Scaling MDB Renewable Energy Finance: Economic and Environmental Implications

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Abstract

We quantify how increased financing of solar and wind capacity by multilateral development banks (MDBs) in emerging and developing economies (EMDEs) can expand electricity supply, support economic development, and reduce global CO_2 emissions. Using two interconnected analytical models and a technology-rich computable general equilibrium (CGE) model of the global economy in 2030, we evaluate three scenarios in which annual MDB financing for solar and wind across EMDEs (excluding China and Russia) rises from a business-as-usual (BAU) level of $2.12 billion (2022 USD) to three alternative levels spanning $340.26–$489.58 billion (2022 USD) during 2023–2030. Across 14 aggregated EMDEs, median changes in electricity supply in 2030 relative to BAU are positive, ranging from 1.63–2.18%, depending on the policy scenario. Median changes in GDP are positive, ranging from 0.11–0.12%, depending on the scenario, while median changes in consumption are negative, ranging from -0.29% to -0.12%, depending on the scenario. When financing takes the form of grants rather than loans, the median changes in GDP are positive and 0.14% for each of the three scenarios, and the median changes in consumption are positive, ranging from 0.12–0.14%, depending on the scenario. Globally, total CO_2 emissions fall by 0.46–0.55%, depending on the scenario. These findings indicate that increasing MDB financing for solar and wind can boost electricity supply in EMDEs, generate economic gains when provided as grants, and contribute to reductions in global CO_2 emissions.

Keywords: CGE model; Climate finance; Renewable energy; Sustainable development

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1 Introduction

Given the high investment risks in emerging and developing economies (EMDEs) and their public budget constraints, multilateral development banks (MDBs) have been key financiers of power sector projects. MDBs typically provide concessional loans with lower interest rates and longer repayment periods than market loans. For over 50 years, they have supported power generation in EMDEs, historically prioritizing coal, gas, and large hydropower. Around 1999-2000, MDBs began shifting portfolios toward zero-carbon technologies, though fossil fuel financing has persisted in support of economic development and energy security (Steffen and Schmidt, 2019).

As electricity demand in EMDEs rises, so does the challenge of expanding supply while ensuring access to affordable, reliable, sustainable, and modern energy: Goal 7 of the United Nations Sustainable Development Goals. In 2022, 685 million people, including 571 million in Sub-Saharan Africa, still lacked access to electricity (IEA, IRENA, UNSD, World Bank and WHO, 2024). Meeting this challenge requires increased investment in power generation. Briera and Lefèvre (2024) assess the extent to which international climate finance can help reduce the cost of capital for variable renewable energy (VRE) projects and accelerate renewable energy deployment in developing countries. Using a multi-regional Integrated Assessment Model (IAM), they examine various climate finance scenarios and find that international climate finance can significantly enhance the adoption of renewable energy in regions receiving the financing. For instance, Africa could receive an extra 43% in electricity generation from VRE by 2030 in a scenario with deep risk sharing and mitigation for VRE projects, compared to a no-policy scenario. Because electricity is a key production input, scaling up MDB financing can spur economic development and shape emissions trajectories, with implications for global climate mitigation.

This paper addresses two questions: (1) to what extent can increased MDB financing for solar and wind generation capacity in EMDEs expand electricity supply? and (2) can such financing simultaneously enhance economic development and reduce global CO_2 emissions? To answer these questions, we develop a multi-regional, multi-sector computable general equilibrium (CGE) model of the global economy to simulate MDB solar and wind financing policies in EMDEs, excluding China and Russia.

CGE models are widely used in energy economics because they combine economic theory with empirical data, capturing economy-wide interactions across markets. This represents an advantage over partial equilibrium models, which focus on individual markets and do not capture general equilibrium feedback effects. CGE models enable the quantification of both direct and indirect effects of policy shocks.

We assess three scenarios of expanded MDB financing for solar and wind from 2023 to 2030. The first, inspired by the Independent Expert Group's Triple Agenda Report, calls for EMDEs (excluding China) to receive \$300-\$400 billion annually (2019 prices) in zero-carbon generation financing by 2030 (Independent Experts Group, 2023). In this scenario, MDB solar and wind financing rises from \$2.12 billion (2022 USD) to \$457.88 billion annually (2022 USD). The second scenario, based on the COP28 pledge by 117 countries to triple renewable capacity by 2030 (WRI, 2023), raises MDB financing to \$340.26 billion annually (2022 USD), ensuring that each EMDE's clean electricity capital stock in 2030 is three times its 2023 level. The third scenario, derived from an insight from the analytical modeling in Section 3, sets financing at \$489.58 billion annually (2022 USD). This ensures that by 2030, each EMDE's clean electricity capital stock equals its

2023 level multiplied by the inverse of its 2023 share of clean generation in its aggregate electricity generator's production costs.

Through capital accumulation, increased MDB financing in 2023-2030 leads to higher solar and wind inputs in 2030 relative to business as usual (BAU). Across the 14 aggregated EMDEs studied, median changes in electricity supply in 2030 relative to BAU range from 1.63–2.18%, depending on the scenario. Median changes in GDP range from 0.11–0.12%, depending on the scenario; however, when financing takes the form of grants rather than loans, the median changes in GDP are 0.14% for each scenario. Median changes in consumption range from -0.29% to -0.12%, depending on the scenario; however, when financing takes the form of grants rather than loans, the median changes in consumption range from 0.12–0.14%, depending on the scenario. Global CO_2 emissions fall by 0.46–0.55%, depending on the scenario. A useful way to think about the CO_2 emissions effects is as the interaction of two opposing forces. MDB financing lowers the cost of solar and wind generation, encouraging substitution away from fossil fuel generation toward renewable generation, thereby reducing the carbon intensity of electricity supply and thus CO_2 emissions. At the same time, lower electricity prices increase overall electricity demand across the economy, leading to higher aggregate electricity generation and partially offsetting these emissions reductions. The net effect on emissions depends on the relative strength of these two forces. Section 3 formalizes this trade-off in a stylized analytical framework.

These results indicate that, compared to BAU, increasing MDB financing for solar and wind can expand electricity supply in EMDEs. Scaling up financing can produce mixed economic outcomes: GDP increases, while consumption declines under loan-based financing; when financing is provided as grants rather than loans, both GDP and consumption rise. The financing can also contribute to reductions in global CO_2 emissions. Overall, these findings demonstrate that MDB financing can simultaneously grow electricity supply and advance climate mitigation alongside economic development.

The remainder of the paper is structured as follows. Section 2 reviews the background and literature. Section 3 presents two analytical models. Section 4 describes the CGE data, structure, and simulations, reports the results, and discusses sensitivity analysis. Section 5 concludes.

2 Background and Literature Review

MDBs have long played a crucial role in financing climate initiatives in EMDEs (Schmidt, 2014). In 2023, MDBs provided \$50 billion in climate mitigation finance to low- and middle-income economies (African Development Bank et al., 2024). At COP29 in Baku, MDBs pledged to increase their climate financing to \$120 billion annually by 2030 (World Bank Group, 2024).

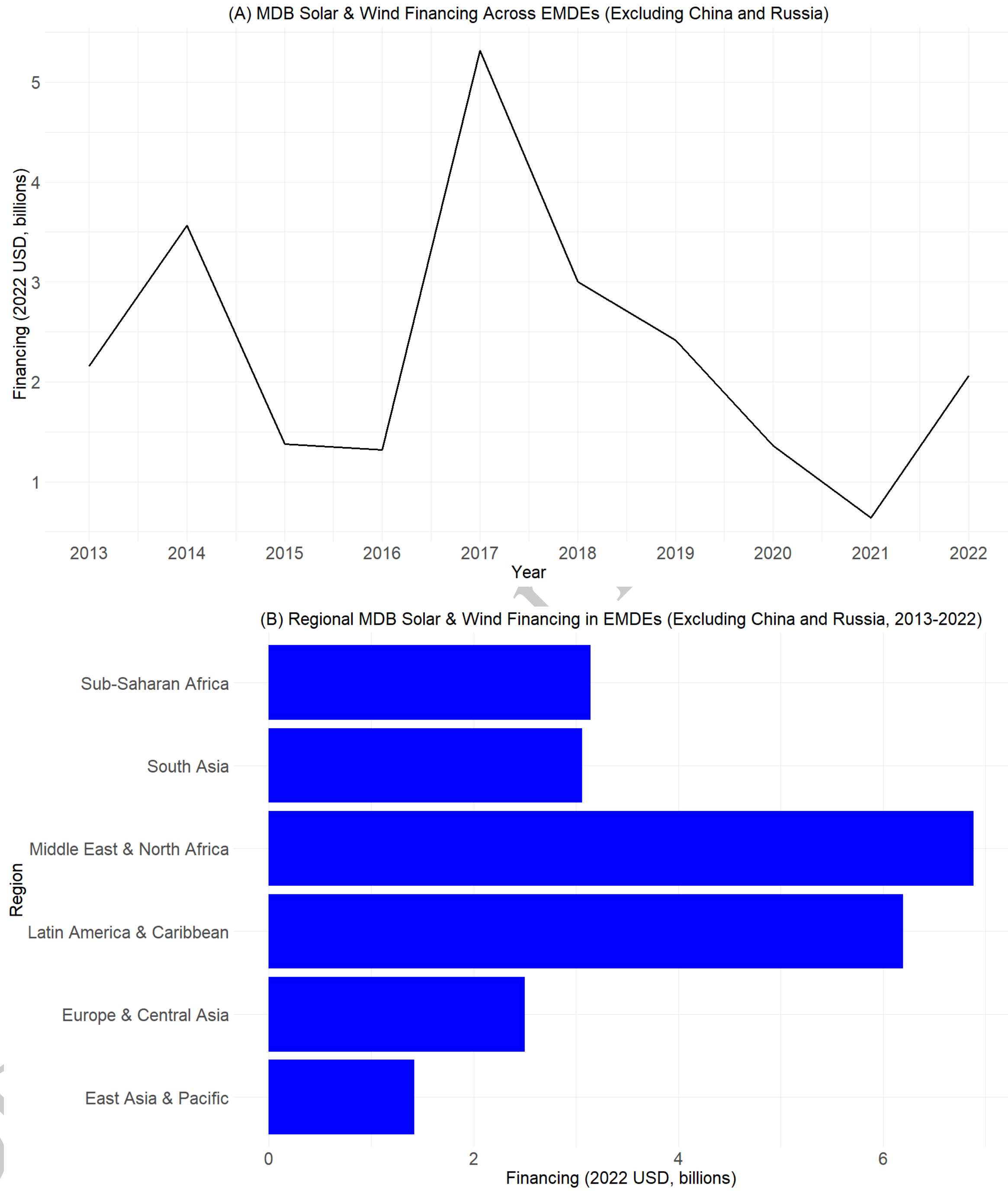
Over time, MDB energy financing has shifted from fossil fuels toward renewables, though fossil fuel projects continue to receive support. For example, World Bank non-hydro renewable energy financing grew from 1% of its portfolio of energy financing in 1985–1990 to 16.5% in 2011–2019 (Kim and Lee, 2021). Basílio (2023) analyzed MDB involvement in energy projects across 64 countries between 2011 and 2018 and found that although MDBs were more active in renewable projects, this is not confirmed by the scale of financial support provided.

Figure 1 summarizes trends in MDB solar and wind financing, expressed in billions of 2022 USD, across EMDEs (excluding China and Russia) from 2013 to 2022, highlighting both total annual financing (Image A) and regional distributions (Image B). The MDBs are the

African Development Bank, Asian Development Bank, Asian Infrastructure Investment Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter-American Development Bank, Islamic Development Bank, New Development Bank, and World Bank Group.

While annual MDB solar and wind financing fluctuated between 2013 and 2022, the overall level in 2022 was approximately the same as in 2013. The Middle East and North Africa received the highest total financing, followed by Latin America and the Caribbean, Sub-Saharan Africa, South Asia, Europe and Central Asia, and East Asia and the Pacific.

Figure 1: Historical MDB Financing in Solar and Wind Capacity in EMDEs



Sources: Oil Change International (2025); Authors' calculations.

