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Abstract
Achieving the Paris Agreement's near-term goals (Nationally Determined Contributions, NDCs) and long-term temperature targets could result in pre-mature retirement, or stranding, of carbon-intensive assets before the end of their useful lifetime. We use an integrated assessment model to quantify the implications of the Paris Agreement for stranded assets in Latin America and the Caribbean (LAC), a developing region with the least carbon-intensive power sector in the world. We find that meeting the Paris goals results in stranding of $37-90 billion and investment of $1.9-2.6 trillion worth of power sector capital (2021-2050) across a range of future scenarios. Strengthening the NDCs could reduce stranding costs by 27-40%. Additionally, while politically shielding power plants from pre-mature retirement could also reduce power sector stranding, such actions could make mitigation more expensive and negatively impact society. Our analysis demonstrates that climate goals are relevant for investment decisions even in developing countries with low emissions.

Main
The Paris Agreement uses NDCs as the near-term foundation for achieving its long-term goal of limiting global warming to "well below 2°C", or even 1.5°C, above pre-industrial levels[1]. NDC targets are initially defined for the years 2025 or 2030[2] and vary greatly across countries, reflecting unique mitigation challenges and opportunities. Regional heterogeneity characterizes many features of emissions mitigation, including stranded assets (Supplementary Note 1). Stranded assets is a key issue for countries in Latin America and the Caribbean (LAC), despite the fact that the region is responsible for less than 10% of global carbon dioxide (CO_2) emissions[3] and generates more than half of its electricity from renewable sources[4,5]. For example, a recent analysis found that the region ranks second (behind only the Middle East) in terms of unburnable oil and gas reserves[6], and fossil fuel production is a key component of many LAC economies. However, the risks associated with man-made stranded assets in LAC have been largely overlooked as few studies have attempted to assess their implications for the region[7]. Additionally, financial institutions in LAC are not as robust as in other regions[8,9], which can hamper countries' ability to deal with the instability created by stranded assets.

Despite its growing prominence as a topic, there has been little analytical work specifically looking at stranded assets in regional contexts[7,10]. While global studies are helpful to provide a sense for the scale of this challenge, regulatory and investment decisions are made predominately at the national and subnational level. Hence, conducting analyses with greater geographic resolution is important for making results relevant to decision-makers.

We provide analysis at the regional level, assessing the issue of stranded assets and long-term decarbonization strategies for LAC. Specifically, we address the following question: *What are the implications in terms of power sector stranded assets and investment needs for LAC countries in delivering their commitments towards achieving the objectives of Paris agreement?* Additionally, to make our findings more salient for decision-makers, we quantify stranded assets in monetary terms (Methods). We also provide a sensitivity analysis around several modeling assumptions, including political willingness to avoid stranded assets, technology availability, and the role of land-use in mitigation, which were identified as key uncertainties by decision-makers in LAC.

1 Scenarios

We use the Global Change Assessment Model (GCAM) to analyze the composition and magnitude of stranded assets in the LAC power sector (Methods). GCAM is an integrated assessment model which captures important interactions between the global economic, energy, agriculture, and land-use systems in 32 geopolitical regions[11-14]. LAC is divided into seven model regions, four of which (Argentina, Brazil, Colombia, and Mexico) represent individual countries (Supplementary Table 1). The model tracks electricity generation by technology vintage (Supplementary Note 2), which facilitates the quantification of stranded assets in monetary terms.

We explore four global greenhouse gas (GHG) mitigation scenarios to assess the implications of the Paris Agreement on stranded assets in LAC (Table 1). These scenarios vary in terms of near-term and long-term mitigation stringency. To represent the Paris Agreement's long-term goals, we constrain the cumulative CO_2 emissions budgets over the century (2011-2100) to levels that are consistent with limiting mean global surface temperature increase to 2°C (1000 $GtCO_2$) or 1.5°C (400 $GtCO_2$)[15]. In the *Straight-to-2°C* and *Straight-to-1.5°C* scenarios, countries are assumed to begin pursuing least-cost mitigation efforts (as implemented by a global carbon price) to achieve these budgets starting in 2021. In the *NDCs-to-2°C* and *NDCs-to-1.5°C* scenarios, countries mitigate according to their NDCs until 2030, after which global least-cost mitigation is employed. Country-level NDCs are aggregated to the GCAM region level in a manner consistent with previous studies[16] (Supplementary Table 2).

Table 1: Scenario Design

Scenario	2016-2020	2021-2030	Beyond 2030
NDCs-to-2°C	Copenhagen	NDCs	Global cumulative CO_2 emissions budget (2011-2100) of 1000 $GtCO_2$
NDCs-to-1.5°C	Copenhagen	NDCs	Global cumulative CO_2 emissions budget (2011-2100) of 400 $GtCO_2$
Straight-to-2°C	Copenhagen	Global cumulative CO_2 emissions budget (2011-2100) of 1000 $GtCO_2$	
Straight-to-1.5°C	Copenhagen	Global cumulative CO_2 emissions budget (2011-2100) of 400 $GtCO_2$	

2 Results

2.1 CO_2 emission pathways

Energy and industry CO_2 emissions continue to rise until 2030 in the *NDCs-to-2°C* and *NDCs-to-1.5°C* scenarios, both globally and in LAC (Figure 1). Globally, emissions in the *NDCs* scenarios are 17% and 77% higher than the *Straight-to-2°C* and *Straight-to-1.5°C* scenarios in 2030; in LAC, this emissions gap is 18% and 62%, respectively (Supplementary Note 3). Consistent with previous studies, the NDCs collectively produce higher emissions than global least-cost mitigation pathways[17-19]. Thus, the *Straight-to* scenarios provide more flexibility to act earlier in decarbonizing the economy and minimize associated financial implications[20], while the *NDCs* scenarios' higher near-term emissions entail steeper reductions beyond 2030. The near-term trend and emissions gap are similar in the power sector, which fully decarbonizes by 2050 in each mitigation scenario (Supplementary Figure 1 provides information about the LAC power sector in the *Reference* scenario).

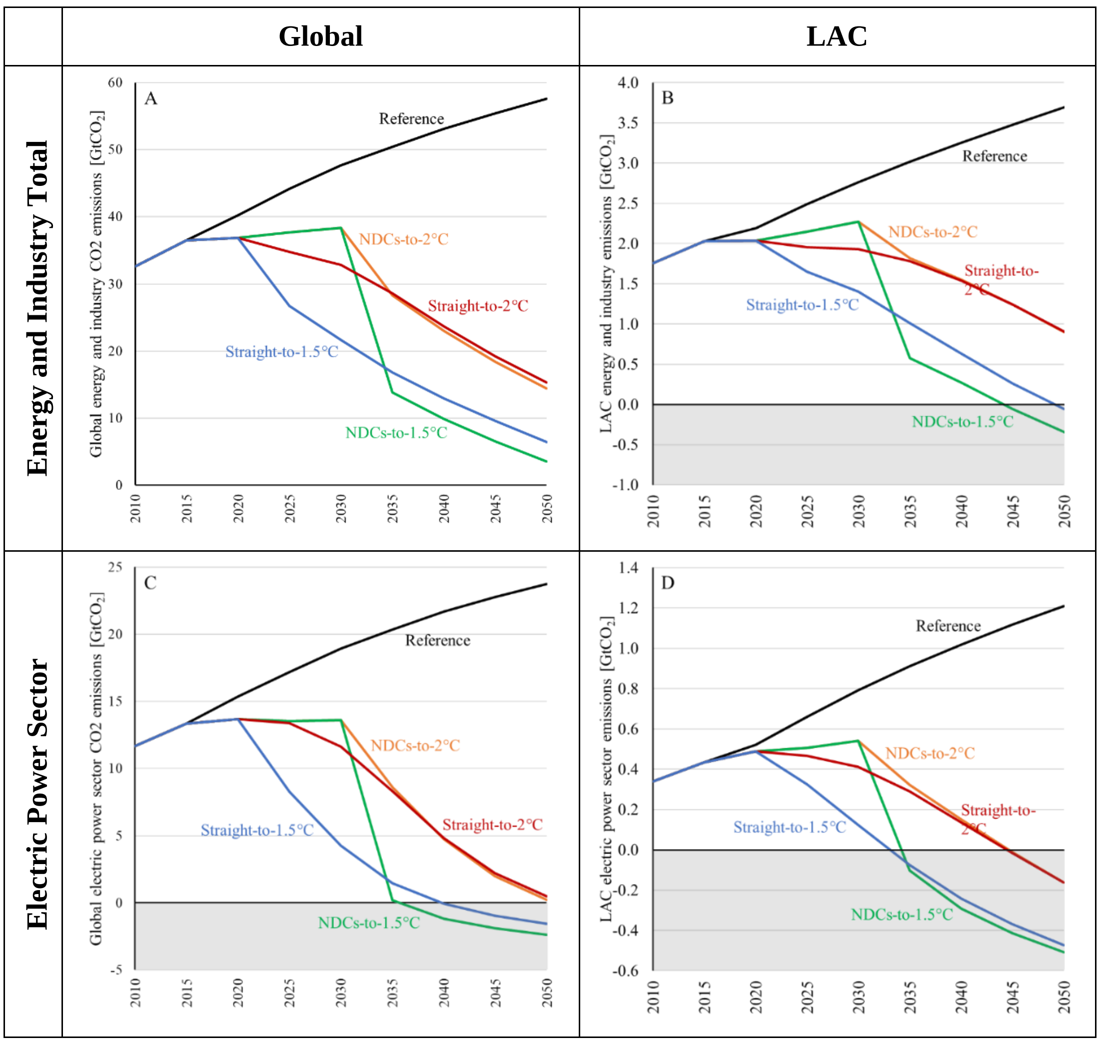

Figure 1: Global (A) and Latin America and Caribbean (B) CO_2 emissions from energy and industry across all model scenarios. Global (C) and Latin America and Caribbean (D) electric power sector CO_2 emissions across all model scenarios. Negative emissions come from bioenergy with carbon capture and sequestration (BECCS; see Supplementary Note 4). Scenarios in which BECCS is unavailable are explored in Section 4: Sensitivity analysis.

2.2 Stranded assets and investments in the LAC power sector

The four mitigation scenarios are characterized by a major transformation of the energy system by 2050 (Supplementary Figure 2), including increased energy efficiency and conservation, a transition from emitting fossil-fuel technologies to low- and non-carbon emitting technologies, and a shift in the type of investments throughout the energy system. Here, we focus on stranded assets and investments in the power sector, an important sector in the context of climate change mitigation[21], as a conservative measure of the scale and value of stranded assets in LAC. Across the mitigation scenarios explored in this study, between 60 GW (*Straight-to-2°C*) and 128 GW (*NDCs-to-1.5°C*) of fossil-fuel power plants are prematurely retired before the end of their physical lifetimes in the LAC power sector from 2021-2050 (Figure 2; Supplementary Table 3). These amounts are equivalent to 15-33% of the total installed capacity in LAC in 2015 (approximately 393 GW)[22]. Since the *NDCs-to-1.5°C* scenario requires the fastest reductions in CO_2 emissions, the magnitude of stranded assets in that scenario is also greatest, resulting in nearly 50% more stranding than the *Straight-to-1.5°C* scenario and more than double the stranded capacity observed in the *Straight-to-2°C* scenario. Most of this stranding occurs between 2031 and 2035, when LAC energy and industry emissions are reduced by nearly 75%. Over 80GW of capacity is prematurely retired during this five-year period.

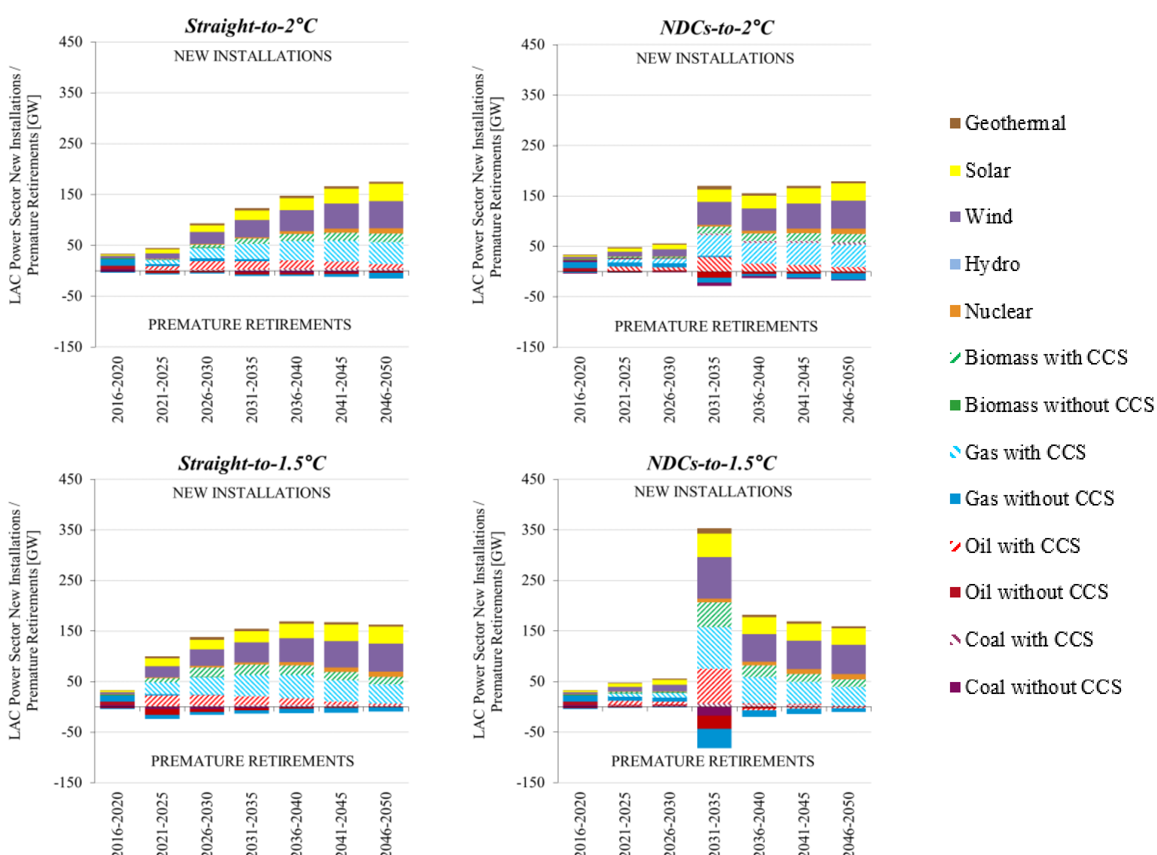

Figure 2: New Installations and Premature Retirements (negative investment values) by Scenario, Period, and Technology in the LAC Power Sector. Bars represent cumulative additions / retirements over a five-year model period. See Supplementary Figure 3 for country-level results.

Natural gas and oil power plants without carbon capture and sequestration (CCS) represent the largest fraction of prematurely retired capacity in LAC. In our scenarios, natural gas without CCS accounts for about 45% of stranded capacity in the *NDCs-to-2°C* scenario and about 54% of stranded capacity in the *NDCs-to-1.5°C* scenario, calling to question natural gas's role as a "bridge fuel"[23]. To meet the growing demand for electricity, between 751 and 967 GW of new capacity are installed from 2021 to 2050 (Supplementary Table 3). These capacity additions are roughly 1.9 to 2.5 times the total electricity generation capacity in LAC in 2015[22,24].

As anticipated, scenarios with the 1.5°C cumulative emissions budget require more capacity additions than the 2°C scenarios. This is because achieving the more stringent budget in the 1.5°C scenarios requires the electricity sector to both (1) decarbonize faster by replacing carbon-intensive plants with new low-carbon capacity and (2) produce more electricity overall, so that end-use sectors can reduce emissions by switching their energy use to electricity. Similarly, the *NDCs* scenarios require more new installations overall than the *Straight-To* scenarios, although the timing of these installations is delayed. Greater near-term mitigation spreads the new installation requirements more evenly across time; low-carbon power installations in the near-term both lower near-term emissions and reduce the rate at which emissions must be curtailed post-2030 (Figure 1), limiting the need for greater investments post-2030 to "catch up" with the cumulative emissions budget[25].

2.3 Stranded capacity and investment costs

Investment costs for the *Straight-to-2°C* scenario are the lowest ($1.9 trillion across LAC between 2021 and 2050, while those for the *NDCs-to-1.5°C* scenario are the highest (nearly $2.6 trillion) (Figure 3; see also Supplementary Table 4). These results are consistent with the insights from Figures 1 and 2 – while the NDCs imply significant challenges to limit warming to 2°C, they imply even more challenges for limiting warming to 1.5°C [26]. Overall, investment requirements in the *NDCs-to-1.5°C* scenario represent about 0.8% of LAC's projected (exogenously specified) GDP from 2021-2050, and reach as high as 2.1% of GDP for the 2031-2035 period.

