now expressed in annual terms. The right plot splits annual climate finance into the annual "inner quantum" of public climate finance (offered in grant-equivalent terms), the annual quantum of mobilized private finance, and the "outer quantum" of annual provided public climate finance and mobilized private climate finance. The bottom left plot shows the fiscal affordability to financier countries. The left bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of the financier countries' 2025–2035 cumulative GDP. The right bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of financier countries 2024 GDP. The latter estimates by how much sovereign debt of financier countries would rise as a percentage of their GDP if they would pay for the 2025–2035 climate finance fully at the beginning, in 2024, by issuing sovereign debt. The former expresses what the climate finance costs are to financier countries as a percentage of their GDP on an annual basis. It is not only in the economic interest of financier coalition countries to offer climate finance at scale to developing recipient countries, but also fiscally affordable; as financiers spend no more than 0.2 percent of their annual GDP.



Supplementary Figure 4: Climate Finance Mitigation needs of Developing Countries (excl. China and petroleum rich countries) to Implement 1.5°C-Aligned NDCs, and Fiscal costs and Benefits to a Financier Coalition (G7+EU, excl. USA).

Figure note: Climate finance provided by a financier coalition (G7+EU, excl. USA) to developing countries (i.e., UNFCCC 1992 non-Annex I, Developing Countries) excluding China and petroleum rich countries (i.e., South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei Darussalam and Kuwait) to implement their 1.5°C-Aligned NDCs. Compared to Appendix Figure 2, Appendix Figure 3 excludes the USA from the financier coalition. The left plot shows total costs, benefits, and net benefits to financier to recipient countries. Total costs are broken down by the "inner quantum" of the provision public climate finance and an "outer quantum" that includes mobilized private finance. Total costs consist of: (i) the opportunity costs of phasing out fossil fuels; and (ii) and investment costs phasing in replacement renewables (i.e., including energy storage and grid extension). We assume that public climate finance (offered in grant-equivalent form) must cover 25 percent of the investment costs in renewables to be able to crowd the remaining 75 percent from private finance (via blended finance). A 100 percent of the opportunity costs of fossil fuels must be paid for with public climate finance (offered in the form of grants), as it does not generate a revenue stream and alternatives are not reliable. The benefits to financier countries (representing the avoided climate adaptation costs and avoided loss and damages to financier countries) are given by the multiplication of the recipients' emission reduction resulting from providing and mobilizing climate finance times the financiers' collective social cost of carbon (SSC). The share of the global SCC of financier countries is 17.9 percent (Ricke et al. (2018)). While the global SCC is uncertain, we take two estimates of the global SCC that represent a together a reasonable range: $190/tCO2 (Biden Administration Estimate; Rennert et al. (2022)) and $1056/tCO2 (in line with Bilal & Känzig (2024)). The economic return on the climate finance investment by financier countries into recipient countries is given

by the difference of financier countries' benefits (over 2025–2035) minus their public climate finance costs (over 2025–2035) expressed relative to their public climate finance costs (over 2025–2035). For a global SCC of $190/tCO2 the economic return to financier countries on the climate finance investment is -7.4 percent. For a global SCC of $1056/tCO2 their economic return is 414.8 percent. A global SCC of $205.1/tCO2 makes the economic return to financier countries 0 percent. It is thus in the economic interest of the financier coalition to offer an "inner quantum" of public climate finance at scale – i.e., $124.3 billion annually ($1.4 trillion in total over 2025–2035) – to the developing country recipients whenever the global SCC is greater than $ 205.1/tCO2. Right top plot shows the same cost as the left plot but now expressed in annual terms. The right plot splits annual climate finance into the annual "inner quantum" of public climate finance (offered in grant-equivalent terms), the annual quantum of mobilized private finance, and the "outer quantum" of annual provided public climate finance and mobilized private climate finance. The bottom left plot shows the fiscal affordability to financier countries. The left bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of the financier countries' 2025–2035 cumulative GDP. The right bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of financier countries 2024 GDP. The latter estimates by how much sovereign debt of financier countries would rise as a percentage of their GDP if they would pay for the 2025–2035 climate finance fully at the beginning, in 2024, by issuing sovereign debt. The former expresses what the climate finance costs are to financier countries as a percentage of their GDP on an annual basis. It is not only in the economic interest of financier coalition countries to offer climate finance at scale to developing recipient countries whenever the global SCC is greater than $ 205.11/tCO2, but also fiscally affordable; as financiers spend no more than 0.2 percent of their annual GDP.