A growing literature examines the impacts of historical MDB and DFI power financing. Steffen and Schmidt (2019) compiled data from 841 projects between 2007 and 2015, showing that 96% of new power generation capacity in low-income countries involved MDB participation, including all non-hydro renewable capacity. Chen et al. (2020) show that between 2000 and 2018, the China Development Bank and the Export-Import Bank of China facilitated 90.40 GW of additional overseas electricity generation capacity, including 1.35 GW from solar and wind. Chen et al. (2021) evaluate overseas electricity financing by China, Japan, and the U.S. from 2000 to 2018, finding that most capacity additions were fossil fuel-based, with less than 15% in non-hydro renewables, and that fossil fuel financing through 2018 will lock in 24 Gt of CO_2 emissions by 2060. Sun et al. (2023) use panel data from 37 countries to show that MDB solar financing can significantly promote technological innovation.

Analytical and CGE models have been widely applied to assess renewable energy policies' economic and environmental impacts. Rivers (2013) finds that U.S. renewable electricity support policies can slightly raise equilibrium unemployment, and that when the elasticity of substitution between labor and capital is low, capital is internationally immobile, and when the labor intensity of renewable generation is higher than that of conventional generation, these policies may reduce equilibrium unemployment. Dai et al. (2016) project that large-scale renewable energy development in China stimulates \$1.18 trillion in upstream output, creates 4.12 million jobs by 2050, and significantly reduces CO_2, NO_x, and SO_2 emissions. Hasudungan and Sabaruddin (2018) simulate a 15% subsidy on renewable generation in Indonesia, finding negligible macroeconomic or emissions impacts under two financing mechanisms–an endogenous electricity tax and a carbon tax adjustment. Oh et al. (2020) analyze Korea, showing that increasing solar and wind shares to 7% slightly reduces GDP, but upstream industries benefit and the negative effect diminishes with greenhouse gas regulation.

While there is a literature that evaluates domestic renewable energy policies using analytical and CGE models and analyzes historical MDB/DFI financing, a gap remains in evaluating the energy, environmental, and economic effects of scaled-up projected MDB solar and wind financing in EMDEs using analytical and CGE models. This paper determines the extent to which increased MDB solar and wind financing can expand electricity supply, spur economic development, and reduce global CO_2 emissions.

3 Analytical Modeling

To provide insight into the mechanisms by which increasing renewable energy financing by MDBs can grow electricity supply and spur economic development in EMDEs while reducing global CO_2 emissions, we set up and solve two interconnected stylized analytical models. Our approach is deliberately simple. We formulate an analytically tractable model of a closed economy, summarized in Table 1, which encompasses top-down and bottom-up components that are linked by the energy market.

In the top-down submodel, a representative expenditure-minimizing household derives utility (U) from energy (Q_U, with price P_Q) and final good consumption (Y, with price P_Y) according to $U = f_1(Q_U, Y; \sigma_U)$, where σ_U is the elasticity of substitution between consumption inputs. The final good is produced by a representative cost-minimizing firm using intermediate energy input (Q_Y, with price P_Q) and a composite factor (Z, which we take as the numeraire, with price

P_Z) according to $Y = f_2(Q_Y, Z; \sigma_Y)$, with σ_Y the elasticity of substitution between inputs. A secular expansion in the composite input endowment, reflecting growth in the factor endowment (e.g., via population growth), drives increases in output and utility. A secular reduction in the energy price expands aggregate energy use ($Q = Q_U + Q_Y$). Using a hat over a variable to denote the logarithmic differential or fractional change (e.g., $\widehat{x} = d \ln x = dx/x$), this submodel can be expressed in log-linearized form as a system of seven equations (1a)-(1g) in as many unknowns, $\{\widehat{U}, \widehat{Y}, \widehat{P}_Y, \widehat{Q}, \widehat{Q}_U, \widehat{Q}_Y, \widehat{P}_Z\}$, in which expansion of the composite input endowment ($\widehat{Z}$) and decline in the price of energy ($\widehat{P}_Q$) are exogenous forcing variables.

The bottom-up model draws on the SIMPLE framework (Hertel et al., 2016) to represent the aggregate energy sector, whose equilibrium facilitates analysis of the consequences of expanded clean energy financing by MDBs. A representative producer satisfies total demand for energy by combining the outputs of a clean technology (quantity Q_C, with price P_C) and a dirty technology (quantity Q_D, with price P_D), according to a neoclassical production function: $Q = f_3(Q_C, Q_D)$. We treat Q_D as being synonymous with fossil fuels—and associated CO_2 emissions. Dirty energy follows an upward-sloping supply schedule, while clean energy expands exogenously. In log-linearized form, this model of the energy sector consists of five equations (1h)-(1l) in as many unknowns, $\{\widehat{Q}, \widehat{P}_Q, \widehat{Q}_D, \widehat{P}_D, \widehat{P}_C\}$, with expansion of the composite input endowment ($\widehat{Z}$) and expansion of the supply of clean energy ($\widehat{Q}_C$) as exogenous forcing variables.

Table 1: Summary of the Analytical Model

A. Variables

U	Household utility	Y	Final good demand	P_Y	Final good price
Q_U	Household energy demand	Q_Y	Intermediate energy demand	Q	Total energy demand
P_Q	Total energy price	Z	Composite input supply	P_Z	Composite input price
Q_D	Dirty energy supply	P_D	Dirty energy price		
Q_C	Clean energy supply	P_C	Clean energy price		
Q_C^M	MDB clean energy supply	Q_C^N	non-MDB clean energy supply		

B. Parameters

$\alpha \in (0,1)$	Share of household energy demand in household expenditure
$\beta \in (0,1)$	Share of intermediate energy demand in final good production costs
$\gamma \in (0,1)$	Share of household energy demand in total energy demand
$\delta \in (0,1)$	Share of clean energy demand in total energy production costs
$\sigma_U \in (0,1]$	Elasticity of substitution between inputs to household consumption
$\sigma_Y \in (0,1]$	Elasticity of substitution between inputs to final good production
$\sigma_Q > 0$	Elasticity of substitution between inputs to total energy production
$\rho \in (0,1]$	Price elasticity of total energy demand (magnitude)
$\epsilon > 0$	Price elasticity of dirty energy supply
$\phi \in (0,1)$	MDB share of clean energy supply

C. Top-down economy-wide submodel

Utility function:	$\widehat{U} = \alpha \widehat{Q}_U + (1-\alpha)\widehat{Y}$	(1a)
Household consumption substitution:	$\widehat{Q}_U - \widehat{Y} = -\sigma_U(\widehat{P}_Q - \widehat{P}_Y)$	(1b)
Final good production function:	$\widehat{Y} = \beta \widehat{Q}_Y + (1-\beta)\widehat{Z}$	(1c)
Final good zero profit:	$\widehat{P}_Y + \widehat{Y} = \beta(\widehat{P}_Q + \widehat{Q}_Y) + (1-\beta)(\widehat{P}_Z + \widehat{Z})$	(1d)
Final good input substitution:	$\widehat{Q}_Y - \widehat{Z} = -\sigma_Y(\widehat{P}_Q - \widehat{P}_Z)$	(1e)
Energy market clearance:	$\widehat{Q} = \gamma \widehat{Q}_U + (1-\gamma)\widehat{Q}_Y$	(1f)
Numeraire:	$\widehat{P}_Z = 0$	(1g)

D. Bottom-up energy sector submodel

Aggregate energy demand function:	$\widehat{Q} = \widehat{Z} - \rho \widehat{P}_Q$	(1h)
Energy production function:	$\widehat{Q} = \delta \widehat{Q}_C + (1-\delta)\widehat{Q}_D$	(1i)
Energy zero profit:	$\widehat{P}_Q + \widehat{Q} = \delta(\widehat{P}_C + \widehat{Q}_C) + (1-\delta)(\widehat{P}_D + \widehat{Q}_D)$	(1j)
Energy input substitution:	$\widehat{Q}_C - \widehat{Q}_D = -\sigma_Q(\widehat{P}_C - \widehat{P}_D)$	(1k)
Dirty energy supply function:	$\widehat{Q}_D = \epsilon \widehat{P}_D$	(1l)
Clean energy supply composition:	$\widehat{Q}_C = \phi \widehat{Q}_C^M + (1-\phi)\widehat{Q}_C^N$	(1m)

The solution to the top-down economy-wide submodel shows equilibrium increases in utility, output of the final good, and total energy supply depend linearly on $\widehat{Z}$ and $\widehat{P}_Q$:

$$\widehat{U} = \widehat{Z} - (\beta\sigma_Y + \alpha(1-\beta)\sigma_U)\widehat{P}_Q > 0 \tag{2a}$$

$$\widehat{Y} = \widehat{Z} - \beta\sigma_Y\widehat{P}_Q > 0 \tag{2b}$$

$$\widehat{Q} = \widehat{Z} - \rho\widehat{P}_Q > 0 \tag{2c}$$

where the magnitude of the price elasticity of demand for total energy,

$$\rho = \rho^* = (1-\beta)\gamma\sigma_U + (1-(1-\beta)\gamma)\sigma_Y \tag{3}$$

is determined by the structure of the economy. In particular, the equivalence between the economy-wide equilibrium solution (2c) and the aggregate energy demand function (1h) means that ρ^* is the key link between the top-down and bottom-up submodels. This parameter is a convex combination of consumer and producer substitution elasticities, which, given the top-down submodel's highly aggregate character, take on values that are at most unity, indicating inelastic energy demand: $\rho^* \in (0, 1]$.

Bottom-up solutions reveal that the equilibrium aggregate energy price change reflects upward pressure from composite input supply expansion and downward pressure from clean energy supply expansion:

$$\widehat{P}_Q = \mathcal{D}^{-1}[(\delta\epsilon + \sigma_Q)\widehat{Z} - \delta(\epsilon + \sigma_Q)\widehat{Q}_C] \tag{4}$$

where the denominator $\mathcal{D} = \delta\epsilon\rho^* + ((1-\delta)\epsilon + \rho^*)\sigma_Q > 0$. Aggregate energy price declines with expansion of clean energy supply that is sufficiently rapid:

$$\widehat{Q}_C > \widehat{Q}_C^{\dagger} = \frac{\delta\epsilon + \sigma_Q}{\delta(\epsilon + \sigma_Q)}\widehat{Z} \tag{5}$$

Under this condition, $\widehat{P}_Q < 0$, driving increases in utility, final good production, and total energy supply.

Equilibrium changes in dirty energy supply, and therefore emissions, depend linearly on the exogenous forcing variables:

$$\widehat{Q}_D = \mathcal{D}^{-1}[\epsilon\sigma_Q\widehat{Z} - \delta\epsilon(\sigma_Q - \rho^*)\widehat{Q}_C] \tag{6}$$

If clean and dirty energy are sufficiently inelastic substitutes ($\sigma_Q < \rho^*$), clean energy supply expansion can "backfire", increasing dirty energy use and emissions. If $\sigma_Q > \rho^*$, sufficiently rapid clean energy supply expansion reduces dirty energy use and emissions:

$$\widehat{Q}_C > \widehat{Q}_C^{\ddagger} = \frac{\sigma_Q}{\delta(\sigma_Q - \rho^*)}\widehat{Z} \tag{7}$$

This reflects the tug-of-war between substitution and income effects: clean energy supply expansion lowers relative clean energy prices, inducing substitution away from dirty energy, while simultaneously increasing total energy consumption via income effects from reduction in the aggregate energy price. Substitution dominates if the elasticity of substitution between clean and dirty energy exceeds the magnitude of the price elasticity of total energy demand, enabling reductions in dirty energy use and emissions. Conversely, when the magnitude of the price elasticity of total energy demand is greater than the elasticity of substitution between clean and dirty energy, the income effect dominates, raising overall energy consumption, thereby increasing dirty energy use and emissions despite growth in clean energy supply. This aligns with Casey et al. (2023), who find clean energy subsidies raise dirty energy production if and only if the elasticity of substitution between clean and dirty energy is smaller than the magnitude of the total energy demand elasticity.

