MOODY'S ANALYTICS

ANALYSIS
NOVEMBER 2022

Prepared by

Mark Zandi
Mark.Zandi@moodys.com
Chief Economist

Chris Lafakis
Chris.Lafakis@moodys.com
Director

Bernard Yaros
Bernard.Yarosjr@moodys.com
Assistant Director/Economist

Contact Us

Email
help@economy.com

U.S./Canada
+1.866.275.3266

EMEA
+44.20.7772.5454 (London)
+420.224.222.929 (Prague)

Asia/Pacific
+852.3551.3077

All Others
+1.610.235.5299

Web
www.economy.com
www.moodysanalytics.com

The Macroeconomic Cost of Climate Inaction

Introduction

Rising global temperatures caused by increasing greenhouse gas pollution pose substantial risks to the global economy. Increasingly severe weather events from hurricanes, droughts, flooding and wildfires tied to climate change are already doing serious property damage and disrupting economic activity, while rising sea levels, heat stress, and changing precipitation patterns threaten to ignite mass migration and diminish long-term productivity growth.

The Macroeconomic Cost of Climate Inaction

BY MARK ZANDI, CHRIS LAFAKIS AND BERNARD YAROS

Rising global temperatures caused by increasing greenhouse gas pollution pose substantial risks to the global economy. Increasingly severe weather events from hurricanes, droughts, flooding and wildfires tied to climate change are already doing serious property damage and disrupting economic activity, while rising sea levels, heat stress, and changing precipitation patterns threaten to ignite mass migration and diminish long-term productivity growth.

In this white paper, we quantify the U.S. environmental, macroeconomic and federal fiscal impacts under four scenarios that assume different climate-related interventions by federal lawmakers.[1] The first scenario assumes that policymakers had taken no action to mitigate climate change, including those in the recently passed Inflation Reduction Act of 2022, while the second assumes no additional climate-related provisions other than those in the IRA legislation. The other two scenarios assume the implementation of a tax on carbon emissions, including a modest carbon tax that is slowly but steadily increased, and a more aggressive carbon tax designed to achieve net zero carbon emissions by 2050.

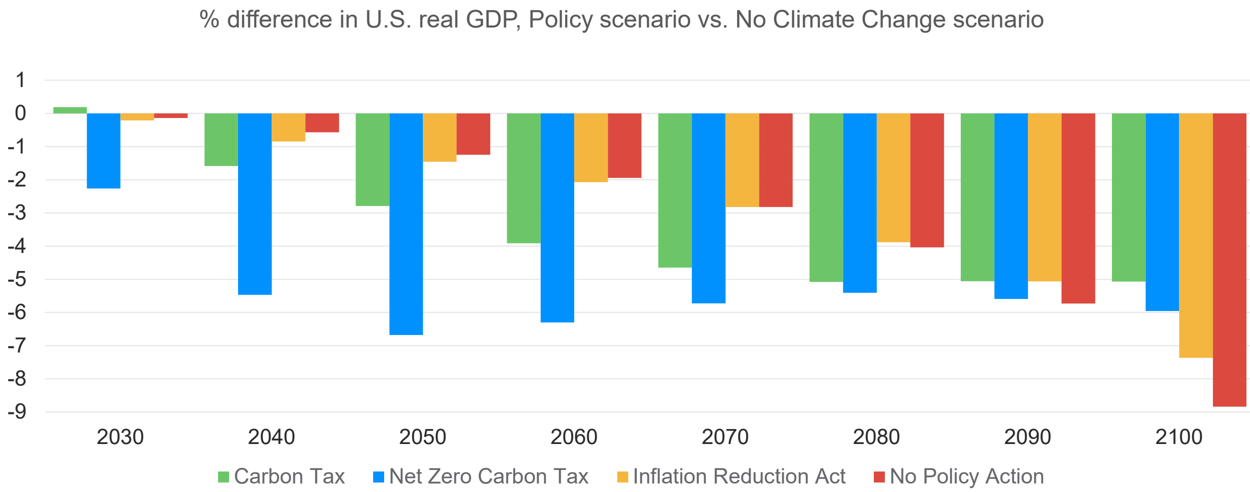
Our scenario analysis shows that substantial carbon emissions reduction can be achieved at modest short-run economic cost, while in the longer term, the cost of policy inaction significantly outweighs the cost of responding to climate change (see Chart 1). We also show that a modest, steady increase in the price of carbon is the most economically efficient approach to combat the threat of climate change. A carbon tax would be more effective at reducing emissions than if the government were to phase out internal combustion engine vehicles, cap pollution, or mandate renewable energy production. Moreover, lawmakers could design the carbon tax to further mitigate its fallout on business competitiveness and to help households that suffer the greatest financial burden.

Climate economics

Climate change broadly impacts the economy by increasing physical and transition risks. Physical risks result from climate inaction that raises the global temperature, causing large changes in the physical world. Acute physical risks are weather-related natural disasters such as hurricanes, wildfires and floods, which are

1 The climate-related assumptions in the scenarios considered in this analysis differ from the assumptions used in the Moody's Analytics baseline, or most-likely scenario. For a thorough description of the climate risk assumptions used in our baseline outlook, see here.

Chart 1: Climate Change Is a Serious Long-Term Economic Threat



Source: Moody's Analytics

occurring with greater frequency and intensity because of rising temperatures. These cause large economic losses, only some of which are privately insured, pressuring governments to provide disaster relief.

Chronic physical risks are the fallout of rising temperatures over a longer time, often decades, and include sea level rise caused in part by the melting of polar ice caps and oppressive heat.[2] Chronic physical risks weigh on labor force productivity, have serious consequences for agriculture, tourism and other industries, and cause significant shifts in global immigration patterns.[3]

Transition risks are the financial costs of decarbonizing the economy. They include macroeconomic transition risk, which refers to the cost of transitioning the economy away from fossil fuels, and industrial transition risk, which describes the changing fortunes across industries regardless of how the world decarbonizes. The economy could be decarbonized through technological innovations and market forces, in which there is no economic transition risk, or decarbonization could be accelerated through policy interventions.

Carbon taxation, emission trading schemes, or government-mandated phaseouts of technology such as coal-fired power generation or internal combustion engines are common types of policies, which typically impose a cost on the economy. The transition from fossil fuels to renewable energy sources also creates challenges and opportunities. Traditional energy producers must reinvent themselves or fall behind in the new energy future. Industries closer to the epicenter of the transition are more at risk.

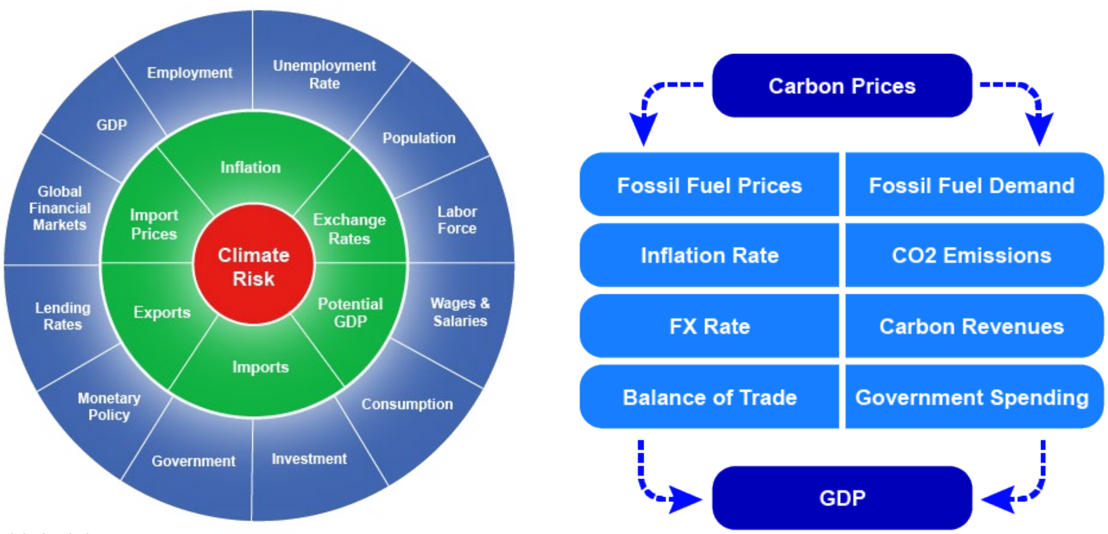
Physical risks are much more important in scenarios where policymakers do little to decarbonize the economy. Conversely, if policymakers take more action to address climate change, the transition to a sustainable energy economy happens more quickly, easing some of the more dire physical risks. In the most extreme case where policymakers fail to respond to climate change, there are substantial physical risks, but there are no transition costs borne by the economy.

2 These four scenarios are all based on our U.S. macroeconomic assumptions as of the July 2022 forecast vintage.
3 For a more thorough accounting of chronic physical risk, see The Economic Implications of Climate Change.

Modeling climate risk

To quantify the environmental, macroeconomic and fiscal consequences of different policy responses to climate change we use our structural model of the global economy.[4] We have expanded our model to include energy demand by fossil fuel source, including coal, natural gas and oil, and the CO_2 emissions of these fuel sources (see Chart 2 and Appendix 1). This allows us to estimate the reduction in fossil fuel demand if U.S. policymakers were to put a price on carbon. We then use our fossil fuel demand forecasts to estimate CO_2 emissions generated by the combustion of each fossil fuel source. We calculate the revenue generated by a carbon tax by multiplying carbon price by emissions. Federal lawmakers are able to use the tax revenue to help cover climate-related costs or to help households defray their higher cost of living due to the tax.

Chart 2: Climate Risk in the Moody's Analytics Macroeconomic Model



Source: Moody's Analytics

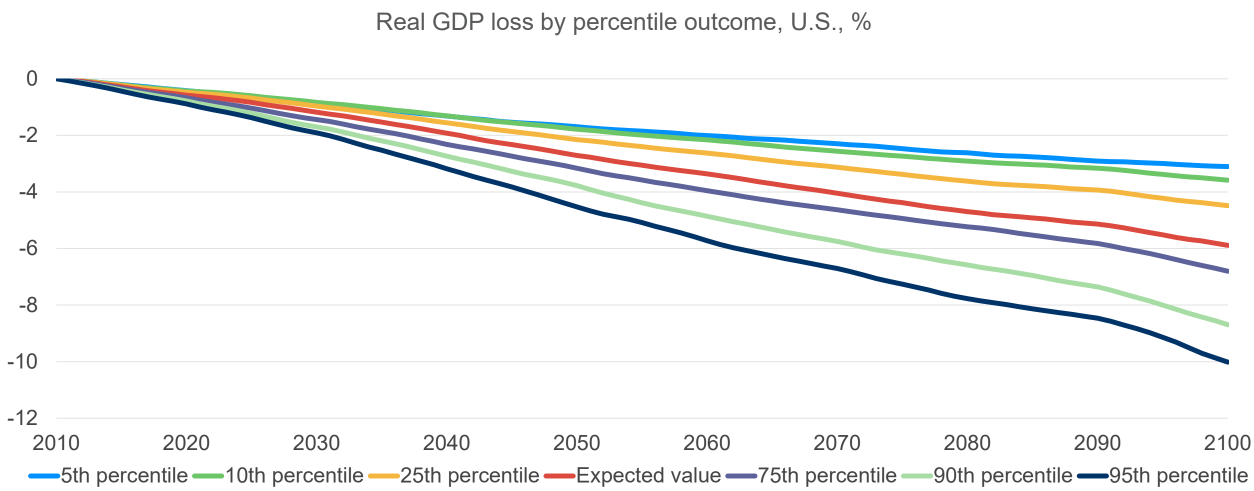
Transition risk affects the economy in our model by increasing the cost of energy goods and thus inflation broadly. Carbon taxes are levied on producers with an assumed border adjustment so as not to erode American business competitiveness. Fossil fuel producers that export their output receive a tax credit, offsetting their tax liability, and fossil fuel importers are required to pay a levy at the border. Fossil fuel producers pass through some of the cost of the carbon tax to their customers, resulting in higher inflation, at least until the supply side of the economy responds and the Federal Reserve adjusts monetary policy. Long term, we assume inflation is consistent with the Fed's inflation target. Moreover, because firms are not able to pass along all of their increased costs, their profitability weakens. Industries closer to the epicenter of the transition have a more difficult time passing through increases in their costs, and their profits fall more.

Acute and chronic physical risks affect the economy in our model by increasing the economic losses associated with these risks. The cost of chronic physical risk is based on estimates from the Network for Greening the Financial System, a network of the world's major central banks, including the Federal Reserve. The NGFS has emerged as a benchmark for climate risk scenarios, as most climate stress tests of the financial system to date have been structured around NGFS parameters. The NGFS estimates chronic physical risk using the Kalkuhl & Wenz (2020) framework. While we use the median expected value estimate for the GDP loss under chronic

4 Our global model is a large-scale structural model that is similar to the Bank of England's NIGEM model and the Federal Reserve's FRB-US. For a description of our model, see Moody's Analytics Global Macroeconomic Model.

physical risk derived from this framework, it is important to note that there is a wide distribution around this estimate (see Chart 3). As the NGFS has yet to estimate the costs of acute physical risk, we have derived estimates based on historical cost data and a methodology proposed in the academic literature.[5]

Chart 3: The Distribution of Chronic Physical Risk Losses



Sources: NGFS, Moody's Analytics

Climate change assumptions

To determine the economic impact of climate change under the different scenarios, we need to make a number of assumptions. While our analysis focuses on the U.S., the challenge of climate change is global. To simplify our analysis, we assume that the world decarbonizes in tandem with the U.S. Of course, countries will not decarbonize at the same rate. A case in point is the European Union, which is leading the way on climate risk mitigation, agreeing to a common framework for pricing carbon and the phasing out of internal combustion vehicles. The Bank of England and the European Central Bank have also conducted climate stress tests, whereas the Federal Reserve is only now gearing up to conduct such tests. Conversely, countries such as China and India are still erecting coal-fired power plants. If the rest of the world decarbonizes faster than the U.S., physical risks will be overstated across all scenarios, while slower rates of decarbonization will mean that physical risks are understated.

