# Supplementary Information

Post-COVID-19 recovery stimulus dwarfs near-term climate change investment needs

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**Energy system investments:**

Energy system investment portfolios [REF McCollum et al. 2018] were derived from six global energy-economy models (IAMs): AIM/CGE [REF Fujimori et al. 2014, Fujimori et al. 2012], IMAGE [REF Stehfest et al. 2014], MESSAGEix-GLOBIOM [REF Fricko et al. 2017, Krey et al. 2016], POLES [REF Criqui et al. 2015], REMIND-MAgPIE [REF Kriegler et al. 2017, Luderer et al. 2013] and WITCH-GLOBIOM [REF Bosetti et al. 2006, Emmerling et al. 2016]. We focus on investments under the current policies (used as each model’s baseline) and on upscaling requirements necessary for the energy system compatible with the 1.5°C target of the Paris Agreement. The models cover different types of energy technologies, including resource extraction, power generation, fuel conversion, transmission, energy storage and end-use demand services. We group these technologies into two broad sectors: **fossil fuels** (extraction and conversion of fossil fuels, electricity from fossil fuels without Carbon Capture and Storage (CCS) technologies and hydrogen from fossil fuels) and **low carbon sources** (extraction and conversion of nuclear energy, CCS, electricity from non-bio renewables, hydrogen from non-fossil fuels, extraction and conversion of bioenergy, electricity transmission and distribution and storage, and energy efficiency). The investment figures were corrected for inflation (from USD 2015 to current USD) [REF World Bank].

Our analysis focuses on the near term investment needs from 2020 to 2024, with the taking the model average for the underlying yearly data.

Figures xxx show the total investment needs over the 5-year time period.

Figures xxx show the change in the investment needs over the 5-year time period, from the current policy baseline to the 1.5°C-compatible pathway.

Figures xxx show the average yearly investment relative to the 2018 Gross Domestic Product (GDP) [REF World Bank].

**Stimulus packages:**

International Monetary Fund (IMF) has been tracking the policy measures announced by governments in response to the COVID-19 pandemic [REF]. For this analysis, we focus on the fiscal policy responses, which span a wide range of instruments such as spending and revenue measures (primarily in the health sector, and different types of liquidity support for affected businesses and workers), equity injections, asset purchases, extra-budgetary funds, guarantees on loans, etc. We extracted data for 175 countries and the European Union, announced up to May 15, 2020.

Countries announced their stabilization packages in different levels of detail and scope. Here we group the fiscal measures broadly into those targeted at the health sector, those aimed at supporting individuals and households, those that refer to loans and guarantees, and pool the rest into a category of general measures. Portions of fiscal measures allocated to the *general* category are either unspecified or do not belong to one of the categories above.

**Regional definitions:**

**OECD**+: Includes the OECD 1990 countries as well as EU members and candidates

Albania, Australia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Fiji, Finland, France, French Polynesia,

Germany, Greece, Guam, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania,

Luxembourg, Malta, Macedonia, Montenegro, Netherlands, New Caledonia, New Zealand,

Norway, Poland, Portugal, Romania, Samoa, Serbia, Slovakia, Slovenia, Solomon Islands,

Spain, Sweden, Switzerland, Turkey, United Kingdom, United States of America, Vanuatu

**REF:** Countries from the Reforming Economies of the Former Soviet Union.

Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova,

Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan

**ASIA:** The region includes most Asian countries with the exception of the Middle East,

Japan and Former Soviet Union states.

Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, China Hong Kong

SAR, China Macao SAR, Democratic People's Republic of Korea, East Timor, India,

Indonesia, Lao People's Democratic Republic, Malaysia, Maldives, Mongolia, Myanmar,

Nepal, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Singapore, Sri Lanka,

Taiwan, Thailand, Viet Nam

**MAF:** This region includes the countries of the Middle East and Africa.

Algeria, Angola, Bahrain, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde,

Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Democratic Republic of

the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Eswatini, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kenya, Kuwait,

Lebanon, Lesotho, Liberia, Libyan Arab Jamahiriya, Madagascar, Malawi, Mali, Mauritania,

Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Oman, Qatar, Reunion,

Rwanda, Saudi Arabia, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Syrian Arab Republic, Togo, Tunisia, Uganda, United Arab Emirates, United Republic of

Tanzania, Western Sahara, Yemen, Zambia, Zimbabwe

**LAM:**  This region includes the countries of Latin America and the Caribbean.

Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba,

Dominican Republic, Ecuador, El Salvador, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay,