As shown in Appendix A.1, if $\sigma_Q > \rho^*$, $\widehat{Q}_C^{\ddagger}$ in condition (7) is the minimum clean energy supply growth rate required to expand total energy supply while achieving an economic development-climate mitigation win-win, characterized by simultaneous increases in utility and final good production, alongside reductions in dirty energy supply and CO_2 emissions.

To gain insight into the impacts of policies that increase MDB financing in clean energy, we expand on this by assuming that exogenous increases in clean energy supply come from two sources, MDBs (Q_C^M) and other sources (Q_C^N): $Q_C = Q_C^M + Q_C^N$, which in log-differential form is eq. (1m). Plugging the latter expression into condition (7) yields:

$$\widehat{Q}_C = \phi \widehat{Q}_C^M + (1-\phi)\widehat{Q}_C^N > \widehat{Q}_C^{\ddagger} = \frac{\sigma_Q}{\delta(\sigma_Q - \rho^*)}\widehat{Z} \tag{8}$$

revealing that assuming $\sigma_Q > \rho^*$, the MDB-financed clean energy supply expansion necessary to achieve increased total energy supply and the economic development-climate mitigation win-win is:

$$\widehat{Q}_C^M > \widehat{Q}_C^{M\prime} = \frac{\sigma_Q}{\phi\delta(\sigma_Q - \rho^*)}\widehat{Z} - \frac{1-\phi}{\phi}\widehat{Q}_C^N \tag{9}$$

where ϕ is the share of aggregate clean energy supply that is financed by MDBs.

A growing body of literature estimates the elasticity of substitution between clean and dirty energy, with values often exceeding unity (Lanzi and Sue Wing, 2011; Papageorgiou et al., 2017; Jo, 2025). Meanwhile, a broad literature estimates the magnitude of the price elasticity of energy demand across energy sources, with findings generally below unity (Auffhammer and Rubin, 2018; Krichene, 2005; Espey, 1998; Coyle et al., 2012; Hughes et al., 2008; Burke and Liao, 2015; Hirth et al., 2022; Csereklyei, 2020; Labandeira et al., 2017).

Therefore, it is possible that the elasticity of substitution between clean and dirty energy exceeds the magnitude of the price elasticity of total energy demand, giving rise to a theoretically grounded threshold for MDB-financed clean energy expansion. In the subsequent CGE analysis, we assess policies that increase MDB financing in solar and wind capacity to determine if these expansions meet this threshold, enabling evaluation of whether MDB financing can simultaneously enhance electricity supply, promote economic development, and reduce CO_2 emissions.

4 Numerical Modeling

4.1 Data

To study the electricity sector, economic, and CO_2 emissions implications of MDB-financed solar and wind capacity expansion in EMDEs, we develop a CGE model to simulate the BAU equilibrium of the global economy in 2030. We then run comparative statics to simulate counterfactual equilibria in response to increasing MDB-financed solar and wind capital inputs in 14 aggregated EMDEs excluding China and Russia under three policy scenarios that raise projected annual MDB financing from 2023–2030 beyond BAU levels.

We calibrate the CGE model with the Global Trade Analysis Project (GTAP) database (a) and use historical MDB electricity sector financing data (b) to calculate MDB-financed technology-specific capital stocks for solar and wind generation in the 14 EMDEs in 2017, the GTAP reference year. From these, we estimate MDB- and non-MDB-financed capital stocks for solar and wind in the 14 EMDEs, the solar and wind capital stocks in the other 6 non-EMDEs, China, and Russia, and the capital stocks in the other generating technologies and T&D in all 22 regions (14 EMDEs, 6 non-EMDEs, China, Russia). Using MDB data, along with historical and projected installed capacity data (c), we expand these capital stocks to their levels in 2030, compute the corresponding capital inputs, and compute repayment outflows. We further scale capital inputs in non-electricity sectors, labor inputs, fossil fuel fixed factors, clean generation fixed resources, and the autonomous energy efficiency improvement (AEEI) parameter to their amounts in 2030 with historical and projected real GDP and primary energy consumption data (d). Finally, we incorporate donor country MDB financing (e) to compute 2030 financing outflows from, and repayment inflows into, donor regions, and use installed capacity and generation data from 2017 (f) to assess capacity and generation outcomes.

(a) *Multinational Economic Accounts:* We employ the GTAP-Power Version 11 database, which provides input–output accounts linked by bilateral trade flows for 76 sectors, 141 countries, and 19 composite regions for 2017, including factor and commodity inputs to eight generation technologies (solar, wind, hydro, other renewables, nuclear, coal, oil, and gas) and T&D (Chepeliev, 2023). We aggregate these into five energy sectors, five non-energy sectors, and 14 EMDEs of focus, plus six non-EMDEs, China, and Russia. China is excluded as they have the capacity to finance their energy transition and Russia is excluded because they lack MDB solar and wind financing data. Electricity is modeled as a CES composite of eight generation technologies and T&D.

(b) *MDB Financing:* Historical data on MDB electricity sector financing come from Oil Change International's Public Finance for Energy Database (Oil Change International, 2025), covering 2013–2022 financing from ten MDBs (African Development Bank, Asian Development Bank, Asian Infrastructure Investment Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter-American Development Bank, Islamic Development Bank, New Development Bank, and World Bank Group). We restrict the data to multilateral financing in solar and wind electricity production projects, aggregate to solar and wind x EMDE groupings, and convert to 2017 USD. These annual MDB financing flows form the basis of our policy scenarios.

(c) *Installed Capacity:* The International Renewable Energy Agency (IRENA) Power Capacity and Generation Statistics database provides historical installed capacity across 21 generating technologies in 224 countries (International Renewable Energy Agency, 2025). For 2017 and 2023, we aggregate capacity by generating technology x region, retrieving installed capacity in each of eight generating technologies across the 22 regions. We grow 2017 capital stocks to their levels in 2023 using 2017–2023 CAGRs, assigning CAGRs in solar and wind in EMDEs to their respective non-MDB-financed capital stocks, CAGRs in solar and wind in non-EMDEs, China, and Russia to their respective capital stocks, and CAGRs in the other generating technologies in all regions to their respective capital stocks. Capital stocks in T&D in regions in 2017 grow to their levels in 2023 using 2017-2023 CAGRs in total generation capital stock.

We also use the 2024 International Energy Agency (IEA) World Energy Outlook (International Energy Agency, 2024), which projects installed capacity across 13 generating technologies in 19 countries and regions under three scenarios. We apply the Stated Policies Scenario, which reflects current policy settings, aggregate to match our technology x region groupings, and retrieve 2023 and 2030 capacity for eight technologies in all 22 regions. We grow 2023 capital stocks to their levels in 2030 using 2023–2030 CAGRs, assigning CAGRs in solar and wind in EMDEs to their respective non-MDB-financed capital stocks, and CAGRs in solar and wind in non-EMDEs, China, and Russia to their respective capital stocks, and CAGRs in the other generating technologies in all regions to their respective capital stocks. Capital stocks in T&D in regions in 2017 grow to their levels in 2030 using 2017-2030 CAGRs in total generation capital stock.

(d) *Real GDP and Primary Energy Consumption:* The 2025 International Monetary Fund (IMF) World Economic Outlook (International Monetary Fund, 2025) provides population and constant-price PPP GDP per capita for 2017, 2023, and 2030. Multiplying yields real GDP, which we aggregate into 22 regions to compute 2017–2023 and 2023–2030 CAGRs.[1] The Energy Information Administration (EIA) (U.S. Energy Information Administration, 2025) provides historical primary energy consumption and GDP, which we aggregate to our 22 regions for 2017 and 2023. We calculate energy intensity by dividing energy consumption by GDP and compute regional CAGRs from 2017–2023.

(e) *Donor Financing:* OECD data on Official Development Assistance (ODA) flows (Organization for Economic Co-operation and Development, 2025) provide annual multilateral disbursements by 45 donor countries to the International Development Association (IDA), other World Bank entities (the International Bank for Reconstruction and Development [IBRD], International Finance Corporation [IFC], and Multilateral Investment Guarantee Agency [MIGA]), and regional development banks from 2013–2022, in constant 2023 USD (millions). These flows include electricity and non-electricity financing and do not delineate between the two. We aggregate by the 22 regions over the ten year period, and calculate each region's share of total ODA disbursed.

(f) *Electricity Generation:* IRENA also provides 2017 electricity generation by technology and country, measured in GWh (International Renewable Energy Agency, 2025). We aggregate to the 22 regions and eight generating technologies, aligning generation with the technology x region groupings.

4.2 CGE Model Structure

We construct a static, multi-region, multi-sector CGE model of the global economy with 22 aggregated regions, 14 of which are EMDEs excluding China and Russia, each comprising representative households, firms in ten sectors including electricity, and a government that taxes and redistributes revenue. Following Armington (1969), regions are linked through bilateral trade where total consumption of a commodity is a CES aggregate of domestic and imported goods, the latter itself a CES composite of partner imports, and equilibrium arises from utility-maximizing consumers, profit-maximizing producers, and clearing of all factor and commodity markets under constant returns to scale. Consumers have CES preferences and own endowments of

[1] Given the lack of real GDP data for the "Rest of World" region in 2017, 2023, and 2030, we set the 2017–2023 and 2023–2030 CAGRs for "Rest of World" to 0%.

labor, capital used in non-electric sectors, technology-specific capital used in the electricity sector, fixed-factor fuels (coal, oil, gas), and fixed-factor resources (solar, wind, hydro, other renewables, nuclear), with solar and wind generation capital in EMDEs divided into MDB-financed and non-MDB-financed portions. Non-electricity sector producers use nested CES production technologies (Sue Wing, 2009) with outputs from a value-added composite (KL) of capital and labor, an energy-materials composite (EM) of intermediate energy (E) and non-energy (M) commodities, and, for coal, oil, and gas sectors, fixed-factor fuels, allowing substitution.

The GTAP Power Version 11 database enables us to use a bottom-up representation to disaggregate the electricity sector (Sue Wing and Balistreri, 2018) with output as a CES composite of aggregate generation and T&D services which are gross complements with an elasticity of substitution between them of $\sigma^{Ely} < 1$. Generation itself is a CES composite of eight generation technologies which are gross substitutes with an elasticity of substitution between them of $\sigma^{Gen} > 1$. Each generating technology and T&D services are a CES production function combining a value-added composite of labor and technology-specific capital, a composite of non-energy commodities, and intermediate energy commodities. Solar, wind, hydro, other renewables, and nuclear generating technologies also employ fixed-factor resources. Inputs to each generator and T&D services are gross complements with an elasticity of substitution between them of $\sigma_{Tech} < 1$. In the main results, we set $\sigma_{Ely} = 0.5$, $\sigma_{Gen} = 2$, and $\sigma_{Tech} = 0.5$.

4.3 Scenarios

We consider four forward-looking scenarios that project electricity capital stocks in 2030 by scaling 2023 levels forward across technologies and regions. The scenarios only differ in assumptions about MDB financing in solar and wind capacity in EMDEs (excluding China and Russia) between 2023 and 2030. Each scenario reflects a distinct financing ambition—grounded in historical trends, policy goals, or the logic of our analytical model. Table 2 summarizes the rationale behind each scenario and reports the corresponding annual total MDB financing in solar and wind across EMDEs (excluding China and Russia), in billions of 2022 USD, from 2023-2030.