We also assume the federal government will provide emergency aid to help defray the cost of natural disasters. We have estimated the economic losses resulting from major U.S. natural disasters since Hurricane Hugo hit in 1989, and the amount of economic aid that federal lawmakers have appropriated in response. Consistent with this historical experience, we assume that in future natural disasters, lawmakers will appropriate federal aid equivalent to approximately half of the associated economic loss (see Table 1). Providing less relief would reduce the nation's fiscal burden of such disasters, but it would shift more of the economic burden of climate change to households and businesses.

Finally, we assume that 60% of any carbon tax revenue collected by the federal government is returned to households through a dividend payment, and the payment is the same regardless of income. The remainder is

5 We use historical data collected by reinsurer Aon to approximate the economic loss from natural disasters. And IMPAX provides a range of academic estimates on the cost of acute physical risk.

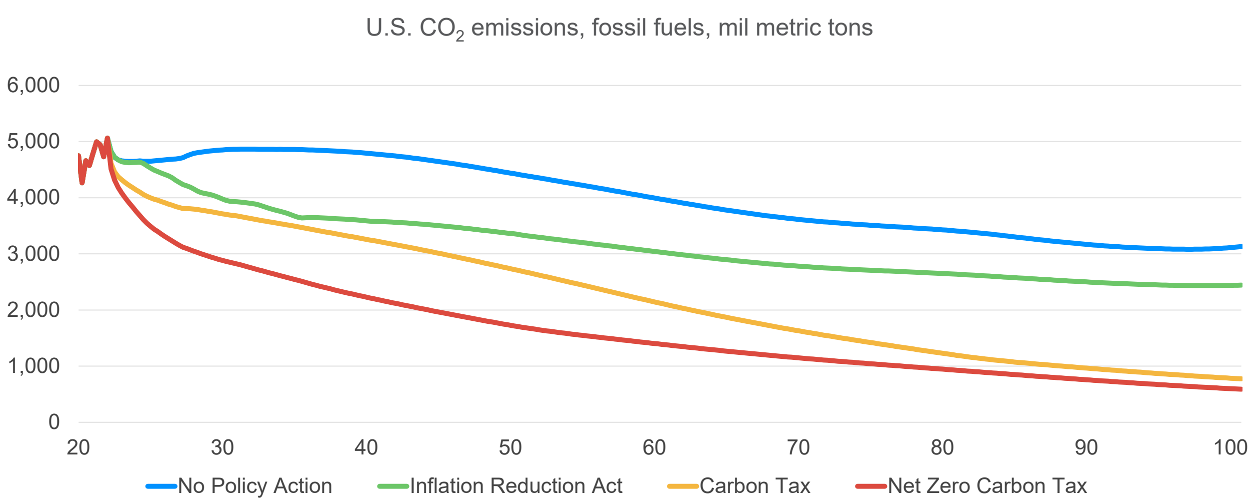
used to cover the government's administrative and other costs, helping to prevent a serious erosion in the government's fiscal situation, particularly in the second half of the century. The government retaining a meaningful share of the carbon tax revenues helps to offset climate-related costs, mitigating the increase in the government's debt load, and thus lowering interest rates and supporting stronger long-term economic growth.

No Policy Action scenario

In this scenario, policymakers are assumed to take no meaningful steps to mitigate greenhouse gas emissions. This includes assuming that the recently enacted Inflation Reduction Act did not pass. This scenario provides a good benchmark against which to assess the environmental, economic and fiscal impacts of the different policy interventions considered in the other scenarios.

Given that there is no policy action in this scenario, there is no transition risk, but acute and chronic physical risks intensify because of greater CO_2 emissions. Emissions still decline in this scenario, from 4.6 million metric tons in 2020 to approximately 3 million metric tons by 2100, as we assume that even without policy support there will be improvements in technologies that make battery and renewable energy sources cheaper and partially displace fossil fuels (see Chart 4 and Table 2).[6]

Chart 4: Policy Action Accelerates the Decline in Carbon Emissions



Sources: EIA, Moody's Analytics

This emissions outlook does not include the CO_2 that is released into the atmosphere by the combustion of non-fossil fuels such as biodiesel and ethanol, nor non-CO_2 greenhouse gases such as methane. Biomass and renewables are expected to increase, but we do not explicitly forecast them. The economy thus decarbonizes in this scenario, but much more slowly than in the other scenarios in which policymakers act to reduce carbon emissions.

Climate-related natural disasters occur with increasing frequency and severity in this scenario as temperatures rise. By 2100, temperatures are 3.2°C hotter than their pre-industrial average. The economic losses

6 The electric-vehicle battery is an illustration of this. According to Bloomberg New Energy Finance, EV battery costs have declined by approximately 90% since 2010 alone. See here and here. Rapid construction of gigafactories will increasingly allow automakers to achieve economies of scale, lowering costs further.

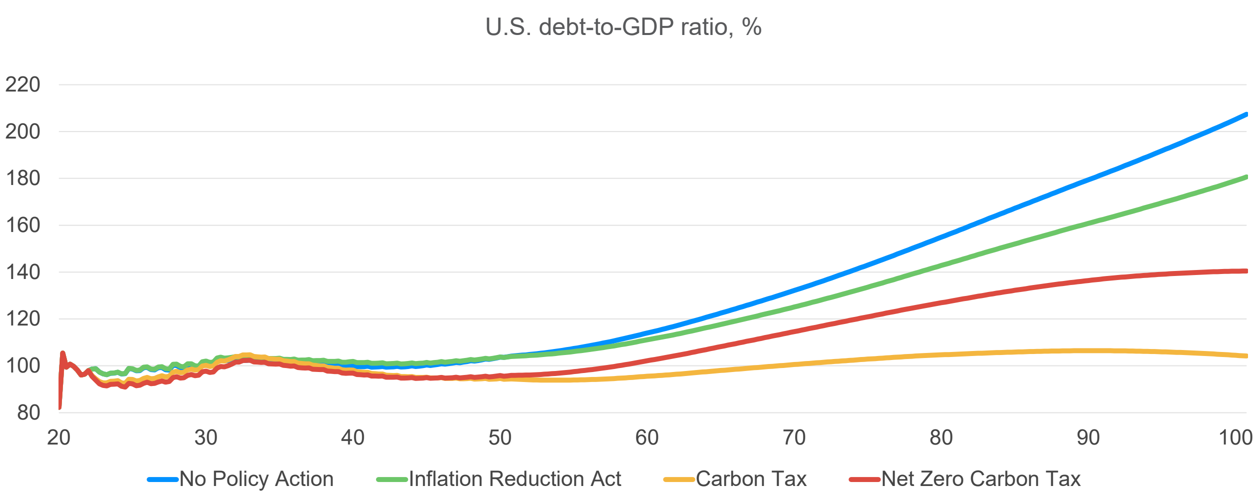
from natural disasters increase by just over 5% per annum through the remainder of the century, compared with growth of 3.5% over the past quarter century. This is not a big difference in any given year, but the cumulative economic loss due to policy inaction is significant.

The economic cost of not responding to climate change and the resulting heightened physical risks are substantial. Real GDP is nearly 9% lower by 2100 compared with a world in which climate change is not a problem (see Table 3). Greater chronic physical risk significantly diminishes productivity growth given the impact of greater heat stress and human health effects. Agriculture suffers from changes in precipitation patterns, tourism from changes in temperature, and sea level rise renders an increasing swath of land inundated or unusable.[7]

The economic losses from the greater physical risk in the No Policy Action scenario are borne by businesses through lower corporate profitability, financial institutions including insurance companies, and households that have effectively self-insured.

The federal government also suffers a significant hit to revenues due to slower economic growth, and to higher costs, primarily to provide more emergency aid to deal with the property and economic damage caused by increasingly intense natural disasters (see Chart 5). The fiscal impact is modest in the next several decades—the debt-to-GDP ratio rises from 97% in 2020 to 104% by 2050—but escalates quickly longer term, reaching 206% by 2100 (see Table 4). The high and rising debt loads are exacerbated by the government's higher borrowing costs (see Chart 6).

Chart 5: Policy Inaction Erodes the Nation's Fiscal Position…



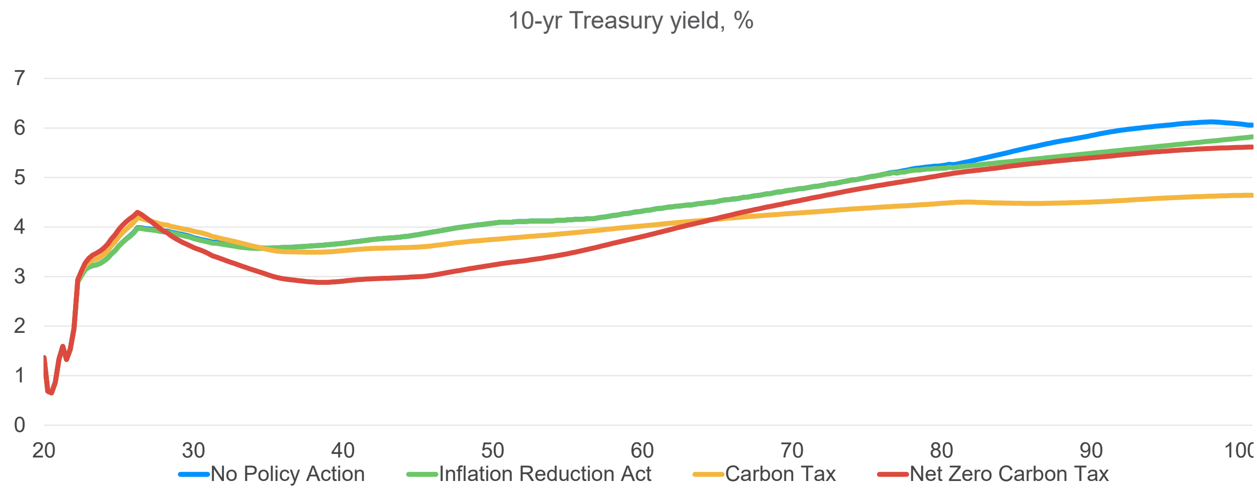
Source: Moody's Analytics

Inflation Reduction Act scenario

In this scenario we assume that the climate-related tax and spending policies in the recently legislated Inflation Reduction Act are quickly implemented. We also assume that no additional policy steps are taken by federal lawmakers, allowing us to isolate the impacts of the legislation.

7 A discussion of chronic physical risk factors can be found here.

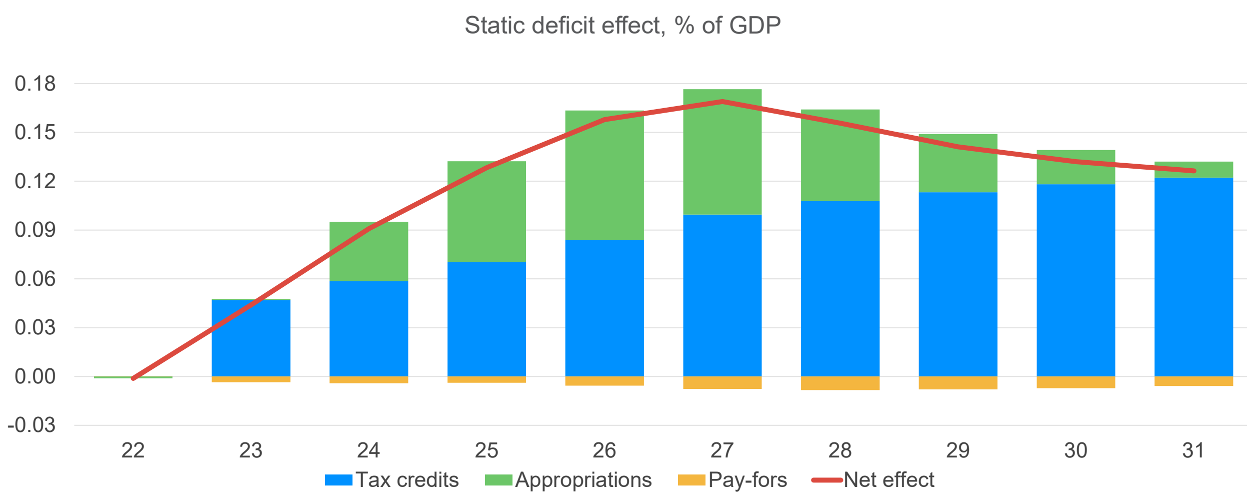
Chart 6: …Pushing Up Long-Term Interest Rates



Source: Moody's Analytics

The climate provisions in the IRA have an estimated static budget cost of $372 billion over the next decade (see Chart 7, Tables 5 and 6, and Appendix 2). Not quite three-quarters of these funds go to tax credits that extend, enhance or create incentives to produce electricity from clean energy sources, invest in renewable energy technologies, and address climate change through carbon sequestration, renewable fuel production, and clean energy manufacturing. The tax credits also lower the cost to households and businesses of investing in energy efficiency and purchasing electric vehicles.