Supplementary Figure 5: Climate Finance Mitigation needs of Developing Countries (excl. China and petroleum rich countries) to Implement 1.5°C-Aligned NDCs, and Fiscal costs and Benefits to Financier Coalition (G7+EU (excl. USA), China, Norway, Switzerland, Australia, South Korea).

Figure note: Climate finance provided by a financier coalition (G7+EU (excl. USA), China, Norway, Switzerland, Australia, South Korea) to developing countries (i.e., UNFCCC 1992 non-Annex I, Developing Countries) excluding China and petroleum rich countries (i.e., South Korea, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Brunei Darussalam and Kuwait) to implement their 1.5°C-Aligned NDCs. Compared to main body Figure 1, Appendix Figure 5 includes China into the financier coalition. The left plot shows total costs, benefits, and net benefits to financier to recipient countries. Total costs are broken down by the "inner quantum" of the provision public climate finance and an "outer quantum" that includes mobilized private finance. Total costs consist of: (i) the opportunity costs of phasing out fossil fuels; and (ii) and investment costs phasing in replacement renewables (i.e., including energy storage and grid extension). We assume that public climate finance (offered in grant-equivalent form) must cover 25 percent of the investment costs in renewables to be able to crowd the remaining 75 percent from private finance (via blended finance). A 100 percent of the opportunity costs of fossil fuels must be paid for with public climate finance (offered in the form of grants), as it does not generate a revenue stream and alternatives are not reliable. The benefits to financier countries (representing the avoided climate adaptation costs and avoided loss and damages to financier countries) are given by the multiplication of the recipients' emission reduction resulting from providing and mobilizing climate finance times the financiers' collective social cost of carbon (SSC). The share of the global SCC of financier countries is 23.2 percent (Ricke et al. (2018)). While the global SCC is uncertain, we take two estimates of the global SCC that represent a together a reasonable range: $190/tCO2 (Biden Administration Estimate; Rennert et al. (2022)) and $1056/tCO2 (in line with Bilal & Känzig (2024)). The economic return on the climate finance investment by financier countries into recipient countries is given by the difference of financier countries' benefits (over 2025–2035) minus their public climate finance costs (over 2025–2035) expressed relative to their public climate finance costs (over 2025–2035). For a global SCC of $190/tCO2 the economic return to financier countries on the climate finance investment is 66.7 percent. For a global SCC of $1056/tCO2 their economic return is 828.4 percent. It is thus in the economic interest of the financier coalition to offer an "inner quantum" of public climate finance at scale – i.e., $124.3 billion annually ($1.4 trillion in total over 2025–2035) – to these developing country recipients. Right top plot shows the same cost as the left plot but now expressed in annual terms. The right plot splits annual climate finance into the annual "inner quantum" of public climate finance (offered in grant-equivalent terms), the annual quantum of mobilized private finance, and the "outer quantum" of annual provided public climate finance and mobilized private climate finance. The bottom left plot shows the fiscal affordability to financier countries. The left bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of the financier countries' 2025–2035 cumulative GDP. The right bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of financier countries 2024 GDP. The latter estimates by how much sovereign debt of financier countries would rise as a percentage of their GDP if they would pay for the 2025–2035 climate finance fully at the beginning, in 2024, by issuing sovereign debt. The former expresses what the climate finance costs are to financier countries as a percentage of their GDP on an annual basis. It is not only in the economic interest of financier coalition countries to offer climate finance at scale to developing recipients, but also fiscally affordable; as financiers spend no more than 0.2 percent of their annual GDP. Compared to main body Figure 1, where China is not included in the financier group, the fiscal cost drop from 0.3% to 0.2% (as climate finance costs are more broadly shared), the economic returns increase from 8.7-504 percent to 66.7-828.4 percent (as a larger geographic group is included in the avoided climate damage and adaption costs, for an unchanged absolute climate finance cost), whilst the absolute climate finance costs (of $124.3 billion annually) are left unchanged.