Peru, Puerto Rico, Suriname, Trinidad and Tobago, Uruguay, Venezuela

**Four individual economies:** China, European Union, India, United States

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| **Stimulus packages in response to COVID-19 (IMF, 2020) (USD billion)** | | | | | | |
| Country code | Region | Economy | General | Health | Individuals | Total |
| AFG | ASIA | - | 0.08 | 0.02 | - | 0.10 |
| AGO | MAF | - | - | 0.04 | - | 0.04 |
| ALB | OECD+ | 0.37 | 0.02 | 0.03 | - | 0.42 |
| ARE | MAF | 4.40 | 2.82 | - | - | 7.22 |
| ARG | LAM | - | 3.70 | - | - | 3.70 |
| ARM | REF | - | 0.14 | - | - | 0.14 |
| AUS | OECD+ | - | 45.88 | - | 96.07 | 141.96 |
| AUT | OECD+ | 10.88 | 33.69 | 4.35 | - | 48.91 |
| AZE | REF | - | - | - | - | - |
| BDI | MAF | - | 0.05 | - | 0.03 | 0.08 |
| BEL | OECD+ | 56.52 | 10.87 | - | 4.67 | 72.07 |
| BEN | MAF | - | 0.01 | - | - | 0.01 |
| BFA | MAF | - | - | - | - | - |
| BGD | ASIA | 6.59 | - | - | 0.45 | 7.04 |
| BGR | OECD+ | - | 1.37 | - | - | 1.37 |
| BHR | MAF | - | 1.10 | 0.47 | 0.01 | 1.59 |
| BHS | LAM | 0.05 | 0.01 | 0.00 | 0.01 | 0.07 |
| BIH | OECD+ | 0.30 | 0.86 | 0.02 | - | 1.18 |
| BLR | REF | - | - | - | - | - |
| BLZ | LAM | - | 0.02 | - | - | 0.02 |
| BOL | LAM | 0.22 | - | 0.20 | - | 0.42 |
| BRA | LAM | - | 149.00 | - | - | 149.00 |
| BRB | LAM | - | - | - | - | - |
| BRN | ASIA | - | - | - | - | - |
| BTN | ASIA | - | - | 0.03 | - | 0.03 |
| BWA | MAF | 0.10 | 0.06 | 0.05 | - | 0.20 |
| CAF | MAF | - | 0.04 | - | - | 0.04 |
| CAN | OECD+ | 65.60 | - | 2.45 | 81.03 | 149.08 |
| CHE | OECD+ | 50.11 | 16.36 | - | - | 66.47 |
| CHL | LAM | 3.00 | 11.75 | - | 2.00 | 16.75 |
| CHN | ASIA | - | 340.00 | - | - | 340.00 |
| CIV | MAF | 0.77 | 0.13 | 0.13 | - | 1.03 |
| CMR | MAF | 0.04 | - | 0.11 | - | 0.15 |
| COD | MAF | - | 0.14 | - | - | 0.14 |
| COG | MAF | - | 0.18 | - | - | 0.18 |
| COL | LAM | - | 9.27 | - | - | 9.27 |
| COM | MAF | - | - | - | - | - |
| CPV | MAF | 0.03 | - | - | 0.02 | 0.06 |
| CRI | LAM | - | - | - | - | - |
| CUB | LAM | - | - | - | - | - |
| CYP | OECD+ | 0.00 | 0.86 | 0.11 | - | 0.97 |
| CZE | OECD+ | 36.20 | 10.22 | - | - | 46.41 |
| DEU | OECD+ | 902.00 | 115.00 | - | 107.00 | 1,124.00 |
| DJI | MAF | - | - | - | - | - |
| DNK | OECD+ | 10.67 | 22.76 | - | - | 33.43 |
| DOM | LAM | - | 0.58 | - | - | 0.58 |
| DZA | MAF | - | - | - | - | - |
| ECU | LAM | 0.05 | - | - | 0.11 | 0.16 |
| EGY | MAF | 0.00 | 0.00 | 0.00 | - | 0.01 |
| ERI | MAF | - | - | - | - | - |
| ESP | OECD+ | 20.65 | 5.32 | 4.62 | 20.05 | 50.64 |
| EST | OECD+ | 1.90 | 0.14 | 0.23 | 0.27 | 2.55 |
| ETH | MAF | - | 0.29 | 0.43 | 0.92 | 1.64 |