Similarly, the costs of stranded capacity (or "stranding costs"; see Methods) are highest in the *NDCs-to-1.5°C* scenario, with cumulative costs of $90 billion between 2021 and 2050 (Figure 4). These costs are about 67% higher than the *Straight-to-1.5°C* scenario and more than double the costs in the *Straight-to-2°C* scenario. In contrast, the difference in stranding costs between the *Straight-to-2°C* and *NDCs-to-2°C* scenarios is about 37% ($13 billion USD) over the course of 30 years. For the 1.5°C scenarios in particular, the timing of asset stranding is driven by their vastly different emissions pathways (Figure 1). While the *Straight-to-1.5°C* scenario requires more mitigation in the near-term, the *NDCs-to-1.5°C* scenario requires a rapid decline in emissions post-2030. This in turn results in much more dramatic stranding of assets in the *NDCs-to-1.5°C* scenario compared to the *Straight-to-1.5°C* scenario. In other words, the value of strengthening near-term ambition is even greater for a 1.5°C temperature target.

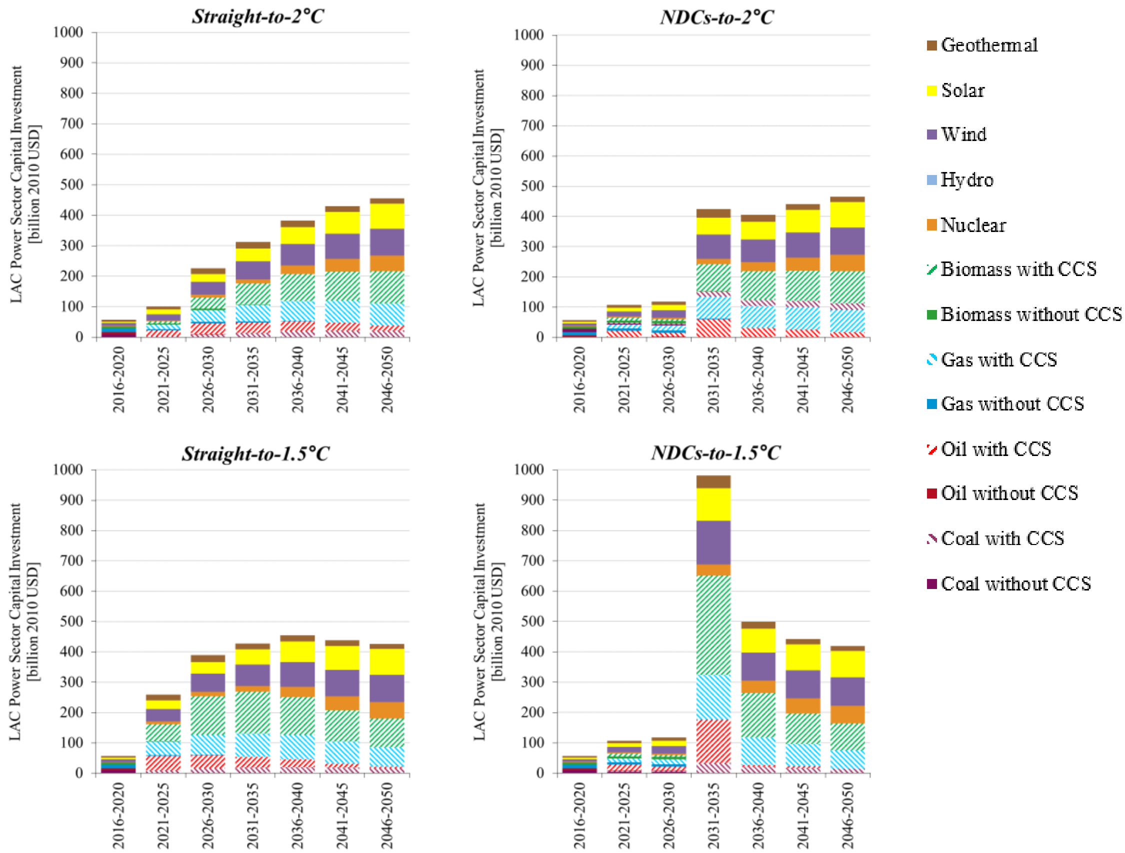

Figure 3: LAC Power Sector Capital Investment by Scenario, Period, and Technology. Bars represent cumulative costs over a five-year model period.

An interesting result from our analysis is that the cost of stranding coal technologies is the greatest across scenarios, even though these technologies make up a relatively small percentage of the total capacity stranded (see Figure 5). This is because (1) coal power plants are more capital intensive than gas and oil plants, and (2) coal power plants are assumed to have longer lifetimes (60 years) than gas and oil plants (45 years) and hence the economic value of coal power plants depreciates slower than gas and oil plants. In addition, oil with CCS plants contribute significantly to stranding costs for the 1.5°C scenarios between 2041 and 2050 because not only are these plants capital intensive, but they are also relatively new. Hence, although a small amount of capacity is retired, the plants have comparably large economic value when their operations cease.

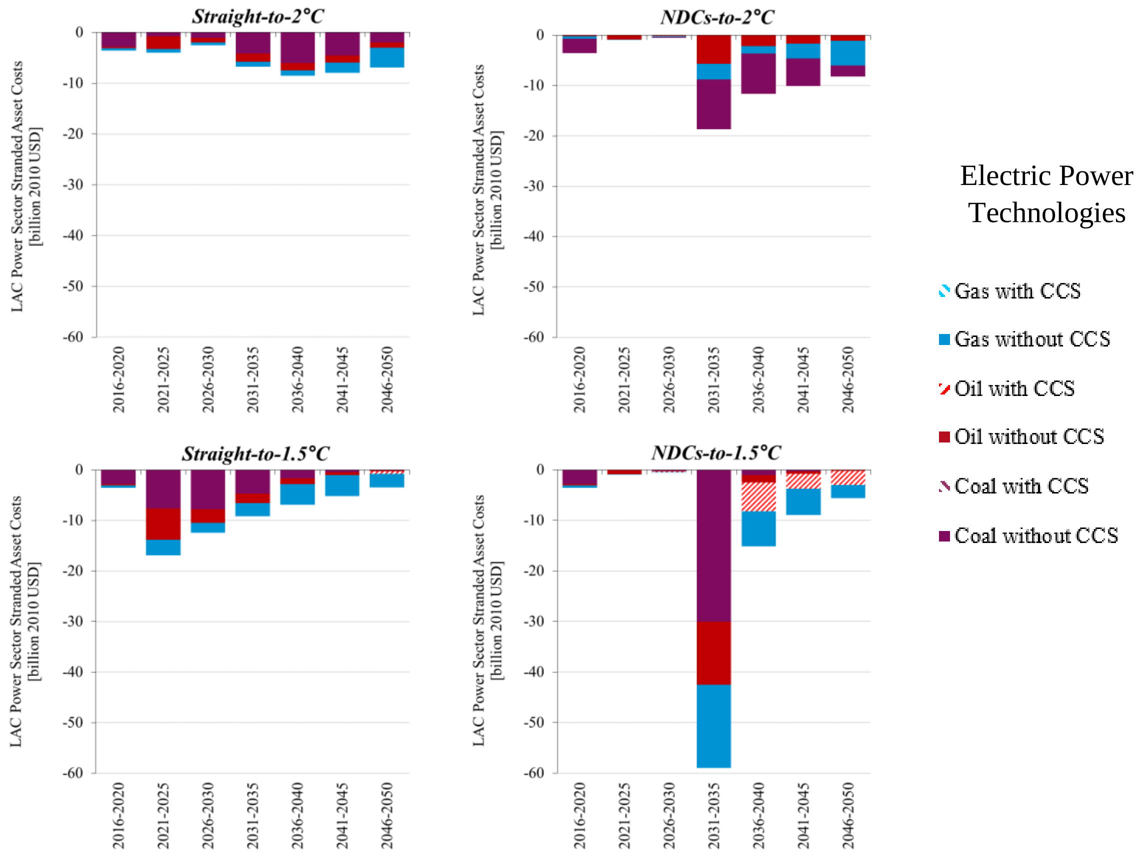

Figure 4: LAC Power Sector Stranded Asset Costs by Scenario, Period, and Technology. Bars represent cumulative costs over a five-year model period.

3 Sensitivity analysis

To assess the extent to which our estimates of power sector investment and stranding costs are influenced by key modeling parameters, we conduct a sensitivity analysis on assumptions about (1) political willingness to avoid stranded assets, (2) technology availability, and (3) the role of land-use change (LUC) in mitigation (Figure 5, Supplementary Note 5). Our results suggest that depending on how these factors affect the role of the power sector in mitigation, they could displace mitigation effort into other sectors and negatively impact consumers. For example, we find that while increased political willingness to avoid stranded assets reduces stranding costs in the *NDCs-to-2°C* scenario by 27 billion USD from 2031-2050 (56%, Figure 5), such avoidance shifts emissions mitigation to other sectors such as refining (Supplementary Figure 6), resulting in higher carbon prices (17% in 2050; Supplementary Table 7) and higher food prices (9% in 2050; Supplementary Table 8). Likewise, with CCS unavailable, mitigation effort in LAC is shifted to the land system, resulting in food price increases of 44% in 2050 due to increased competition for land for afforestation[27,28]. Mitigation that cannot be shifted to the land sector is accomplished by energy efficiency and conservation, with primary energy consumption, final energy consumption, and passenger vehicle miles traveled reduced by 23%, 11%, and 7% respectively.

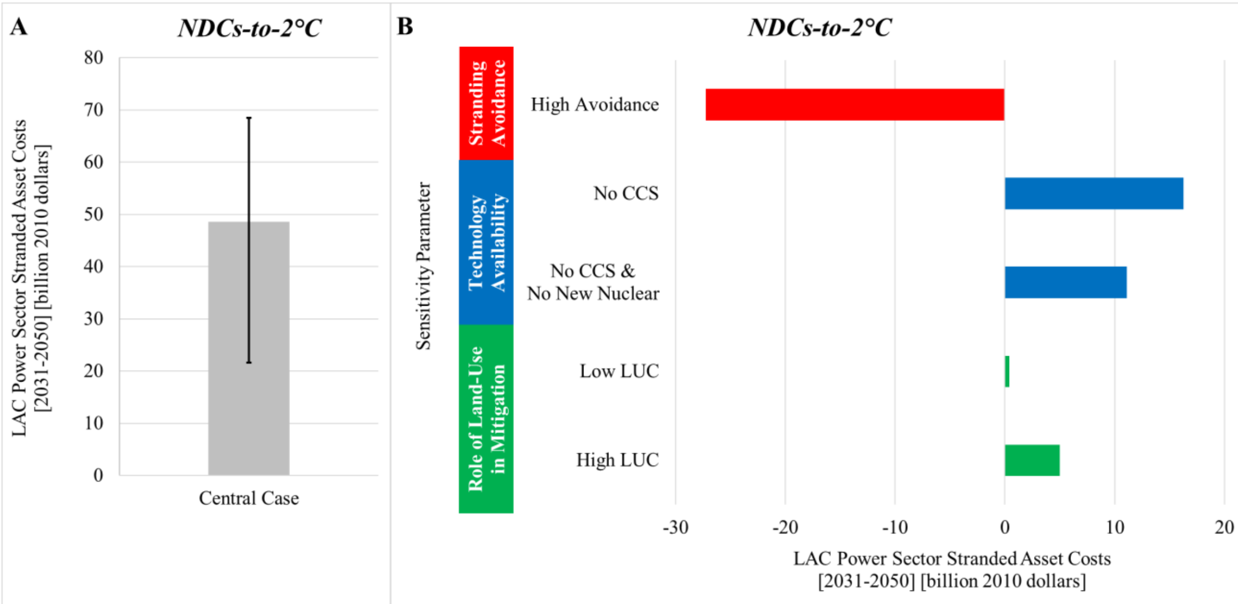

Figure 5: Sensitivity of LAC power sector stranded asset costs to changes in key parameters (see Supplementary Note 5).

A: Bar represents cumulative stranded asset costs for the central NDCs-to-2°C case (2031-2050). Error bar represents the range of cumulative stranded asset costs over the same period across every NDCs-to-2°C case (n = 18).

B: Tornado diagram of stranded asset cost sensitivity to changes in key parameters. Bars represent the change in cumulative stranded asset costs (2031-2050) associated with moving from the central case assumptions to the corresponding sensitivity assumption, holding all other parameters at their central case values. Low and High LUC refer to low and high mitigation from land-use change.

4 Conclusions

Our analysis demonstrates that power sector stranded assets are an important issue in LAC. Stranded assets costs represent huge potential losses for a relatively narrow group of stakeholders and coincide with substantial new capacity investment requirements. Our study also shows that strengthening near-term mitigation effort could reduce stranded asset costs in LAC, reinforcing the findings of global analyses that near-term investment decisions will have important economic implications in the mid-to-long-term[20], even in a developing region such as LAC where power-sector emissions are currently low.

More broadly, our study highlights the value of regional analyses using integrated tools with regional, sectoral, and technological detail to inform decision-making about decarbonization and explore the implications of different policy choices. Additionally, our analysis demonstrates the need for better investment planning consistent with global climate goals. Our methodology can be adapted to other sectors and regions; our study also opens several interesting avenues for future research, such as exploring the extent to which it is possible to avoid stranded assets while still achieving the Paris Agreement goals. Such assessments can provide valuable quantitative information about interactions between investment decisions and climate targets, which governments can incorporate into their planning processes from an early stage.

Methods

The Global Change Assessment Model

We use the Global Change Assessment Model (GCAM) to analyze the composition and magnitude of stranded assets in the LAC power sector (Supplementary Figure 10). GCAM is an open-source, global integrated assessment model which captures important interactions between the global economic, energy, agriculture, and land-use systems[11-14]. Dynamic-recursive models of each system are linked through markets and paired with a reduced-form atmosphere-carbon-cycle-climate model called Hector[29].

GCAM contains 32 geopolitical regions and operates in five-year time steps from 2010 (the last base year) to 2100. The LAC region is represented by seven model regions: Argentina, Brazil, Central America and Caribbean, Colombia, Mexico, Northern South America, and Southern South America (see Supplementary Table 1 for a breakdown of countries contained in each GCAM LAC region). Key inputs which drive model results include socioeconomic assumptions (population, labor participation rates, and labor productivity growth rates for each geopolitical region) and representations of the physical world (resources, biophysical processes like net primary productivity), technologies, and policy. In each model period, the model solves for the equilibrium prices and quantities of various energy, agricultural, and greenhouse gas (GHG) markets at either the global or regional level. GCAM tracks emissions of 24 GHGs and air pollutants endogenously based on activity in the energy, agriculture, and land-use systems.

GCAM's energy system includes detailed representations of depletable primary resources (coal, oil, natural gas, uranium) and renewable sources (bioenergy, hydro, solar, and wind) at regional levels, the prices of which are calculated endogenously. The model also includes representations of the processes that transform these resources to final energy carriers, which are ultimately used to deliver goods and services demanded by end users in buildings, transportation, and industrial sectors. Each technology in the model has a lifetime, and investment is tracked by vintage. Once installed, technologies operate until the end of their lifetime unless they are no longer economic to operate (variable cost exceeds the market price). Technology deployment depends on relative costs and is implemented via an implicit probabilistic formulation, using a logit function, which reflects heterogeneity of investment behavior and prevents unrealistic winner-take-all outcomes[30-32].

The agriculture and land use module of GCAM determines the demands for and production of products originating on the land, the prices of these products, the allocation of land to competing uses, and the carbon stocks, flows, and emissions of other gases associated with land use. The energy system and agriculture and land-use systems are coupled through bioenergy and fertilizer. For the former, the energy system determines the demand for bioenergy and the agriculture and land-use system determines the supply. For the latter, the agriculture and land-use system determines the demand for fertilizer and the energy system determines the supply.

Implementation of the Copenhagen pledges and NDCs in GCAM

Country-level NDCs are aggregated to the GCAM region level in a manner consistent with previous studies[16]. Our representation of the NDCs assumes economy-wide mitigation, implemented through a carbon price. Real-world measures will differ from this approach. Regardless, our results are meant to be illustrative and our idealized implementation is sufficient to illustrate the key points raised in this paper. Additionally, our representation of national mitigation pledges includes only quantifiable Copenhagen pledges that have not been formally rescinded and unconditional NDC targets; all such commitments are assumed to be achieved. Countries which have no quantifiable Copenhagen commitment are assumed to

face no emissions constraint through 2020; countries which have not submitted NDCs or have no unconditional pledges in their NDCs are assumed to face no emissions constraint through 2030 (*NDCs-to-2°C* and *NDCs-to-1.5°C* scenarios). Supplementary Table 2 provides further detail on how each LAC country's NDC target is implemented in GCAM.

Several other key assumptions are made to represent the NDCs in GCAM. Emissions trajectories between 2020 and 2030 are assumed to be linear; if a target is only available for 2025 or 2030, a target for the missing period is linearly interpolated. At the country level, NDC targets are implemented as articulated by the country, with limitations on individual gasses modeled according to the NDC (which may or may not include non-CO_2 gases). However, for all regions, we assume that reductions in non-CO_2 emissions are obtained in an economically efficient manner with lowest cost mitigation undertaken before more expensive options and with equal marginal abatement costs across all economic sectors. Finally, CO_2 emissions from land-use change (LUC) are assumed to face a carbon price that is 1% of the price per ton of carbon on other gases, in order to avoid unrealistically rapid afforestation or land-use conversion for bioenergy production [33]. Since other assumptions about the price on land-use change emissions would affect the numerical results, we test the sensitivity of our results to this assumption.