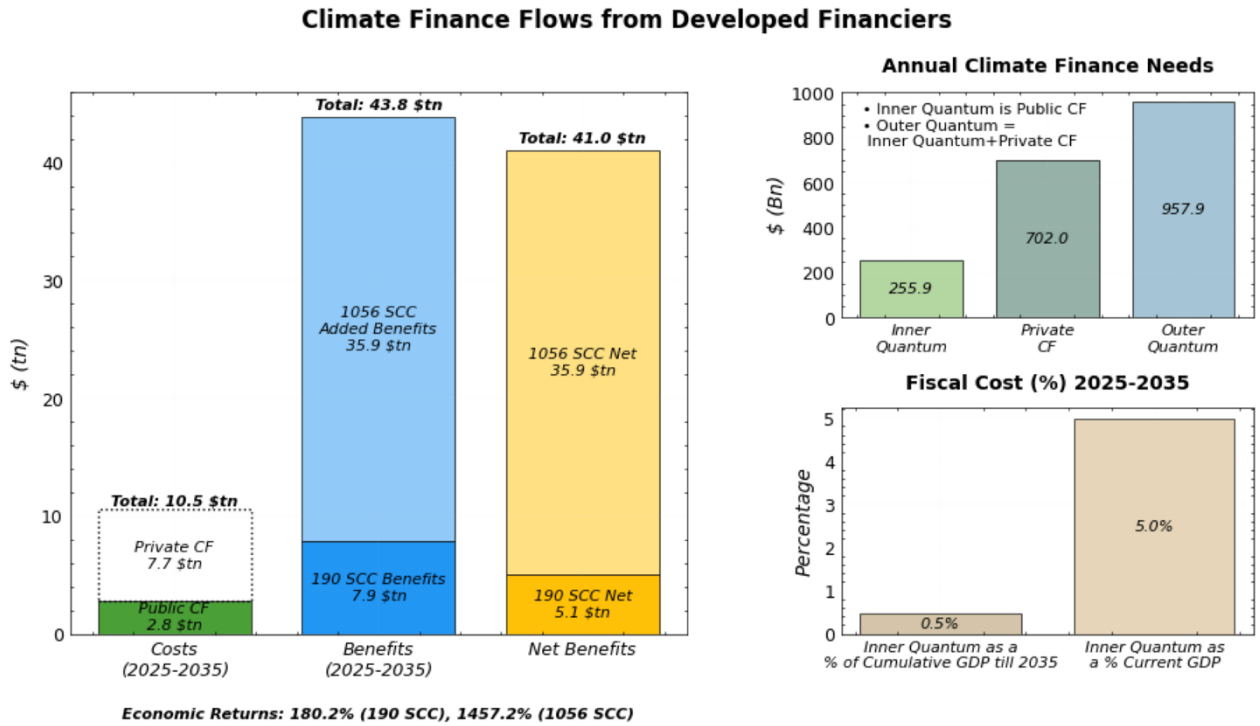
A3. Baseline Case of "Developed Countries" (UNFCCC 1992 Annex II) providing Climate Finance to "Developing Countries" (UNFCCC 1992 non-Annex I) to Implement 1.5°C-Aligned NDCs

Supplementary Figure 6 reports the baseline case of climate finance provision under the COP15 (2009), Paris Agreement (2015), and COP29 New Quantified Goal of Climate Finance agreement (2024) – in terms of who is classified as a financier and recipient. Under these agreements, the expectation is that developed countries (as classified under UNFCCC 1992; Annex II) take the lead in providing climate finance to developing countries (as classified under UNFCCC 1992; non-Annex I). When all countries classified as developing under the 1992 UNFCC agreement are set to be recipients of climate finance then the total climate finance need is around $1 trillion per year ($10.5 trillion over 2025-2035). Assuming 25% of public funds can crowd in private capital for the remaining 75% of investment costs in renewables, this then results in an annual public climate finance need of $256bn for developing countries, posing a fiscal cost of 0.5% of annual GDP to developed countries. Their economic return on this investment is large (180%-1457%), amounting to a net economic benefit of between $5.1-$41 trillion over 2025-2035.