Chart 7: Budget Cost of the Inflation Reduction Act



Sources: CBO, JCT, Moody's Analytics

The remainder of the climate change investments in the IRA are direct federal government spending. The funds are used to support conservation practices to help mitigate emissions from agriculture and forestry, and to provide grants, rebates and federal procurement to promote the adoption of clean energy technologies and energy efficiency improvements in housing and commercial real estate. The legislation also invests in the climate resilience of at-risk communities and addresses air pollution.

We assume that a number of potential roadblocks to deploying clean energy at the scale envisaged in the IRA are overcome in a timely way. One such roadblock is that developers proposing new solar, wind or energy storage capacity must allow for regional grid operators to determine the cost and timeline of any necessary grid improvements to accommodate the project before a green light is given. As this process plays out, developers wait in an interconnection queue, and wait times have almost doubled for projects built in the past decade compared with those approved from the decade prior.[8] The backlogs may intensify with the implementation of the IRA as the legislation spurs developers to propose even more capacity additions. Mitigating the risk of queue bottlenecks are proposed reforms by the Federal Energy Regulatory Commission to the interconnection process and investment funds provided in the Inflation Reduction Act to improve the accuracy and timeliness of environmental review processes.[9]

Decarbonizing the economy to the extent envisaged in the IRA also involves extending the existing grid to regions where abundant sun and wind can be converted to renewable energy via large transmission lines cutting across state lines. Planning and siting interstate electricity transmission lines can be an intrepid affair for developers, who have to contend with not only state authorities but also grassroots opposition.[10] That said, the Infrastructure Investment and Jobs Act that became law late last year includes some reforms to transmission siting. For example, one provision would make it easier for the Department of Energy to designate areas where FERC can supplant state authority over transmission siting. Moreover, the IRA provides grants to accelerate the siting and permitting of interstate transmission projects.

Another potential problem is the resilience of the nation's clean energy supply to trade tensions and other unanticipated disruptions such as a pandemic, which could hamstring supplies and thus the deployment of decarbonization resources. The IRA does address this risk by providing a production credit for domestic manufacturing of solar panels, wind turbines, and critical minerals processing. In addition, strict sourcing provisions will put most current electric-vehicle models out of reach of the IRA's new EV credit in the short run. However, the scenario assumes more consumers benefit from the credit later in this decade as the auto industry brings more of its battery manufacturing and supply chain into North America.

The IRA scenario is also premised on the sufficient availability of a trained workforce, which could be a constraint given what is likely to be a perennially tight labor market. The IRA potentially alleviates such concern by providing a plus-up to tax credits for clean electricity projects that are located in energy communities, defined as brownfield sites or fossil fuel communities, where the existing workforce can be engaged.

The climate policies in the IRA will meaningfully reduce carbon emissions, and thus ultimately the acute and chronic physical risks and economic losses resulting from climate change. We estimate the reduction in CO_2 emissions due to provisions in the Inflation Reduction Act based on work done by the REPEAT project.

8 J. Rand, R. Wiser, W. Gorman, D. Millstein, J. Seel, S. Jeong, and D. Robson, "Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2021," Lawrence Berkeley National Laboratory, April 2022.

9 See "FERC Proposes Interconnection Reforms to Address Queue Backlogs."

10 Siting interstate electricity transmission lines involves assembling the necessary property rights and regulatory permissions to secure the strip of land that will be used to construct, operate, maintain and repair a transmission line. States have jurisdiction over the siting of electricity transmission property. Yet even if affected states do not stand in the way of a proposed transmission line, opponents to the project can still avail themselves of state laws and other avenues to stymie its progress. In November 2021, Maine voters rejected a $1 billion project to bring hydropower from Quebec into New England in what turned out to be the state's most expensive referendum question.

By 2050, we estimate emissions will be reduced by nearly 25% compared with a scenario in which there are no additional policy changes to address climate change. Our estimate of emissions reduction under the IRA are in line with other preliminary analyses.[11] Although the IRA requires the federal government to auction off more public lands and waters for oil drilling, the resulting increase in emissions is more than offset by the accelerated pace of decarbonization due to the rest of the legislation. Temperatures will increase by 2.8°C compared with their pre-industrial average.[12]

The IRA has a small impact on economic activity during the first half of this century, but because it significantly reduces CO_2 emissions, the economic benefits are more substantial in the second half of the century and are long-lasting. Real GDP is estimated to be approximately 2% higher by 2100 than in the scenario where there is no additional climate policy action (see Table 3). It is clear that upfront investments in addressing climate change reap substantial long-term economic benefits.

Carbon Tax scenario

The quick adoption of a modest carbon tax is considered in this scenario. The economic logic of a carbon tax is straightforward; it requires carbon emitters to bear more of the cost of their emissions. However, the political opposition to a carbon tax is fierce, in significant part because the tax could potentially put American companies at a disadvantage against businesses in countries that do not tax carbon. The tax could also be regressive, hurting the finances of lower-income populations significantly more than those with higher incomes. To address these potential drawbacks, we assume the carbon tax is combined with rebates for fossil fuel exporters and a border adjustment fee for fossil fuel importers. Government revenues generated by the carbon tax are also used to finance a non-taxable per-household dividend payment. The payment would be the same for all households, so that lower-income households would receive more as a percent of their total income than higher-income households.[13]

More explicitly, we assume a $40 per metric ton carbon tax is levied beginning in 2023 and the tax increases annually by the inflation rate plus 5 percentage points (see Table 7). It is ultimately capped at the much higher carbon tax that we model in the next scenario, which considers a carbon tax sufficient to achieve net zero carbon emissions by 2050. We assume there is a border adjustment, and the revenues generated by the tax are used to fund quarterly dividend payments to households equal to $1,000 for the typical household, or about 1.5% of their annual income.

In this Carbon Tax scenario, carbon dioxide emissions are reduced by almost 40% by 2050 compared with the No Policy Action scenario (see Table 2). Carbon emissions by oil and natural gas producers fall noticeably over the next 30 years, which is significant given the much larger economy and increased energy needs. Emissions by coal producers effectively go to zero as coal becomes an uneconomic source of energy because of its high carbon content and the industry effectively shuts down. By 2100, fossil fuel carbon dioxide emissions are reduced by more than 75%. This substantially limits temperature rise, which is 1.9 °C above its pre-industrial average, and thus also limits physical risk and its economic costs.

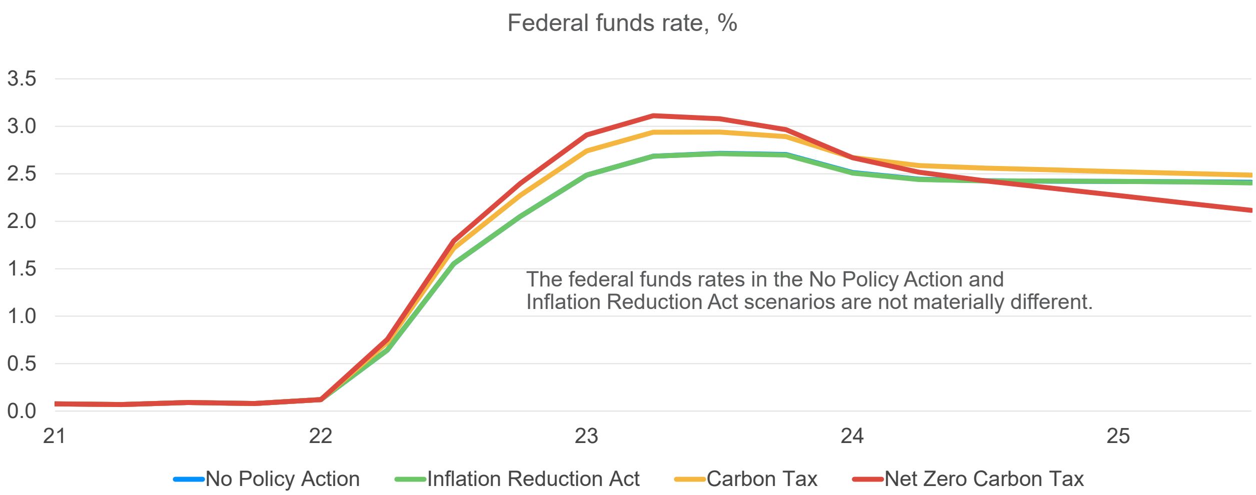
11 B. King, J. Larsen, and H. Kolus, "A Congressional Climate Breakthrough," Rhodium Group, July 28, 2022. M. Mahajan, O. Ashmoore, J. Rissman, R. Orvis, and A. Gopal, "Modeling the Inflation Reduction Act Using the Energy Policy Simulator," Energy Innovation, August 2022. J. Jenkins, E. Mayfield, J. Farbes, R. Jones, N. Patankar, Q. Xu, and G. Schivley, "Preliminary Report: The Climate and Energy Impacts of the Inflation Reduction Act of 2022," REPEAT Project, August 4, 2022.

12 This assumes global climate change action commensurate with the emissions reduction provided by the Inflation Reduction Act.

13 This carbon tax in this scenario is similar to the Carbon Dividends Plan proposed by the Climate Leadership Council.

A carbon tax does result in transition risks, pushing up consumer and producer prices as businesses paying the tax pass much of it on to their customers. This in turn reduces households' real incomes and purchasing power.[14] Moreover, the Federal Reserve responds to the higher energy prices by raising interest rates, consistent with its price stability mandate (see Table 8 and Chart 8).[15] What part of the tax businesses are unable to pass along to customers, given competitive pressures, reduces their after-fee profitability and thus investment and hiring. Government also pays more for its energy use, particularly for defense, and there are some administrative costs associated with implementing the plan.

Chart 8: Fed Adjusts Monetary Policy in Response to Climate Policy



Source: Moody's Analytics

Working to offset these negative economic impacts is the dividend payment that households receive, financed by the carbon revenues the U.S. government collects. All households receive the same dividend amount. But, as a percent of income, the dividend is much larger for lower-income households. Since these households are likely to spend more of the dividend than high-income households that have more financial resources, the boost provided by the dividend on consumer spending and the economy is magnified.

The economy ultimately adjusts to the higher cost of carbon with few ill-effects. Given the transition costs to the new tax and that the benefits to reduced physical risk take longer to manifest, real GDP is modestly lower than in the No Policy Action scenario in the next few decades—1.6% lower by 2050. But in the second half of the century, physical risks are much lower in the Carbon Tax scenario because of the significant reduction in carbon emissions. By 2100, fewer costly natural disasters and less fallout from other chronic physical risks mean real GDP is 4.1% higher in the Carbon Tax scenario than in the No Policy Action scenario.

The federal government's fiscal situation is better and long-term interest rates are lower in the Carbon Tax scenario, as the cost to the federal government of coping with natural disasters is minimized. This short-circuits the vicious cycle that occurs in the No Policy Action scenario where higher interest rates lead to larger

14 This is mitigated as energy goods and services account for just 5% of consumer spending, down from 14% in 1970.

15 The long-term inflation rate is the same across all scenarios as we assume the Federal Reserve will conduct monetary policy so as to ensure inflation is consistent with its target.

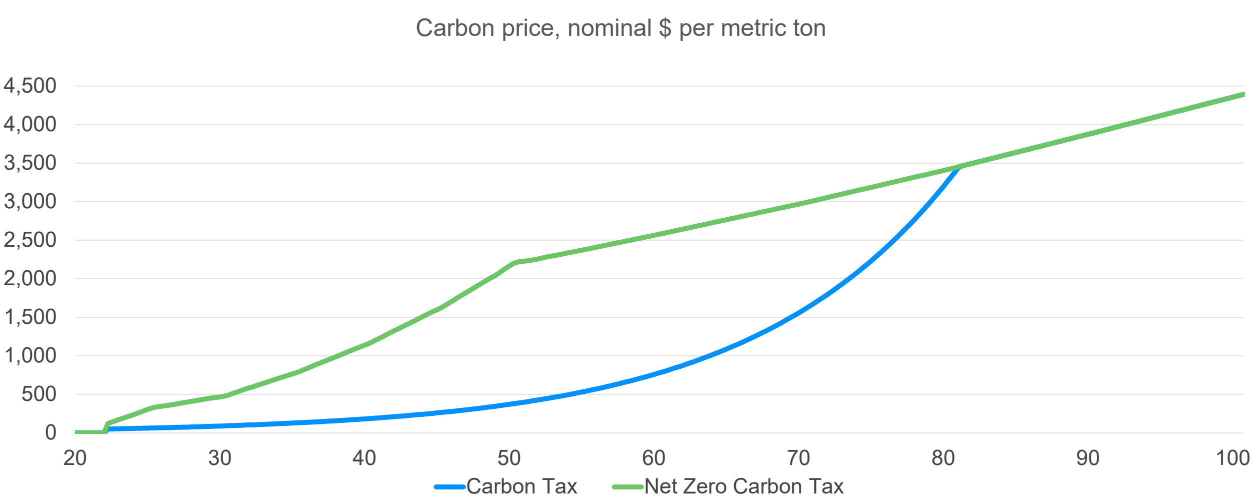
debt loads that result in further increases in interest rates. The federal debt-to-GDP ratio increases from 97% in 2020 to 104% by 2100. This is well below the federal debt load under the No Policy Action and Inflation Reduction Act scenarios (see Table 4). Pricing carbon delivers sufficient carbon emissions reduction at a modest cost to the economy.