Table 2: Summary of MDB Solar and Wind Financing Scenarios

Scenario	Description	Annual Financing
Business as Usual	Annual MDB financing in solar and wind in each EMDE from 2023–2030 are held constant at their historical average levels from 2013–2022, reflecting a continuation of existing financing trends without additional policy ambition	2.12
Triple Agenda	Inspired by the ambitious financing target proposed in the Triple Agenda report, annual MDB financing in solar and wind in each EMDE from 2023–2030 are scaled to reach a total of $400 billion (2019 USD) per year across EMDEs	457.88
COP28	Based on COP28's goal to triple global renewable capacity, annual MDB financing in solar and wind in each EMDE from 2023–2030 are scaled to achieve a tripling of clean electricity capital stock by 2030, relative to 2023 levels	340.26
Analytical Model	Reflecting the analytical model's finding that the threshold clean energy supply growth rate needed to boost economic development and reduce emissions is inversely proportional to the clean energy share of total energy sector production costs, annual MDB financing in solar and wind in each EMDE from 2023–2030 are scaled so that clean electricity capital stock expands by the inverse of each EMDE's 2023 clean generation share of electricity generation sector production costs by 2030, relative to 2023 levels	489.58

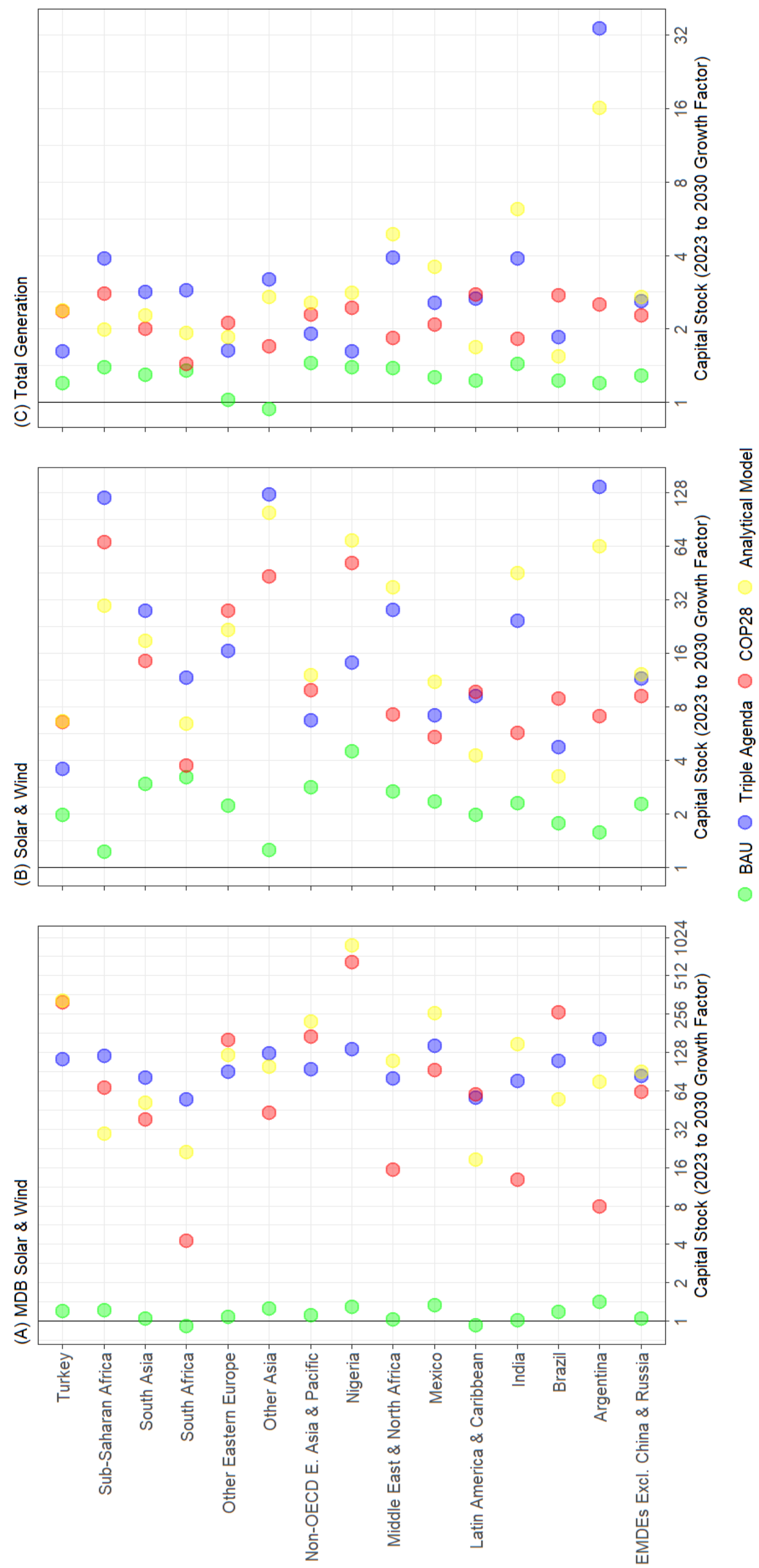
Source: Authors' calculations.

4.4 Results

In this section, we examine the effects of increased MDB financing in solar and wind capacity in EMDEs–excluding China and Russia–on electricity sector, economic, and CO_2 emissions variables. Figure 2 illustrates the gains for recipient EMDEs. Image A shows the increases in MDB-financed solar and wind capital stock. These increases directly raise total solar and wind capital stock, though less dramatically than the increases in MDB-financed solar and wind capital stock as shown in Image B. Expansions in total solar and wind capital stock increase total electricity generation capital stock, though more modestly than the increases in total solar and wind capital stock, as shown in Image C.

Aggregated across all recipient EMDEs, according to Image A, the growth factor in MDB-financed solar and wind capital stock across EMDEs is highest under the Analytical Model scenario, followed by the Triple Agenda scenario, and lowest under the COP28 scenario, reflecting total MDB financing of $489.58B, $457.88B, and $340.26B, respectively, versus $2.12B under BAU. This ranking holds when examining aggregated growth factors for total solar and wind capital stock and total electricity generation capital stock. For each capital stock variable, no single scenario produces the largest growth factor in every EMDE.

Figure 2: Changes in Generation Capital Stock



Source: Authors' calculations.

Figure 3 shows the impacts of MDB-financed solar and wind financing on generation capacity levels in recipient EMDEs. Specifically, they display 2030 growth factors—relative to BAU—for MDB-financed solar and wind capacity, total (MDB- and non-MDB-financed) solar and wind capacity, and total generation capacity, as shown in Images A, B, and C of Figure 3, respectively.[2]

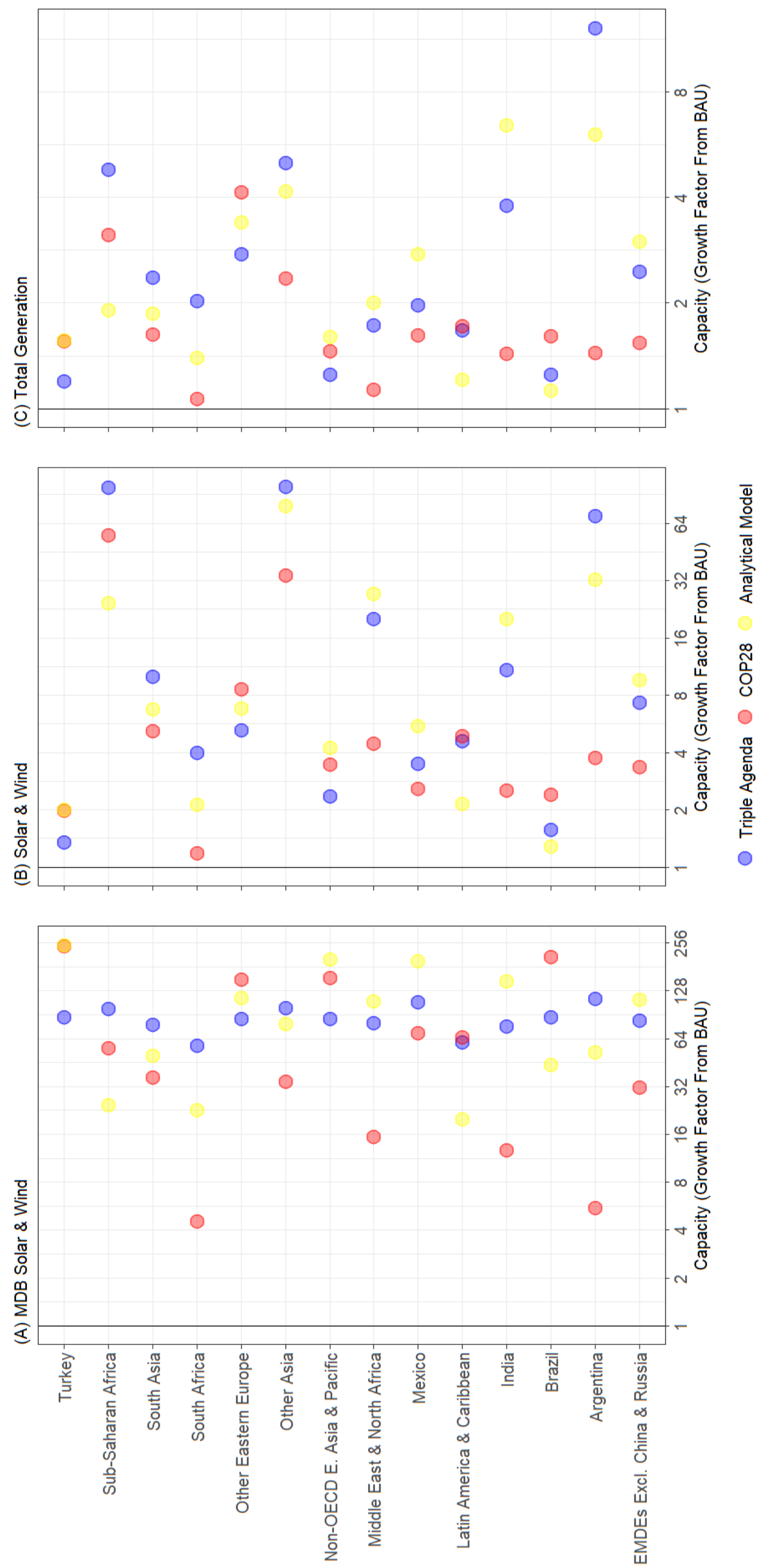
These capacity trends follow the same trajectory as those of the capital stocks. Growth factors for MDB- and non-MDB-financed solar and wind capital stocks over 2017–2030, under both the BAU and policy scenarios, are used to directly scale the corresponding capacities in each of the 14 EMDEs. For the six other generation technologies, we apply the same 2017–2030 capacity growth factors—estimated under BAU—to all scenarios. As a result, their installed capacities in 2030 are identical across BAU and the three policy scenarios.

Relative to BAU, the largest growth in MDB-financed solar and wind capacity across recipient EMDEs occurs under the Analytical Model scenario, followed by the Triple Agenda scenario, and is smallest under the COP28 scenario. 2030 growth factors relative to BAU range from 4.56 in South Africa under the COP28 scenario to 248.76 in Turkey under the Analytical Model scenario.

As a result, total solar and wind capacity, as well as aggregate electricity generation capacity, expands across all EMDEs and scenarios, with heterogeneity in the growth factors. As expected, growth factors for total generation capacity are lower than those for total solar and wind capacity, which in turn are lower than those for MDB-financed solar and wind capacity.

[2]Nigeria is excluded from the plot because MDB-financed solar and wind capacity is 0 in both the BAU and all three policy counterfactuals. As a result, there is no change to report. Consequently, while total (MDB + non-MDB) solar and wind capacity in Nigeria is greater than zero, it does not change between BAU and policy scenarios, yielding a growth factor of 1. The same holds for Nigeria's total generation capacity across all technologies, which remains unchanged across scenarios, also resulting in a growth factor of 1.

