

Supplementary Materials for

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

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**This PDF file includes:**

Materials and Methods

Figs. S1 to S8

Table S1

References

**Other Supplementary Materials for this manuscript include the following:**

Data

R script

Materials and Methods

Energy system investments

Energy system investment portfolios (*1*) were derived from six global energy-economy models (IAMs): AIM/CGE (*2*), IMAGE (*3*), MESSAGEix-GLOBIOM (*4*), POLES (*5*),REMIND-MAgPIE (*6*), and WITCH-GLOBIOM (*7*). In this analysis we focus on the near-term (2020-2024) investment needs 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
* 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), and are reported as model averages for the underlying annual data.

Stimulus packages

The International Monetary Fund (IMF) has been tracking the policy measures announced by governments in response to the COVID-19 pandemic (*8*). 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 until 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 (in figures labeled as *Health*); measures aimed at supporting individuals and households (labeled *Individuals*); measures that aim at the economy at large, including loans and guarantees (labeled *Economy*) and pool the rest into a category of general measures (labeled *General*). Portions of fiscal measures allocated to the general category are either unspecified or do not belong to one of the categories above. We do not account for governments' announcements to channel funds into international assistance, nor the recovery funds agreed between governments and the international finance institutions. See Table S1 for country-level detail.

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Fig. S1.

Total amount of stimulus packages for five macro regions and the world, disaggregated in four categories based on the targets of the fiscal instruments.

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Fig. S2.

Total amount of stimulus packages for four large economies, disaggregated in four categories based on the targets of the fiscal instruments.

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Fig. S3.

Annual energy system investments between 2020 and 2024 for the current policy baseline (left) and a pathway compatible with the 1.5°C limit of global mean temperature (right) for five macro regions and the world.

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Fig. S4.

Annual energy system investments between 2020 and 2024 for the current policy baseline (left) and a pathway compatible with the 1.5°C limit of global mean temperature (right) for four large economies.

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Fig. S5.

Annual shift in energy investments from the current policy baseline scenario to a pathway compatible with the 1.5°C limit of global mean temperature for five macro regions and the world (left) and four large economies (right).

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Fig. S6.

Average annual energy investments compatible with the 1.5°C global mean temperature limit, and fiscal stimulus packages in response to COVID-19, expressed as a percentage of the 2018 Gross Domestic Product (GDP) for five macro regions and the world (left) and four major economies (right).

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Fig. S7.

Annual energy investments compatible with the 1.5°C global mean temperature limit, and fiscal stimulus packages in response to COVID-19, expressed in current USD, for five macro regions and the world (left) and four major economies (right).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table S1.  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 |

Data S1. (separate file)

All data underlying this analysis are available at: <https://github.com/marina-andrijevic/covid_recovery/tree/master/data>