| EU | OECD+ | 0.46 | 366.00 | 261.00 | - | 627.46 |
| FIN | OECD+ | 5.60 | - | 1.09 | 4.40 | 11.09 |
| FJI | OECD+ | - | 0.48 | - | - | 0.48 |
| FRA | OECD+ | 342.00 | 120.00 | - | - | 462.00 |
| GAB | MAF | - | 0.68 | - | - | 0.68 |
| GBR | OECD+ | 37.36 | - | 19.61 | 9.34 | 66.31 |
| GEO | REF | 0.43 | - | 0.14 | - | 0.57 |
| GHA | MAF | - | 0.31 | - | - | 0.31 |
| GMB | MAF | - | 0.03 | - | - | 0.03 |
| GNB | MAF | - | - | 0.00 | 0.00 | 0.00 |
| GNQ | MAF | - | - | 0.00 | - | 0.00 |
| GRC | OECD+ | 2.17 | 11.41 | - | - | 13.59 |
| GTM | LAM | - | 2.67 | - | - | 2.67 |
| GUM | OECD+ | - | - | - | - | - |
| GUY | LAM | - | - | - | - | - |
| HKG | ASIA | 23.79 | - | 3.83 | 9.06 | 36.68 |
| HND | LAM | - | 1.89 | 0.22 | 0.29 | 2.40 |
| HRV | OECD+ | - | - | - | - | - |
| HTI | LAM | - | 0.08 | 0.04 | 0.02 | 0.14 |
| HUN | OECD+ | 8.57 | - | 0.95 | - | 9.52 |
| IDN | ASIA | 10.54 | 20.25 | - | - | 30.79 |
| IND | ASIA | - | 272.00 | - | - | 272.00 |
| IRL | OECD+ | 5.00 | 7.46 | 2.00 | - | 14.46 |
| IRN | MAF | 35.26 | 28.97 | 0.19 | 0.39 | 64.82 |
| IRQ | MAF | - | 0.03 | - | - | 0.03 |
| ISL | OECD+ | - | 2.12 | - | - | 2.12 |
| ISR | MAF | 11.42 | 6.13 | 3.06 | 5.57 | 26.18 |
| ITA | OECD+ | 446.96 | 0.33 | 3.48 | 10.87 | 461.63 |
| JAM | LAM | - | 0.17 | - | - | 0.17 |
| JOR | MAF | - | - | - | 0.02 | 0.02 |
| JPN | OECD+ | 795.00 | 229.00 | - | 24.86 | 1,048.86 |
| KAZ | REF | - | - | - | - | - |
| KEN | MAF | - | 0.39 | - | - | 0.39 |
| KGZ | REF | 0.02 | 0.54 | 0.02 | - | 0.57 |
| KHM | ASIA | - | - | 0.06 | - | 0.06 |
| KOR | ASIA | - | 20.26 | - | - | 20.26 |
| KWT | MAF | - | 1.60 | - | - | 1.60 |
| LAO | ASIA | - | 0.01 | - | - | 0.01 |
| LBN | MAF | - | - | - | - | - |
| LBR | MAF | - | - | - | - | - |
| LBY | MAF | - | 0.37 | - | - | 0.37 |
| LKA | ASIA | - | 0.01 | - | - | 0.01 |
| LSO | MAF | 0.03 | 0.03 | 0.03 | 0.06 | 0.14 |
| LTU | OECD+ | 2.50 | 0.39 | 0.54 | 1.46 | 4.89 |
| LUX | OECD+ | 9.62 | 0.03 | 0.21 | 1.45 | 11.30 |
| LVA | OECD+ | 1.12 | 0.86 | 0.02 | 0.01 | 2.00 |
| MAC | ASIA | - | 6.67 | - | - | 6.67 |
| MAR | MAF | - | 3.18 | - | - | 3.18 |
| MDA | REF | - | - | - | - | - |
| MDG | MAF | - | - | - | - | - |
| MDV | ASIA | - | 0.23 | - | - | 0.23 |
| MEX | LAM | 1.30 | 8.05 | - | - | 9.35 |
| MKD | OECD+ | - | 0.03 | - | - | 0.03 |
| MLI | MAF | - | 0.09 | - | - | 0.09 |
| MLT | OECD+ | - | 0.42 | 0.14 | - | 0.57 |
| MMR | ASIA | 0.07 | - | 0.00 | 0.03 | 0.10 |
| MNE | OECD+ | - | 0.21 | - | - | 0.21 |
| MNG | ASIA | - | - | 0.05 | 0.26 | 0.31 |
| MOZ | MAF | - | - | 0.02 | - | 0.02 |
| MRT | MAF | - | 0.08 | - | - | 0.08 |
| MUS | MAF | 0.09 | 0.25 | 0.01 | 0.00 | 0.34 |