Estimation of monetary value of stranded assets

GCAM tracks electricity generation by technology vintage. Generation in a vintage's initial year of operation represents full utilization and the generation for a vintage can never exceed full utilization. If a technology cannot cover its operating costs, it is retired before the end of its lifetime. We employ a logistical method to retire power production capacity when variable costs approach the price received for power. An s-curve function defines the fraction of power plants which must retire when the variable cost of operation exceeds the market price of electricity (Supplementary Note 2). These retirements are tracked as a reduction of the vintage's generation capacity.

Our estimate of the value of retired production capacity is based on the original investment to bring the capacity on line and its expected physical lifetime at the time of installation, as well as the fraction of the vintage retired. The cost to bring the vintage of capital on line is the original overnight capital cost (Supplementary Table 10). The financial value of installed capacity is assumed to decline linearly with time from its initial overnight capital cost. That is, the economic value of the capital stock in subsequent years is the original capital cost times the fraction of the capital stock's foregone useful life (Supplementary Figure 11). In other words, the foregone value of a prematurely retired power plant is calculated as the total capital cost of the asset times the fraction of expected (physical) lifetime (Supplementary Table 11) foregone due to premature retirement. This can be expressed as:

$$SV = CC * ((EL - AL) / EL)$$, where:

SV = stranded value,
CC = capital costs,
EL = expected lifetime, and
AL = actual lifetime

Our methodology extends the one developed by Johnson, et al. [34], by applying asset depreciation.

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Supplementary Materials

Supplementary Notes

Supplementary Note 1: Stranded Assets

Paris temperature targets require reaching net-zero global carbon dioxide (CO_2) emissions before the end of the century[1]. Achieving these goals would require policies to shift the current methods of energy production from carbon-intensive sources to low and non-carbon-emitting sources. Such a shift could in turn result in the devaluation or retirement of carbon-intensive assets before the end of their expected lifetime, referred to as "stranding" of assets[2-5]. The issue of stranded assets is important because they could result in financial market instability which in turn could create macro-economic instability[6]. Stranded assets could also create political instabilities due to a rapid loss of wealth for the owners of affected capital assets, potentially resulting in lobbying and rent-seeking behavior[7].

In the context of climate change mitigation, stranded assets could manifest in various forms such as fossil-fuel resources that cannot be burned in order to maintain a long-term temperature goal or pre-mature retirement of man-made capital assets due to climate policies[8]. Previous quantitative studies of stranded assets in the context of climate change mitigation have focused on quantifying unburnable fossil fuels[9-12], quantifying "committed" future emissions implied by current investments[13-16], and on assessing stranded power sector capital assets under global long-term mitigation scenarios with different levels of stringency of near-term mitigation policies[5,17,18]. These studies have largely quantified stranded assets results in physical terms such as GW of stranded capacity, seldom assigning monetary values to these stranding outcomes. We extend previous studies by quantifying stranded assets in monetary terms.

Supplementary Note 2: Representation of capital stock turnover in GCAM

This section explains the representation of capital stock turnover in GCAM's electric power sector. GCAM tracks power plant capital by technology and vintage over the lifetime of the technology. The model represents two types of retirements of power plants – natural and profit-induced. Electricity generation by a technology T and vintage V (V represents the year in which the capital investment was made) in time period t $(>V)$ in a state or region s is calculated as follows:

$$G_{T,V,s}\,(t) = G_{T,V,s}\,(t-1) * (1 - y_{natural,T,s}(t)) * (1 - y_{profit,T,s}(t))$$

where $y_{natural,T,s}(t)$ is the fraction of natural retirements and $y_{profit,T,s}(t)$ is the fraction of profit-induced retirements in time period t for technology T in state or region s.

1. ***Natural retirements:*** Each power plant technology, T has a lifetime (Table A1). The fraction of natural retirements in time period t, $y_{natural,T,s}(t)$ is calculated as follows: $1 - y_{natural,T,s}(t) = \frac{1}{1+e^{b(t-x)}}$; where b is a steepness coefficient, t is the elapsed time, and x is the "mid-life" where 50% of the capital stock is retired. An example of the $1 - y_{natural,T,s}(t)$ function is shown in Supplementary Figure 12. The parameters b and x are assumed to be same for all technologies and uniform across the globe.

2. ***Profit-induced retirements:*** The model also includes a representation of power plants retiring when the variable cost of operation exceeds the market price of electricity. The fraction of profit-induced retirements in time period t, $y_{profit,T,s}(t)$ is calculated as follows: $y_{profit,T,s}(t) = 1 - \frac{(x+1)^b}{(x+1)^b + (mp_{T,s}(t)+1)^b}$; where $mp_{T,s}(t)$ is the profit rate, b is a steepness coefficient and x is the marginal profit when 50% of the stock will be retired. $mp_{T,s}(t)$ is calculated as: $mp_{T,s}(t) = \frac{mr_s(t) - (vc_{T,s}(t))}{mr_s(t)}$; where $mr_s(t)$ is the marginal revenue, $vc_{T,s}(t)$ is the variable cost that includes fuel costs, variable O&M costs and carbon taxes. An example of the $1 - y_{profit,T,s}(t)$ function is shown in Supplementary Figure 13. The parameters b and x are assumed to be same for all technologies and uniform across the globe.

Supplementary Note 3: Latin America and Caribbean Emissions Pathways

It is notable that Latin America and the Caribbean reaches net-negative energy and industry CO_2 emissions by 2050 in both of the 1.5°C scenarios, while global emissions in those scenarios remain positive through mid-century. This result is driven by the use of a uniform global carbon price to achieve the cumulative emissions budget. Under such a regime, emission-reduction efforts are directed toward lowest cost, irrespective of the source of emissions.

LAC's energy system is presently less carbon-intensive than the average for the rest of the world, which enables it to reach net-zero emissions more quickly than regions which have more carbon-intensive infrastructure already locked in place (assuming a uniform global carbon price). In addition, the share of bioenergy in primary energy consumption in LAC has historically been greater than the rest of the world. Since GCAM is calibrated to historical energy production, the model tends to deploy more bioenergy technologies, including bioenergy with carbon capture and sequestration (BECCS) in LAC compared to the rest of the world. The negative emissions from BECCS also contribute to LAC emissions dropping below zero before the rest of the world. However, it is important to note the deployment of BECCS is likely to be constrained by a range of social, political and technological factors[19,20]; changes in the availability of BECCS will change the regional distribution of mitigation burdens.

Supplementary Note 4: Bioenergy with Carbon Capture and Sequestration

Carbon capture and sequestration (CCS) technologies remove carbon dioxide (CO_2) from hydrocarbon fuels (including fossil fuels and biofuels). Depending on the technology, CO_2 can be captured either before or after the fuels are combusted. CCS technologies capture most, but not all, of a fuel's CO_2 emissions, preventing them from being released into the atmosphere. This captured CO_2 is then stored (sequestered) in geologic reservoirs deep underground. These technologies have yet to be commercialized, and only a few industrial-scale installations currently exist worldwide. Most current CCS plants do not store CO_2 in geologic reservoirs, but re-use it in other industrial applications (enhanced oil recovery, for example). Bioenergy in combination with CCS (often abbreviated as BECCS) is a "negative emissions technology" in which CO_2 is removed from the atmosphere by plants during photosynthesis, then captured and stored when that plant matter (biomass) is transformed into useful energy. The net effect of energy from BECCS is thus CO_2 removal, or "negative emissions"[20].

Supplementary Note 5: Sensitivity analysis

To assess the extent to which our estimates of power sector investment and stranding costs are influenced by key modeling parameters, we conduct a sensitivity analysis on assumptions about (1) political willingness to avoid stranded assets, (2) technology availability, and (3) the role of land-use change (LUC) in mitigation (Supplementary Tables 5-6). In total, all combinations of these assumptions result in 36 sensitivity cases (18 cases each for the *NDCs-to-2°C* and *NDCs-to-1.5°C* scenarios). It should be noted that beyond 2030 the regional allocation of emissions within the emissions budget is based on global least-cost mitigation and thus can vary across scenarios.

Different sensitivity cases result in different investment and stranding outcomes (Supplementary Figures 4-5) and CO_2 emissions pathways (Supplementary Figure 5). For example, increased political willingness to avoid stranded assets reduces power sector stranded asset costs by 27 billion USD over the twenty-year period from 2031-2050 (*NDCs-to-2°C*), holding all other parameters at their central assumption values (Figure 5). However, increased stranding avoidance in the power sector shifts emissions mitigation to other sectors such as refining (Supplementary Figure 6) and results in higher carbon prices (17% in 2050) to achieve emissions mitigation goals (Supplementary Table 7). This heightened refining sector mitigation in turn requires a significant increase in biofuels, intensifying the competition for cropland and raising food prices (by 9% in 2050; see Supplementary Table 8). Although conducting a detailed evaluation of the implications of food price increases for consumers is beyond the scope of this study, our results suggest that avoiding stranding in the energy sector could have important implications for other sustainable development priorities.

Additionally, our analysis suggests that the *NDCs-to-1.5°C* scenarios are not feasible in cases with limited technology availability, in particular, without CCS technologies (Supplementary Figure 4). This is because, by the time the current NDCs are implemented in 2030, cumulative global CO_2 emissions are already 300 $GtCO_2$ higher than the century-wide 1.5°C budget (Supplementary Figure 5). Without CCS and hence CO_2 removal from bioenergy with carbon capture and sequestration (BECCS; Supplementary Note 4), the level of net-negative emissions needed in the second half of the century to bring cumulative global CO_2 emissions back below the 1.5°C budget by 2100 is simply not feasible in the GCAM modeling paradigm. While this finding about the importance of CCS for 1.5°C scenarios is consistent with recent studies[27,28], it is also important to note that all of the feasible *NDCs-to-1.5°C* scenarios in this study imply a temporary overshoot of the 1.5°C temperature target, since the emissions budget is always exceeded before being met by the end-of-century.

While limited technology availability renders the *NDCs-to-1.5°C* scenarios infeasible within our modeling paradigm, the *NDCs-to-2°C* scenarios were found to be feasible, albeit at higher costs. Reducing technology availability from *Full Tech* to *No CCS* increases power sector stranded asset costs (2031-2050) by $16 billion (Figure 5). Despite these higher stranding costs, power sector CO_2 emissions remain higher in the *No CCS* sensitivity cases compared to their *Full Tech* counterparts. Further, with CCS unavailable, power sector mitigation cannot be easily displaced to the refining sector. Instead, additional mitigation effort in LAC is shifted from the energy system to the land system, which results in food price increases of 44% (in 2050) due to increased competition for land for afforestation[29,30]. Mitigation that cannot be shifted to the land sector is accomplished by energy efficiency and conservation, with primary energy consumption, final energy consumption, and passenger vehicle miles traveled reduced 23%, 11%, and 7% respectively in the *No CCS* case compared with the *Full Tech* case in 2050 (Supplementary Figure 7, Supplementary Table 9).

Furthermore, while changes to the role of land-use in mitigation tend to have small average impacts on power sector stranding costs in LAC (Figure 5), the range of potential impacts is fairly large (Supplementary Figure 8). Shifting to a high role for LUC in mitigation (*High LUC*) can either increase or decrease stranding costs, depending on assumptions about technology availability. With full technology availability, increasing the role of LUC in mitigation results in lower production of bioenergy feedstocks, making BECCS a less economic mitigation strategy (Supplementary Figure 9) and thereby resulting in increased power sector stranding and associated costs. In contrast, with limited technology availability, increasing the role of LUC in mitigation reduces the role of the energy system and results in lower stranding costs.

Supplementary Tables

Supplementary Table 1

Supplementary Table 1: Latin America and Caribbean countries in GCAM

GCAM Region	Country
Argentina	Argentina
Brazil	Brazil
Central America and Caribbean	Anguilla; Antigua & Barbuda; Aruba; Bahamas; Barbados; Belize; Bermuda; Cayman Islands; Costa Rica; Cuba; Dominica; Dominican Republic; El Salvador; Grenada; Guadeloupe; Guatemala; Haiti; Honduras; Jamaica; Martinique; Montserrat; Netherlands Antilles; Nicaragua; Panama; Saint Kitts and Nevis; Saint Lucia; Saint Vincent and the Grenadines; Trinidad and Tobago
Colombia	Colombia
Mexico	Mexico
Northern South America	French Guiana; Guyana; Suriname; Venezuela
Southern South America	Bolivia; Chile; Ecuador; Paraguay; Peru; Uruguay

Supplementary Table 2

Supplementary Table 2: LAC NDC Commitments as Implemented in GCAM

GCAM Region	Country	Representation of Copenhagen Commitments	Representation of INDCs		Source for History/BAU emissions	Notes	Links
		2020	2025	2030			
Argentina	Argentina		Linear interpolation between 2020 BAU and 2030 emissions constraint	15% reduction in all GHG (including LUC) below BAU	BAU based on INDC submission		http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
Brazil	Brazil	37.5% (average of 36.1-38.9%) reduction in all GHG (including LUC) below BAU	37% reduction in all GHG (including LUC) below 2005	43% reduction in all GHG (including LUC) below 2005	Historical emissions and 2020 BAU based on INDC submission	The Copenhagen target is non-binding	http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
Central America and Caribbean	Grenada		30% reduction in all GHG (including LUC) below 2010		Historical emissions based on INDC submission		http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
	Trinidad and Tobago			30% reduction in CO2 from fossil fuels and industry below BAU	BAU based on INDC submission		http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
Colombia	Colombia		Linear interpolation between 2020 BAU and 2030 emissions constraint	20% reduction in all GHG (including LUC) below BAU	BAU based on INDC submission		http://www4.unfccc.int/submissions/INDC/Published%20Documents/Colombia/1/Colombia%20iNDC%20Unofficial%20translation%20Eng.pdf
Mexico	Mexico	30% reduction in all GHG (including LUC) below BAU	Linear interpolation between 2020 and 2030 emissions constraints	22% reduction in all GHG (including LUC) below BAU	BAU based on INDC submission		http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
South America_Northern	Peru		Linear interpolation between 2020 BAU and 2030 emissions constraint	20% reduction in all GHG (including LUC) below BAU	BAU based on INDC submission		http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
	Uruguay			Reduction of 1.4 MtCO2 in all GHG (including LUC) below BAU	Emissions reductions from BAU based on INDC submission		
	Paraguay			10% reduction in all GHG (including LUC) below BAU	BAU based on INDC submission		
South America_Southern							

Supplementary Table 3

Supplementary Table 3A: LAC Power Sector New Installations and Premature Retirements by Technology for the Straight-to-2°C scenario. Numbers represent cumulative additions / retirements, in GW, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	Straight-to-2°C	Oil w/o CCS	6.5	0.1	0.2	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-2°C	Oil w/ CCS	0.0	8.7	16.4	16.3	16.2	13.3	9.0	GW
LAC	Straight-to-2°C	Gas w/o CCS	12.4	3.5	6.1	3.5	0.7	0.0	0.0	GW
LAC	Straight-to-2°C	Gas w/ CCS	0.0	8.1	20.4	30.0	37.9	42.1	42.9	GW
LAC	Straight-to-2°C	Coal w/o CCS	3.6	0.3	0.2	0.1	0.0	0.0	0.0	GW
LAC	Straight-to-2°C	Coal w/ CCS	0.0	0.4	1.6	2.8	3.9	4.4	4.5	GW
LAC	Straight-to-2°C	Biomass w/o CCS	1.6	0.8	1.2	0.3	0.0	0.0	0.0	GW
LAC	Straight-to-2°C	Biomass w/ CCS	0.0	0.9	5.3	10.3	13.6	15.0	16.8	GW
LAC	Straight-to-2°C	Nuclear	0.4	0.7	1.8	2.7	5.5	8.2	10.2	GW
LAC	Straight-to-2°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-2°C	Wind	4.5	10.6	23.2	33.8	41.2	48.9	53.8	GW
LAC	Straight-to-2°C	Solar	2.9	8.4	12.7	18.7	23.8	29.8	33.7	GW
LAC	Straight-to-2°C	Geothermal	1.3	2.2	4.3	5.0	5.1	4.6	4.4	GW
LAC	Straight-to-2°C	TOTAL	33.3	44.6	93.3	123.4	147.8	166.3	175.3	GW

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	Straight-to-2°C	Oil w/o CCS	0.5	4.0	2.4	4.0	3.6	3.5	2.8	GW
LAC	Straight-to-2°C	Oil w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-2°C	Gas w/o CCS	1.5	2.1	1.8	3.1	3.3	5.8	10.9	GW
LAC	Straight-to-2°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-2°C	Coal w/o CCS	2.0	0.6	1.0	2.9	3.8	2.8	1.4	GW
LAC	Straight-to-2°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-2°C	TOTAL	4.1	6.7	5.2	10.0	10.7	12.1	15.1	GW