Since the 1992 UNFCCC classification of development status is regarded by many to provide an outdated view of which countries count as a developed and developing (for instance, China, South Korea and petroleum rich states – classified as developing under the 1992 UNFCCC – clearly do not need external climate finance from HICs to be able to afford their own decarbonization), we consider in main body Figure 1 a HIC coalition and LMIC recipient group that: excludes China, South Korea and petroleum rich states from developing country recipients, and we exclude the United States from developed country financiers, given the reality of the United States' withdrawal from the Paris Agreement. The question we posed in the main body is: is it still in the economic interest of a smaller coalition of developed countries to finance the decarbonization of needful developing countries? The answer, as shown in the main body Figure 1, is yes.

When we include all developing countries as the recipients, our quantitative estimates are broadly consistent with the $1 trillion that the High-Level Expert Group (HLEG) report on climate finance (2024) reports developing countries need by 2030. Importantly, we stress that developing countries need this not by 2030 (as the HLEG recommends) but by 2025 – to implement Paris-aligned NDCs in 2025 and for the world to stay within the 1.5°C carbon budget.[11]

[11] In a "Joint Statement on the New Common Quantified Goal (NCQG) of Climate Finance and Its Delivery on the 1.5°C Paris Agreement Goal" by Rockström, Kleinnijenhuis, Bolton, Zettelmeyer et al. (2024), we explain that the COP29 NCQG is completely inconsistent with the 1.5°C goal of the Paris Agreement, and call for a revision. This paper offers a way how to do this: by forming a climate finance club of HIC financiers that commit to providing climate finance to those developing countries that submit credible 1.5°C- Paris decarbonization pledges.



Supplementary Figure 6: Climate Finance Mitigation needs of Developing Countries (UNFCCC 1992 non-Annex I) to Implement 1.5°C-Aligned NDCs, and Fiscal costs and Benefits to Developed Countries (UNFCCC 1992 Annex II).

Figure note: Climate finance provided by developed (i.e., UNFCCC 1992 Annex II, Developed Countries) to developing countries (i.e., UNFCCC 1992 non-Annex I, Developing Countries) to implement their 1.5°C-Aligned NDCs. Compared to Figure 1, Appendix Figure 3 provides the Paris Agreement base case scenario where developed countries provide climate finance to developing countries. It, however, did not turn out possible to agree at COP29 on an ambitious enough New Common Quantified Goal of Climate Finance between developed and developing countries. Hence, why we are considering smaller financier coalitions (in Figure 1, and Appendix Figures 1, 2, and 3) and smaller recipient groups (including individual developed countries) where higher ambition aligned with the 1.5°C Paris goal may be possible. The left plot shows total costs, benefits, and net benefits to financier to recipient countries in the baseline case. Total costs are broken down by the “inner quantum” of the provision public climate finance and an “outer quantum” that includes mobilized private finance. Total costs consist of: (i) the opportunity costs of phasing out fossil fuels; and (ii) and investment costs phasing in