Net Zero Carbon Tax scenario

Climate scientists have demonstrated that the best way to preserve ecosystems, stave off the worst-case outcomes, and avoid irreparable damage is to transition to net zero carbon dioxide emissions by 2050. Net zero 2050 would limit the rise in global temperatures to no more than 1.5°C above pre-industrial levels, which is a goal that virtually all countries have committed to achieving. Drastic action would be needed to achieve net zero. The International Energy Agency estimates that annual clean energy investment worldwide would need to triple to around $4 trillion to facilitate the transition. Powerful incentives such as tax credits, mandates, and higher carbon taxes would be needed to make this happen.

In the Net Zero Carbon Tax scenario we assume a carbon tax is imposed along the lines of that in the Carbon Tax scenario, with tax revenues redistributed back to households, a border adjustment, and with the Fed adjusting monetary policy to achieve its inflation target. However, the net zero scenario assumes a much more aggressive increase in the carbon price to $2,200 per metric ton by 2050 to reach net zero emissions by 2050 (see Table 7). This is consistent with the NGFS estimate of the price needed to achieve net zero by 2050, which is substantially greater than the $376 price that we assume in the Carbon Tax scenario (see Chart 9). The carbon tax in the net zero scenario initially generates $1.2 trillion in annual tax revenue that is used to fund a carbon dividend of approximately $5,000 per household.

Chart 9: Drastic Action Is Needed to Go Net Zero by 2050



Source: Moody's Analytics

To reach net zero carbon emissions by 2050, coal is phased out even more quickly than in the Carbon Tax scenario. Biomass is used to generate electricity alongside renewables, providing a further sink for carbon dioxide emissions from the biomass's photosynthesis. Moreover, carbon emissions are captured and stored. This combination, which is accounted for by negative emissions, is what allows net carbon dioxide emissions to fall to zero even though fossil fuels are still being burned. Carbon emissions from fossil fuels fall by

61% in this scenario by 2050, and 81% by 2100 (see Table 2).[16] The large reduction in fossil fuel emissions limits the rise in global temperature to 1.8°C above its pre-industrial average.

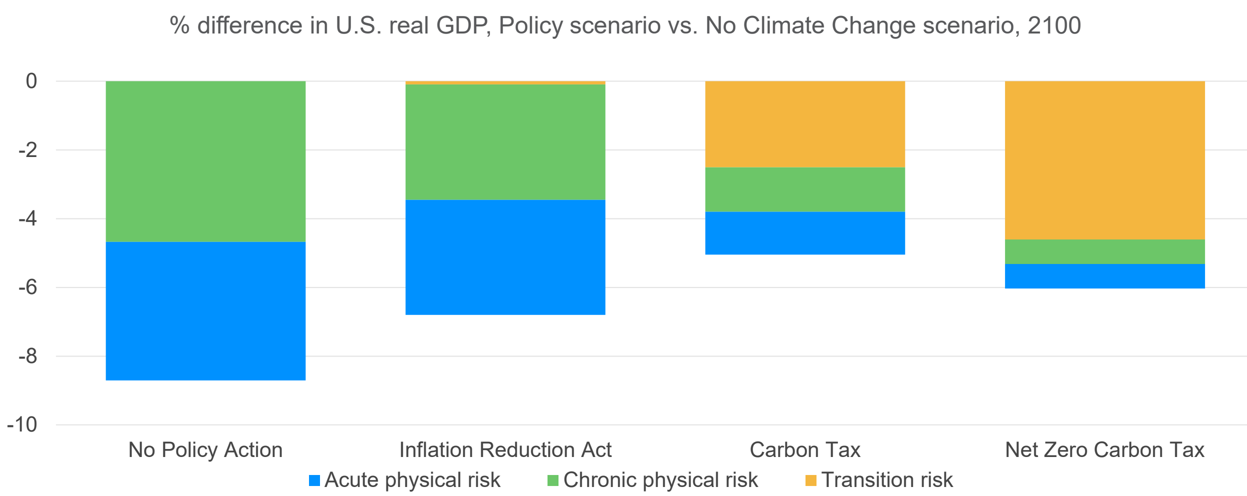
The costs needed to transition the economy to net zero by 2050 are steep. Real GDP is close to 6% lower than in the No Policy Action scenario by 2050, of which 5 percentage points is because of transition risk, and employment is 8.2 million jobs lower. The overall price level is 3% higher by 2050 than in the No Policy Action scenario, even though the Fed has tamed the rate of inflation long before then.

However, long term, the economy performs meaningfully better in the net zero scenario than in the No Policy Action scenario given the much-reduced physical risk. By 2100, physical risks reduce real GDP in the net zero scenario by 1.4%, compared with 8.7% in the No Policy Action scenario. Even after also accounting for the transition costs from the carbon tax in the Net Zero Carbon Tax scenario, real GDP is 3.2% higher than in the No Policy Action scenario, there are 1.9 million more jobs, and the unemployment rate is 0.8 percentage point lower (see Table 8). Taking aggressive policy steps to rein in carbon emissions results in a much better long-term outcome for the economy than policy inaction.

Conclusion

The U.S. economy can be decarbonized at a modest economic cost provided that the transition begins soon and occurs gradually. Efforts to decarbonize the economy today will promote stronger economic growth over the long term. The Inflation Reduction Act is a good start that will ensure that the U.S. has the opportunity to become the leading energy technology economy in the post-carbon world. But more needs to be done to protect the economy and indeed the planet against the worst-case climate outcomes. Transitioning to a carbon neutral economy by 2050 would safeguard against these risks, but it would also do so at greater cost. We find that the optimal policy in terms of economic consequence is to immediately price carbon and slowly increase this price over time (see Chart 10).

Chart 10: Policy Action Trumps No Action



Source: Moody's Analytics

16 It is important to note that our emission forecasts include the carbon dioxide that is released into the atmosphere by the combustion of fossil fuels. The combustion of non-fossil fuels such as biodiesel and ethanol is not included, nor are non-CO_2 greenhouse gases such as methane. Biomass and renewables are more important in the future, but we do not explicitly account for them. Biomass and carbon sequestration are critical to reaching net zero carbon emissions by 2050 in the Net Zero Carbon Tax scenario, for instance.

Appendix 1: Modeling Climate Risk

To determine the macroeconomic impacts of climate change policies, we made a number of enhancements to our global macroeconomic model. The most significant enhancement is the introduction of carbon dioxide emissions by fuel source, including for coal, natural gas and oil. Non-energy carbon emissions are also included, based on data from the Environmental Protection Agency and the Energy Information Administration.

Emissions are modeled as a function of energy demand by source. Each fuel source has a different carbon emissions coefficient. Therefore, certain fuels such as coal will be hurt more by a carbon tax. Because these CO_2 coefficients are constant, CO_2 emissions by source will grow according to fluctuations in the demand for that source. It was necessary that the energy demand equations by source reflect the decline in demand in fossil fuels in response to the implementation of a carbon tax.

Energy demand by energy source is modeled using two-stage least squares estimation. This ensures that our regression results are not biased by the endogeneity between energy demand and energy price. Work by James H. Stock, et al. indicates that traditional least squares estimates of the price elasticity of energy demand tend to be implausibly low. We used different instrumental variables to instrument for energy prices by energy source. For oil prices, we instrumented using federal and state gas taxes, consistent with Stock. For natural gas prices, we used the levelized cost of energy for new generation resources entering five years in advance. The EIA has reported this time series consistently since 2010. For coal prices, we used the coal levelized cost of energy in addition to the natural gas levelized cost of energy and coal electricity generating plant retirements. We constructed a time series of coal retirements using EIA data that were first introduced in 2002.

The variables used in these regressions differed by fuel source, but the equations had similar specifications. First, the equations account for differences in short- and long-term price demand elasticities. The elasticities differ because it takes households and businesses time to respond to energy prices by changing their fuel consumption. For example, a spike in gasoline prices might not result in reduced gasoline demand today, but it could lead to the purchase of a more fuel-efficient vehicle in five years. Second, all of the equations included industrial production by utilities. This variable reflects the increase in energy demand that results from rapid and extreme temperature fluctuations, be it increased demand for electricity, natural gas or heating oil. Third, macroeconomic factors such as the unemployment rate, industrial production, and per capita disposable income are used.

Last, fuel-specific variables are included in the equations. These include CAFE standards for petroleum demand and the ratio of coal to gas prices for coal demand. Coal demand was especially sensitive to the level of coal price in addition to fluctuations in the coal price. For petroleum product demand, we accounted for the presence of biofuels and biodiesel in motor gasoline and diesel fuel. We chose to forecast seasonally adjusted demand to be consistent with the rest of the macroeconomic model and prevent seasonality from obscuring our estimates of the price elasticities of energy demand. Non-energy CO_2 emissions were modeled directly as a function of fossil fuel prices and economic variables.

The shock properties of the equations are important, and the price elasticities of energy demand for the fuel sources are consistent with economic literature.

Appendix 2: Inflation Reduction Act in Detail

The Inflation Reduction Act includes $119 billion in direct federal spending and $271 billion in tax credits over the next decade. The majority of the IRA's tax changes extend, enhance or create tax credits for electricity production from clean energy sources, investment in renewable energy technologies, and other activities addressing climate change such as carbon sequestration, renewable fuel production, and clean energy manufacturing. Other tax expenditures lower the cost of investing in energy efficiency and purchasing electric vehicles for households and businesses. Finally, the IRA reinstates the Superfund tax on crude oil and imported petroleum.

The clean energy tax credits are in effect for varying durations. Two-thirds of the incentives sunset within the next 10 years, while most of the rest begin to phase out in the late 2030s. Less than 3% of the IRA tax policies are assumed to be permanent through 2100. These tax credits manifest themselves as a reduction in effective personal and corporate tax rates, which in turn flow through to consumer spending and nonresidential fixed investment, respectively. Specifically, four-fifths of the IRA's tax credits are modeled as a cut to corporate tax receipts, while the remaining fifth reduces individual income taxes in the model.

The IRA's green energy tax credits check off many boxes that are necessary to achieve maximum results in reducing emissions.[17] First, the duration of its tax policies is long enough that it will provide certainty for clean energy developers and investors, who have faced repeated lapses and last-minute extensions of federal tax incentives. Second, the IRA allows for greater flexibility in green energy tax policy, of which the production tax credit and investment tax credit are key components. The PTC is a per-kilowatt-hour incentive for the first decade of a renewable energy facility's operation, while the ITC is an up-front credit against the capital expense of investing in a renewable energy project.

Prior to the IRA, utility-scale solar properties were only eligible for the ITC. However, the IRA revives the PTC for solar energy. This is important, because if solar costs continue to decline, this trend will erode the value of the ITC vis-à-vis the PTC for owners of solar energy property. In terms of flexibility, the IRA adds a "direct pay" option for a dozen green energy tax credits and also makes nearly all of these credits transferable, allowing developers of clean energy projects to monetize these tax breaks without having to resort to tax equity financing.[18] Easier monetization of clean energy tax credits will particularly benefit developers of emerging technologies. Tax equity investors typically prefer large-scale projects that are based on proven technologies such as onshore wind and solar, whereas their appetite for nascent technologies may be limited, given the higher capital costs and longer development schedules.

17 See J. Larsen, B. King, H. Kolus, N. Dasari, and W. Herndon, "Pathways to Build Back Better: Maximizing Clean Energy Tax Credits," Rhodium Group, July 8, 2021.

18 Renewable energy projects have benefited from federal tax breaks, including the production tax credit and the investment tax credit. However, the PTC and ITC have been nonrefundable, limiting their benefit to owners or developers of clean energy facilities whose tax liabilities are lower than the credit amount. Those most disadvantaged by the non-refundability of the PTC and ITC have included tax-exempt entities such as public power agencies and rural electric cooperatives, cities, counties, school districts, Indian tribal governments, and nonprofit organizations, among others. The IRA addresses this issue by allowing tax-exempt entities to elect to receive a direct cash payment in the form of a tax refund from the federal government. Under the "direct pay" option, the IRS treats an eligible owner of a clean energy property as having paid taxes in an amount equal to the credit. In such a way, the owner would receive a refund to the extent that the deemed payment of tax exceeds their tax liability. Besides the "direct pay" option, the IRA endows the PTC, ITC, and other green energy credits with transferability, allowing taxpayers that are not tax-exempt entities to transfer their tax credits to a third party. In effect, taxpayers can sell their tax credits for cash. In this transfer of credits, the buyer cannot deduct from their gross income the amount paid for the credit, but the payment received in exchange for the transfer of the credit is not taxable for the original recipient of the credit. Prior to the IRA, the difficulties that developers of renewable energy projects face in efficiently using federal tax credits, as well as depreciation deductions, has made tax-equity financing important to the industry. A tax-equity transaction is one in which an investor such as a commercial bank provides capital for a clean energy project in exchange for the prerogative to claim the available tax credits and depreciation deductions. The IRA will not do away with tax-equity financing, but it will provide appealing alternatives for developers of smaller clean energy projects that cannot afford the high transaction cost of tax equity partnerships.