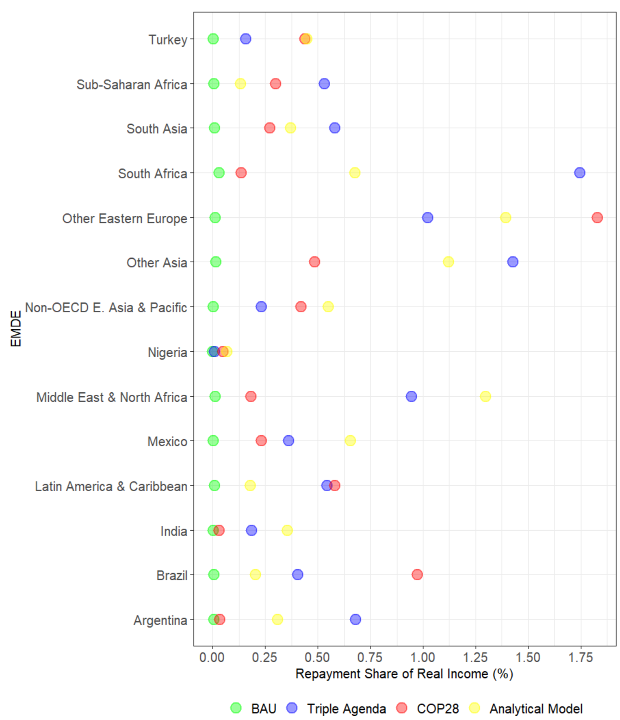
Figure 3: Changes in Generation Capacity



Source: Authors' calculations.

As we noted previously, the results we present below take into account the flows of loan repayments between recipient EMDEs and donor regions under loan-based financing. As such, we display the percentage of real income in each recipient EMDE allocated to repayment outflows in 2030 under the BAU trajectory and the three policy scenarios, in both Figure 4. Across all policy scenario-EMDE combinations, the median repayment outflow share of real income in 2030 is 0.41%. The highest repayment share occurs in Other Eastern Europe under the COP28 scenario, with a share of 1.83%. In Figure 6, we show the degree to which these repayment flows impact GDP and consumption in the recipient EMDEs, when we compare GDP and consumption outcomes under loan- vs grant-based financing.

Figure 4: Repayment Share of Real Income in 2030



Source: Authors' calculations.

Image A in Figure 5 shows the effects of increased MDB-financed solar and wind capital stock in EMDEs on solar and wind generation. In 2030, solar and wind generation rises relative to BAU under all policy scenarios, reflecting expanded solar and wind capital stock that lowers their respective generation unit costs. In the CGE framework, lower generation costs reduce effective prices for these technologies within the aggregate generation sector, driving: (i) a substitution effect, as the composite generator shifts demand toward lower-cost solar and wind and away from other technologies, and (ii) an aggregate demand effect, as lower generation costs reduce the composite generation price and stimulate higher overall demand from the electricity sector for generation, increasing generation across all generating technologies. Median shares of solar and wind in total generation across the EMDEs, reach 14.95% under the Triple Agenda scenario, 12.38% under the COP28 scenario, and 13.33% under the Analytical Model scenario.

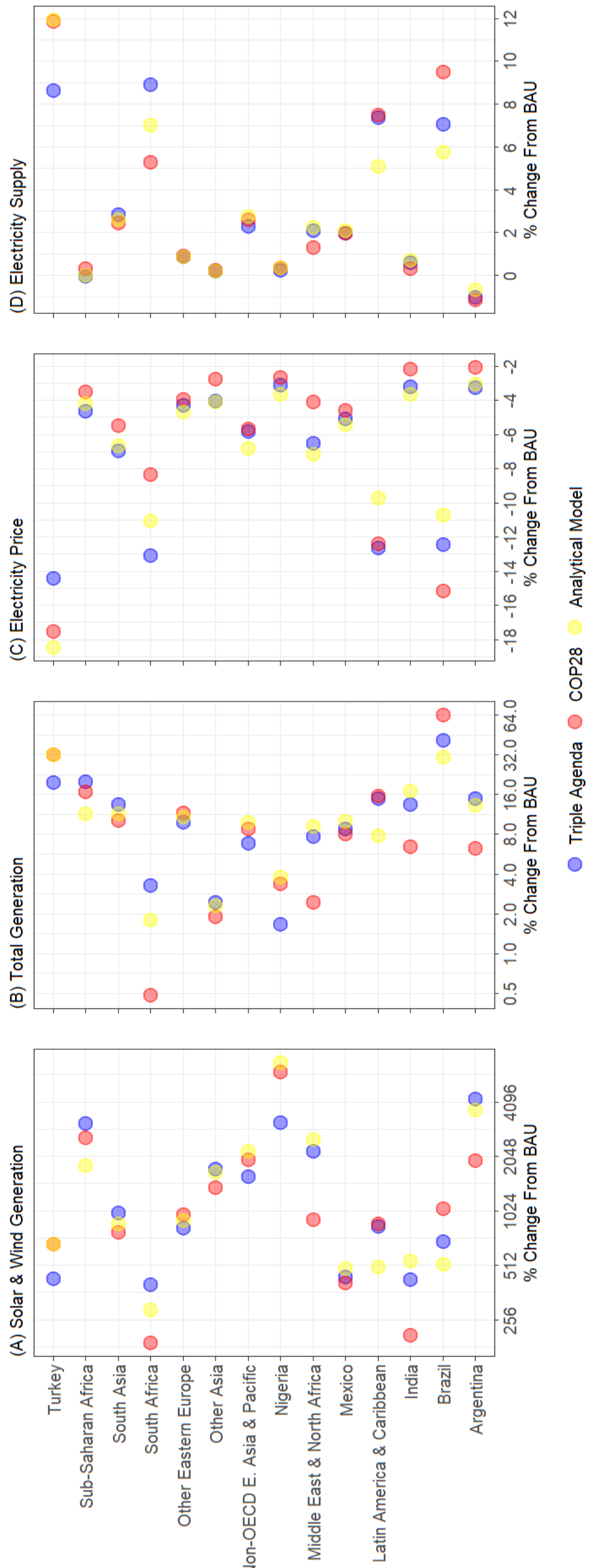
Image B shows that aggregate electricity generation rises in 2030 relative to BAU, as lower solar and wind prices yield reduce composite generation prices through the zero-profit condition, stimulating overall demand for aggregate generation by the composite electricity sector. As such, total electricity generation increases through the market clearing condition.

Image C shows electricity prices decline in 2030 relative to BAU, with median declines across the EMDEs of 5.45% under the Triple Agenda scenario, 4.33% under the COP28 scenario, and 6.05% under the Analytical Model scenario. Because the composite electricity price is a CES function of aggregate generation and T&D services, lower total generator prices pull down the overall electricity price under the zero-profit condition.

Finally, lower electricity prices increase demand for electricity from producers and consumers, translating to increases electricity supply relative to BAU through the market-clearing condition, as shown in Image D. Median expansions across the EMDEs relative to BAU are 2.03% under the Triple Agenda scenario, 1.63% under the COP28 scenario, and 2.18% under the Analytical Model scenario.

These results show that MDB-financed solar and wind expansions can increase electricity supply in EMDEs, though impacts of large expansions in solar and wind capital stock are limited by the relatively small technical coefficients for solar and wind in aggregate generation sectors in the EMDEs.

Figure 5: Changes in Electricity Sector Activity



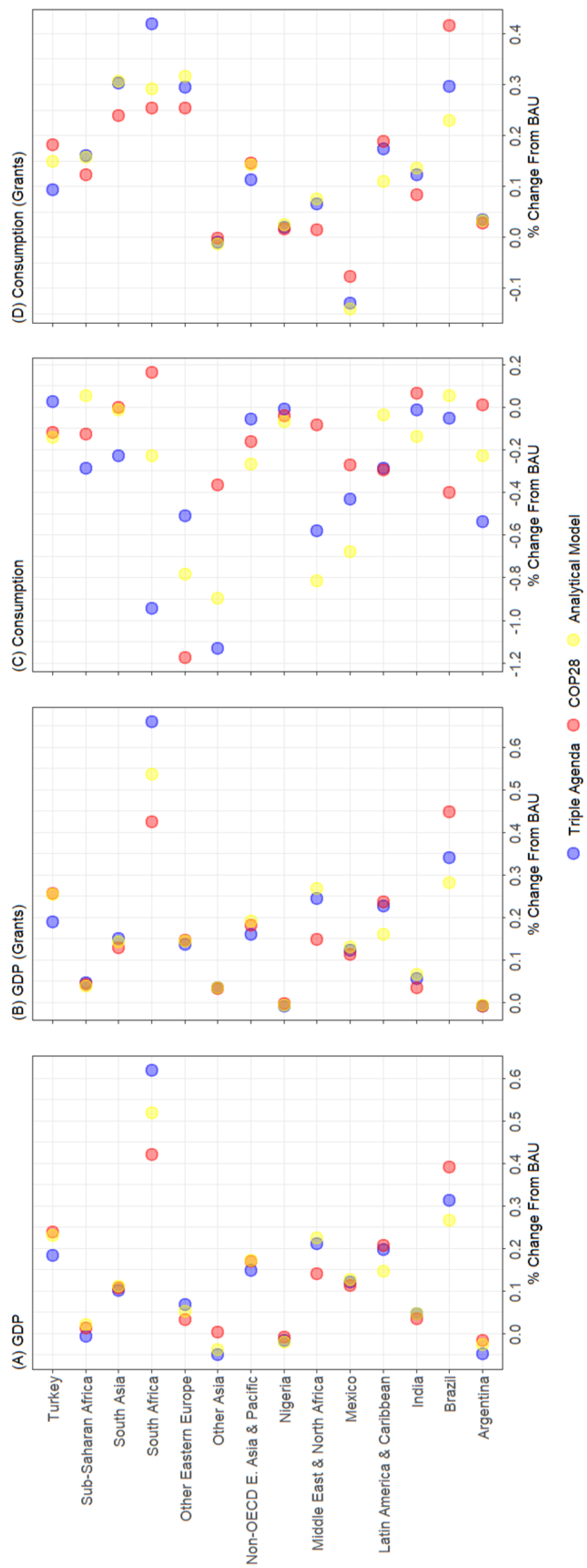
Source: Authors' calculations.

Images A and B in Figure 6 show that GDP generally increases across recipient EMDEs and scenarios, regardless of whether the financing takes the form of loans or grants, the latter of which doesn't require EMDEs to give loan repayments. Growth is driven by expanded electricity supply and downstream production, which raise overall output. When the financing takes the form of loans, it moderates these gains. In particular, recipient EMDEs transfer part of their resources abroad, reducing the household resources available for spending on domestically produced goods. This reduction in aggregate expenditure feeds back into the general equilibrium, lowering GDP growth compared with the case when the financing takes the form of grants. As shown in Figure A, across EMDEs, median GDP growth rates relative to BAU are 0.11% under the Triple Agenda scenario, 0.11% under the COP28 scenario, and 0.12% under the Analytical Model scenario. However, as shown in Figure B, under grant-based financing, median GDP growth rates relative to BAU increase to 0.14% across all three scenarios.

Image C in Figure 6 shows that consumption generally declines relative to BAU under loan-based financing. Across EMDEs, median declines in consumption relative to BAU are 0.29% under the Triple Agenda scenario, 0.12% under the COP28 scenario, and 0.18% under the Analytical Model scenario. The expansion of electricity supply and downstream industries raises overall output, which increases demand for factors of production owned by each EMDE's representative household. This boosts household income, thereby increasing consumption. However, repayment outflows are modeled as a secular withdrawal of the final consumption good, thereby lowering consumption. This produces overall declines in consumption. According to Image D in Figure 6, under grant-based financing, consumption generally increases. Across EMDEs, median increases in consumption relative to BAU, under grant-based financing, are 0.12% under the Triple Agenda scenario, 0.13% under the COP28 scenario, and 0.14% under the Analytical Model scenario.

These findings indicate that MDB-financed expansions of solar and wind capacity generally have a positive impact on GDP growth, regardless of whether the financing is loan- or grant-based. However, these MDB-financed expansions create relative declines in consumption under loan-based financing, but lead to relative increases in consumption under grant-based financing. This reflects the potential economic benefits of expanded electricity supply. Overall, the magnitude of these economic impacts is limited by electricity representing a relatively small share of total production costs in sectors across EMDEs. Among non-energy sectors, manufacturing and agriculture are the most electricity-intensive, with the regional median share of electricity in their production costs across the EMDEs at 2% and 1.25%, respectively.

