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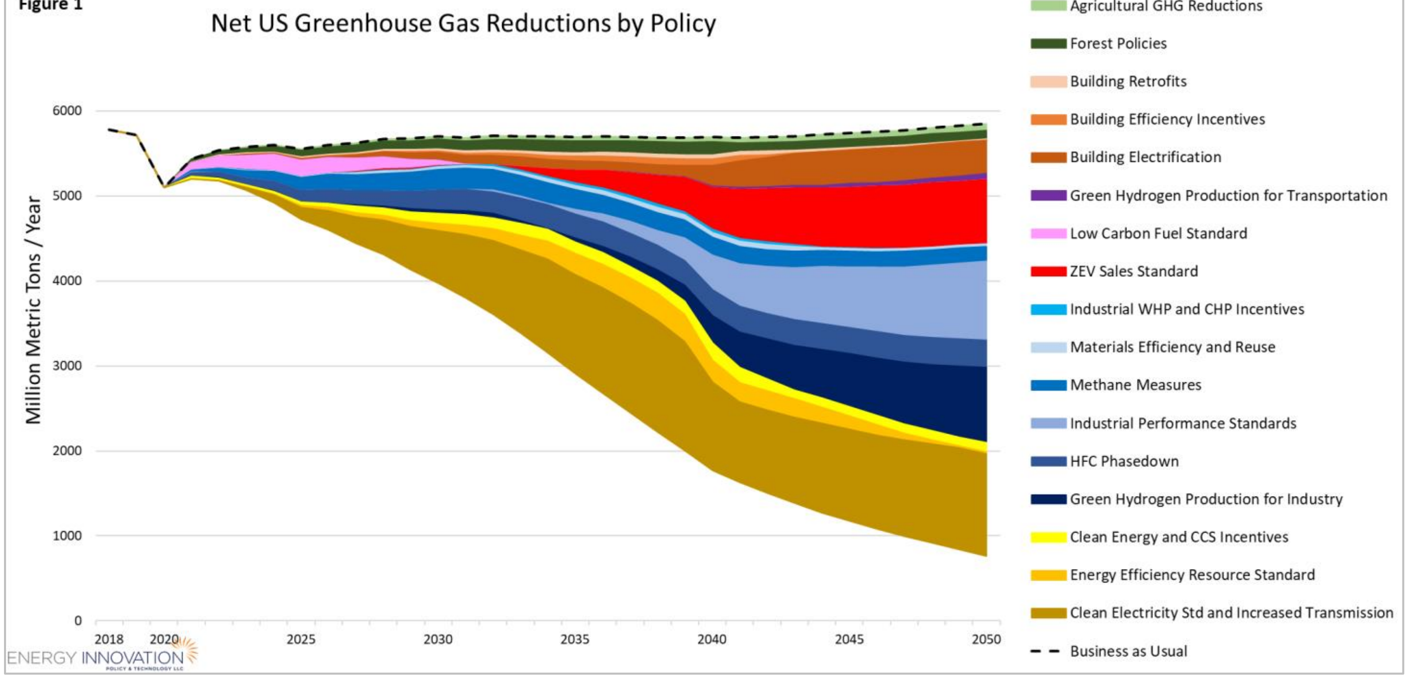
MODELING THE CLIMATE CRISIS ACTION PLAN