Finally, the IRA does not neglect established clean resources such as nuclear generation, which is vulnerable to early retirement due to competition from relatively low natural gas prices. When nuclear plants are retired, for example, it makes the process of decarbonizing the power sector even tougher, as natural gas replaces the loss in nuclear power to a greater extent than renewable resources. Toward this end, the IRA provides a credit for electricity production from a qualified nuclear power source.

Direct spending by the federal government accounts for the remaining $119 billion of gross fiscal support under this climate-only package. The IRA mitigates emissions from agriculture by climate-smart practices such as soil-based carbon sequestration. Grants, loans, rebates and federal procurement promote the adoption of clean energy technologies, particularly in rural and low-income communities, as well as energy efficiency improvements in residential and industrial structures. The IRA also invests in the resilience of fire-prone forests and coastal communities, addresses air pollution, and establishes a Methane Emissions Reduction Program to curtail leaks associated with natural gas output. All this federal spending is modeled as a onetime event, with outlays mostly ending after 2032.

Table 1: The Economics of Natural Disasters

2022$ bil

Major natural catastrophe	Impacted region	Date	ECONOMIC LOSS Destruction	ECONOMIC LOSS Lost output	ECONOMIC LOSS Total loss	ECONOMIC AID Insurance	ECONOMIC AID Government aid	ECONOMIC AID Total aid	Government aid as a share of economic loss, %
Total			**769.4**	**281.7**	**1051.1**	**356.5**	**490.9**	**847.3**	**46.7**
Hurricane Ian (2022) preliminary	Florida, Carolinas	Sep 2022	50.0	8.5	45.0	na	na	na	na
Hurrican Ida (2021)	Louisiana, Northeast U.S.	Aug 2021	38.0	7.0	45.0	38.8	2.6	41.4	5.8
West Coast Wildfires (2020)	Pacific Coast	Aug 2021	5.5	2.0	7.5	8.6	0.1	8.8	1.6
Hurricane Laura	Gulf of Mexico, LA	Aug 2020	7.9	5.0	12.9	12.4	1.8	14.3	14.2
California Wildfires (2019)	California	Oct 2019	0.4	0.2	0.6	1.1	0.1	1.2	16.4
California Wildfires (2018)	California	Nov 2018	8.0	0.0	8.0	16.5	0.7	17.1	8.2
Hurricane Michael	FL panhandle, GA, AL	Oct 2018	18.5	5.0	23.5	15.3	2.2	17.5	9.2
Hurricane Florence	Carolinas	Sep 2018	30.1	4.0	34.1	5.8	2.3	8.1	6.8
California Wildfires (2017)	Northern California	Oct 2017	5.6	0.8	6.5	16.5	0.7	17.3	11.2
Hurricane Maria	Puerto Rico	Sep 2017	92.3	30.8	123.1	0.0	20.5	20.5	16.7
Hurricane Irma	Florida, Georgia	Sep 2017	72.0	14.4	86.4	10.3	7.2	17.4	8.3
Hurricane Harvey	Gulf of Mexico	Aug 2017	128.8	8.8	137.6	19.6	39.5	59.0	28.7
Hurricane Matthew	South Atlantic Coast	Oct 2016	11.8	4.3	16.1	19.9	40.1	59.9	248.7
California Wildfires	California	Sep 2015	0.4	0.0	0.5	1.2	0.3	1.5	66.2
Super Storm Sandy	Northeast U.S.	Oct 2012	48.4	27.2	75.6	22.5	63.3	85.8	83.7
Hurricane Irene	Northeast U.S.	Aug 2011	11.1	2.7	13.7	5.4	1.9	7.3	13.8
Hurricane Ike	Gulf of Mexico	Sep 2008	32.3	6.7	39.0	14.4	14.8	29.2	37.9
Hurricane Katrina	Gulf of Mexico	Aug 2005	148.7	32.0	180.7	51.8	140.5	192.3	77.7
Hurricane Ivan	Gulf of Mexico	Sep 2004	9.3	8.4	17.7	9.5	8.1	17.6	45.9
9/11	U.S.	Sep 2001	33.4	80.0	113.4	26.1	87.1	113.3	76.8
Los Angeles Northridge Quake	Los Angeles	Jan 1994	30.6	16.2	46.8	20.9	20.0	40.9	42.8
Midwest Floods	MN to MO	Summer 1993	7.9	12.2	20.1	1.7	9.1	10.8	45.2
Hurricane Andrew	Miami	Aug 1992	47.6	15.1	62.7	27.6	14.0	41.6	22.3
Loma Prieta Quake	Bay Area CA	Oct 1989	13.7	7.1	20.8	2.0	9.9	11.9	47.6
Hurricane Hugo	Charleston SC	Sep 1989	18.8	6.1	24.9	8.5	4.1	12.6	16.3

Notes:

Loss estimates for Hurricanes Florence and Michael, along with California wildfires, are preliminary and uncertain and shown in the table at the midpoint of the range

Lost output associated with the Midwest floods includes $5 bil in crop losses

The Bay Area includes the metro areas of San Francisco, Oakland, San Jose and Santa Cruz

9/11 insurance includes only property coverage

Lost output due to Katrina and Harvey does not include the impact of higher energy prices

Sources: ISO, Insurance Information Institute, NOAA, FEMA, RMS, California Department of Insurance, Willis Re, Moody's Analytics

Table 2: Carbon Emissions by Scenario

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
Total fossil fuel CO_2 emissions (Mmt)											Avg emissions		
No Policy Action	4561	4857	4785	4422	3977	3604	3420	3161	3120	4738	4729	3580	4009
Inflation Reduction Act	4561	3950	3582	3351	3031	2774	2645	2495	2441	4424	3607	2764	3186
% difference with No Policy Action	0%	-19%	-25%	-24%	-24%	-23%	-23%	-21%	-22%	-7%	-24%	-23%	-21%
Carbon Tax	4561	3698	3240	2714	2122	1612	1215	957	779	4114	3228	1528	2279
% difference with No Policy Action	0%	-24%	-32%	-39%	-47%	-55%	-64%	-70%	-75%	-13%	-32%	-57%	-43%
Net Zero Carbon Tax	4561	2859	2207	1711	1392	1139	939	750	594	3648	2239	1071	1694
% difference with No Policy Action	0%	-41%	-54%	-61%	-65%	-68%	-73%	-76%	-81%	-23%	-53%	-70%	-58%
Coal emissions											Avg emissions		
No Policy Action	868	811	503	252	223	252	285	305	331	933	511	269	415
Inflation Reduction Act	868	529	409	59	34	69	111	142	177	835	371	92	260
% difference with No Policy Action	0%	-35%	-19%	-77%	-85%	-72%	-61%	-53%	-47%	-10%	-27%	-66%	-37%
Carbon Tax	868	412	111	20	6	2	1	0	0	697	148	3	130
% difference with No Policy Action	0%	-49%	-78%	-92%	-97%	-99%	-100%	-100%	-100%	-25%	-71%	-99%	-69%
Net Zero Carbon Tax	868	383	115	26	9	4	1	0	0	663	147	5	126
% difference with No Policy Action	0%	-53%	-77%	-90%	-96%	-98%	-100%	-100%	-100%	-29%	-71%	-98%	-70%
Oil emissions											Avg emissions		
No Policy Action	2042	2163	2132	2078	2009	1931	1843	1744	1637	2151	2127	1877	1973
Inflation Reduction Act	2042	1669	1277	1533	1554	1558	1505	1448	1336	1986	1382	1501	1534
% difference with No Policy Action	0%	-23%	-40%	-26%	-23%	-19%	-18%	-17%	-18%	-8%	-35%	-20%	-22%
Carbon Tax	2042	2041	1906	1722	1496	1243	980	776	603	2091	1896	1131	1441
% difference with No Policy Action	0%	-6%	-11%	-17%	-26%	-36%	-47%	-56%	-63%	-3%	-11%	-40%	-27%
Net Zero Carbon Tax	2042	1800	1529	1269	1072	900	737	580	428	1977	1531	826	1148
% difference with No Policy Action	0%	-17%	-28%	-39%	-47%	-53%	-60%	-67%	-74%	-8%	-28%	-56%	-42%
Natural gas emissions											Avg emissions		
No Policy Action	1651	1883	2150	2092	1745	1422	1292	1111	1152	1655	2091	1434	1621
Inflation Reduction Act	1651	1751	1896	1759	1443	1147	1030	905	929	1602	1854	1171	1392
% difference with No Policy Action	0%	-7%	-12%	-16%	-17%	-19%	-20%	-19%	-19%	-3%	-11%	-18%	-14%
Carbon Tax	1651	1245	1224	971	620	368	234	181	175	1327	1184	393	708
% difference with No Policy Action	0%	-34%	-43%	-54%	-64%	-74%	-82%	-84%	-85%	-20%	-43%	-73%	-56%
Net Zero Carbon Tax	1651	676	563	416	310	235	201	170	166	1008	561	240	420
% difference with No Policy Action	0%	-64%	-74%	-80%	-82%	-83%	-84%	-85%	-86%	-39%	-73%	-83%	-74%

Sources: EIA, Moody's Analytics

Table 3: Macroeconomic Impact of Climate Change

Comparison with No Climate Change scenario

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
Real GDP, 2012$ bil											Avg annual growth		
No Climate Change	18,385	24,273	30,020	36,600	44,491	53,938	65,358	79,473	97,072	2.82	2.07	1.97	2.10
No Policy Action	18,385	24,239	29,850	36,143	43,627	52,417	62,719	74,916	88,491	2.80	2.02	1.81	1.98
% difference with No Climate Change	0.0%	-0.1%	-0.6%	-1.2%	-1.9%	-2.8%	-4.0%	-5.7%	-8.8%	(0.01)	(0.06)	(0.16)	(0.12)
Inflation Reduction Act	18,385	24,222	29,767	36,067	43,569	52,415	62,822	75,448	89,919	2.80	2.01	1.84	2.00
% difference with No Climate Change	0.0%	-0.2%	-0.8%	-1.5%	-2.1%	-2.8%	-3.9%	-5.1%	-7.4%	(0.02)	(0.06)	(0.13)	(0.10)
Carbon Tax	18,385	24,319	29,545	35,578	42,750	51,431	62,038	75,454	92,153	2.8	1.9	1.9	2.0
% difference with No Climate Change	0.0%	0.2%	-1.6%	-2.8%	-3.9%	-4.6%	-5.1%	-5.1%	-5.1%	0.02	(0.15)	(0.05)	(0.07)
Net Zero Carbon Tax	18,385	23,724	28,378	34,154	41,688	50,850	61,825	75,027	91,291	2.6	1.8	2.0	2.0
% difference with No Climate Change	0.0%	-2.3%	-5.5%	-6.7%	-6.3%	-5.7%	-5.4%	-5.6%	-6.0%	(0.23)	(0.24)	0.02	(0.08)
Employment, mil											Avg annual growth		
No Climate Change	142.1	160.1	166.9	173.5	178.1	182.2	185.2	186.6	187.3	1.2	0.4	0.2	0.3
No Policy Action	142.1	160.2	166.7	172.6	176.5	179.5	180.6	178.9	177.1	1.2	0.4	0.1	0.3
% difference with No Climate Change	0.0%	0.0%	-0.1%	-0.5%	-0.9%	-1.5%	-2.5%	-4.1%	-5.4%	0.00	(0.03)	(0.10)	(0.07)
Inflation Reduction Act	142.1	159.9	166.0	171.9	175.7	178.7	179.8	179.0	178.2	1.2	0.4	0.1	0.3
% difference with No Climate Change	0.0%	-0.1%	-0.6%	-0.9%	-1.4%	-2.0%	-2.9%	-4.1%	-4.9%	(0.01)	(0.04)	(0.08)	(0.06)
Carbon Tax	142.1	160.3	164.8	169.7	172.4	174.9	176.7	178.6	180.6	1.2	0.3	0.1	0.3
% difference with No Climate Change	0.0%	0.1%	-1.3%	-2.2%	-3.2%	-4.0%	-4.6%	-4.3%	-3.6%	0.01	(0.12)	(0.03)	(0.05)
Net Zero Carbon Tax	142.1	157.7	160.0	164.4	168.6	172.9	175.8	177.4	179.0	1.0	0.2	0.2	0.3
% difference with No Climate Change	0.0%	-1.5%	-4.2%	-5.3%	-5.4%	-5.1%	-5.0%	-4.9%	-4.4%	(0.16)	(0.19)	0.02	(0.06)
Unemployment rate, %											Avg		
No Climate Change	8.1	4.0	3.8	3.4	3.2	3.2	3.3	3.3	3.4	4.3	3.7	3.3	3.5
No Policy Action	8.1	3.9	3.9	3.6	3.5	3.7	4.0	4.0	5.2	4.3	3.8	3.9	3.9
% difference with No Climate Change	-	(0.0)	0.1	0.2	0.3	0.5	0.8	0.7	1.8	(0.0)	0.1	0.6	0.4
Inflation Reduction Act	8.1	4.1	4.1	3.8	3.7	3.9	4.2	4.1	5.1	4.4	4.0	4.1	4.1
% difference with No Climate Change	-	0.1	0.3	0.4	0.5	0.7	1.0	0.8	1.7	0.0	0.3	0.8	0.6
Carbon Tax	8.1	3.9	4.3	4.2	4.3	4.4	4.5	4.4	4.5	4.3	4.3	4.4	4.4
% difference with No Climate Change	-	(0.1)	0.6	0.8	1.1	1.2	1.2	1.1	1.1	(0.0)	0.6	1.1	0.8
Net Zero Carbon Tax	8.1	4.6	5.5	5.3	4.6	4.2	4.0	4.0	4.4	4.9	5.4	4.3	4.7
% difference with No Climate Change	-	0.6	1.7	1.9	1.4	1.0	0.7	0.7	0.9	0.6	1.7	1.1	1.2
10-yr Treasury yield, %											Avg		
No Climate Change	0.9	3.9	3.7	3.9	4.0	4.0	4.0	4.0	3.9	3.2	3.8	4.0	3.8
No Policy Action	0.9	3.8	3.7	4.1	4.3	4.8	5.3	5.9	6.1	3.2	3.8	5.1	4.5
% difference with No Climate Change	-	(0.1)	(0.1)	0.2	0.3	0.7	1.2	1.9	2.2	(0.1)	(0.0)	1.1	0.7
Inflation Reduction Act	0.9	3.7	3.7	4.1	4.3	4.8	5.2	5.5	5.8	3.2	3.8	4.9	4.4
% difference with No Climate Change	-	(0.1)	(0.1)	0.2	0.3	0.7	1.2	1.5	1.9	(0.1)	(0.0)	1.0	0.6
Carbon Tax	0.9	3.9	3.5	3.8	4.0	4.3	4.5	4.5	4.6	3.3	3.6	4.3	4.0
% difference with No Climate Change	-	0.0	(0.2)	(0.1)	0.0	0.2	0.5	0.5	0.7	0.1	(0.2)	0.3	0.2