Supplementary Table 3B: LAC Power Sector New Installations and Premature Retirements by Technology for the NDCs-to-2°C scenario. Numbers represent cumulative additions / retirements, in GW, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	NDCs-to-2°C	Oil w/o CCS	6.5	1.4	2.3	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-2°C	Oil w/ CCS	0.0	8.8	5.7	28.4	15.3	13.1	9.1	GW
LAC	NDCs-to-2°C	Gas w/o CCS	12.4	8.0	8.4	2.9	0.2	0.0	0.0	GW
LAC	NDCs-to-2°C	Gas w/ CCS	0.0	6.4	8.6	40.5	41.0	43.4	44.1	GW
LAC	NDCs-to-2°C	Coal w/o CCS	3.6	1.7	1.5	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-2°C	Coal w/ CCS	0.0	0.4	0.5	3.6	4.1	4.4	4.5	GW
LAC	NDCs-to-2°C	Biomass w/o CCS	1.6	1.6	1.8	0.3	0.0	0.0	0.0	GW
LAC	NDCs-to-2°C	Biomass w/ CCS	0.0	1.2	0.9	13.2	14.7	15.5	16.8	GW
LAC	NDCs-to-2°C	Nuclear	0.4	0.9	0.9	3.4	5.8	8.4	10.6	GW
LAC	NDCs-to-2°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-2°C	Wind	4.5	9.1	13.3	45.5	43.6	50.1	55.3	GW
LAC	NDCs-to-2°C	Solar	2.9	6.5	9.2	25.2	25.4	30.5	34.3	GW
LAC	NDCs-to-2°C	Geothermal	1.3	2.0	2.6	6.6	5.5	4.7	4.5	GW
LAC	NDCs-to-2°C	TOTAL	33.3	48.0	55.8	169.7	155.6	170.2	179.2	GW

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	NDCs-to-2°C	Oil w/o CCS	0.5	1.5	0.4	12.4	4.6	4.0	3.1	GW
LAC	NDCs-to-2°C	Oil w/ CCS	0.0	0.0	0.1	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-2°C	Gas w/o CCS	1.5	0.1	0.2	9.5	4.1	7.8	13.0	GW
LAC	NDCs-to-2°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-2°C	Coal w/o CCS	2.0	0.0	0.2	6.6	4.6	3.2	1.4	GW
LAC	NDCs-to-2°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	TOTAL	4.1	1.5	0.9	28.4	13.3	15.0	17.5	GW

Supplementary Table 3C: LAC Power Sector New Installations and Premature Retirements by Technology for the Straight-to-1.5°C scenario. Numbers represent cumulative additions / retirements, in GW, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	Straight-to-1.5°C	Oil w/o CCS	6.5	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-1.5°C	Oil w/ CCS	0.0	21.1	20.3	17.2	12.8	6.7	2.6	GW
LAC	Straight-to-1.5°C	Gas w/o CCS	12.4	2.3	0.6	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-1.5°C	Gas w/ CCS	0.0	23.5	35.5	42.1	46.2	42.7	38.4	GW
LAC	Straight-to-1.5°C	Coal w/o CCS	3.6	0.1	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-1.5°C	Coal w/ CCS	0.0	1.7	3.1	3.7	4.1	3.8	3.4	GW
LAC	Straight-to-1.5°C	Biomass w/o CCS	1.6	0.2	0.1	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-1.5°C	Biomass w/ CCS	0.0	7.9	18.4	20.8	19.1	16.1	15.0	GW
LAC	Straight-to-1.5°C	Nuclear	0.4	1.6	2.8	3.6	6.6	8.9	10.6	GW
LAC	Straight-to-1.5°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-1.5°C	Wind	4.5	22.0	33.2	39.8	47.3	52.2	55.3	GW
LAC	Straight-to-1.5°C	Solar	2.9	15.4	18.3	22.5	28.3	32.7	33.4	GW
LAC	Straight-to-1.5°C	Geothermal	1.3	4.4	5.5	4.4	5.0	4.4	4.0	GW
LAC	Straight-to-1.5°C	TOTAL	33.3	100.3	137.9	154.2	169.3	167.4	162.7	GW

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	Straight-to-1.5°C	Oil w/o CCS	0.5	11.2	5.9	4.2	2.8	1.5	0.8	GW
LAC	Straight-to-1.5°C	Oil w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.5	GW
LAC	Straight-to-1.5°C	Gas w/o CCS	1.5	8.0	5.3	6.3	8.9	10.1	7.8	GW
LAC	Straight-to-1.5°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-1.5°C	Coal w/o CCS	2.0	4.4	4.4	2.4	0.9	0.3	0.1	GW
LAC	Straight-to-1.5°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	Straight-to-1.5°C	TOTAL	4.1	23.6	15.6	12.9	12.6	11.9	9.1	GW

Supplementary Table 3D: LAC Power Sector New Installations and Premature Retirements by Technology for the NDCs-to-1.5°C scenario. Numbers represent cumulative additions / retirements, in GW, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	NDCs-to-1.5°C	Oil w/o CCS	6.5	1.4	2.3	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	Oil w/ CCS	0.0	8.8	5.7	68.4	2.8	2.7	0.1	GW
LAC	NDCs-to-1.5°C	Gas w/o CCS	12.4	8.0	8.4	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	Gas w/ CCS	0.0	6.4	8.6	82.7	52.1	43.2	36.8	GW
LAC	NDCs-to-1.5°C	Coal w/o CCS	3.6	1.7	1.5	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	Coal w/ CCS	0.0	0.4	0.5	6.7	4.3	3.5	2.9	GW
LAC	NDCs-to-1.5°C	Biomass w/o CCS	1.6	1.6	1.8	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	Biomass w/ CCS	0.0	1.2	0.9	49.1	22.4	15.6	14.1	GW
LAC	NDCs-to-1.5°C	Nuclear	0.4	0.9	0.9	7.1	7.8	9.8	11.3	GW
LAC	NDCs-to-1.5°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	Wind	4.5	9.1	13.3	82.3	54.5	55.6	57.3	GW
LAC	NDCs-to-1.5°C	Solar	2.9	6.5	9.2	46.5	33.2	33.8	32.8	GW
LAC	NDCs-to-1.5°C	Geothermal	1.3	2.0	2.6	10.1	5.4	4.5	3.9	GW
LAC	NDCs-to-1.5°C	TOTAL	33.3	48.0	55.8	353.0	182.5	168.8	159.2	GW

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Units
LAC	NDCs-to-1.5°C	Oil w/o CCS	0.5	1.5	0.4	26.5	3.0	1.3	0.6	GW
LAC	NDCs-to-1.5°C	Oil w/ CCS	0.0	0.0	0.1	0.0	3.4	2.1	2.4	GW
LAC	NDCs-to-1.5°C	Gas w/o CCS	1.5	0.1	0.2	37.8	12.9	11.0	6.9	GW
LAC	NDCs-to-1.5°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	Coal w/o CCS	2.0	0.0	0.2	17.3	0.5	0.2	0.0	GW
LAC	NDCs-to-1.5°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GW
LAC	NDCs-to-1.5°C	TOTAL	4.1	1.5	0.9	81.6	19.9	14.6	9.9	GW

Supplementary Table 4

Supplementary Table 4A: LAC Power Sector Capital Investments and Stranded Asset Costs by Technology for the Straight-to-2°C scenario. Numbers represent cumulative costs, in billion 2010 USD, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	Straight-to-2°C	Oil w/o CCS	5.8	0.1	0.2	0.0	0.0	0.0	0.0
LAC	Straight-to-2°C	Oil w/ CCS	0.0	19.6	35.3	33.8	32.8	26.2	17.5
LAC	Straight-to-2°C	Gas w/o CCS	12.0	3.6	6.1	3.5	0.7	0.0	0.0
LAC	Straight-to-2°C	Gas w/ CCS	0.0	15.5	37.4	53.5	65.9	71.6	71.8
LAC	Straight-to-2°C	Coal w/o CCS	10.4	1.1	0.9	0.3	0.0	0.0	0.0
LAC	Straight-to-2°C	Coal w/ CCS	0.0	1.9	8.3	14.3	19.1	21.0	21.2
LAC	Straight-to-2°C	Biomass w/o CCS	6.4	3.4	5.3	1.8	0.0	0.0	0.0
LAC	Straight-to-2°C	Biomass w/ CCS	0.0	6.6	36.7	68.9	89.2	96.5	105.4
LAC	Straight-to-2°C	Nuclear	2.4	3.6	9.4	14.1	28.4	42.0	52.1
LAC	Straight-to-2°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-2°C	Wind	8.7	19.8	41.7	59.0	70.2	81.5	87.9
LAC	Straight-to-2°C	Solar	5.3	15.6	26.2	41.7	55.2	71.5	82.3
LAC	Straight-to-2°C	Geothermal	5.7	9.3	18.3	20.9	21.2	19.1	17.8
LAC	Straight-to-2°C	TOTAL	56.7	99.9	225.9	311.8	382.6	429.4	456.0

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	Straight-to-2°C	Oil w/o CCS	0.2	2.5	0.9	1.6	1.5	1.4	1.0
LAC	Straight-to-2°C	Oil w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-2°C	Gas w/o CCS	0.5	0.8	0.6	1.0	1.0	2.0	3.9
LAC	Straight-to-2°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-2°C	Coal w/o CCS	2.9	0.7	1.1	4.2	6.0	4.6	2.0
LAC	Straight-to-2°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-2°C	TOTAL	3.6	4.0	2.6	6.7	8.5	8.0	6.9

Supplementary Table 4B: LAC Power Sector Capital Investments and Stranded Asset Costs by Technology for the NDCs-to-2°C scenario. Numbers represent cumulative costs, in billion 2010 USD, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	NDCs-to-2°C	Oil w/o CCS	5.8	1.3	2.3	0.0	0.0	0.0	0.0
LAC	NDCs-to-2°C	Oil w/ CCS	0.0	19.7	12.3	59.0	31.0	25.9	17.7
LAC	NDCs-to-2°C	Gas w/o CCS	12.0	8.0	8.3	2.9	0.2	0.0	0.0
LAC	NDCs-to-2°C	Gas w/ CCS	0.0	12.2	15.9	72.1	71.3	73.8	73.7
LAC	NDCs-to-2°C	Coal w/o CCS	10.4	5.0	4.6	0.1	0.0	0.0	0.0
LAC	NDCs-to-2°C	Coal w/ CCS	0.0	2.3	2.6	18.2	20.5	21.3	21.4
LAC	NDCs-to-2°C	Biomass w/o CCS	6.4	7.0	7.6	1.6	0.0	0.0	0.0
LAC	NDCs-to-2°C	Biomass w/ CCS	0.0	8.8	6.3	88.7	96.3	99.7	106.1
LAC	NDCs-to-2°C	Nuclear	2.4	4.7	4.9	17.8	30.2	43.3	53.8
LAC	NDCs-to-2°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	NDCs-to-2°C	Wind	8.7	16.9	23.9	79.5	74.3	83.5	90.4
LAC	NDCs-to-2°C	Solar	5.3	12.1	17.7	56.6	58.7	73.6	84.4
LAC	NDCs-to-2°C	Geothermal	5.7	8.6	11.1	27.8	22.7	19.4	18.2
LAC	NDCs-to-2°C	TOTAL	56.7	106.7	117.7	424.2	405.2	440.4	465.7

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	NDCs-to-2°C	Oil w/o CCS	0.2	0.9	0.1	5.7	2.1	1.7	1.2
LAC	NDCs-to-2°C	Oil w/ CCS	0.0	0.0	0.1	0.0	0.0	0.0	0.0
LAC	NDCs-to-2°C	Gas w/o CCS	0.5	0.0	0.1	3.1	1.5	3.0	4.9
LAC	NDCs-to-2°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	NDCs-to-2°C	Coal w/o CCS	2.9	0.0	0.2	9.8	8.0	5.5	2.2
LAC	NDCs-to-2°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	TOTAL	3.6	0.9	0.6	18.7	11.6	10.1	8.2

Supplementary Table 4C: LAC Power Sector Capital Investments and Stranded Asset Costs by Technology for the Straight-to-1.5°C scenario. Numbers represent cumulative costs, in billion 2010 USD, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	Straight-to-1.5°C	Oil w/o CCS	5.8	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-1.5°C	Oil w/ CCS	0.0	47.4	43.7	35.8	25.8	13.2	5.0
LAC	Straight-to-1.5°C	Gas w/o CCS	12.0	2.4	0.7	0.0	0.0	0.0	0.0
LAC	Straight-to-1.5°C	Gas w/ CCS	0.0	44.9	65.2	75.0	80.4	72.6	64.2
LAC	Straight-to-1.5°C	Coal w/o CCS	10.4	0.3	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-1.5°C	Coal w/ CCS	0.0	9.1	16.4	19.0	20.3	18.2	15.9
LAC	Straight-to-1.5°C	Biomass w/o CCS	6.4	1.2	0.5	0.0	0.0	0.0	0.0
LAC	Straight-to-1.5°C	Biomass w/ CCS	0.0	56.5	126.7	139.3	124.8	103.2	94.9
LAC	Straight-to-1.5°C	Nuclear	2.4	8.5	14.8	19.0	34.0	45.9	54.1
LAC	Straight-to-1.5°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-1.5°C	Wind	8.7	40.9	59.7	69.6	80.8	87.0	90.5
LAC	Straight-to-1.5°C	Solar	5.3	29.1	38.6	51.2	67.5	79.8	85.0
LAC	Straight-to-1.5°C	Geothermal	5.7	19.0	23.3	18.3	20.6	18.0	16.2
LAC	Straight-to-1.5°C	TOTAL	56.7	259.4	389.7	427.2	454.4	437.9	425.9

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	Straight-to-1.5°C	Oil w/o CCS	0.2	6.3	2.7	1.9	1.2	0.6	0.2
LAC	Straight-to-1.5°C	Oil w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.5
LAC	Straight-to-1.5°C	Gas w/o CCS	0.5	3.1	1.9	2.6	4.1	4.2	2.7
LAC	Straight-to-1.5°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-1.5°C	Coal w/o CCS	2.9	7.6	7.8	4.7	1.7	0.4	0.1
LAC	Straight-to-1.5°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	Straight-to-1.5°C	TOTAL	3.6	16.9	12.4	9.1	6.9	5.2	3.5

Supplementary Table 4D: LAC Power Sector Capital Investments and Stranded Asset Costs by Technology for the NDCs-to-1.5°C scenario. Numbers represent cumulative costs, in billion 2010 USD, over a five-year model period.

New Installations

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	NDCs-to-1.5°C	Oil w/o CCS	5.8	1.3	2.3	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	Oil w/ CCS	0.0	19.7	12.3	142.1	5.6	5.4	0.2
LAC	NDCs-to-1.5°C	Gas w/o CCS	12.0	8.0	8.3	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	Gas w/ CCS	0.0	12.2	15.9	147.4	90.7	73.5	61.5
LAC	NDCs-to-1.5°C	Coal w/o CCS	10.4	5.0	4.6	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	Coal w/ CCS	0.0	2.3	2.6	34.0	21.4	17.1	13.9
LAC	NDCs-to-1.5°C	Biomass w/o CCS	6.4	7.0	7.6	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	Biomass w/ CCS	0.0	8.8	6.3	327.5	146.5	100.4	89.0
LAC	NDCs-to-1.5°C	Nuclear	2.4	4.7	4.9	37.4	40.6	50.3	57.5
LAC	NDCs-to-1.5°C	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	Wind	8.7	16.9	23.9	144.0	93.1	92.7	93.8
LAC	NDCs-to-1.5°C	Solar	5.3	12.1	17.7	107.1	79.0	84.5	87.3
LAC	NDCs-to-1.5°C	Geothermal	5.7	8.6	11.1	42.4	22.5	18.6	15.8
LAC	NDCs-to-1.5°C	TOTAL	56.7	106.7	117.7	981.9	499.3	442.6	419.0

Premature Retirements

Region	Scenario	Power Sector Technology	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
LAC	NDCs-to-1.5°C	Oil w/o CCS	0.2	0.9	0.1	12.4	1.5	0.5	0.2
LAC	NDCs-to-1.5°C	Oil w/ CCS	0.0	0.0	0.1	0.0	5.7	3.0	2.8
LAC	NDCs-to-1.5°C	Gas w/o CCS	0.5	0.0	0.1	16.5	6.9	5.2	2.6
LAC	NDCs-to-1.5°C	Gas w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	Coal w/o CCS	2.9	0.0	0.2	30.0	1.1	0.3	0.1
LAC	NDCs-to-1.5°C	Coal w/ CCS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAC	NDCs-to-1.5°C	TOTAL	3.6	0.9	0.6	59.0	15.1	8.9	5.6

Supplementary Table 5

Supplementary Table 5: Sensitivity scenarios considered in this study.