| MWI | MAF | 0.05 | - | 0.02 | - | 0.07 |
| MYS | ASIA | - | 10.31 | - | - | 10.31 |
| NAM | MAF | 0.17 | 0.26 | 0.17 | - | 0.60 |
| NCL | OECD+ | - | - | - | - | - |
| NER | MAF | - | - | - | - | - |
| NGA | MAF | 0.03 | 1.35 | 0.02 | - | 1.40 |
| NIC | LAM | - | - | - | - | - |
| NLD | OECD+ | - | 21.85 | - | - | 21.85 |
| NOR | OECD+ | - | 17.09 | - | - | 17.09 |
| NPL | ASIA | - | - | - | - | - |
| NZL | OECD+ | 8.99 | 5.12 | 0.35 | 1.66 | 16.12 |
| OMN | MAF | - | - | - | - | - |
| PAK | ASIA | 0.82 | 7.06 | 0.12 | 1.85 | 9.85 |
| PAN | LAM | 0.19 | - | - | 0.01 | 0.20 |
| PER | LAM | 0.09 | - | 0.33 | 1.03 | 1.46 |
| PHL | ASIA | 2.28 | 3.92 | 1.11 | 3.89 | 11.20 |
| PNG | ASIA | - | 1.71 | - | - | 1.71 |
| POL | OECD+ | 41.77 | 22.20 | - | - | 63.96 |
| PRI | LAM | - | - | - | - | - |
| PRT | OECD+ | 10.76 | - | - | - | 10.76 |
| PRY | LAM | 0.05 | 1.00 | 0.50 | 0.40 | 1.95 |
| PYF | OECD+ | - | - | - | - | - |
| QAT | MAF | - | 20.60 | - | - | 20.60 |
| ROU | OECD+ | - | 8.88 | - | - | 8.88 |
| RUS | REF | - | 46.41 | - | - | 46.41 |
| RWA | MAF | - | 0.31 | - | - | 0.31 |
| SAU | MAF | 18.70 | 13.78 | 12.53 | - | 45.01 |
| SDN | MAF | - | 3.52 | 1.24 | 1.03 | 5.79 |
| SEN | MAF | 0.12 | 1.44 | 0.13 | - | 1.69 |
| SGP | ASIA | 41.00 | 1.41 | 0.59 | 4.23 | 47.23 |
| SLB | OECD+ | - | 0.04 | - | - | 0.04 |
| SLE | MAF | - | 0.01 | - | - | 0.01 |
| SLV | LAM | - | - | - | - | - |
| SOM | MAF | - | - | - | - | - |
| SRB | OECD+ | 4.81 | - | 0.39 | 0.65 | 5.85 |
| SUR | LAM | - | - | - | 0.05 | 0.05 |
| SVK | OECD+ | - | 2.03 | - | - | 2.03 |
| SVN | OECD+ | 0.65 | 5.82 | - | 0.05 | 6.52 |
| SWE | OECD+ | 52.00 | 15.99 | - | - | 67.99 |
| SWZ | MAF | - | 0.01 | - | - | 0.01 |
| SYR | MAF | - | - | - | - | - |
| TCD | MAF | - | - | 0.06 | 0.01 | 0.07 |
| TGO | MAF | - | 0.13 | - | - | 0.13 |
| THA | ASIA | 12.38 | 46.42 | 18.57 | - | 77.37 |
| TJK | REF | - | - | - | - | - |
| TKM | REF | 4.65 | - | 0.82 | 0.12 | 5.58 |
| TLS | ASIA | - | - | - | - | - |
| TTO | LAM | - | - | - | - | - |
| TUN | MAF | - | 0.62 | 0.04 | 0.28 | 0.94 |
| TUR | OECD+ | 5.18 | 15.53 | - | - | 20.71 |
| TZA | MAF | 0.38 | - | 0.30 | - | 0.68 |
| UGA | MAF | - | 0.08 | - | - | 0.08 |
| UKR | REF | - | 0.22 | - | - | 0.22 |
| URY | LAM | - | - | - | 0.40 | 0.40 |
| USA | OECD+ | 1,240.00 | 637.00 | 200.00 | 716.00 | 2,793.00 |
| UZB | REF | - | - | - | - | - |
| VEN | LAM | - | - | - | - | - |
| VNM | ASIA | 7.96 | 2.21 | - | 1.59 | 11.77 |
| WSM | OECD+ | - | 0.03 | - | - | 0.03 |
| ZAF | MAF | 0.01 | - | 0.01 | - | 0.01 |
| ZMB | MAF | - | 0.25 | - | - | 0.25 |
| ZWE | MAF | - | 0.00 | - | - | 0.00 |