Figure 6: Changes in Economic Indicators

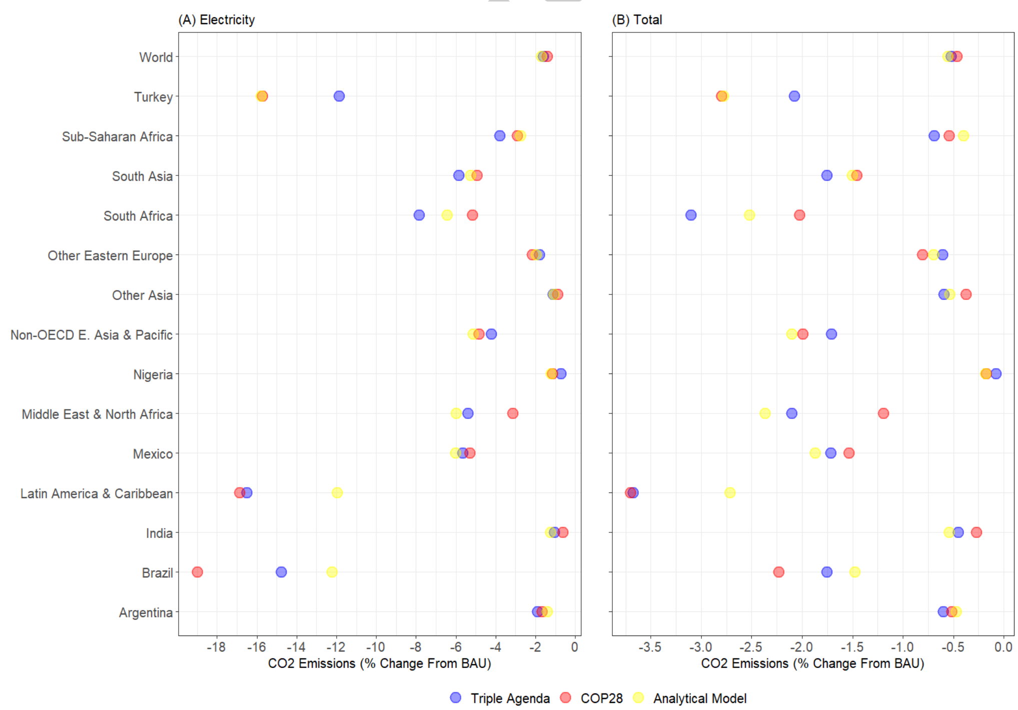


Source: Authors' calculations.

According to Image A in Figure 7, CO_2 emissions from the power sector decline relative to BAU across all recipient EMDEs. MDB financing lowers the effective cost of solar and wind generation, inducing substitution away from fossil fuel inputs toward renewables within the aggregate electricity generation CES nest. This displacement reduces the carbon intensity of electricity supply, yielding direct emissions reductions. However, lower electricity prices stimulate increased electricity demand across the economy, expanding total generation and partially offsetting emissions abatement by increasing fossil fuel-based generation and associated CO_2 combustion. Median declines in power-sector emissions across EMDEs relative to BAU are 4.82% under the Triple Agenda scenario, 4.00% under the COP28 scenario, and 5.22% under the Analytical Model scenario. Globally, power-sector emissions decline more modestly-—by 1.61%, 1.40%, and 1.70% under the same scenarios—-since recipient EMDEs account for a portion of global power-sector emissions.

According to Image B in Figure 7, total CO_2 emissions decline relative to BAU across all recipient EMDEs, primarily driven by relative reductions in power-sector emissions. Median declines in total emissions across EMDEs relative to BAU are 1.71% under the Triple Agenda scenario, 1.33% under the COP28 scenario, and 1.49% under the Analytical Model scenario. Globally, total CO_2 emissions fall relative to BAU by 0.52%, 0.46%, and 0.55% under the respective scenarios. These impacts are limited by recipient EMDEs representing a fraction of global CO_2 emissions.

Figure 7: Changes in CO_2 Emissions



Source: Authors' calculations.

4.5 Sensitivity Analysis

We double key substitution elasticities to assess their influence on the estimated impacts of MDB financing in solar and wind capacity. We examine three elasticities: (i) substitution between electricity generation and T&D (σ_{Ely}), (ii) substitution among generation technologies (σ_{Gen}), and (iii) substitution across inputs to each generation technology and T&D (σ_{Tech}). Each elasticity is doubled individually while the others are held constant, and then all three are doubled simultaneously. Table 3 presents median estimates across the 14 EMDEs for the three policy scenarios, reporting changes in electricity price and supply, GDP and consumption (both under loan- and grant-based financing), electricity sector and total CO_2 emissions, and solar & wind generation share.

Doubling σ_{Ely} from 0.5 to 1 produces the smallest changes in the median estimates of any of the elasticity perturbations. This is expected since this elasticity operates at a higher level of aggregation, farther away from the location of the policy shocks. This perturbation increases the median declines in electricity price, increases the median expansions in electricity supply, maintains the same median increases in GDP under loan-based financing, increases or maintains the same median increases in GDP under grant-based financing, reduces or maintains the same median declines in consumption under loan-based financing, maintains the same median increases in consumption under grant-based financing, reduces the median declines in both electricity sector emissions and total emissions, and increases the median solar & wind generation shares.

Doubling σ_{Gen} from 2 to 4 produces larger changes in the median estimates than doubling σ_{Ely} from 0.5 to 1. This perturbation increases the median declines in electricity price, increases the median expansions in electricity supply and GDP (under both loan- and grant-based financing), reduces the median declines in consumption under loan-based financing, increases the median expansions in consumption under grant-based financing, increases the median declines in both electricity sector emissions and total emissions, and increases the median solar & wind generation shares. The results align with the insight from the analytical models: if the elasticity of substitution between clean and dirty energy exceeds the price elasticity of total energy demand, increasing substitution between clean and dirty energy lowers the clean energy supply growth rate needed to achieve joint development and decarbonization objectives.

Doubling σ_{Tech} from 0.5 to 1 produces larger changes in the median estimates than doubling σ_{Ely}, but smaller changes than doubling σ_{Gen}. This perturbation increases the median declines in electricity price, increases the median expansions in electricity supply and GDP (both under loan- and grant-based financing), reduces the median declines in consumption under loan-based financing, increases the median expansions in consumption under grant-based financing, increases the median declines in both electricity sector and total emissions, and increases the median solar & wind generation shares. These results are consistent with expectations given that the policy shocks target this layer of the electricity sector.

Doubling all three elasticities simultaneously produces the largest changes in the median estimates when compared with doubling each of the elasticities while keeping the others the same. This perturbation increases the median declines in electricity price, increases the median expansions in electricity supply and GDP (under both loan- and grant-based financing), reduces the median declines in consumption under loan-based financing, increases the median expansions in consumption under grant-based financing, increases the median declines in electricity sector and total emissions, and increases the median solar & wind generation shares.

Table 3: Sensitivity Analysis

	Electricity Price (% Change)	Electricity Supply (% Change)	GDP (% Change)	GDP (Grants) (% Change)	Consumption (% Change)	Consumption (Grants) (% Change)	Electricity Emissions (% Change)	Total Emissions (% Change)	Solar & Wind Generation Share (%)
					$(\sigma_{Ely} = 0.5, \sigma_{Gen} = 2, \sigma_{Tech} = 0.5)$				
Triple Agenda	-5.45	2.03	0.11	0.14	-0.29	0.12	-4.82	-1.71	14.95
COP28	-4.33	1.63	0.11	0.14	-0.12	0.13	-4.00	-1.33	12.38
Analytical Model	-6.05	2.18	0.12	0.14	-0.18	0.14	-5.22	-1.49	13.33
					$(\sigma_{Ely} = 1, \sigma_{Gen} = 2, \sigma_{Tech} = 0.5)$				
Triple Agenda	-5.46	2.08	0.11	0.15	-0.28	0.12	-4.31	-1.39	15.08
COP28	-4.39	1.67	0.11	0.14	-0.12	0.13	-3.54	-1.16	12.70
Analytical Model	-6.07	2.23	0.12	0.14	-0.18	0.14	-4.53	-1.20	14.12
					$(\sigma_{Ely} = 0.5, \sigma_{Gen} = 4, \sigma_{Tech} = 0.5)$				
Triple Agenda	-6.48	2.84	0.21	0.23	-0.19	0.23	-11.57	-3.72	24.83
COP28	-5.07	2.08	0.18	0.22	-0.04	0.22	-8.76	-2.79	19.35
Analytical Model	-7.39	3.28	0.21	0.23	-0.08	0.22	-12.65	-3.67	22.19
					$(\sigma_{Ely} = 0.5, \sigma_{Gen} = 2, \sigma_{Tech} = 1)$				
Triple Agenda	-5.70	2.26	0.16	0.19	-0.24	0.14	-6.06	-2.20	20.53
COP28	-4.62	1.71	0.15	0.17	-0.09	0.16	-4.99	-1.55	16.02
Analytical Model	-6.67	2.61	0.17	0.20	-0.11	0.17	-6.93	-1.91	18.80
					$(\sigma_{Ely} = 1, \sigma_{Gen} = 4, \sigma_{Tech} = 1)$				
Triple Agenda	-6.97	3.01	0.26	0.31	-0.12	0.28	-14.92	-4.51	29.06
COP28	-5.51	2.38	0.24	0.26	-0.02	0.25	-10.71	-3.66	21.73
Analytical Model	-8.21	3.73	0.28	0.32	-0.04	0.25	-14.96	-4.08	26.72

Source: Authors' calculations.

5 Conclusions

This paper examines the electricity, economic, and environmental impacts of expanding projected MDB financing in solar and wind capacity in EMDEs, excluding China and Russia, from 2023 to 2030 under three policy scenarios. In the Triple Agenda scenario, MDB financing reaches $400 billion (2019 prices) across these EMDEs. The COP28 scenario targets a tripling of clean electricity capital stock in each EMDE by 2030 relative to 2023 levels. A third scenario, derived from our analytical models, targets an expansion of clean electricity capital stock in each EMDE by the inverse of its 2023 clean electricity share of generation sector production costs by 2030 relative to 2023 levels.

Simulations with a multi-region, multi-sector CGE model show that across the 14 aggregated EMDEs, median changes in electricity supply in 2030 relative to BAU range from 1.63—2.18%, depending on the policy scenario. Median changes in GDP range from 0.11—0.12%, depending on the scenario, while median changes in consumption range from -0.29% to -0.12%, depending on the scenario. When financing takes the form of grants rather than loans, the median changes in GDP are 0.14% for each of the three scenarios, and the median changes in consumption range from 0.12-–0.14%, depending on the scenario. Globally, total CO_2 emissions fall by 0.46-–0.55%, depending on the scenario. Therefore expanding MDB solar and wind financing can potentially grow electricity supply and spur economic development in EMDEs while contributing to global climate change mitigation. Consumption outcomes depend on financing terms, suggesting grants are critical to spurring economic development.

The increases in electricity supply represent accelerations amid rapidly rising demand in EMDEs. Impacts are limited by the CGE model's share-preserving CES structure and the relatively small technical coefficients for solar and wind from the GTAP Power database. Percentage increases in MDB-financed capital therefore translate into smaller percentage increases in electricity supply. Future research could examine the role of complementary transmission and distribution (T&D) financing in supporting clean generation expansion and its implications for economic and environmental outcomes.

Economic impacts are limited by electricity constituting a relatively small share of total production costs across sectors in EMDEs. Compared to Oh et al. (2020), which used a CGE model to find that renewable energy expansion in Korea reduced GDP, with the negative impact diminishing when greenhouse gas emissions are regulated, our results show median GDP gains, underscoring the importance of MDB renewable generation financing in stimulating economic growth.

The economic and emissions outcomes should be interpreted against physical climate risks. Network for Greening of the Financial System analyses project long-run economic losses under current policy pathways (Network for Greening the Financial System, 2024). Reductions in global emissions have the potential to contribute to the avoidance of long-run climate damages and generate economic benefits, particularly in climate-vulnerable EMDEs. The combination of positive GDP effects, mixed consumption outcomes, and potential benefits from reduced climate risk suggests that MDB renewable financing could yield net economic benefits—even under loan-based financing.