Sensitivity Parameter	Sensitivity Scenario	Description	Regional Application
Political willingness to avoid stranded assets*	Mid Avoidance	Assumes medium premature asset retirement in the power sector in response to changing profit margins for utilities (Central Assumption).	Global
	High Avoidance	Assumes low premature asset retirement in the power sector in response to changing profit margins for utilities.	Global
Technology availability	Full Tech	Assumes that the full suite of power sector technologies is available globally (Central Assumption).	Global
	No CCS	Assumes no deployment of carbon capture and storage technologies.	Global
	No CCS and No New Nuclear	Assumes no deployment of carbon capture and storage technologies globally, and no new deployment of nuclear technologies in LAC.	No CCS global; no new nuclear in LAC only
Role of land-use in mitigation	Low LUC	Assumes low mitigation in the land-use sector through lower price signal on emissions from land-use and land cover change.	Global
	Mid LUC	Assumes medium mitigation in the land-use sector through medium price signal on emissions from land-use and land cover change (Central Assumption).	Global
	High LUC	Assumes high mitigation in the land-use sector through high price signal on emissions from land-use and land cover change.	Global

* Very high stranding avoidance assumptions (no stranding allowed in the power sector) was found to be infeasible within the GCAM modeling paradigm.

Supplementary Table 6

Supplementary Table 6: Sensitivity analysis parameters

Sensitivity Variable	**GCAM parameter**	**Low**	**Mid** *(Central Assumption)*	**High**
Political willingness to avoid stranded assets	median shutdown point with respect to profit margin	-	-0.1	-0.5*
Role of land-use in mitigation	% of carbon price faced by land sector	1%	10%	50%

* A case which did not allow any stranding in the power sector failed to solve.

Supplementary Table 7

Supplementary Table 7: CO_2 Prices for All Scenarios in 2050

Temperature Target	Stranding Avoidance	Technology availability	Role of land-use in mitigation	CO2 price (2050) (2010$ / tCO2)
Straight-to-2°C	Mid Avoidance	Full Tech	Mid LUC	$237
Straight-to-1.5°C	Mid Avoidance	Full Tech	Mid LUC	$418
NDCs-to-2°C	Mid Avoidance	Full Tech	Mid LUC	$251
NDCs-to-2°C	Mid Avoidance	Full Tech	Low LUC	$251
NDCs-to-2°C	Mid Avoidance	Full Tech	High LUC	$279
NDCs-to-2°C	Mid Avoidance	No CCS	Mid LUC	$558
NDCs-to-2°C	Mid Avoidance	No CCS	Low LUC	$614
NDCs-to-2°C	Mid Avoidance	No CCS	High LUC	$558
NDCs-to-2°C	Mid Avoidance	No CCS and No New Nuclear	Mid LUC	$558
NDCs-to-2°C	Mid Avoidance	No CCS and No New Nuclear	Low LUC	$614
NDCs-to-2°C	Mid Avoidance	No CCS and No New Nuclear	High LUC	$558
NDCs-to-2°C	High Avoidance	Full Tech	Mid LUC	$293
NDCs-to-2°C	High Avoidance	Full Tech	Low LUC	$293
NDCs-to-2°C	High Avoidance	Full Tech	High LUC	$335
NDCs-to-2°C	High Avoidance	No CCS	Mid LUC	$641
NDCs-to-2°C	High Avoidance	No CCS	Low LUC	$683
NDCs-to-2°C	High Avoidance	No CCS	High LUC	$628
NDCs-to-2°C	High Avoidance	No CCS and No New Nuclear	Mid LUC	$641
NDCs-to-2°C	High Avoidance	No CCS and No New Nuclear	Low LUC	$697
NDCs-to-2°C	High Avoidance	No CCS and No New Nuclear	High LUC	$628
NDCs-to-1.5°C	Mid Avoidance	Full Tech	Mid LUC	$516
NDCs-to-1.5°C	Mid Avoidance	Full Tech	Low LUC	$516
NDCs-to-1.5°C	Mid Avoidance	Full Tech	High LUC	$586
NDCs-to-1.5°C	High Avoidance	Full Tech	Mid LUC	$586
NDCs-to-1.5°C	High Avoidance	Full Tech	Low LUC	$614
NDCs-to-1.5°C	High Avoidance	Full Tech	High LUC	$655

Supplementary Table 8

Supplementary Table 8: Food Prices for Selected NDCs-to-2°C Scenarios in 2050

Temperature Target	**Stranding Avoidance**	**Technology availability**	**Role of land-use in mitigation**	**Aggregate Food Price* (2050) (2010$ / Mcal)**
NDCs-to-2°C	Mid Avoidance	Full Tech	Mid LUC	$1.53
NDCs-to-2°C	Mid Avoidance	No CCS	Mid LUC	$2.21
NDCs-to-2°C	Mid Avoidance	No CCS and No New Nuclear	Mid LUC	$2.21
NDCs-to-2°C	High Avoidance	Full Tech	Mid LUC	$1.67
NDCs-to-2°C	High Avoidance	No CCS	Mid LUC	$2.41
NDCs-to-2°C	High Avoidance	No CCS and No New Nuclear	Mid LUC	$2.41

* Consumption-weighted average food price (crops & meat) for Latin America and the Caribbean in 2050. Average prices calculated by multiplying prices and consumption for each food good / GCAM region, summing to get total food expenditures across LAC, and dividing by total food consumption in LAC to get an average price per Mcal consumed.

Supplementary Table 9

Supplementary Table 9: Passenger Transportation Service for All Scenarios in 2050

Temperature Target	Stranding Avoidance	Technology availability	Role of land-use in mitigation	Passenger Transportation (million passenger km)
NDCs-to-2°C	Mid Avoidance	Full Tech	Mid LUC	725,874
NDCs-to-2°C	Mid Avoidance	Full Tech	Low LUC	729,213
NDCs-to-2°C	Mid Avoidance	Full Tech	High LUC	719,352
NDCs-to-2°C	Mid Avoidance	No CCS	Mid LUC	672,816
NDCs-to-2°C	Mid Avoidance	No CCS	Low LUC	670,120
NDCs-to-2°C	Mid Avoidance	No CCS	High LUC	672,218
NDCs-to-2°C	Mid Avoidance	No CCS and No New Nuclear	Mid LUC	671,559
NDCs-to-2°C	Mid Avoidance	No CCS and No New Nuclear	Low LUC	668,842
NDCs-to-2°C	Mid Avoidance	No CCS and No New Nuclear	High LUC	670,954
NDCs-to-2°C	High Avoidance	Full Tech	Mid LUC	717,154
NDCs-to-2°C	High Avoidance	Full Tech	Low LUC	719,301
NDCs-to-2°C	High Avoidance	Full Tech	High LUC	708,349
NDCs-to-2°C	High Avoidance	No CCS	Mid LUC	663,570
NDCs-to-2°C	High Avoidance	No CCS	Low LUC	662,440
NDCs-to-2°C	High Avoidance	No CCS	High LUC	664,508
NDCs-to-2°C	High Avoidance	No CCS and No New Nuclear	Mid LUC	662,423
NDCs-to-2°C	High Avoidance	No CCS and No New Nuclear	Low LUC	659,892
NDCs-to-2°C	High Avoidance	No CCS and No New Nuclear	High LUC	663,368
NDCs-to-1.5°C	Mid Avoidance	Full Tech	Mid LUC	680,352
NDCs-to-1.5°C	Mid Avoidance	Full Tech	Low LUC	680,080
NDCs-to-1.5°C	Mid Avoidance	Full Tech	High LUC	670,707
NDCs-to-1.5°C	High Avoidance	Full Tech	Mid LUC	671,267
NDCs-to-1.5°C	High Avoidance	Full Tech	Low LUC	668,308
NDCs-to-1.5°C	High Avoidance	Full Tech	High LUC	662,713

Supplementary Table 10

Supplementary Table 10: Capital cost assumptions for the electric power sector (2010 USD / kW)[a]

Electricity Generation Technology	**Overnight Capital Costs (2010 USD / kW)**		
	2020	**2030**	**2050**
Biomass (conv)	$ 3,951	$ 3,818	$ 3,702
Biomass (IGCC)	$ 5,745	$ 5,180	$ 4,819
Biomass (conv CCS)	$ 7,317	$ 6,568	$ 6,168
Biomass (IGCC CCS)	$ 8,337	$ 7,298	$ 6,720
Coal (conv pul)	$ 2,337	$ 2,242	$ 2,196
Coal (IGCC)	$ 3,060	$ 2,854	$ 2,769
Coal (conv pul CCS)	$ 5,503	$ 4,925	$ 4,619
Coal (IGCC CCS)	$ 4,020	$ 3,607	$ 3,448
Gas (CC)	$ 859	$ 824	$ 807
Gas (steam/CT)	$ 911	$ 875	$ 857
Gas (CC CCS)	$ 1,864	$ 1,677	$ 1,605
Refined liquids (steam/CT)	$ 742	$ 717	$ 694
Refined liquids (CC)	$ 1,036	$ 1,004	$ 972
Refined liquids (CC CCS)	$ 2,356	$ 2,079	$ 1,937
Gen II LWR (Nuclear)	$ 5,500	$ 5,500	$ 5,500
Gen III (Nuclear)	$ 4,400	$ 4,044	$ 3,901
CSP	$ 3,415	$ 3,077	$ 2,946
CSP with storage	$ 7,430	$ 6,329	$ 5,771
PV	$ 1,856	$ 1,534	$ 1,514
PV with storage	$ 4,212	$ 3,799	$ 3,534
Wind	$ 1,662	$ 1,526	$ 1,481
Wind with storage	$ 5,555	$ 5,006	$ 4,661
Rooftop PV	$ 4,499	$ 4,057	$ 3,776
Geothermal	$ 4,348	$ 4,199	$ 4,073

[a] This table presents only the overnight capital costs. A fixed charge rate of 13% is assumed to amortize capital costs over the capital lifetime of a power plant.

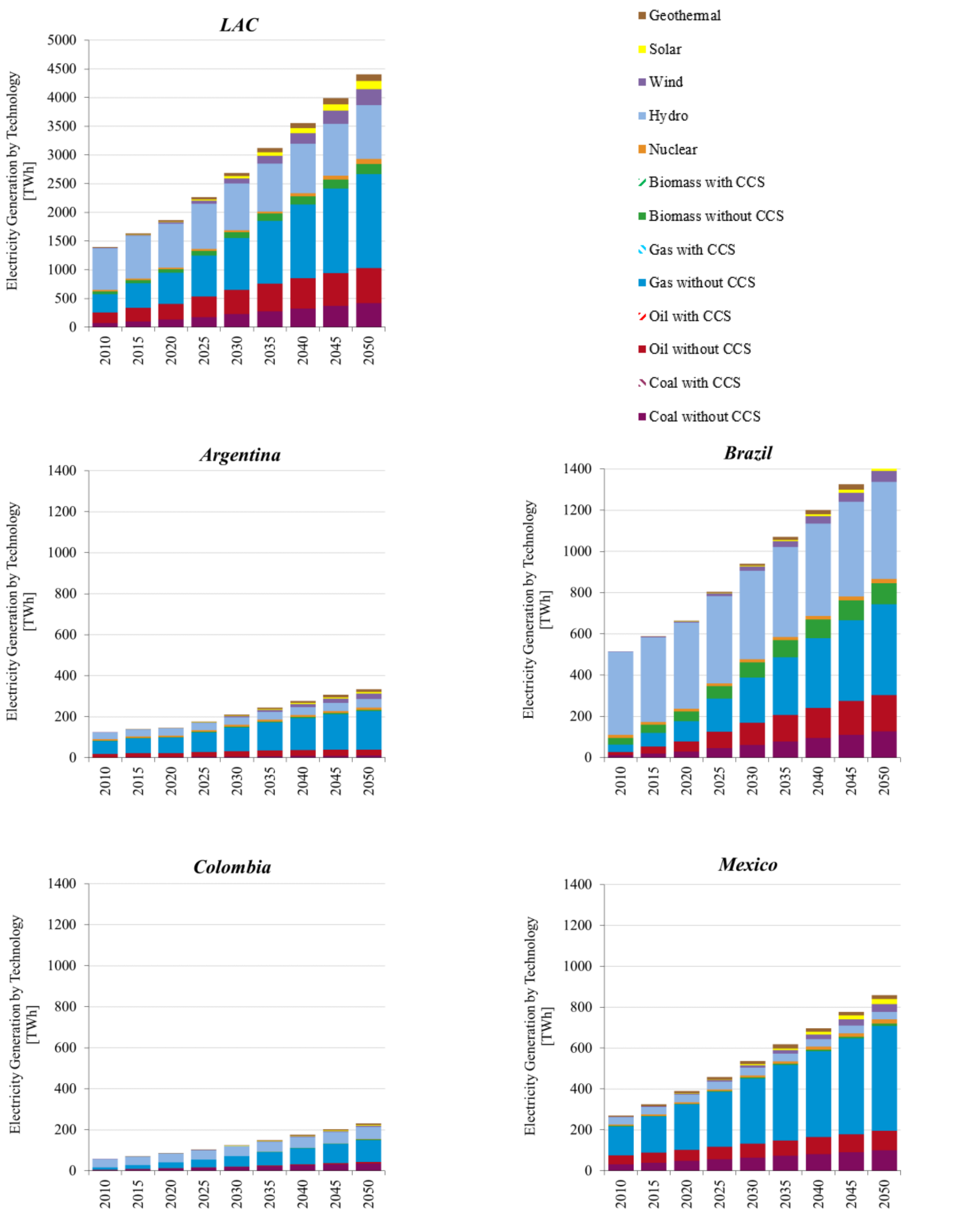
Supplementary Table 11

Supplementary Table 11: Physical lifetime assumptions for technologies in the electric power sector

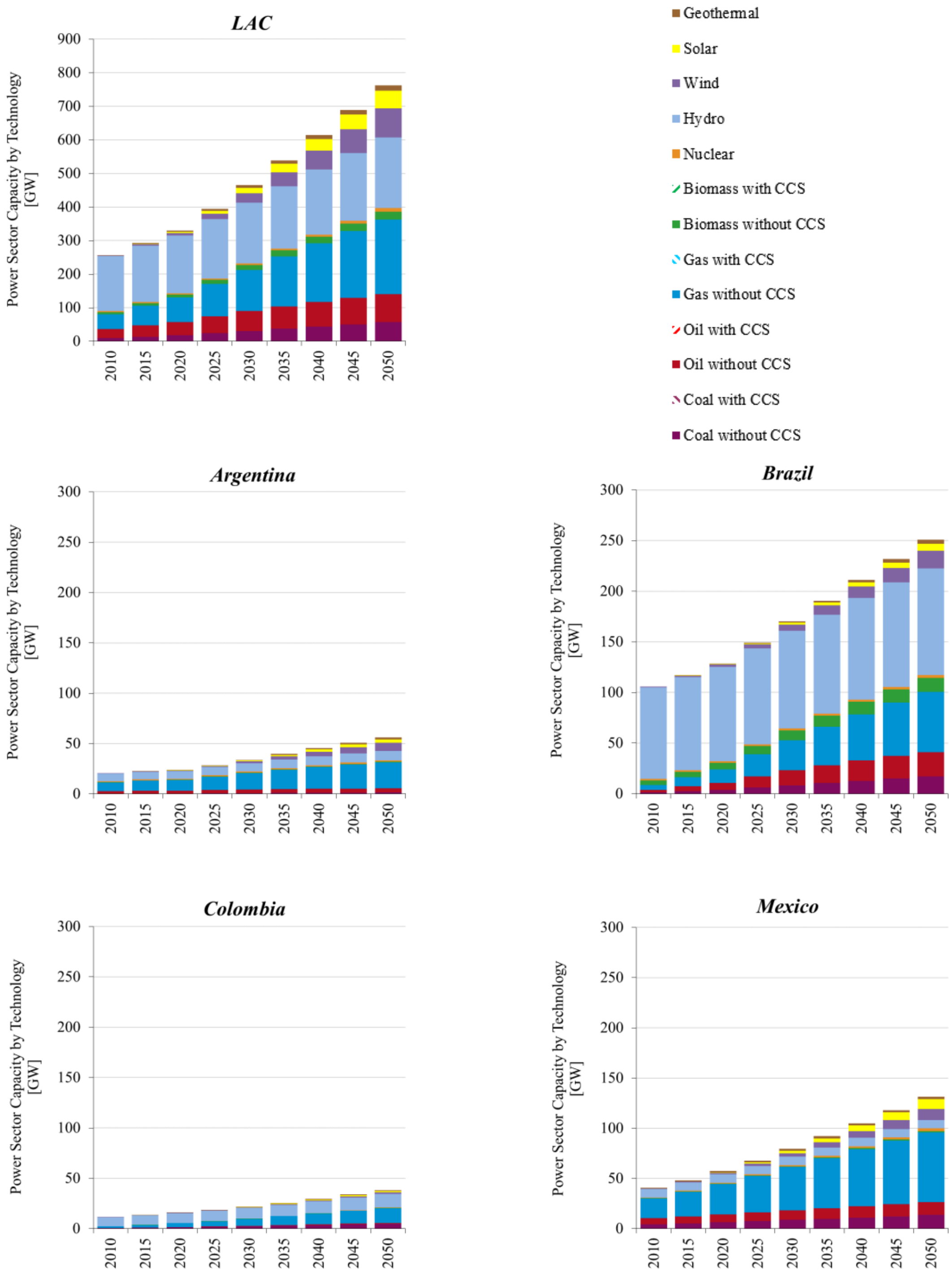
Technology	**Lifetime (years)**
Biomass (conv)	60
Biomass (IGCC)	60
Biomass (conv CCS)	60
Biomass (IGCC CCS)	60
Coal (conv pul)	60
Coal (IGCC)	60
Coal (conv pul CCS)	60
Coal (IGCC CCS)	60
Gas (steam/CT)	45
Gas (CC)	45
Gas (CC CCS)	45
Refined liquids (steam/CT)	45
Refined liquids (CC)	45
Refined liquids (CC CCS)	45
Gen_II_LWR (nuclear)	60
Gen_III (nuclear)	60
Wind	30
Wind_storage	30
PV	30
PV_storage	30
CSP	30
CSP_storage	30
Geothermal	30