replacement renewables (i.e., including energy storage and grid extension). We assume that public climate finance (offered in grant-equivalent form) must cover 25 percent of the investment costs in renewables to be able to crowd the remaining 75 percent from private finance (via blended finance). A 100 percent of the opportunity costs of fossil fuels must be paid for with public climate finance (offered in the form of grants), as it does not generate a revenue stream and alternatives are not reliable. The benefits to financier countries (representing the avoided climate adaptation costs and avoided loss and damages to financier countries) are given by the multiplication of the recipients' emission reduction resulting from providing and mobilizing climate finance times the financiers' collective social cost of carbon (SSC). The share of the global SCC of financier countries is 48 percent (Ricke et al. (2018)). While the global SCC is uncertain, we take two estimates of the global SCC that represent a together a reasonable range: $190/tCO2 (Biden Administration Estimate; Rennert et al. (2022)) and $1056/tCO2 (in line with Bilal & Känzig (2024)). The economic return on the climate finance investment by financier countries into recipient countries is given by the difference of financier countries' benefits (over 2025–2035) minus their public climate finance costs (over 2025–2035) expressed relative to their public climate finance costs (over 2025–2035). For a global SCC of $190/tCO2 the economic return to financier countries on the climate finance investment is 180.2 percent. For a global SCC of $1056/tCO2 their economic return is 1457.2 percent. It is thus in the economic interest of the financier coalition to offer an "inner quantum" of public climate finance at scale – i.e., $255.9 billion annually ($2.8 trillion in total over 2025–2035) – to the developing country recipients. Right top plot shows the same cost as the left plot but now expressed in annual terms. The right plot splits annual climate finance into the annual "inner quantum" of public climate finance (offered in grant-equivalent terms), the annual quantum of mobilized private finance, and the "outer quantum" of annual provided public climate finance and mobilized private climate finance. The bottom left plot shows the fiscal affordability to financier countries. The left bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of the financier countries' 2025–2035 cumulative GDP. The right bar shows the total 2025–2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of left plot) expressed as a percentage of financier countries 2024 GDP. The latter estimates by how much sovereign debt of financier countries would rise as a percentage of their GDP if they would pay for the 2025–2035 climate finance fully at the beginning, in 2024, by issuing sovereign debt. The former expresses what the climate finance costs are to financier countries as a percentage of their GDP on an annual basis. It is not only in the economic interest of financier coalition countries to offer climate finance at scale to developing recipient countries, but also fiscally affordable as financiers spend no more than 0.5 percent of their annual GDP.

In Supplementary Table 6, we report the fiscal cost breakdown for the case where developed countries (UNFCCC 1992 Annex II) provide $256bn of climate finance per year to developing countries (UNFCCC 1992 non-Annex I). The fiscal cost breakdown of Supplementary Table 6 provides the climate finance cost for each developed country, associated to Supplementary Figure 5. The fiscal cost breakdown of Supplementary Table 6 is of the same set up as the fiscal cost breakdown of Supplementary Table 1. We include Supplementary Table 6 as a baseline case (of developed-to-developing country climate finance cost) against which to compare the climate finance fiscal costs of the smaller coalition of developing countries (G7+EU (excl. USA), Norway, Switzerland, Australia, and South Korea) for a smaller group of developing country recipients, excluding China, South Korea, and petroleum rich states.

Supplementary Table 6: Climate Finance Contribution of Developed Countries (UNFCCC 1992 Annex II) to meet Climate Finance Mitigation needs ($255 Bn/y) of Developing Countries (UNFCCC 1992 non-Annex I) to Implement 1.5°C-Aligned NDCs.

Table notes: This fiscal cost table provides the Paris Agreement base case scenario where developed countries provide climate finance to developing countries. As in Table 1, we assume a "burden sharing agreement" among developed countries, to meet the climate finance mitigation need of developing countries to implement 1.5°C-aligned NDCs ($255 Bn/y), in which each developed country contributes proportionally to its GDP (relative to total developed country GDP).

[1]The $ 255 Bn amount has been explained in the E-axes Forum Policy Brief by Kleinnijenhuis & Bolton (2024)
[2]Oxfam Climate Finance Shadow Report 2023 Annex 1, Table A1
[3] Grant Equivalent Climate Finance
[4] United Kingdom of of Great Britain and Northern Ireland
[5] Projections of 2023 climate finance reported in US Department of State, Progress Report on President Biden's Climate Finance Pledge.
[6] This is mentioned in the Oxfam Report however, not clearly defined what countries are part of this group
[7] Europe's contribution to climate finance (in €bn) states 28.6 € Bn converted to USD using an exchange rate of 1.04 USD