Global emissions impacts are limited by the policies focusing only on EMDEs excluding China and Russia, which contributed only 32.4% of global emissions in 2023, and targeting only the electricity sector, which produced only 38% of emissions across these EMDEs in 2023. Across

EMDEs, median emissions declines are 1.49–1.71% relative to BAU across the three policies, and median relative electricity sector emissions declines are 4–5.22% as shown in 3. Larger reductions require policies that cover more sectors and regions, particularly major emitters.

MDB financing alone cannot deliver on climate change mitigation goals. Complementary measures are necessary: scaling domestic resource mobilization (DRM) and private capital mobilization (PCM), adopting carbon pricing, eliminating fossil fuel subsidies, and the phase-out of coal (Songwe et al., 2022). The Triple Agenda Report highlights the need for $3 trillion (2019 prices) annual incremental financing across EMDEs by 2030, including $1.8 trillion in climate financing. The report also calls for MDBs to contribute only $260 billion (IEG, 2023). Expanded financing from both domestic and external sources is therefore critical.

Limitations on our research include assumptions of projected flat annual MDB solar and wind financing based on 2013–2022 averages and that increasing these financing flows won't crowd-in funding from domestic or other external financing sources. While IEG (2023) notes that MDBs have mobilized $0.6 per $1 lent, and Gallagher et al. (2024) found using data from 2022 that they mobilized $0.76 for every $1 they lend for climate finance, such multipliers for clean energy remain uncertain. Future research should quantify the degree to which expanding MDB renewable electricity financing catalyzes DRM and PCM and estimate avoided damages from reduced exposure to chronic physical climate risks in EMDEs, enabling cost-benefit analysis of expanding these financing flows.

In sum, MDB-financed solar and wind expansion yields positive effects on electricity supply, mixed economic outcomes, and relative declines in emissions in EMDEs, with potentially greater benefits through complementary electricity infrastructure, mobilized domestic and private finance, and broader climate policies.

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Appendices

A.1 Analytical Modeling Section Proof

We showed in Section 3 that if the growth in clean energy supply $\widehat{Q}_C$ exceeds the threshold:

$$\widehat{Q}_C^{\dagger} = \frac{\delta\epsilon + \sigma_Q}{\delta(\epsilon + \sigma_Q)}\widehat{Z}, \tag{10}$$

the aggregate energy price declines, inducing increased total energy supply, final good output, and utility. We also showed that if $\sigma_Q > \rho^*$, a clean energy supply expansion beyond:

$$\widehat{Q}_C^{\ddagger} = \frac{\sigma_Q}{\delta(\sigma_Q - \rho^*)}\widehat{Z} \tag{11}$$

reduces dirty energy use and CO_2 emissions.

Thus, under $\sigma_Q > \rho^*$, a clean energy supply expansion satisfying:

$$\widehat{Q}_C > \max(\frac{\delta\epsilon + \sigma_Q}{\delta(\epsilon + \sigma_Q)}\widehat{Z}, \frac{\sigma_Q}{\delta(\sigma_Q - \rho^*)}\widehat{Z}) \tag{12}$$

achieves both higher total energy supply and a development-mitigation win-win: increased output and utility alongside reduced emissions.

We now show that under $\sigma_Q > \rho^*$, condition (12) reduces to:

$$\widehat{Q}_C > \frac{\sigma_Q}{\delta(\sigma_Q - \rho^*)}\widehat{Z} \tag{13}$$

It suffices to show that:

$$\frac{\sigma_Q}{\delta(\sigma_Q - \rho^*)} > \frac{\delta\epsilon + \sigma_Q}{\delta(\epsilon + \sigma_Q)}$$

Subtract the right-hand side from the left-hand side:

$$\frac{\sigma_Q}{\delta(\sigma_Q - \rho^*)} - \frac{\delta\epsilon + \sigma_Q}{\delta(\epsilon + \sigma_Q)} > 0$$

Multiply both sides by $\delta(\epsilon + \sigma_Q)(\sigma_Q - \rho^*)$:

$$\sigma_Q(\epsilon + \sigma_Q) - (\delta\epsilon + \sigma_Q)(\sigma_Q - \rho^*) > 0$$

Expand:

$$\epsilon\sigma_Q + \sigma_Q^2 - \delta\epsilon\sigma_Q + \delta\epsilon\rho^* - \sigma_Q^2 + \rho^*\sigma_Q > 0$$

Simplify:

$$(1 - \delta)\epsilon\sigma_Q + \delta\epsilon\rho^* + \rho^*\sigma_Q > 0$$

Since $0 < \delta < 1$, $0 < \epsilon < 1$, and $\sigma_Q > \rho^* > 0$, this inequality holds. Therefore, the condition (12) reduces to condition (13). Therefore, under $\sigma_Q > \rho^*$, a sufficiently large clean energy supply expansion in condition (13) achieves both increased total energy supply and the economic development-climate mitigation win-win.

A.2 Additional Data

The 2024 IEA WEO database provides projections of installed capacity for electricity generation technologies across IEA-defined regional aggregates. Because these regions do not align directly with the 22 GTAP-aggregated regions we use in our model, we construct a region-mapping table, Table 4, to align IEA regions with their corresponding GTAP counterparts. The GTAP region ”Middle East and North Africa” is mapped to both the ”Middle East” and ”Africa” regions in the IEA data. The technology-specific CAGRs are calculated by summing the installed capacities in each generating technology from both regions in 2023 and 2030, and then applying the standard CAGR formula. Similarly, the GTAP region ”Rest of World”, which we map to the IEA's ”OECD” and ”non-OECD” categories, is aggregated using the same method.

Table 4: Model Regions

CGE Model	IEA World Energy Outlook
Argentina	Central & South America
Brazil	Brazil
Canada	North America
China	China
European Union	European Union
India	India
Latin American & Caribbean	Central & South America
Mexico	North America
Middle East & North Africa	Africa/Middle East
Non-OECD E. Asia & Pacific	Southeast Asia
Nigeria	Africa
Other Asia	Eurasia
OECD E. Asia & Pacific	Asia Pacific
Other Eastern Europe	Europe
Other Western Europe	Europe
Rest of World	OECD/non-OECD
Russia	Russia
South Asia	Asia Pacific
Sub-Saharan Africa	Africa
Turkey	Europe
United States	United States
South Africa	Africa

Sources: International Energy Agency (2024); Authors' calculations.

Table 5 displays the share of clean generation in the production costs of aggregate electricity generation in 2023 for each of the 14 aggregated EMDEs. As noted in the Scenarios section, under the Analytical Model scenario, annual MDB financing in solar and wind from 2023 to 2030 are scaled such that clean electricity capital stock in each EMDE expands by the inverse of its respective 2023 clean generation share by 2030, relative to 2023 levels. The shares range from 4.7% in Argentina to 56.1% in Latin America and the Caribbean.

Table 5: Share of Clean Generation in the Aggregate Generator's Production Costs (2023, 0–1 Scale)

	Clean Generation Share
Argentina	0.047
Brazil	0.625
India	0.062
Latin America & Caribbean	0.561
Mexico	0.181
Middle East & North Africa	0.090
Nigeria	0.283
Non-OECD E. Asia & Pacific	0.290
Other Asia	0.178
Other Eastern Europe	0.390
South Africa	0.211
South Asia	0.279
Sub-Saharan Africa	0.474
Turkey	0.330

Source: Authors' calculations.

Table 6 displays annual MDB financing in solar and wind capacity from 2023 through 2030. Across EMDEs excluding China and Russia, there are increases in annual financing relative to the BAU scenario: 230.93 under the Analytical Model scenario, 215.98 under the Triple Agenda scenario, and 160.50 under the COP28 scenario. While these aggregate growth factors follow this ranking, there is heterogeneity across individual EMDEs. For example, in Sub-Saharan Africa, financing levels are highest under the Triple Agenda scenario, followed by COP28 and then the Analytical Model scenario. In contrast, in non-OECD East Asia and the Pacific, the ranking is Analytical Model, followed by COP28 and then Triple Agenda. These variations in financing rankings drive heterogeneous impacts on clean capacity expansion, electricity generation, and downstream economic and emissions outcomes.

Table 7 presents the repayment outflows from recipient EMDEs in 2030 in BAU and the counterfactual scenarios. There are increases in repayment outflows relative to BAU. There is also heterogeneity in repayment outflows across individual EMDEs, which drives heterogeneous impacts on the consumption consequences of the MDB financing in particular.

Table 6: Annual MDB Solar and Wind Financing (2023-2030, billions of 2022 USD)

	BAU	Triple Agenda	COP28	Analytical Model
Argentina	0.09	19.48	0.86	8.87
Brazil	0.18	38.89	93.84	19.42
India	0.16	33.56	5.34	65.09
Latin America & Caribbean	0.25	55.04	58.91	17.60
Mexico	0.08	17.86	11.49	32.39
Middle East & North Africa	0.58	125.28	23.14	171.61
Nigeria	0.00	0.23	1.12	1.54
Non-OECD E. Asia & Pacific	0.14	30.72	55.43	72.89
Other Asia	0.12	26.31	8.91	20.72
Other Eastern Europe	0.07	15.28	27.24	20.81
South Africa	0.12	25.60	1.71	9.79
South Asia	0.15	32.57	15.11	20.79
Sub-Saharan Africa	0.14	29.83	16.75	7.25
Turkey	0.03	7.23	20.41	20.82
EMDEs Excl. China & Russia	2.12	457.88	340.26	489.58

Source: Authors' calculations.

Table 7: Repayment Outflows From Recipient EMDEs (2030, billions of 2022 USD)

	BAU	Triple Agenda	COP28	Analytical Model
Argentina	0.04	4.29	0.21	1.96
Brazil	0.09	8.58	20.63	4.31
India	0.10	7.43	1.24	14.34
Latin America & Caribbean	0.20	12.21	13.06	4.00
Mexico	0.04	3.94	2.54	7.12
Middle East & North Africa	0.36	27.71	5.31	37.87
Nigeria	0.00	0.05	0.25	0.34
Non-OECD E. Asia & Pacific	0.08	6.78	12.20	16.04
Other Asia	0.06	5.80	1.99	4.57
Other Eastern Europe	0.04	3.38	6.00	4.59
South Africa	0.10	5.68	0.44	2.22
South Asia	0.09	7.20	3.37	4.62
Sub-Saharan Africa	0.07	6.58	3.71	1.63
Turkey	0.02	1.60	4.49	4.58

Source: Authors' calculations.

A.3 Additional Scenario Details

We project MDB-financed capital in solar and wind power generation in EMDEs (excluding China and Russia). We estimate MDB- and non-MDB financed capital stocks for solar and wind in 14 aggregated EMDEs in the GTAP 11 2017 benchmark year. Capital accumulation follows the perpetual inventory equation, $K(t+1) = (1-\lambda)K(t) + I(t)$, where t indexes time, K is capital stock, I denotes investment flow, and λ is the depreciation rate. Iterating this expression forward from $t = t_0$ to $t = \tau$ yields

$$K(\tau) = (1-\lambda)^{\tau - t_0} K(t_0) + \sum_{t=t_0}^{\tau-1} (1-\lambda)^{\tau-1-t} I(t) \tag{14}$$

which, with constant average investment, $I(t) = \overline{I}$, over a sufficiently long period, reduces to $K(\tau) \approx \overline{I}/\lambda$.

We use this expression to approximate the MDB-financed capital stocks using 2013-2016 average MDB solar and wind financing from the OCI database (Oil Change International, 2025) and a depreciation rate of 0.056 for electric power engineering construction depreciation rate of 0.056 from Statistics Canada (2007). Equivalent MDB-financed capital inputs are obtained by multiplying them by the rate of return based on the average monthly global GDP-weighted interest rate in 2017 of 0.025 (MacroMicro, 2025).

Non-MDB financed capital inputs are imputed as the residual between GTAP-recorded inputs and MDB-financed inputs. Corresponding non-MDB capital stocks are recovered by dividing inputs by the rate of return.[3] For the remaining six generating technologies and T&D in the EMDEs, and all nine electricity technologies in the non-EMDEs, China, and Russia, GTAP capital inputs are divided by the rate of return to obtain non-MDB capital stocks.