Supplementary Figures

Supplementary Figure 1

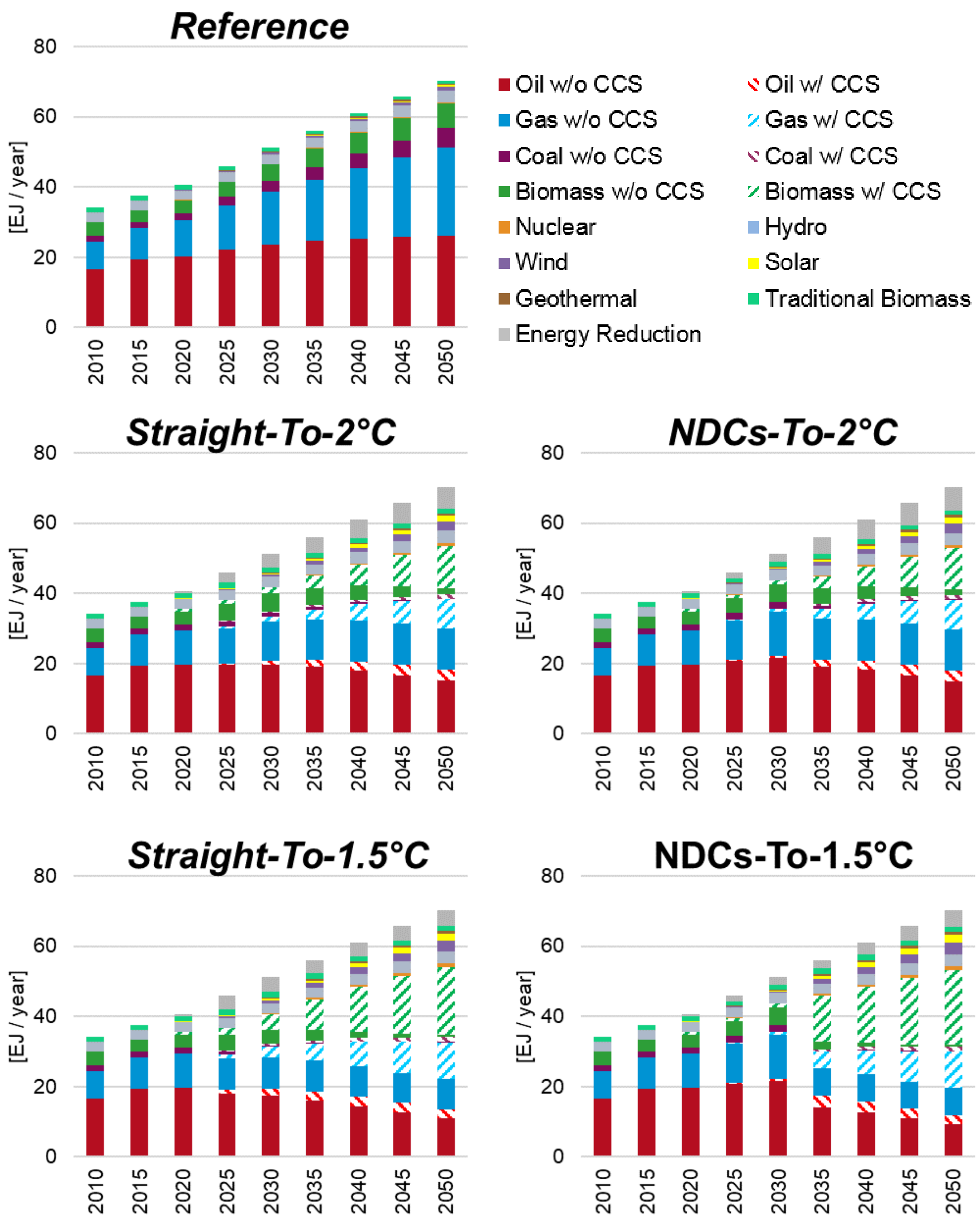


Supplementary Figure 1A: Electricity Generation by Technology in Reference Scenario, for Latin America and the Caribbean (LAC) and the region's four largest economies.



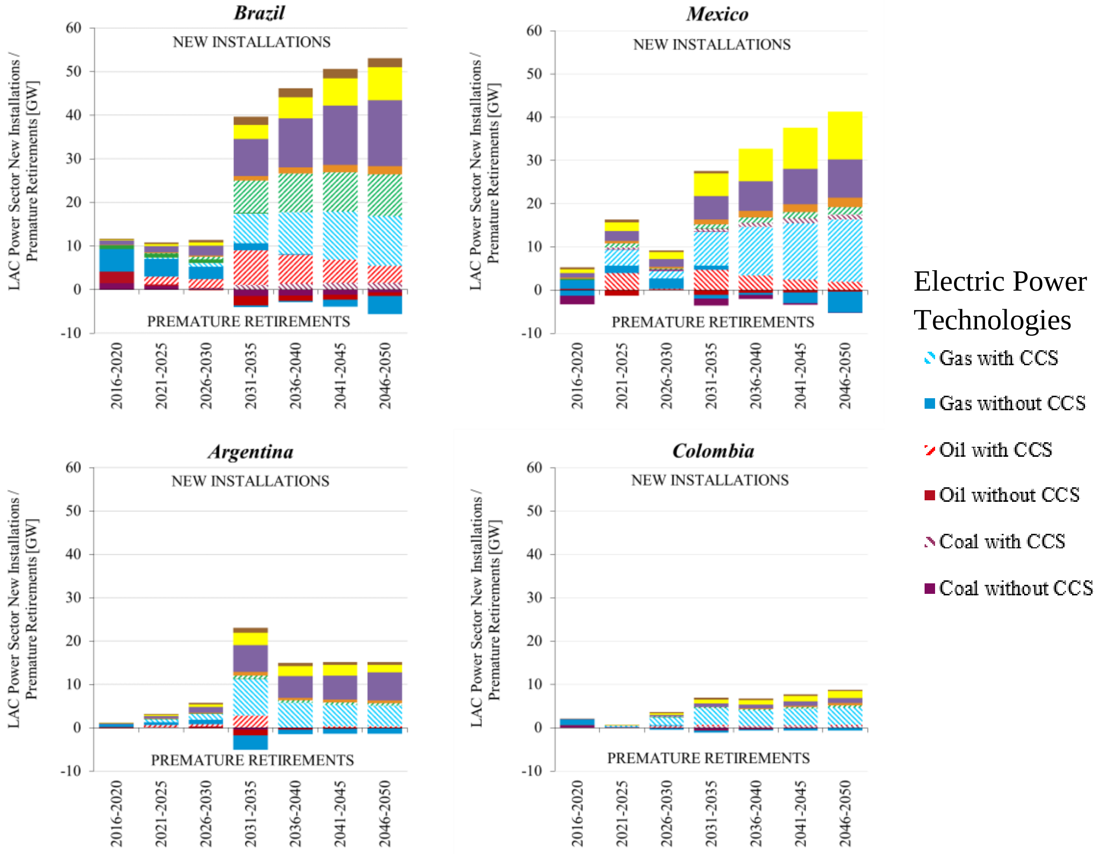
Supplementary Figure 1B: Power Sector Capacity by Technology in Reference Scenario, for Latin America and the Caribbean (LAC) and the region's four largest economies.

Supplementary Figure 2

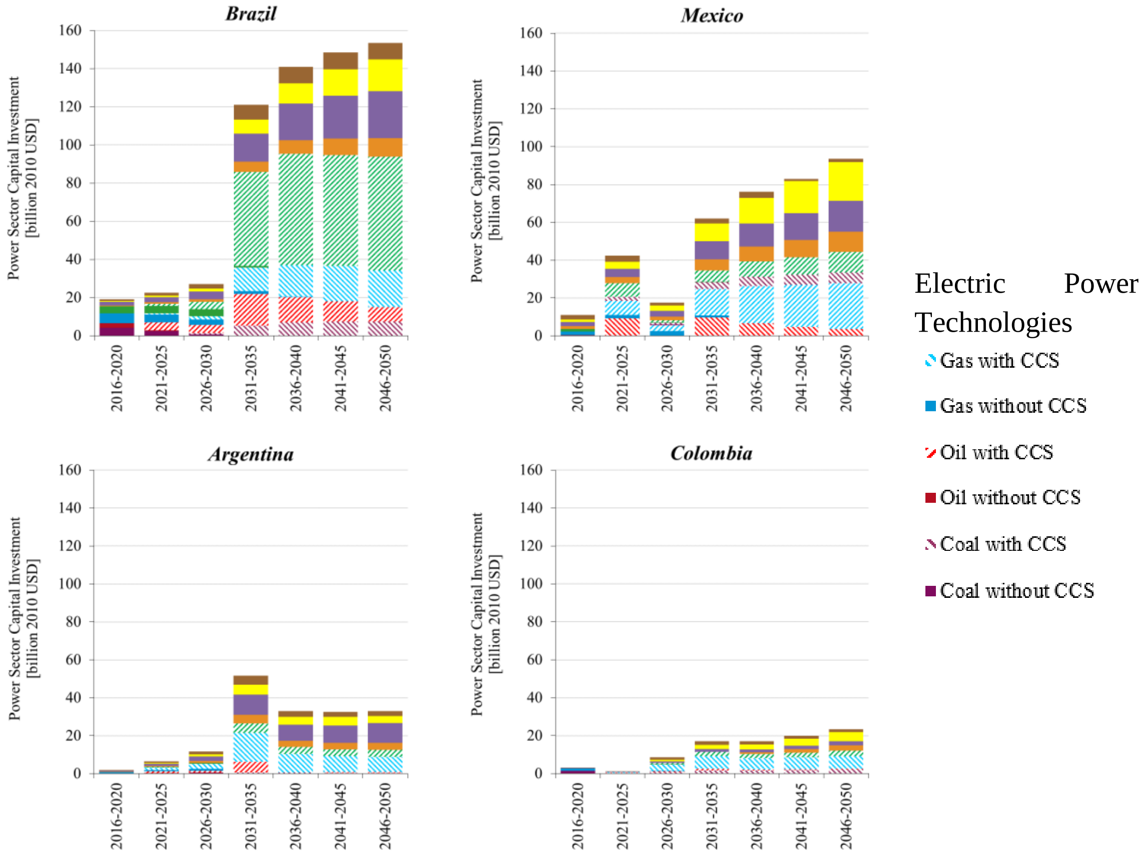


Supplementary Figure 2: Primary energy consumption (direct equivalent) by fuel in Latin America and Caribbean for each model scenario. "Energy Reduction" (gray) for each mitigation scenario is relative to Reference.

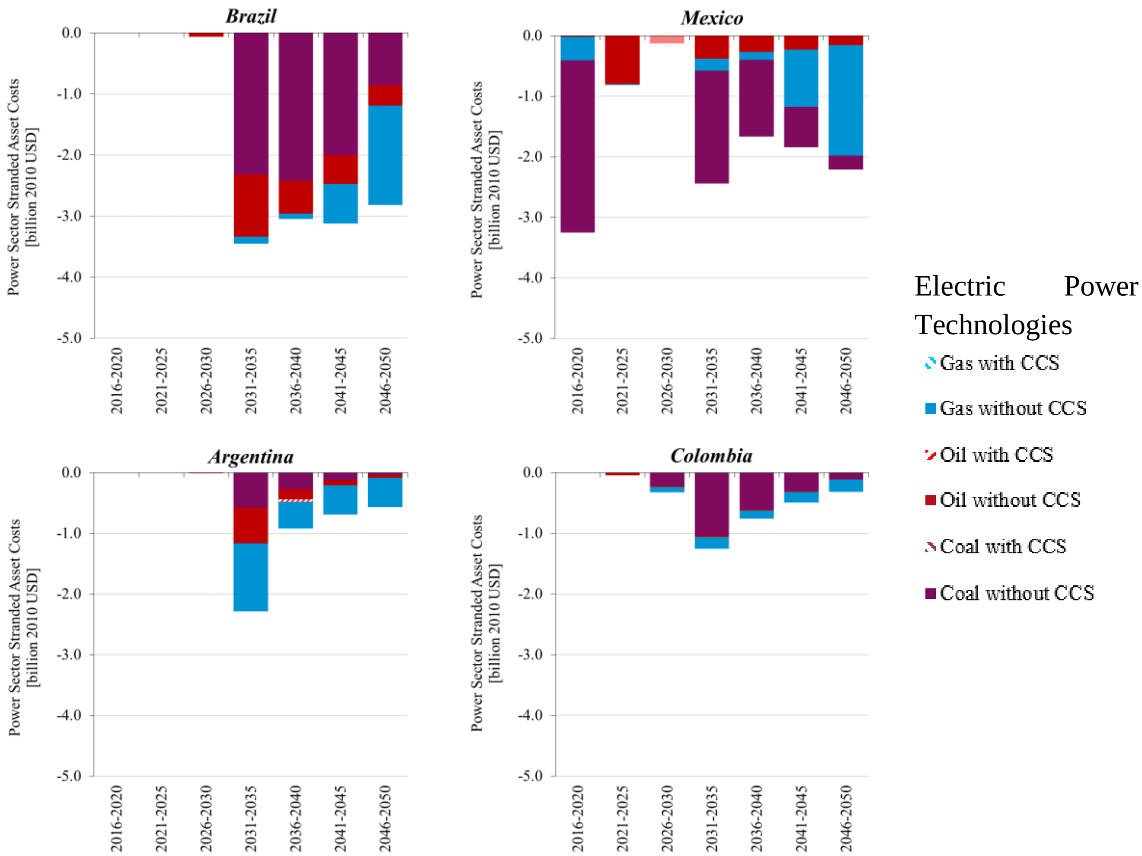
Supplementary Figure 3



Supplementary Figure 3A: Country-Level Power Sector New Installations and Premature Retirements (negative values) by Period and Technology (NDCs-to-2°C scenario). Bars represent cumulative additions / retirements over a five-year model period.

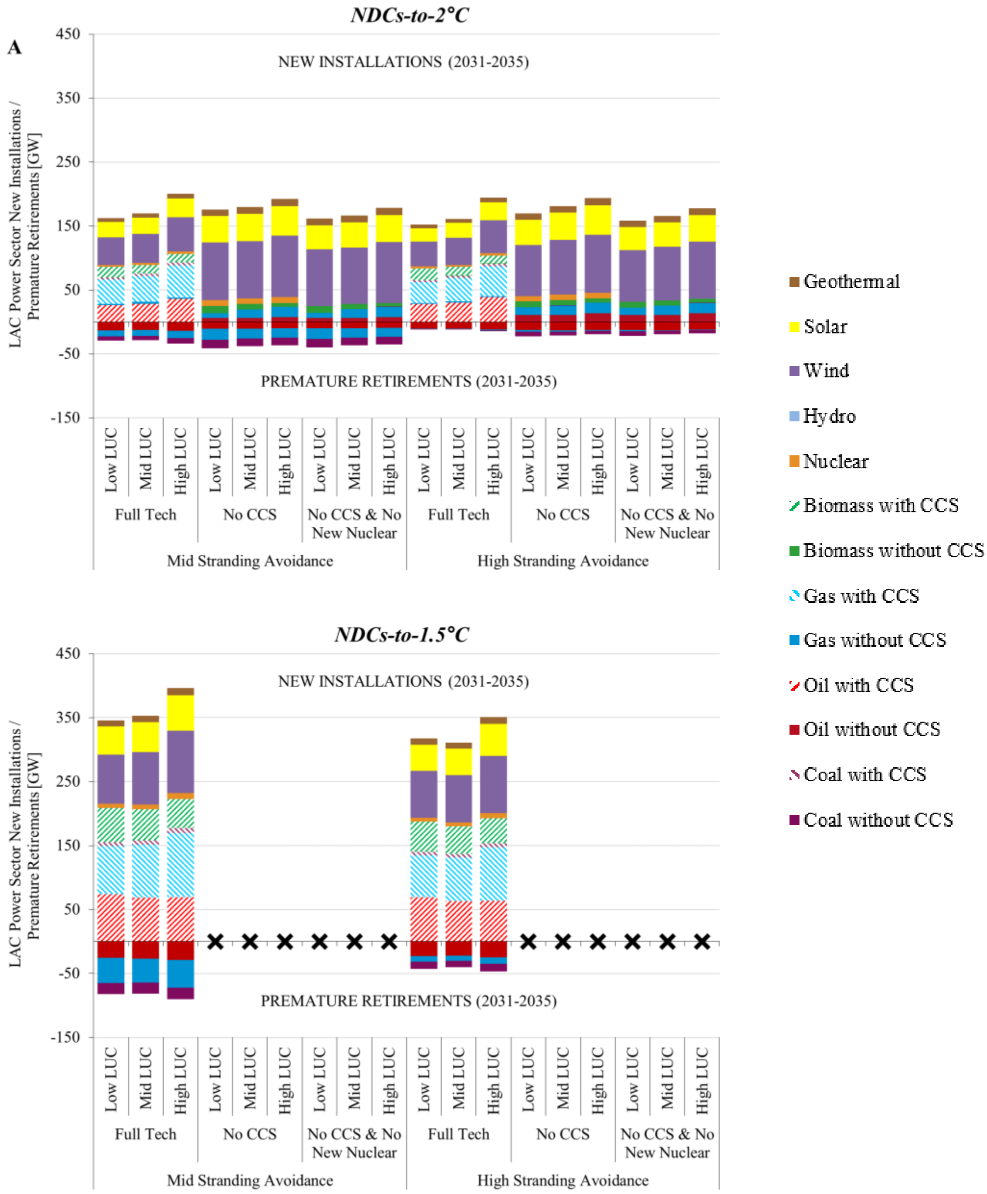


Supplementary Figure 3B: Country-Level Power Sector Capital Investment by Period and Technology (NDCs-to-2°C scenario). Bars represent cumulative costs over a five-year model period.