Table 3: Macroeconomic Impact of Climate Change

Comparison with No Climate Change scenario

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
Net Zero Carbon Tax	0.9	3.5	2.9	3.3	3.8	4.5	5.1	5.4	5.6	3.3	3.1	4.7	4.1
% difference with No Climate Change	-	(0.3)	(0.8)	(0.6)	(0.2)	0.5	1.0	1.4	1.7	0.0	(0.7)	0.7	0.3
Federal government debt as a share of GDP, %											**Avg**		
No Climate Change	97.0	100.3	92.5	84.3	78.4	76.1	74.1	70.4	63.9	98.2	92.7	74.6	82.0
No Policy Action	97.0	101.2	99.7	103.8	114.6	132.9	155.8	180.3	206.3	98.5	101.0	147.5	129.9
% difference with No Climate Change	-	1	7	20	36	57	82	110	142	0	8	73	48
Inflation Reduction Act	97.0	102.1	101.5	103.8	111.5	125.7	143.5	161.4	179.8	98.8	102.3	136.6	123.4
% difference with No Climate Change	-	2	9	19	33	50	69	91	116	1	10	62	41
Carbon Tax	97.0	100.3	97.6	94.4	95.7	100.7	104.8	106.5	104.3	96.2	98.3	101.4	100.0
% difference with No Climate Change	-	0	5	10	17	25	31	36	40	(2)	6	27	18
Net Zero Carbon Tax	97.0	97.8	96.4	95.8	102.6	115.1	127.3	136.7	140.4	94.6	97.3	119.9	111.2
% difference with No Climate Change	-	(2)	4	11	24	39	53	66	77	(4)	5	45	29

Sources: BEA , BLS, Census Bureau, FHFA, S&P, Moody's Analytics

Table 4: Federal Fiscal Impact by Scenario

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
Federal budget deficit, $ bil											Avg		
No Additional Action	(3,110)	(651)	(926)	(1,103)	(1,267)	(2,398)	(5,000)	(9,434)	(19,874)	(971)	(917)	(5,578)	(3,860)
IRA	(3,110)	(703)	(931)	(975)	(847)	(1,384)	(2,858)	(5,178)	(12,161)	(995)	(914)	(3,245)	(2,395)
IRA, % diff from NAA	0.0%	8.0%	0.5%	-11.6%	-33.2%	-42.3%	-42.8%	-45.1%	-38.8%	(24)	2	2,333	1,465
Carbon Tax	(3,110)	(487)	(814)	(830)	(620)	(503)	132	1,450	4,352	(875)	(791)	390	(62)
Carbon Tax, % diff from NAA	0.0%	-25.2%	-12.1%	-24.8%	-51.1%	-79.0%	-102.6%	-115.4%	-121.9%	96	126	5,968	3,798
Net Zero	(3,110)	(373)	(728)	(883)	(1,308)	(2,211)	(3,380)	(4,540)	(5,435)	(783)	(724)	(2,927)	(2,122)
Net Zero, % diff from NAA	0.0%	-42.7%	-21.3%	-19.9%	3.2%	-7.8%	-32.4%	-51.9%	-72.6%	187	193	2,651	1,738
Federal government debt, $ bil											Avg		
No Additional Action	20,214	35,953	52,644	80,176	129,045	217,557	370,591	627,877	1,054,216	28,370	54,655	377,757	254,436
IRA	20,214	36,229	53,437	80,232	126,154	207,389	345,152	571,502	940,607	28,456	55,203	348,083	235,902
IRA, % diff from NAA	0.0%	0.8%	1.5%	0.1%	-2.2%	-4.7%	-6.9%	-9.0%	-10.8%	85	547	(29,674)	(18,534)
Carbon Tax	20,214	36,477	51,947	73,321	108,380	166,645	254,440	381,943	560,790	28,062	53,213	244,107	169,949
Carbon Tax, % diff from NAA	0.0%	1.5%	-1.3%	-8.6%	-16.0%	-23.4%	-31.3%	-39.2%	-46.8%	(308)	(1,443)	(133,650)	(84,487)
Net Zero	20,214	35,416	49,859	71,278	110,777	181,671	295,272	468,370	719,568	27,553	51,306	287,950	197,028
Net Zero, % diff from NAA	0.0%	-1.5%	-5.3%	-11.1%	-14.2%	-16.5%	-20.3%	-25.4%	-31.7%	(817)	(3,349)	(89,807)	(57,408)
Federal government debt as a share of GDP, %											Avg		
No Additional Action	97.0	101.2	99.7	103.8	114.6	132.9	155.8	180.3	206.3	98.5	101.0	147.5	129.9
IRA	97.0	102.1	101.5	103.8	111.5	125.7	143.5	161.4	179.8	98.8	102.3	136.6	123.4
IRA, % diff from NAA	-	1	2	(0)	(3)	(7)	(12)	(19)	(26)	0	1	(11)	(7)
Carbon Tax	97.0	100.3	97.6	94.4	95.7	100.7	104.8	106.5	104.3	96.2	98.3	101.4	100.0
Carbon Tax, % diff from NAA	-	(1)	(2)	(9)	(19)	(32)	(51)	(74)	(102)	(2)	(3)	(46)	(30)
Net Zero	97.0	97.8	96.4	95.8	102.6	115.1	127.3	136.7	140.4	94.6	97.3	119.9	111.2
Net Zero, % diff from NAA	-	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(4)	(4)	(28)	(19)

Sources: BEA , BLS, Census Bureau, FHFA, S&P, Moody's Analytics

Table 5: Clean Energy and Climate Policies in the Inflation Reduction Act of 2022

Static budget deficit effect, $ bil

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2022-2026	2022-2031
Net budget deficit effect	**-0.3**	**11.6**	**25.2**	**37.3**	**48.1**	**53.9**	**52.0**	**49.2**	**47.9**	**47.6**	**121.9**	**372.4**
Tax credits	**0.0**	**12.4**	**16.2**	**20.4**	**25.5**	**31.8**	**36.0**	**39.4**	**42.8**	**46.1**	**74.6**	**270.7**
Clean electricity and reducing carbon emissions	0.0	3.8	6.2	9.4	13.5	13.4	12.5	12.8	13.1	13.4	33.0	98.3
Incentives for clean electricity and clean transportation	0.0	0.0	0.0	0.6	1.3	6.9	11.1	13.0	15.2	17.6	1.9	65.6
Clean energy and efficiency incentives for individuals	0.0	2.4	2.9	4.0	4.4	4.5	4.5	4.6	4.7	4.8	13.7	36.9
Investment in clean energy manufacturing and energy security	0.0	3.2	3.9	3.7	4.0	4.2	4.4	4.8	4.7	4.1	14.7	36.9
Clean fuels	0.0	2.6	2.3	1.7	1.1	1.2	1.6	2.1	2.7	3.5	7.7	18.8
Clean vehicles	0.0	0.5	0.8	1.0	1.3	1.6	1.9	2.1	2.4	2.6	3.7	14.2
Direct spending	**-0.3**	**0.1**	**10.1**	**18.0**	**24.3**	**24.6**	**18.8**	**12.5**	**7.6**	**3.7**	**52.2**	**119.4**
Pollution	0.1	1.3	3.9	7.2	9.4	8.8	5.5	2.5	1.2	0.5	21.9	40.4
Agriculture	-0.4	-2.1	2.3	3.8	5.4	6.8	6.9	5.9	4.1	2.1	9.0	34.7
Energy	0.0	0.3	1.9	4.2	6.4	6.5	5.1	3.4	2.0	1.0	12.9	31.0
Natural resources	0.0	0.3	1.0	1.2	1.1	0.8	0.4	0.2	0.0	-0.0	3.6	5.0
Climate resilience	0.0	0.1	0.5	1.0	1.4	1.0	0.4	0.1	0.0	0.0	3.0	4.5
Federal procurement	0.0	0.2	0.4	0.6	0.7	0.7	0.6	0.4	0.3	0.1	1.9	4.0
Pay-fors	**0.0**	**-0.9**	**-1.2**	**-1.1**	**-1.7**	**-2.4**	**-2.8**	**-2.7**	**-2.6**	**-2.2**	**-4.9**	**-17.7**
Superfund	0.0	-0.9	-1.2	-1.3	-1.3	-1.3	-1.4	-1.4	-1.4	-1.5	-4.7	-11.7
Methane Emissions Reduction Program	0.0	0.1	0.2	0.3	-0.3	-0.9	-1.3	-1.2	-1.0	-0.6	0.3	-4.8
Other	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.5	-1.2

Sources: CBO, JCT, Moody's Analytics

Table 6: Clean Energy and Climate Policies in the Inflation Reduction Act of 2022

10-yr static budget deficit effect, $ bil

	2022-2026	2022-2031
Net budget deficit effect	**121.9**	**372.4**
Tax policies	**69.4**	**257.8**
Clean Electricity and Reducing Carbon Emissions	**33.0**	**98.3**
Extension and Modification of Credit for Electricity Produced from Certain Renewable Resources	11.8	51.1
Zero-Emission Nuclear Power Production Credit	9.1	30.0
Extension and Modification of Energy Credit	10.7	14.0
Extension and Modification of Credit for Carbon Oxide Sequestration	1.3	3.2
Incentives for Clean Electricity and Clean Transportation	**1.9**	**65.6**
Clean Electricity Investment Credit	0.5	50.9
Clean Electricity Production Credit	0.0	11.2
Clean Fuel Production Credit	1.4	2.9
Cost Recovery for Qualified Facilities, Qualified Property, and Grid Improvement Property	0.0	0.6
Clean Energy and Efficiency Incentives for Individuals	**13.7**	**36.9**
Extension of Residential Clean Energy Efficient Credit	6.7	22.0
Extension, Increase, and Modifications of Nonbusiness Energy Property Credit	5.8	12.5
Extension, Increase, and Modifications of New Energy Efficient Home Credit	0.9	2.0
Energy Efficient Commercial Buildings Deduction	0.2	0.4
Investment in Clean Energy Manufacturing and Energy Security	**14.7**	**36.9**
Advanced Manufacturing Production Credit	10.1	30.6
Extension of the Advanced Energy Project Credit	4.6	6.3
Clean Fuels	**7.7**	**18.8**
Credit for Production of Clean Hydrogen	2.0	13.2
Extension of Incentives for Biodiesel, Renewable Diesel and Alternative Fuels	5.6	5.6
Extension of Second Generation Biofuel Incentives	0.1	0.1
Sustainable Aviation Fuel Credit	0.0	0.0
Clean Vehicles	**3.7**	**14.2**
Clean Vehicle Credit	1.8	7.5
Credit for Qualified Commercial Clean Vehicles	0.9	3.6
Alternative Fuel Refueling Property Credit	0.6	1.7
Credit for Previously-Owned Qualified Plug-In Electric	0.5	1.3
Superfund	**-4.7**	**-11.7**
Reinstatement of Superfund	-4.7	-11.7
Other Provisions	**-0.5**	**-1.2**
Permanent Extension of Tax Rate to Fund Black Lung Disability Trust Fund	-0.5	-1.2
Direct spending	**52.5**	**114.6**
Agriculture	**9.0**	**34.7**
Conservation	**4.6**	**16.7**
Additional Agricultural Conservation Investments	4.1	15.3
Conservation Technical Assistance	0.5	1.4
Rural Development	**2.6**	**13.2**
Additional Funding for Electric Loans for Renewable Energy	0.5	1.0
Rural Energy for America Program	0.4	2.0
Biofuel Infrastructure and Agriculture Product Market Expansion	0.3	0.5
USDA Assistance for Rural Electric Cooperatives	2.7	9.6
Additional USDA Rural Development Administrative Funds	0.1	0.1
Farm Loan Immediate Relief for Borrowers With At-Risk Agricultural Operations	3.1	3.1
USDA Assistance and Support for Underserved Farmers, Ranchers, and Foresters	0.5	1.9
Repeal of Farm Loan Assistance	-5.0	-5.0
Forestry	**1.8**	**4.8**
National Forest System Restoration and Fuels Reduction Projects	0.6	2.1
Competitive Grants for Non-Federal Forest Landowners	0.3	0.5
State and Private Forestry Conservation Programs	0.8	2.0
Administrative Costs	0.1	0.1

Table 6: Clean Energy and Climate Policies in the Inflation Reduction Act of 2022 (Cont.)