We update the 2017 benchmark stocks to 2023. MDB-financed solar and wind capital stocks in the EMDEs are updated using OCI financing series with equation (14). Lacking similar data on non-MDB investment, non-MDB capital stocks are scaled by 2017-2023 compound annual growth rates (CAGRs) of installed capacity from IRENA (International Renewable Energy Agency, 2025). Capital stocks in the other seven technologies in the EMDEs, and in the nine technologies in the non-EMDEs, China, and Russia, are scaled using the 2017-2023 CAGRs in installed capacity from IRENA.[4]

Business as Usual

In this scenario, we project MDB-financed capital stocks using a modified version of equation (14):

$$K^s(\tau) = (1-\lambda)^{\tau - t_0} K(t_0) + \sum_{t=t_0}^{\tau-1} (1-\lambda)^{\tau-1-t} f^s \tilde{I}(t_0) \tag{15}$$

[3]For a number of technology × region combinations (solar in the Middle East and North Africa, Other Asia; Sub-Saharan Africa, and wind in Argentina, Other Asia; Sub-Saharan Africa), MDB capital input imputed from OCI exceeded total capital input recorded by GTAP. In these cases, average MDB financing was scaled downward based on the magnitude of the discrepancy.

[4]For technology × region combinations whose installed capacity was zero in 2017 but positive in 2023 (solar and wind in Rest of World, nuclear in non-OECD East Asia and Pacific, oil in Nigeria), we assigned global technology-specific installed capacity growth rates over the period.

where $K^s(\tau)$ is the MDB-financed capital stock in each of the solar and wind generating technologies in each EMDE, in year $\tau = 2030$ in scenario s, $K(t_0)$ is the MDB-financed capital stock in each of the solar and wind generating technologies in each of the 14 EMDEs, in year $t_0 = 2023$, f^s is the MDB financing scaling factor in scenario s (which we set to 1 in BAU), and $\tilde{I}(t_0)$ is the 10-year average of the annual MDB financing over the period 2013-2022 for each of the solar and wind generating technologies in each of the 14 EMDEs, which we employ because of lack of information regarding what the MDB financing in these technology $\times$ region pairings will be from 2023-2030.

For the non-MDB capital stocks in each of the solar and wind technologies in each EMDE, we assume these grow with their respective projected 2023-2030 CAGRs of installed capacity from the IEA World Energy Outlook database's Stated Policies Scenario. For the capital stocks in each of the six generating technologies and T&D in each EMDE and the capital stocks in each of the nine electricity technologies in each of the non-EMDEs, China, and Russia, grow with their corresponding projected 2023-2030 CAGRs of installed capacity from the IEA World Energy Outlook database's Stated Policies Scenario (International Energy Agency, 2024).[5] We then calculate the MDB- and non-MDB-financed capital inputs in the solar and wind generating technologies in each EMDE and the other capital inputs in 2030 by multiplying their respective capital stocks in 2030 by the 2030 rate of return based on the imputed average monthly global GDP-weighted interest rate in 2030, which is equal to its value in 2023 (0.056). Non-MDB capital inputs in solar and wind, as well as the capital inputs in other generation technologies and T&D in EMDEs and in all electricity technologies in non-EMDEs, China, and Russia, are held constant across the four scenarios.

We also model economies' aggregate expansion and decline in energy intensity. To do this, we scale up each region's endowments of labor, economy-wide "jelly" capital outside the electric power sector, and inputs of fossil and renewable natural resource "fixed factors", according to its 2017-2030 CAGR of real GDP. These quantities will remain the same in 2030 between all four scenarios. For the same period we also calculate the 2017-2023 CAGR in the ratio of primary energy consumption to real GDP, and cumulate the result into an autonomous energy efficiency improvement (AEEI) energy intensity decline factor for the year 2030, which we apply to the coefficient on energy in producing sectors cost functions and the representative agent's expenditure function. These AEEI estimates will also remain the same in 2030 between all four scenarios.

Finally, we introduce flows of loan repayments and financing into the model. To simulate the drag on recipient EMDEs' economies caused by loan repayment outflows, we use the device of a secular withdrawal of the final consumption good. Symmetrically, for each MDB-financing donor region, we model the drag on the economy from financing outflows via a secular withdrawal of the final consumption good, and the boost to the economy from loan repayments as a secular endowment of the final consumption good. We assume that, prior to the focal 2030 year, loan repayment flows are reflected in the regional real GDPs and capital input endowments of both recipient and donor regions. Accordingly, these flows are not explicitly represented, or modeled. However, we do model the effect of repayments on the 2030 equilibrium.

For each recipient EMDE, the 2030 repayment outflow is calculated as the product of its total MDB-financed solar and wind capital stock in 2030 and a capital recovery factor, $CRF = i(1 +$

[5] In the case of nuclear in non-OECD East Asia and Pacific, where installed capacity is 0 TW in both 2023 and 2030, we set the 2023–2030 CAGR to 0%.

$i)^\ell/((1+i)^\ell - 1)$, where i and ℓ denote the effective interest rate and loan repayment period. In the present and subsequent scenarios we assume that the increase in projected 2023–2030 MDB electricity financing across all recipient EMDEs takes the form of concessional finance, with terms similar to those of International Development Association (2025), effective as of April 1, 2025: 40-year maturity, 10-year grace period, and interest rates of 2% and 4% during years 11–20 and 21–40, respectively, which yield $CRF = 0.037$ with assumed effective interest rate, $i = 0.02$ and loan repayment period, $\ell = 40$.

For each donor region, we calculate the 2030 financing outflows from the donor regions by subtracting the product of total annual MDB solar and wind financing across the EMDEs in 2030 and each donor region's share of 2013-2022 total gross multilateral ODA disbursed (covering the electricity and non-electricity sectors). We use total multilateral ODA shares rather than electricity-specific shares because donors' contributions to MDBs are pooled, and ODA flows specifically earmarked to electric power are not disaggregated by donor. Finally, for each donor region, we calculate the 2030 repayment inflow as the product of each donor region's share of the 2013-2022 financing in MDBs and the total repayment outflows summed across all recipient EMDEs.

Triple Agenda

The Triple Agenda Report calls for up to \$400B (2019 USD) in annual zero-carbon generation financing by 2030 across EMDEs excluding China (Independent Experts Group, 2023). To model this policy, we increase MDB financing in solar and wind electricity generation capacity in these EMDEs, excluding China and Russia.

Our first step is to calculate the ratio of the \$400B target to the total MDB financing in solar and wind capacity across the 14 aggregated EMDEs in 2022, as recorded in the OCI database. This allows us to recover the MDB financing scaling factor. Next, we multiply this scaling factor by the projected constant MDB financing in each of the solar and wind technologies in each EMDE from 2023 to 2030 in the BAU scenario. Note that, in the absence of more granular data, we assume a uniform scaling factor across both technologies and EMDEs for simplicity.

In the third step, we quantify the implications of this increased financing for MDB-financed capital stocks in solar and wind generation in each EMDE. We recalculate these capital stocks in 2030 using our estimates for 2023 levels and equation (15). In the fourth step, we incorporate the results as shocks to the endowments of solar and wind generation capital in each EMDE by multiplying these stocks by the rate of return.

Finally, we recalculate and model the impacts of the repayment outflows from the recipient EMDEs, the financing outflows from the donor regions, and the repayment inflows in the donor regions in 2030 using the same process outlined in the BAU scenario.

COP28

At COP28 in 2023, countries agreed to triple global renewable electricity generation capacity by 2030 to align with the Paris Agreement's 1.5 °C target. To reflect this goal, we scale up MDB financing in solar and wind across EMDEs (excluding China and Russia) such that in each EMDE, the total clean electricity generation capital stock in 2030 is three times its 2023 level. In our model, tripling clean electricity capital stock serves as a proxy for tripling clean electricity generation capacity.

Firstly, for each EMDE we compute the shortfall between (i) three times its 2023 total clean electricity capital stock and (ii) its 2030 total clean electricity capital stock under the BAU scenario. We then allocate this shortfall equally between MDB-financed solar and MDB-financed wind. Accordingly, for each EMDE, its 2030 MDB-financed solar capital stock equals its 2030 BAU level plus half of its computed shortfall, and its 2030 MDB-financed wind capital stock is defined analogously.

Our second step is to calculate each EMDE's MDB financing scaling factor. To do so, we will employ a alternative version of equation (15):

$$f_r^s = \big(K_r^s(\tau) - (1-\lambda)^{\tau - t_0} K_r(t_0)\big) / \big(\tilde{I}_r \sum_{t=t_0}^{\tau-1} (1-\lambda)^{\tau-1-t}\big) \tag{16}$$

where for this scenario, f_r^{COP} is the MDB financing scaling factor in EMDE r, $K_r^{COP}(\tau)$ is the combined MDB-financed solar and wind capital stock in time $\tau = 2030$, $K_r(t_0)$ is the combined MDB-financed solar and wind capital stock in time $t_0 = 2023$, and $\tilde{I}_r$ is the ten-year annual average of solar + wind financing by MDBs from 2013-2022 in EMDE r. Our third step is to multiply each EMDE's MDB financing scaling factor by the EMDE's projected constant MDB financing in each of the solar and wind technologies from 2023 to 2030 in the BAU scenario.

In the fourth step, we quantify the impacts of this increased financing for MDB-financed capital stocks in solar and wind generation in each EMDE. We recalculate the capital stocks in 2030 using our estimates for 2023 levels and equation (15). In the fifth step, we incorporate the results as shocks to the endowments of solar and wind generation capital in each EMDE by multiplying these stocks by the rate of return.

Finally, we recalculate and model the impacts of the repayment outflows from the recipient EMDEs, the financing outflows from the donor regions, and the repayment inflows in the donor regions in 2030 using the same process outlined in the BAU and Triple Agenda scenarios.

Analytical Model

In the analytical modeling section, we discover that as long as the elasticity of substitution between clean and dirty energy exceeds the price elasticity of energy demand, the threshold clean energy supply growth rate necessary to both spur economic development while reducing CO_2 emissions in a region is inversely proportional to the share of clean energy in the total (combined clean and dirty) energy sector's production costs. As such, we scale up MDB financing in solar and wind across EMDEs (excluding China and Russia) such that in each EMDE, the total clean electricity generation capital stock in 2030 is the product of its 2023 level and the inverse of its 2023 share of clean generation in their aggregate electricity generation sector's production costs.

Firstly, for each EMDE, we first compute the shortfall between (i) the product of its 2023 total clean electricity capital stock and the inverse of its 2023 share of clean generation in its aggregate electricity generation sector's production costs and (ii) its 2030 total clean electricity capital stock under the BAU scenario. We then, as we did in the COP28 scenario, allocate the shortfall equally between MDB-financed solar and MDB-financed wind. As such, for each EMDE, its 2030 MDB-financed solar capital stock equals its 2030 BAU level plus half of its computed shortfall, and its 2030 MDB-financed wind capital stock is defined analogously.

Our second step is the same as that of the COP28 scenario, where we calculate each EMDE's MDB financing scaling factor in this scenario, using equation (16). In this scenario, f_r^{AM} is the MDB financing scaling factor in EMDE r and $K_r^{AM}(\tau)$ is the combined MDB-financed solar and wind capital stock in EMDE r in time $\tau = 2030$. Our third step is to multiply each EMDE's MDB financing scaling factor by the EMDE's projected constant MDB financing in each of the solar and wind technologies from 2023 to 2030 in the BAU scenario.

In the fourth step, we quantify the impacts of this increased financing for MDB-financed capital stocks in solar and wind generation in each EMDE. We recalculate the capital stocks in 2030 using our estimates for 2023 levels and equation (15). In the fifth step, we incorporate the results as shocks to the endowments of solar and wind generation capital in each EMDE by multiplying these stocks by the rate of return.

Finally, we recalculate and model the impacts of the repayment outflows from the recipient EMDEs, the financing outflows from the donor regions, and the repayment inflows in the donor regions in 2030 using the same process outlined in the BAU, Triple Agenda, and COP28 scenarios.