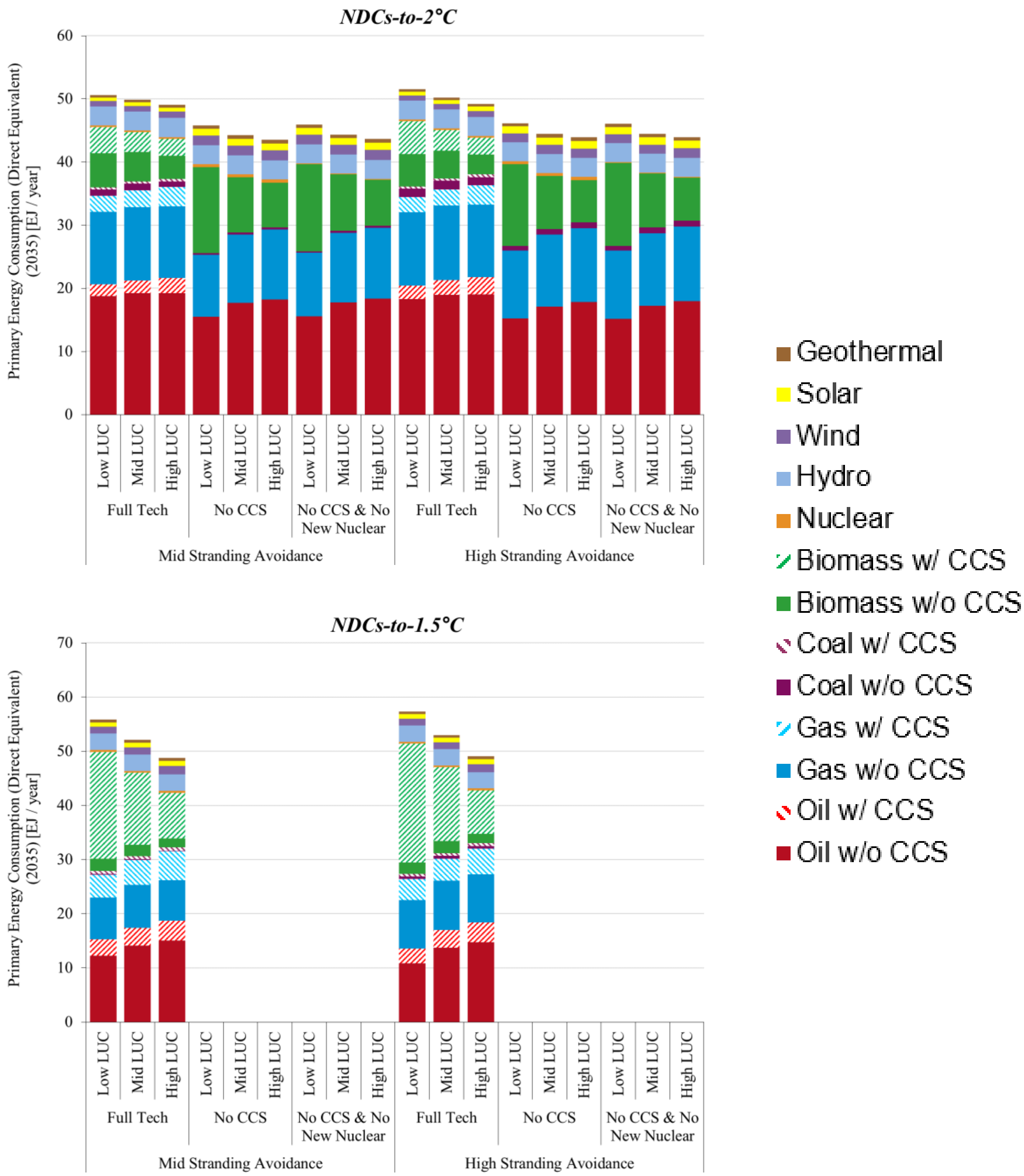


Supplementary Figure 3C: Country-Level Power Sector Stranded Asset Costs by Period and Technology (NDCs-to-2°C scenario). Bars represent cumulative costs over a five-year model period.

Supplementary Figure 4

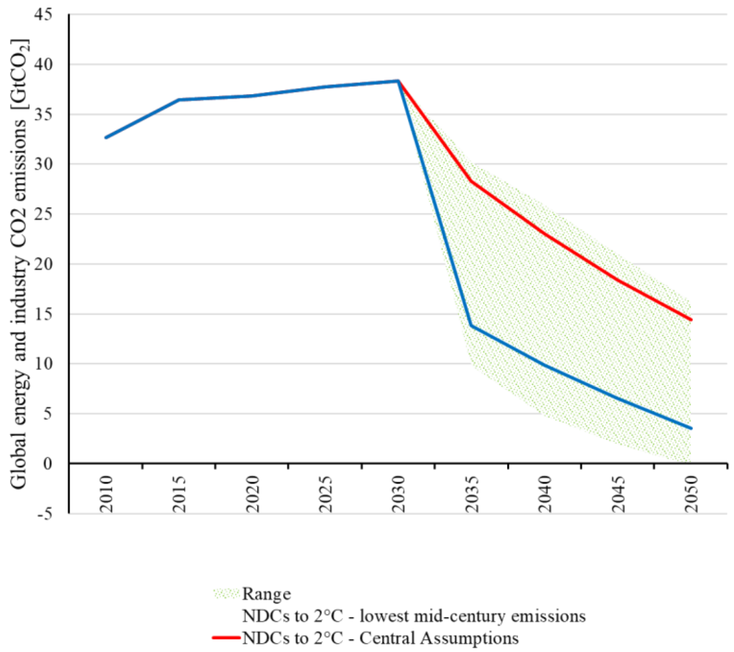


Supplementary Figure 4A: New Installations and Premature Retirements (negative investment values) by Scenario and Technology in the LAC Power Sector (2031-2035) across sensitivity cases. Bars represent cumulative additions / retirements over the five-year model period.

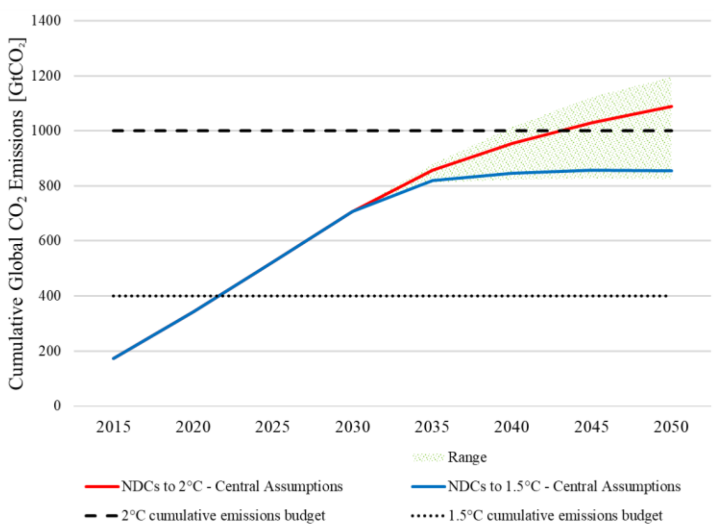


Supplementary Figure 4B: Latin America and Caribbean Primary Energy Consumption (2035) by Scenario and Technology

Supplementary Figure 5

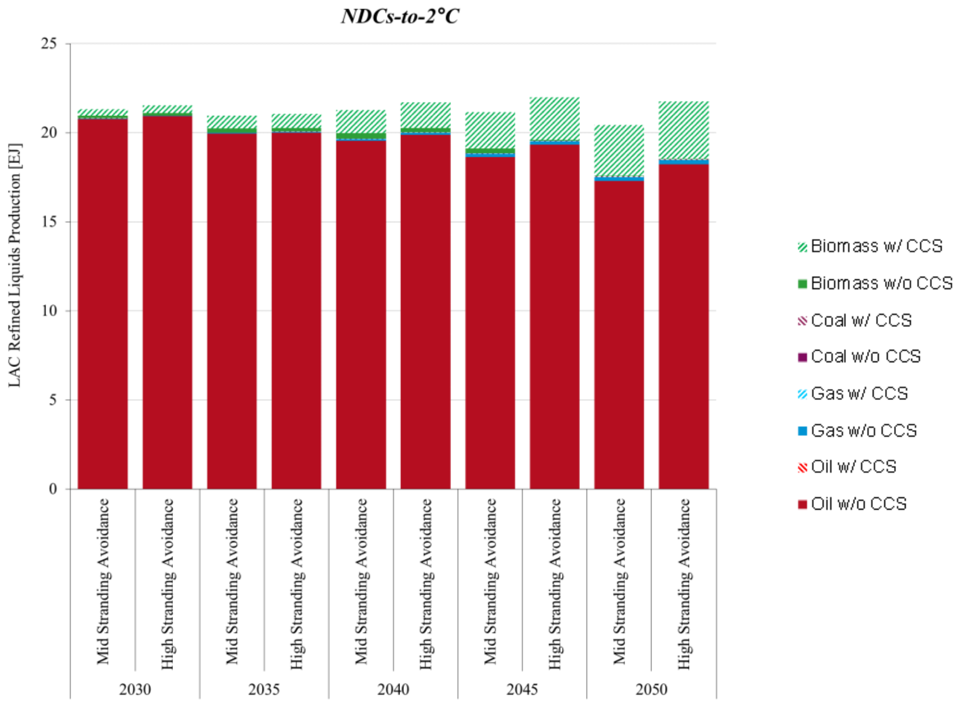


Supplementary Figure 5A: Global energy and industry CO2 emissions. Solid lines represent cumulative emissions from the NDCs-to-2°C scenario and NDCs-to-1.5°C scenario with central assumptions. Shaded area represents the range of cumulative emissions across sensitivity cases.



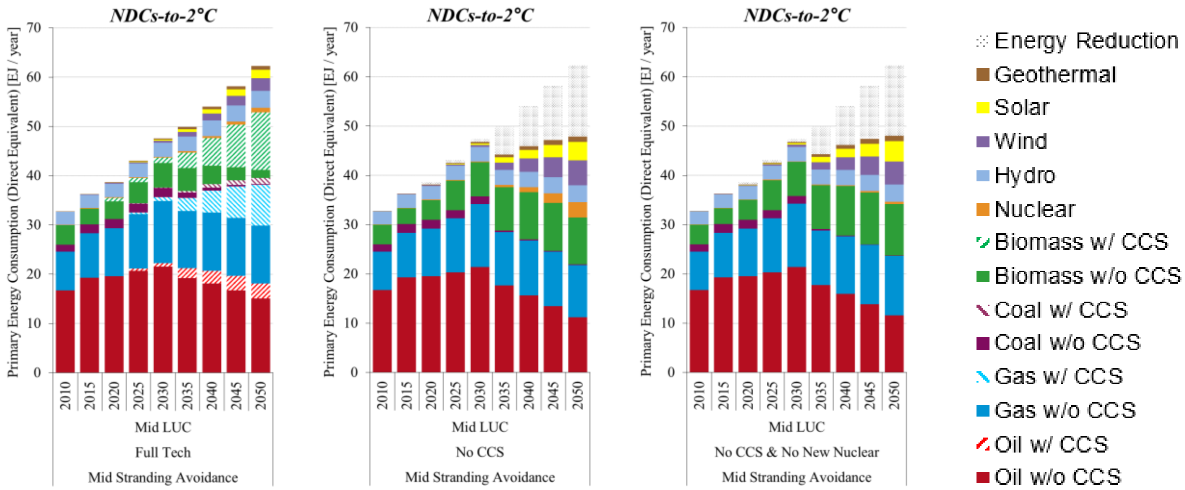
Supplementary Figure 5B: Cumulative global CO_2 emissions (beginning 2011) by scenario. Solid lines represent cumulative emissions from the NDCs-to-2°C scenario and NDCs-to-1.5°C scenario with central assumptions. Dashed lines represent 2°C and 1.5°C cumulative emissions budgets (2011-2100). Shaded area represents the range of cumulative emissions across sensitivity cases.

Supplementary Figure 6

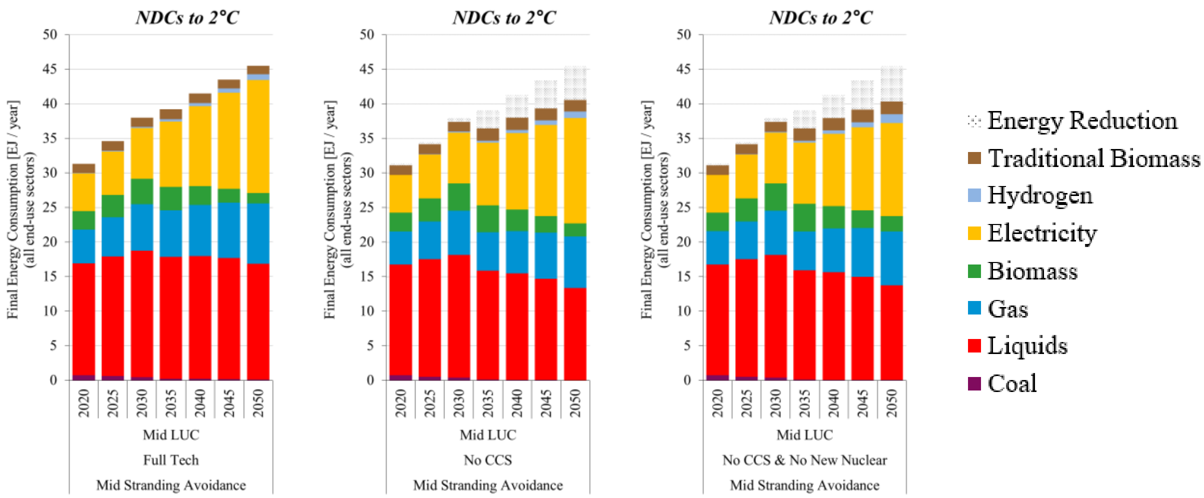


Supplementary Figure 6: Refined liquids production by scenario, period, and technology in LAC for NDCs-to-2°C scenarios with Mid / High Stranding Avoidance and central technology / land-use mitigation assumptions.