10-yr static budget deficit effect, $ bil

	2022-2026	2022-2031
Housing and Defense Production Act of 1950	**0.7**	**1.5**
Enhanced Use of Defense Production Act of 1950	0.3	0.5
Improving Energy Efficiency or Water Efficiency or Climate Resilience of Affordable Housing	0.3	1.0
Climate Resilience	**2.3**	**3.6**
Investing in Coastal Communities and Climate Resilience	1.7	2.5
Facilities of the National Oceanic and Atmospheric Administration and National Marine Sanctuaries	0.1	0.2
NOAA Efficient and Effective Reviews	0.0	0.0
Oceanic and Atmospheric Research and Forecasting for Weather and Climate	0.2	0.2
Computing Capacity and Research for Weather, Oceans, and Climate	0.1	0.2
Acquisition of Hurricane Forecasting Aircraft	0.1	0.1
Alternative Fuel and Low-Emission Aviation Technology Program	0.2	0.3
Energy	**12.5**	**30.0**
Residential Efficiency and Electrification Rebates	**6.2**	**9.0**
Home Energy Performance-Based, Whole-House Rebates	2.5	4.3
High-Efficiency Electric Home Rebate Program	3.7	4.5
State-Based Home Energy Efficiency Contractor Training Grants	0.1	0.2
Building Efficiency and Resilience	**0.2**	**0.9**
Assistance for Latest and Zero Building Energy Code Adoption	0.2	0.9
DOE Loan and Grant Programs	**3.2**	**9.8**
Funding for Department of Energy Loan Programs Office	0.9	3.3
Advanced Technology Vehicle Manufacturing	0.4	0.9
Domestic Manufacturing Conversion Grants	1.0	2.0
Energy Infrastructure Reinvestment Financing	0.9	3.5
Tribal Energy Loan Guarantee Program	0.0	0.1
Electric Transmission	**0.3**	**2.3**
Transmission Facility Financing	0.0	1.5
Grants to Facilitate the Siting of Interstate Electricity Transmission Lines	0.2	0.7
Interregional and Offshore Wind Electricity Transmission Planning, Modeling, and Analysis	0.1	0.1
Industrial	**1.5**	**5.3**
Advanced Industrial Facilities Deployment Program	1.5	5.3
Other Energy Matters	**1.1**	**2.7**
Department of Energy Oversight	0.0	0.0
National Laboratory Infrastructure	0.9	2.0
Availability of High-Assay Low-Enriched Uranium	0.2	0.7
Natural Resources	**3.6**	**5.0**
Public Lands	**0.6**	**1.0**
National Parks and Public Lands Conservation and Resilience	0.2	0.3
National Parks and Public Lands Conservation and Ecosystem Restoration	0.2	0.3
National Park Service Employees	0.2	0.5
Drought Response and Preparedness	**3.0**	**4.2**
Drought Mitigation in the Reclamation States	2.6	3.6
Bureau of Reclamation Domestic Water Supply Projects	0.4	0.6
Canal Improvement Projects	0.0	0.0
Insular Affairs	**0.0**	**0.0**
Office of Insular Affairs Climate Change Technical Assistance	0.0	0.0
Offshore Wind	**-0.0**	**-0.2**
Leasing on the Outer Continental Shelf	-0.0	-0.2
Fossil Fuel Resources	**-0.3**	**-0.5**
United States Geological Survey	**0.0**	**0.0**
United States Geological Survey 3D Elevation Program	0.0	0.0
Other Natural Resources Matters	**0.0**	**0.0**
Department of the Interior Oversight	0.0	0.0
Environmental Reviews	**0.3**	**0.4**
Department of Energy	0.1	0.1
Federal Energy Regulatory Commission	0.1	0.1
Department of the Interior	0.1	0.2

Table 6: Clean Energy and Climate Policies in the Inflation Reduction Act of 2022 (Cont.)

10-yr static budget deficit effect, $ bil

	2022-2026	2022-2031
Environment and Public Works	**22.2**	**35.6**
Air Pollution	**17.3**	**24.2**
Clean Heavy-Duty Vehicles	0.3	1.0
Grants to Reduce Air Pollution at Ports	1.1	3.0
Greenhouse Gas Reduction Fund	12.8	20.0
Diesel Emissions Reductions	0.1	0.1
Funding to Address Air Pollution	0.3	0.3
Funding to Address Air Pollution at Schools	0.1	0.1
Low Emissions Electricity Program	0.1	0.1
Funding for Section 211(O) of the Clean Air Act	0.0	0.0
Funding for Implementation of the American Innovation and Manufacturing Act	0.0	0.0
Funding for Enforcement Technology and Public Information	0.0	0.0
Greenhouse Gas Corporate Reporting	0.0	0.0
Environmental Product Declaration Assistance	0.2	0.3
Methane Emissions Reduction Program	0.3	-4.8
Outlays	1.1	1.6
Revenue	-0.8	-6.4
Climate Pollution Reduction Grants	1.9	4.1
Environmental Protection Agency Efficient, Accurate, and Timely Reviews	0.0	0.0
Low-Embodied Carbon Labeling for Construction Materials	0.1	0.1
Hazardous Materials	**1.8**	**3.0**
Environmental and Climate Justice Block Grants	1.8	3.0
United States Fish and Wildlife Service	**0.2**	**0.3**
Endangered Species Act Recovery Plans	0.1	0.1
Funding for the United States Fish and Wildlife Service to Address Climate-Induced Weather Events	0.1	0.1
Council on Environmental Quality	**0.1**	**0.1**
Environmental and Climate Data Collection	0.0	0.0
Council On Environmental Quality Efficient and Effective Environmental Reviews	0.0	0.0
Transportation and Infrastructure	**2.8**	**8.1**
Neighborhood Access and Equity Grant Program	1.3	2.9
Assistance for Federal Buildings	0.1	0.3
Use of Low-Carbon Materials	0.5	2.1
General Services Administration Emerging Technologies	0.3	1.0
Environmental Review Implementation Funds	0.1	0.1
Low-Carbon Transportation Materials Grants	0.6	1.7
Federal Procurement	**1.9**	**4.0**
DHS Office of Chief Readiness Support Officer	0.4	0.5
United States Postal Service Clean Fleets	1.3	3.0
United States Postal Service	0.0	0.0
Government Accountability Office Oversight	0.0	0.0
Office of Management and Budget Oversight	0.0	0.0
FEMA Building Materials Program	0.1	0.1
Federal Permitting Improvement Steering Council Environmental Review Improvement Fund	0.2	0.4
Indian Affairs	**0.3**	**0.4**
Tribal Climate Resilience	0.2	0.2
Native Hawaiian Climate Resilience	0.0	0.0
Tribal Electrification Program	0.1	0.2
Emergency Drought Relief for Tribes	0.0	0.0

Sources: CBO, JCT, Moody's Analytics

Table 7: Carbon Tax Assumptions

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
Effective carbon tax, $ per ton of CO_2												**Avg price**	
No Policy Action	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Inflation Reduction Act	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Carbon Tax	0.5	90.4	185.6	379.7	779.1	1599.4	3285.0	3892.1	4374.7	55.2	203.5	2364.7	1543.4
Net Zero Carbon Tax	0.5	481.5	1167.8	2199.1	2577.9	2984.0	3420.8	3892.1	4374.7	270.5	1237.7	3233.0	2360.1
Carbon tax revenue, $ bil												**Avg revenue**	
No Policy Action	0.0	2.4	2.3	2.2	2.0	1.8	1.7	1.6	1.6	1.9	2.3	1.8	1.9
Inflation Reduction Act	0.0	1.9	1.8	1.7	1.5	1.4	1.4	1.3	1.3	1.8	1.8	1.4	1.6
Carbon Tax	0.0	348.7	632.8	1100.2	1803.3	2890.8	4614.1	4463.2	4232.4	220.2	666.3	3260.5	2237.7
Net Zero Carbon Tax	0.0	1437.8	2724.4	4047.7	3951.6	3853.2	3759.9	3565.6	3323.0	898.3	2747.7	3763.2	3136.1

Sources: EIA, Moody's Analytics

Table 8: Macroeconomic Impact of Climate Change

Comparison to No Policy Action scenario

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
Real GDP, 2012$ bil											**Avg annual growth**		
No Policy Action	18,385	24,239	29,850	36,143	43,627	52,417	62,719	74,916	88,491	2.80	2.02	1.81	1.98
Inflation Reduction Act	18,385	24,222	29,767	36,067	43,569	52,415	62,822	75,448	89,919	2.80	2.01	1.84	2.00
% difference with No Policy Action	0.0%	-0.1%	-0.3%	-0.2%	-0.1%	-0.0%	0.2%	0.7%	1.6%	(0.01)	(0.01)	0.04	0.02
Carbon Tax	18,385	24,319	29,545	35,578	42,750	51,431	62,038	75,454	92,153	2.8	1.9	1.9	2.0
% difference with No Policy Action	0.0%	0.3%	-1.0%	-1.6%	-2.0%	-1.9%	-1.1%	0.7%	4.1%	0.03	(0.10)	0.11	0.05
Net Zero	18,385	23,724	28,378	34,154	41,688	50,850	61,825	75,027	91,291	2.6	1.8	2.0	2.0
% Difference with No Policy Action	0.0%	-2.1%	-4.9%	-5.5%	-4.4%	-3.0%	-1.4%	0.1%	3.2%	(0.22)	(0.18)	0.18	0.04
Real GDP, 2012$ bil, % change											**Avg**		
No Policy Action	0.5	2.1	2.0	1.9	1.9	1.8	1.8	1.8	1.5	2.48	2.02	1.81	1.95
Inflation Reduction Act	0.5	2.1	2.0	1.9	1.9	1.9	1.8	1.9	1.6	2.47	2.01	1.84	1.97
% difference with No Policy Action	-	(0.03)	(0.01)	0.01	0.02	0.01	0.03	0.07	0.14	(0.01)	(0.01)	0.04	0.02
Carbon Tax	0.5	2.0	1.9	1.9	1.9	1.9	1.9	2.0	2.0	2.50	1.92	1.92	2.00
% difference with No Policy Action	-	(0.09)	(0.08)	(0.04)	(0.00)	0.05	0.10	0.24	0.55	0.02	(0.09)	0.12	0.05
Net Zero	0.5	1.9	1.9	1.9	2.0	2.0	1.9	2.0	2.0	2.27	1.85	1.98	1.99
% difference with No Policy Action	-	(0.18)	(0.12)	0.00	0.16	0.16	0.15	0.20	0.52	(0.21)	(0.17)	0.18	0.04
Employment, mil											**Avg annual growth**		
No Policy Action	142.1	160.2	166.7	172.6	176.5	179.5	180.6	178.9	177.1	1.2	0.4	0.1	0.3
Inflation Reduction Act	142.1	159.9	166.0	171.9	175.7	178.7	179.8	179.0	178.2	1.2	0.4	0.1	0.3
% difference with No Policy Action	0.0%	-0.2%	-0.4%	-0.4%	-0.5%	-0.5%	-0.5%	0.1%	0.6%	(0.02)	(0.01)	0.02	0.01
Carbon Tax	142.1	160.3	164.8	169.7	172.4	174.9	176.7	178.6	180.6	1.2	0.3	0.1	0.3
% difference with No Policy Action	0.0%	0.1%	-1.1%	-1.7%	-2.3%	-2.6%	-2.2%	-0.2%	2.0%	0.01	(0.09)	0.07	0.02
Net Zero	142.1	157.7	160.0	164.4	168.6	172.9	175.8	177.4	179.0	1.0	0.2	0.2	0.3
% difference with No Policy Action	0.0%	-1.6%	-4.0%	-4.8%	-4.5%	-3.7%	-2.7%	-0.8%	1.1%	(0.16)	(0.17)	0.12	0.01
Unemployment rate, %											**Avg**		
No Policy Action	8.1	3.9	3.9	3.6	3.5	3.7	4.0	4.0	5.2	4.3	3.8	3.9	3.9
Inflation Reduction Act	8.1	4.1	4.1	3.8	3.7	3.9	4.2	4.1	5.1	4.4	4.0	4.1	4.1
% difference with No Policy Action	-	0.1	0.2	0.2	0.2	0.2	0.2	0.1	(0.1)	0.0	0.2	0.2	0.2
Carbon Tax	8.1	3.9	4.3	4.2	4.3	4.4	4.5	4.4	4.5	4.3	4.3	4.4	4.4
% difference with No Policy Action	-	(0.1)	0.5	0.6	0.8	0.7	0.4	0.4	(0.7)	0.0	0.5	0.5	0.4
Net Zero	8.1	4.6	5.5	5.3	4.6	4.2	4.0	4.0	4.4	4.9	5.4	4.3	4.7
% difference with No Policy Action	-	0.6	1.7	1.7	1.1	0.5	(0.0)	0.0	(0.8)	0.6	1.6	0.4	0.7

Table 8: Macroeconomic Impact of Climate Change (Cont.)