Financier	**Contribution Breakdown by GDP for Developed Financiers to meet $ 255 Bn Goal[1]**				**Annual Average Reported CF (2019-2020) as per Oxfam Climate Finance Shadow Report 2023[2]**		
	Annual Public CF Need ($ Bn) (Inner Quantum)	**Fiscal Cost (% of country GDP)**	**Financing Instrument** GECF is grant-equivalent climate finance	**2023 Committed Climate Finance ($ Bn)**	**Annual Average (2019-2020)**	**Grant Equivalent Climate Finance %**	**Scaling Need: Multiplier**
Canada	10.0	0.47%	GECF[3]		0.31	34%	33
Iceland	0.1	0.47%	GECF				
Japan	19.7	0.47%	GECF		8.81	9%	2
New Zealand	1.2	0.47%	GECF				
Norway	2.3	0.47%	GECF		0.54	88%	4
Switzerland	4.1	0.47%	GECF		0.22	100%	19
United Kingdom[4]	15.6	0.47%	GECF		1.14	77%	14
United States of America	127.9	0.47%	GECF	9.5[5]	1.56	48%	82

Other Developed Countries[6]					0.32	81%	
EU Financiers	75.0	0.47%	GECF	29.7[7]	17.91		4
Austria	2.4	0.47%			0.19	29%	13
Belgium	3.0	0.47%					
Denmark	1.9	0.47%			0.15	100%	13
Finland	1.4	0.47%					
France	14.2	0.47%			5.83	7%	2
Germany	20.8	0.47%			7.19	50%	3
Greece	1.1	0.47%					
Ireland	2.6	0.47%					
Italy	10.5	0.47%			0.27	70%	38
Luxembourg	0.4	0.47%					
Netherlands	5.2	0.47%			0.46	100%	11
Portugal	1.3	0.47%					
Spain	7.4	0.47%			0.43	12%	17
Sweden	2.8	0.47%			0.49	99%	6
Total Contribution	255.9				30.81		

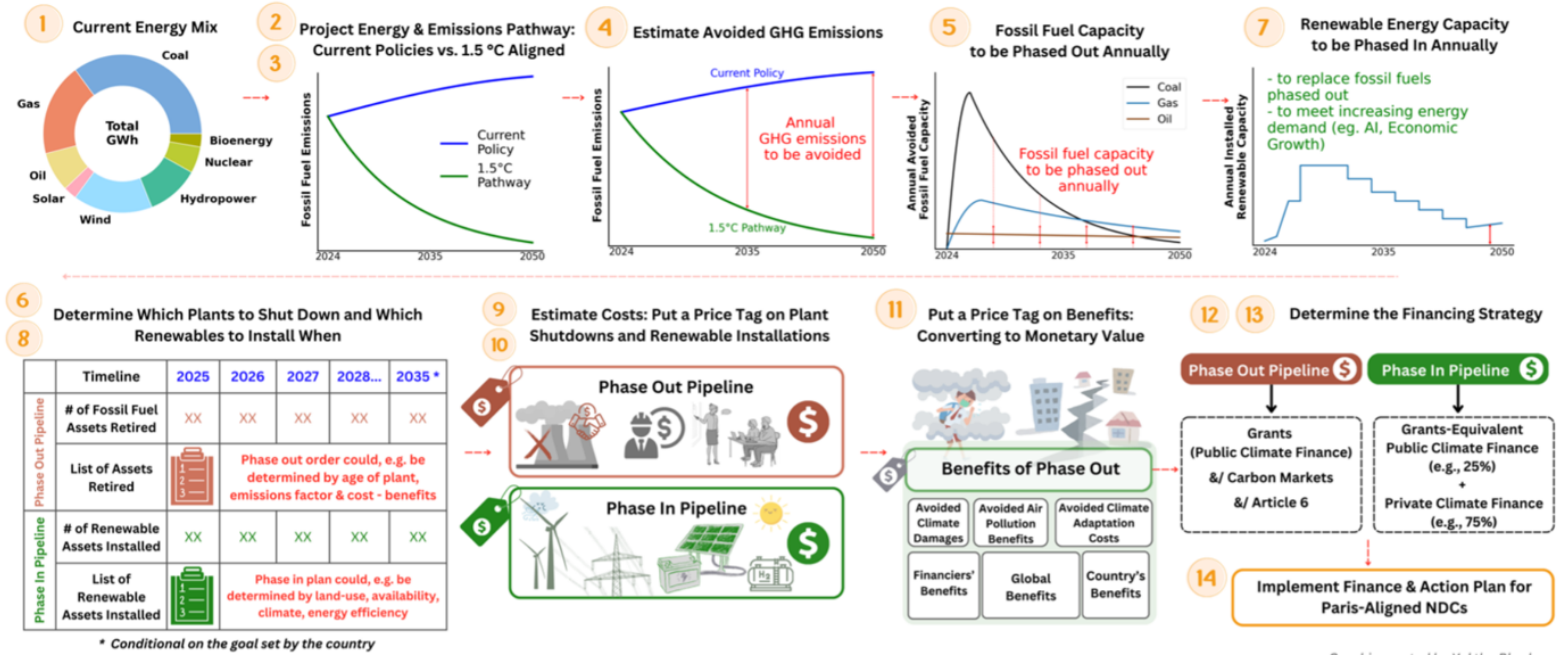
A4. Implementing 1.5°C-Aligned NDCs with Climate Finance