Supplementary Figure 7

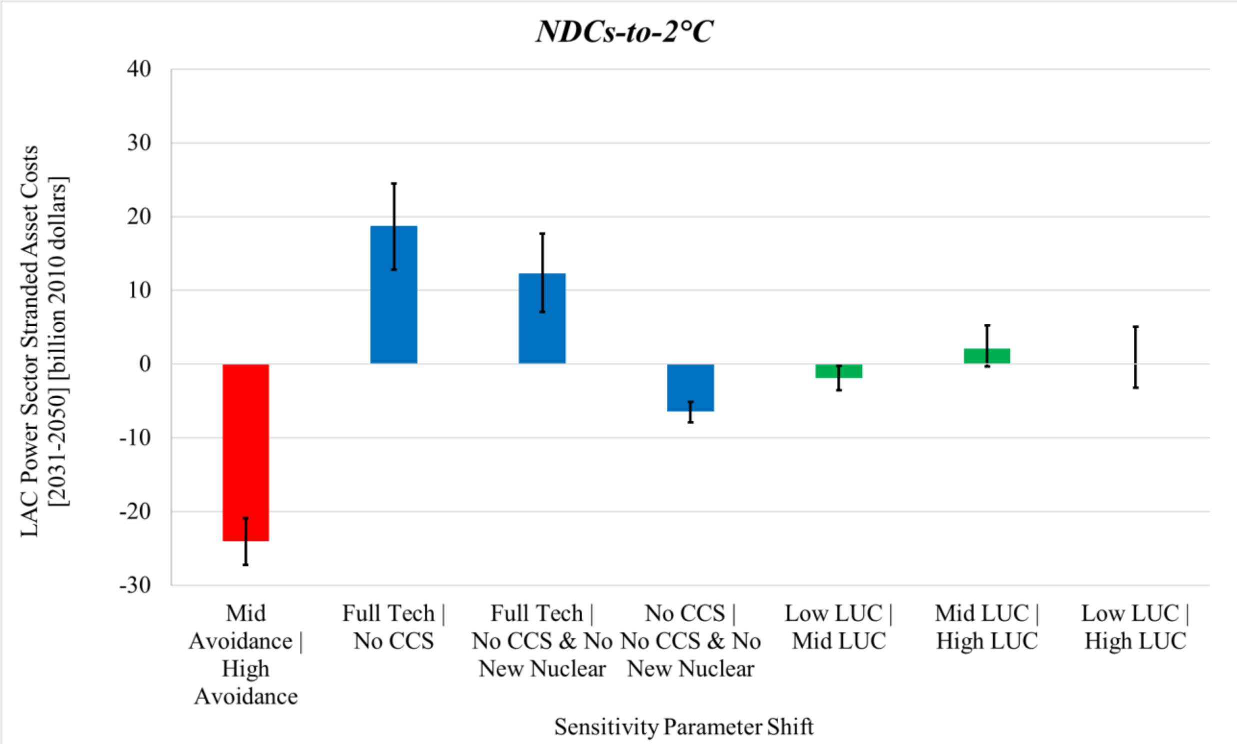


Supplementary Figure 7A: Primary Energy Consumption by Scenario, Period, and Technology in LAC for NDCs-to-2°C scenarios with Full Tech / No CCS / No CCS and No New Nuclear technology assumptions and central stranding avoidance / land-use mitigation assumptions.



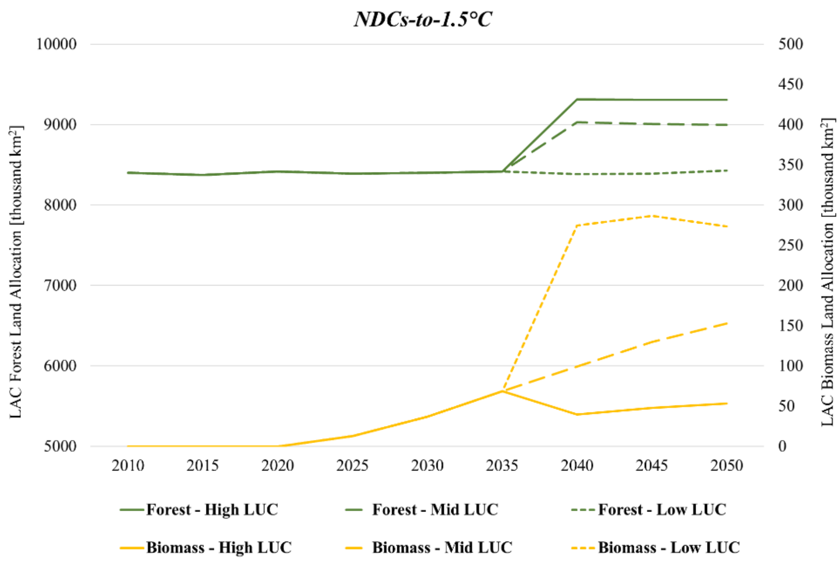
Supplementary Figure 7B: Final Energy Consumption by Scenario, Period, and Fuel in LAC for NDCs-to-2°C scenarios with Full Tech / No CCS / No CCS and No New Nuclear technology assumptions and central stranding avoidance / land-use mitigation assumptions.

Supplementary Figure 8

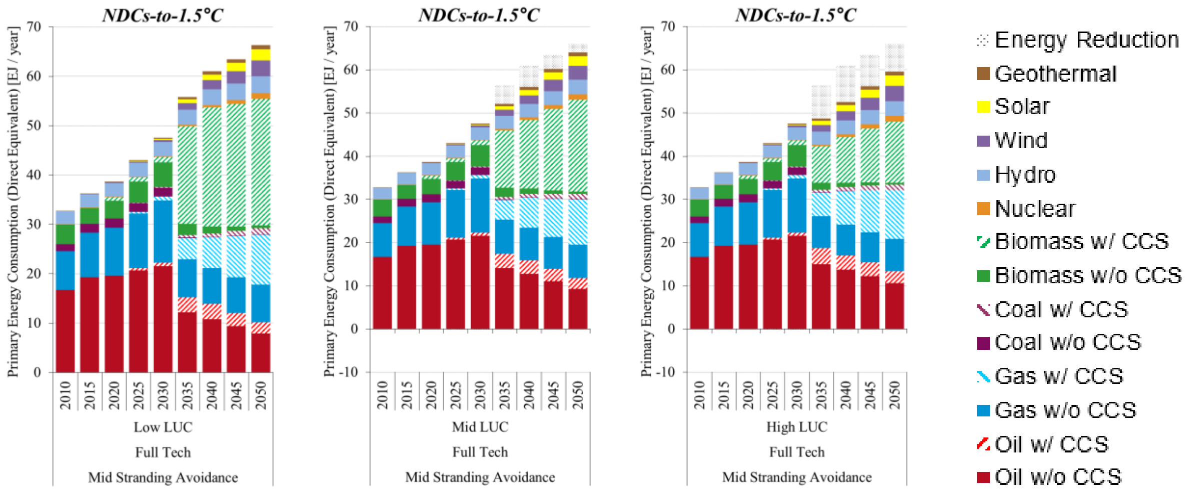


Supplementary Figure 8: Sensitivity of LAC power sector stranded asset costs to changes in sensitivity parameters. Bars represent average additional cumulative stranded asset costs over the twenty-year period from 2031-2050 associated with switching from parameter value 1 to parameter value 2 (where value 1 is before " | " and value 2 is after " | "). Error bars represent the range of average additional cumulative stranded asset costs over the same period. Additional cumulative stranded asset costs are calculated by identifying paired cases where all sensitivity parameters besides the one being perturbed are identical, and calculating the difference in stranding associated with moving from the first parameter value to the second. "Stranding Avoidance" has 9 sets of paired cases; "Technology Availability" and "Role of Land-Use in Mitigation" each have 6 sets of paired cases.

Supplementary Figure 9

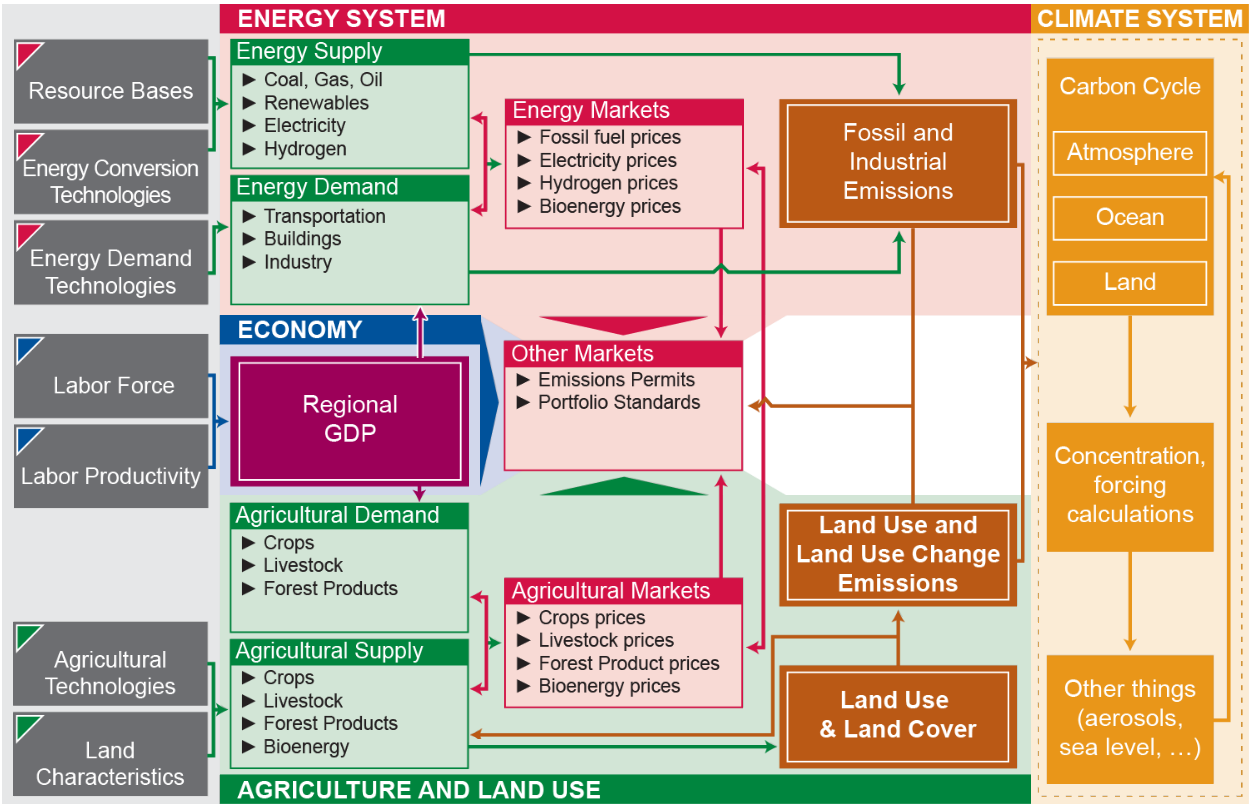


Supplementary Figure 9A: Land Allocation for Forest and Biomass in LAC for NDCs-to-1.5°C scenarios with Low / Mid / High land-use mitigation assumptions and central stranding avoidance / technology assumptions.



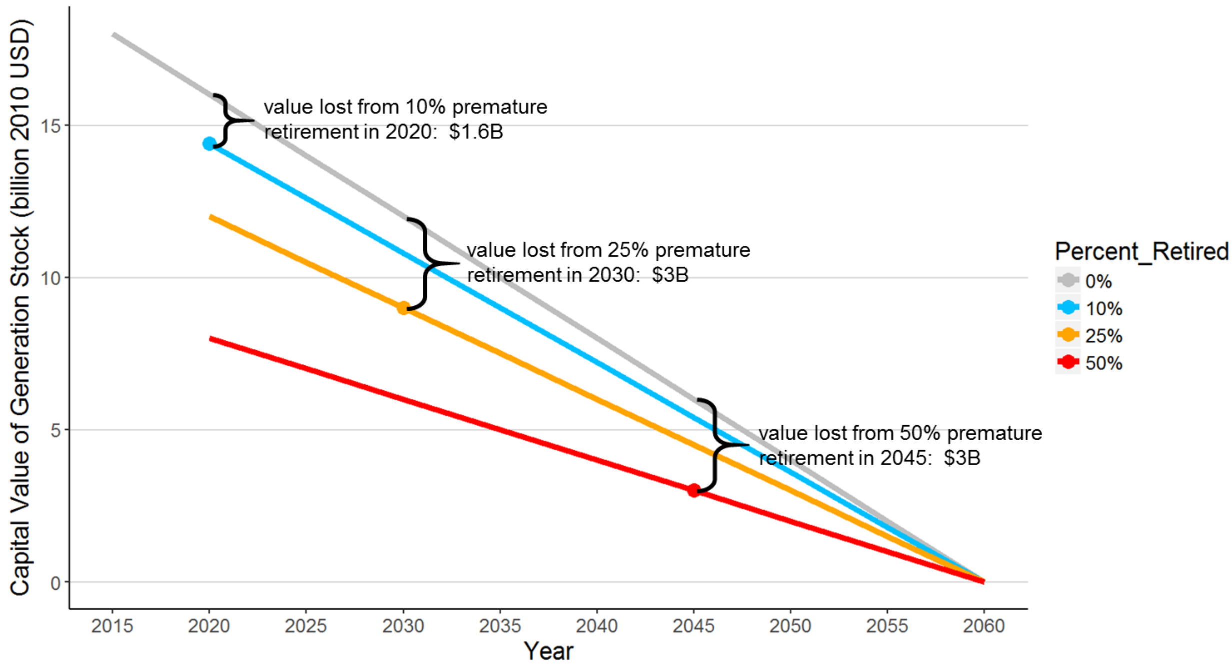
Supplementary Figure 9B: Primary Energy Consumption by Scenario, Period, and Technology in LAC for NDCs-to-1.5°C scenarios with Low / Mid / High land-use mitigation assumptions and central stranding avoidance / technology assumptions.

Supplementary Figure 10



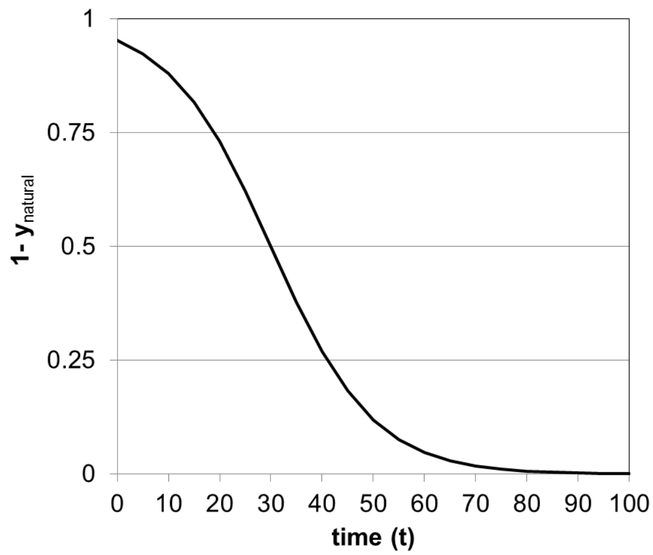
Supplementary Figure 10: Structure of the Global Change Assessment Model

Supplementary Figure 11

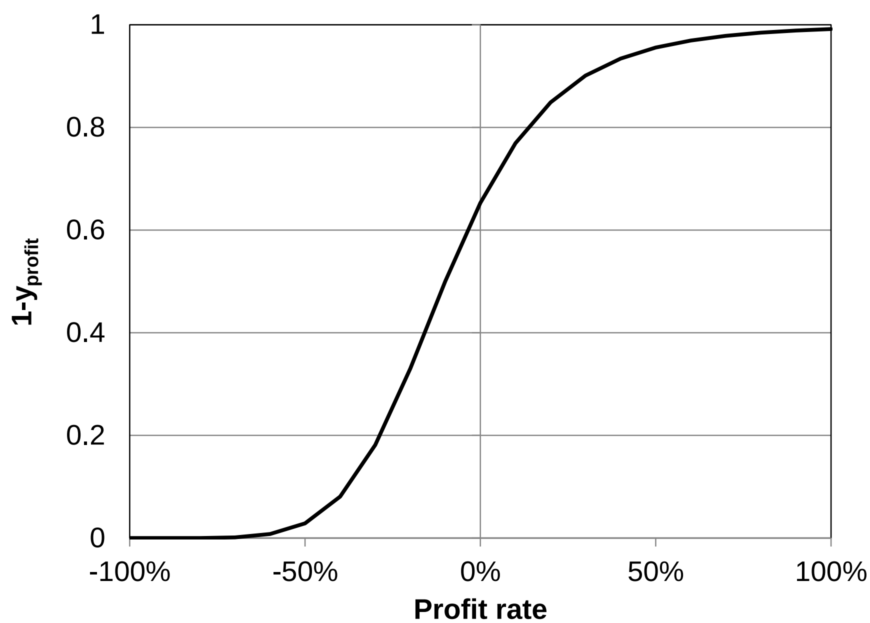


Supplementary Figure 11: Calculation of the foregone value due to premature retirement of hypothetical electric power capital stock. For this example, the vintage is assumed to be 2015 with a capital asset value of $18B 2010 USD, and expected technical lifetime of 45 years. The lines represent value across time for different magnitudes of premature retirement. The gray (0% retired) line reflects a simple linear devaluation of the capital stock. The blue (10% retired), yellow (25% retired), and red (50% retired) lines represent the remaining value of the vintage across time if the specified percent were to be retired in a given year. (A vintage is always fully utilized during its initial operating period; the earliest this hypothetical vintage could be prematurely retired is 2020). The distance between the gray and blue / yellow / red lines represents the loss of value associated with that respective level of premature retirement.

Supplementary Figure 12



Supplementary Figure 12A: $\mathbf{1-}\ y_{natural}(t)$ ***for a steepness coefficient (b) of 0.1 and mid-life (x) of 30 years***



Supplementary Figure 12B: $\mathbf{1-}\ y_{profit}$ ***for a steepness coefficient (b) of 6 and x = -10%***

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