Comparison to No Policy Action scenario

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
Real disposable income, 2012$											**Avg annual growth**		
No Policy Action	15,676	18,590	22,538	27,055	32,543	38,659	45,497	53,100	60,665	1.7	1.9	1.6	1.7
Inflation Reduction Act	15,676	18,612	22,561	27,160	32,806	39,130	46,242	54,440	63,209	1.7	1.9	1.7	1.8
% difference with No Policy Action	0.0%	0.1%	0.1%	0.4%	0.8%	1.2%	1.6%	2.5%	4.2%	0.01	0.01	0.08	0.05
Carbon Tax	15,676	18,519	22,121	26,338	31,441	37,276	44,125	52,257	61,965	1.7	1.8	1.7	1.7
% difference with No Policy Action	0.0%	-0.4%	-1.9%	-2.7%	-3.4%	-3.6%	-3.0%	-1.6%	2.1%	(0.04)	(0.12)	0.10	0.03
Net Zero	15,676	18,047	21,187	25,022	29,884	35,772	42,564	50,400	59,427	1.4	1.6	1.7	1.7
% difference with No Policy Action	0.0%	-2.9%	-6.0%	-7.5%	-8.2%	-7.5%	-6.4%	-5.1%	-2.0%	(0.30)	(0.25)	0.12	(0.03)
Consumer price index, % change											**Avg**		
No Policy Action	1.2	2.1	2.3	2.3	2.3	2.2	2.2	2.2	2.1	2.8	2.2	2.2	2.3
Inflation Reduction Act	1.2	2.1	2.3	2.3	2.3	2.2	2.3	2.3	2.2	2.8	2.3	2.2	2.3
% difference with No Policy Action	-	(0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0	0.0
Carbon Tax	1.2	2.2	2.3	2.3	2.4	2.3	2.4	2.2	2.3	3.0	2.3	2.3	2.4
% difference with No Policy Action	-	0.1	0.0	0.1	0.1	0.1	0.1	(0.0)	0.1	0.2	0.0	0.1	0.1
Net Zero	1.2	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.2	3.2	2.2	2.2	2.3
% difference with No Policy Action	-	0.0	(0.1)	(0.1)	(0.1)	0.0	0.0	0.0	0.1	0.4	(0.1)	(0.0)	0.0
Corporate profits, $, bil											**Avg annual growth**		
No Policy Action	1,908	3,630	5,259	7,665	11,408	16,905	25,230	38,445	59,800	6.6	3.8	4.2	4.4
Inflation Reduction Act	1,908	3,673	5,298	7,741	11,569	17,241	25,930	39,884	62,811	6.8	3.8	4.3	4.5
% difference with No Policy Action	0.0%	1.2%	0.7%	1.0%	1.4%	2.0%	2.8%	3.7%	5.0%	0.13	(0.01)	0.08	0.06
Carbon Tax	1,908	3,346	4,804	7,140	11,083	17,382	27,714	47,648	79,663	5.8	3.9	4.9	4.8
% difference with No Policy Action	0.0%	-7.8%	-8.6%	-6.9%	-2.8%	2.8%	9.8%	23.9%	33.2%	(0.87)	0.06	0.75	0.37
Net Zero	1,908	2,369	3,176	5,344	11,014	19,319	32,063	52,506	85,897	2.2	4.2	5.7	4.9
% difference with No Policy Action	0.0%	-34.7%	-39.6%	-30.3%	-3.5%	14.3%	27.1%	36.6%	43.6%	(4.46)	0.34	1.52	0.47
House prices (FHFA index)											**Avg annual growth**		
No Policy Action	460	657	963	1,445	2,257	3,453	5,260	8,084	12,283	3.6	4.0	4.4	4.2
Inflation Reduction Act	460	655	962	1,459	2,297	3,546	5,440	8,446	12,939	3.6	4.1	4.5	4.3
% difference with No Policy Action	0.0%	-0.3%	-0.1%	1.0%	1.8%	2.7%	3.4%	4.5%	5.3%	(0.03)	0.07	0.09	0.07
Carbon Tax	460	673	952	1,422	2,205	3,384	5,199	8,008	12,519	3.9	3.8	4.4	4.2
% difference with No Policy Action	0.0%	2.5%	-1.2%	-1.5%	-2.3%	-2.0%	-1.2%	-0.9%	1.9%	0.26	(0.21)	0.07	0.02
Net Zero	460	671	885	1,274	1,924	2,954	4,562	7,092	11,068	3.8	3.3	4.4	4.1
% difference with No Policy Action	0.0%	2.1%	-8.2%	-11.8%	-14.7%	-14.5%	-13.3%	-12.3%	-9.9%	0.22	(0.76)	0.05	(0.14)

Table 8: Macroeconomic Impact of Climate Change (Cont.)

Comparison to No Policy Action scenario

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2020-2030	2030-2050	2050-2100	2020-2100
S&P 500 Index											Avg annual growth		
No Policy Action	3,219	5,684	8,970	13,609	19,864	28,058	39,131	54,708	79,167	5.9	4.5	3.6	4.1
Inflation Reduction Act	3,219	5,728	9,073	13,728	20,098	28,542	40,177	57,863	85,960	5.9	4.5	3.7	4.2
% difference with No Policy Action	0.0%	0.8%	1.1%	0.9%	1.2%	1.7%	2.7%	5.8%	8.6%	0.1	0.0	0.2	0.1
Carbon Tax	3,219	5,290	8,299	12,999	19,671	29,610	45,219	72,963	119,569	5.1	4.6	4.5	4.6
% difference with No Policy Action	0.0%	-6.9%	-7.5%	-4.5%	-1.0%	5.5%	15.6%	33.4%	51.0%	(0.8)	0.1	1.0	0.5
Net Zero	3,219	4,049	5,880	9,637	17,711	30,287	48,161	74,771	117,309	2.3	4.4	5.1	4.6
% difference with No Policy Action	0.0%	-28.8%	-34.4%	-29.2%	-10.8%	7.9%	23.1%	36.7%	48.2%	(3.5)	(0.0)	1.5	0.5
Federal funds rate, %											Avg		
No Policy Action	0.4	2.3	2.8	2.8	2.8	2.7	2.5	2.6	1.9	1.9	2.7	2.6	2.5
Inflation Reduction Act	0.4	2.2	2.7	2.7	2.7	2.6	2.4	2.5	2.0	1.9	2.6	2.5	2.5
% difference with No Policy Action	-	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	0.0	(0.0)	(0.1)	(0.1)	(0.1)
Carbon Tax	0.4	2.4	2.5	2.4	2.4	2.4	2.4	2.3	2.3	2.0	2.4	2.4	2.3
% difference with No Policy Action	-	0.1	(0.3)	(0.3)	(0.4)	(0.3)	(0.1)	(0.2)	0.3	0.1	(0.3)	(0.2)	(0.2)
Net Zero	0.4	1.8	1.6	1.7	2.1	2.5	2.6	2.5	2.3	1.7	1.6	2.4	2.1
% difference with No Policy Action	-	(0.5)	(1.2)	(1.0)	(0.7)	(0.3)	0.1	(0.0)	0.4	(0.2)	(1.1)	(0.2)	(0.4)
10-yr Treasury yield, %											Avg		
No Policy Action	0.9	3.8	3.7	4.1	4.3	4.8	5.3	5.9	6.1	3.2	3.8	5.1	4.5
Inflation Reduction Act	0.9	3.7	3.7	4.1	4.3	4.8	5.2	5.5	5.8	3.2	3.8	4.9	4.4
% difference with No Policy Action	-	(0.0)	-	-	-	-	(0.1)	(0.4)	(0.3)	(0.0)	(0.0)	(0.1)	(0.1)
Carbon Tax	0.9	3.9	3.5	3.8	4.0	4.3	4.5	4.5	4.6	3.3	3.6	4.3	4.0
% difference with No Policy Action	-	0.1	(0.2)	(0.3)	(0.3)	(0.5)	(0.8)	(1.4)	(1.4)	0.1	(0.1)	(0.8)	(0.5)
Net Zero	0.9	3.5	2.9	3.3	3.8	4.5	5.1	5.4	5.6	3.3	3.1	4.7	4.1
% difference with No Policy Action	-	(0.2)	(0.8)	(0.8)	(0.5)	(0.2)	(0.2)	(0.5)	(0.5)	0.1	(0.7)	(0.4)	(0.4)

Sources: BEA , BLS, Census Bureau, FHFA, S&P, Moody's Analytics

About the Authors

Mark Zandi is chief economist of Moody's Analytics, where he directs economic research. Moody's Analytics, a subsidiary of Moody's Corp., is a leading provider of economic research, data and analytical tools. Dr. Zandi is a cofounder of Economy.com, which Moody's purchased in 2005.

Dr. Zandi is on the board of directors of MGIC, the nation's largest private mortgage insurance company, and is the lead director of Reinvestment Fund, one of the nation's largest community development financial institutions, which makes investments in underserved communities.

He is a trusted adviser to policymakers and an influential source of economic analysis for businesses, journalists and the public. Dr. Zandi frequently testifies before Congress and conducts regular briefings on the economy for corporate boards, trade associations, and policymakers at all levels. He is often quoted in national and global publications and interviewed by major news media outlets, and is a frequent guest on CNBC, NPR, Meet the Press, CNN, and various other national networks and news programs.

Dr. Zandi is the author of *Paying the Price: Ending the Great Recession and Beginning a New American Century*, which provides an assessment of the monetary and fiscal policy response to the Great Recession. His other book, *Financial Shock: A 360º Look at the Subprime Mortgage Implosion, and How to Avoid the Next Financial Crisis*, is described by the New York Times as the "clearest guide" to the financial crisis.

Dr. Zandi earned his BS from the Wharton School at the University of Pennsylvania and his PhD at the University of Pennsylvania.

Chris Lafakis is a director at Moody's Analytics. He oversees the Moody's Analytics climate risk initiative, and is responsible for climate modeling and scenario creation. He also has expertise in macroeconomics, energy economics, model development and model validation.

Based in West Chester PA, he also contributes to Economic View. Mr. Lafakis has been quoted by media outlets including The Wall Street Journal, CNBC, Bloomberg, and National Public Radio and often speaks at economic conferences and events. Mr. Lafakis received his bachelor's degree in economics from the Georgia Institute of Technology and his master's degree in economics from the University of Alabama.

Bernard Yaros is an assistant director and economist at Moody's Analytics focused primarily on federal fiscal policy. He is responsible for maintaining the Moody's Analytics forecast models for federal government fiscal conditions and presidential elections, as well as providing real-time economic analysis on fiscal policy developments coming out of Capitol Hill. Besides fiscal policy, Bernard covers the District of Columbia and Puerto Rico and develops forecasts for Switzerland.

Bernard holds an MSc in international trade, finance and development from the Barcelona Graduate School of Economics and a BA in political economy from Williams College.

About Moody's Analytics

Moody's Analytics provides financial intelligence and analytical tools supporting our clients' growth, efficiency and risk management objectives. The combination of our unparalleled expertise in risk, expansive information resources, and innovative application of technology helps today's business leaders confidently navigate an evolving marketplace. We are recognized for our industry-leading solutions, comprising research, data, software and professional services, assembled to deliver a seamless customer experience. Thousands of organizations worldwide have made us their trusted partner because of our uncompromising commitment to quality, client service, and integrity.

Concise and timely economic research by Moody's Analytics supports firms and policymakers in strategic planning, product and sales forecasting, credit risk and sensitivity management, and investment research. Our economic research publications provide in-depth analysis of the global economy, including the U.S. and all of its state and metropolitan areas, all European countries and their subnational areas, Asia, and the Americas. We track and forecast economic growth and cover specialized topics such as labor markets, housing, consumer spending and credit, output and income, mortgage activity, demographics, central bank behavior, and prices. We also provide real-time monitoring of macroeconomic indicators and analysis on timely topics such as monetary policy and sovereign risk. Our clients include multinational corporations, governments at all levels, central banks, financial regulators, retailers, mutual funds, financial institutions, utilities, residential and commercial real estate firms, insurance companies, and professional investors.

Moody's Analytics added the economic forecasting firm Economy.com to its portfolio in 2005. This unit is based in West Chester PA, a suburb of Philadelphia, with offices in London, Prague and Sydney. More information is available at www.economy.com.

Moody's Analytics is a subsidiary of Moody's Corporation (NYSE: MCO). Further information is available at www.moodysanalytics.com.

About Moody's Corporation

Moody's Analytics is a subsidiary of Moody's Corporation (NYSE: MCO). MCO reported revenue of $6.2 billion in 2021, employs more than 13,000 people worldwide and maintains a presence in more than 40 countries. Further information about Moody's Analytics is available at www.moodysanalytics.com.