Supplementary Figure 7 provides a step-by-step guideline for how a country can form an implementation and associated financing plan to decarbonize its power sector – which also underlies our methodology. Step 1 involves determining the country's current energy mix. Step 2 involves projecting the country's energy demand and associated emissions under current policies ("business as usual"). Step 3 involves projecting the emission pathway the country would need to follow to implement 1.5°C-aligned decarbonization. Step 4 involves determining the country's avoided emissions, as the cumulative difference between the annual emissions under current policies and the carbon-budget-aligned net-zero scenario. Step 5 involves determining how much fossil fuel capacity must be phased out annually to implement the carbon-budget-aligned net-zero pathway of emissions (of Step 3). Step

6 involves determining the *phase-out pipeline* of which fossil fuel assets must be phased out when to implement the carbon-budget-aligned net-zero pathway of emissions (of Step 3). Step 7 involves determining how much renewable capacity must be added to replace fossil fuel capacity and keep up with any growth in energy demand. Step 8 involves determining the *phase-in pipeline*, specifying how much renewable capacity of what type must be phased in when and where (including also energy storage capacity and grid extension). Step 9 and 10 involve putting a price tag on the phase-out and phase-in pipeline; jointly determining climate finance costs, and thus the country's climate finance needs. Step 11 involves determining the benefits of decarbonization, including the air pollution benefits (largely local) and avoided climate damages and adaptation costs (both local; and cross-country). Step 12 and 13 involve forming a financing strategy (taking into account benefits of Step 11) for how to cover the climate finance costs (Step 9 and 10) to implement decarbonization. The big point is that avoided emission constitute are valuable asset that are often worthwhile for HIC financier coalitions to pay for.

For more details on the methodology, data, and conceptual foundation of this paper, see: Adrian et al. (2022), Bolton et al. (2024), and, particularly, Bolton and Kleinnijenhuis (2024).[12]

[12] See also: Bolton and Kleinnijenhuis (forthcoming 2025), "Climate Finance to Decarbonize the Global Power Sector."



Supplementary Figure 7: Using the climate provision and mobilization by a financier coalition to implement 1.5 °C aligned Nationally Determined Contributions (NDCs) in recipient developing countries.

Table notes: Source, "COP29: The Economic Case for a New Common Quantified Goal (NCQG) of Climate Finance at Scale."

In summary, in “Why coalitions of nations must step in and offer climate finance” (Nature, March 2025) we make the case that:

- **Developing countries** should *submit* credible *conditional* national determined contributions (NDCs), or country decarbonization plans, contingent on receiving external finance, that are aligned with the 1.5°C Paris goal.
- **Developed country coalitions** should *commit* to providing climate finance to those developing countries that submit credible conditional NDCs, or country decarbonization plans outside of this. Such climate finance must be tied emission reductions (linking the phase out fossil fuels to the phase in of renewables).

In these Supplementary Materials, we provided the analysis behind, and variations of, our main result in Figure 1.