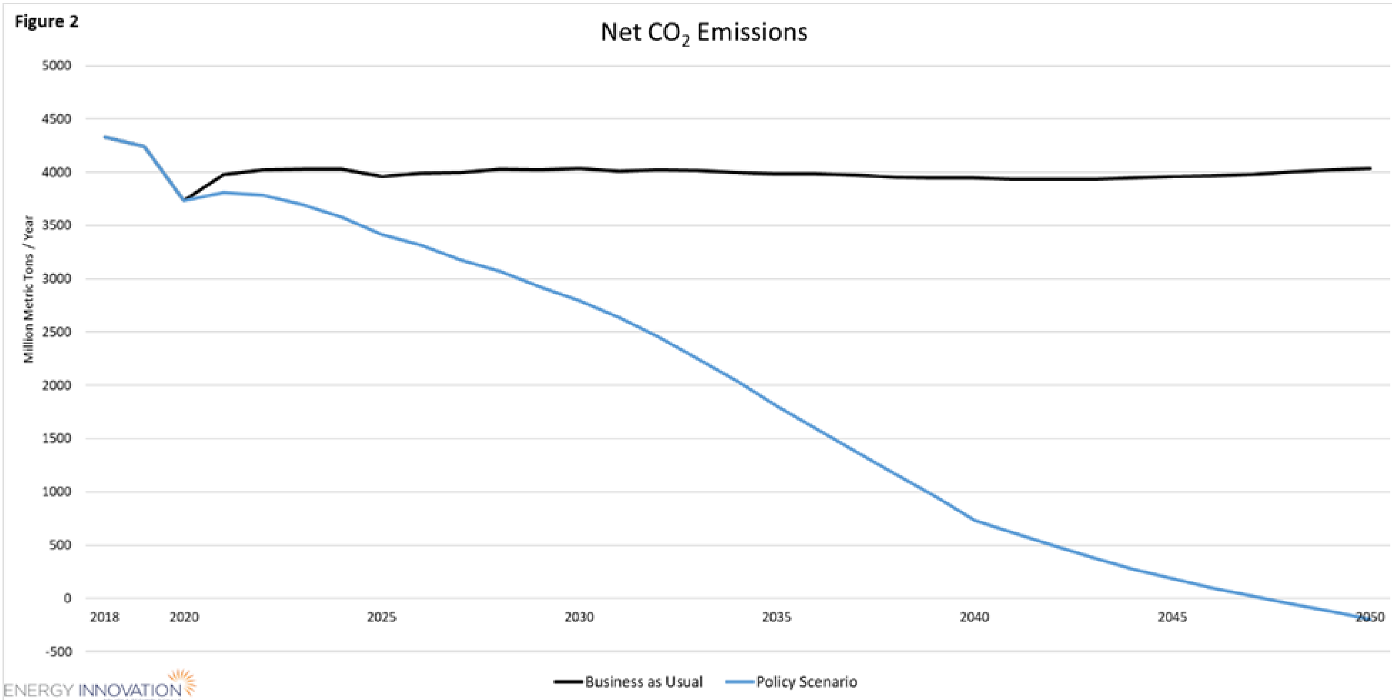
BY MEGAN MAHAJAN, ROBBIE ORVIS, AND SONIA AGGARWAL ● JUNE 2020

The U.S. House Select Committee on the Climate Crisis, created in January 2019, was tasked with delivering detailed and ambitious climate policy recommendations to Congress. In June 2020, these recommendations were released in *Solving the Climate Crisis: The Congressional Action Plan for a Clean Energy Economy and a Healthy, Resilient, and Just America*. Energy Innovation modeled a subset of the recommendations in the Energy Policy Simulator, finding the Climate Crisis Action Plan will lay the groundwork for net zero greenhouse gas emissions by 2050 while generating nearly $8 trillion in monetized health and climate benefits.

Figure 1



Energy Policy Simulator[1] estimates suggest that the subset of policies from the Climate Crisis Action Plan issued by the majority staff for the House Select Committee on the Climate Crisis outlined in this document could eliminate more than 1,700 million metric tonnes (MMT) of carbon dioxide equivalent (CO_2e) annually in 2030, reducing total United States greenhouse gas emissions 40 percent below 2005 levels and 37 percent below 2010 levels in 2030. These policies would eliminate more than 5,000 MMT of CO_2e annually in 2050, reducing total U.S. greenhouse gas emissions 89 percent below 2005 levels and 88 percent below 2010 levels in 2050,[2] while net carbon dioxide (CO_2) emissions would reach zero by 2048 (Figure 2).



[1] Energy Innovation used a custom version of the Energy Policy Simulator for this analysis.

[2] 2005 and 2010 emissions are taken from the 2019 U.S. National Inventory Submission to the United Nations Framework Convention on Climate Change. We use the 2015 National Inventory Submission to adjust forestry emissions because our data source for forecasted land use emissions uses this version of the inventory rather than the most recent inventory (which has significantly revised down emissions).

Moreover, the recommended policy package would generate significant health and climate benefits, avoiding 62,000 premature deaths annually by 2050 (Table 1) and totaling roughly $8 trillion (real 2018 U.S. dollars) by 2050 at a 3 percent discount rate (Table 2).[3] The Energy Policy Simulator calculates monetized health impacts per ton of pollutant reductions,[4] with benefits driven by mitigating PM2.5 emissions. We also present avoided premature mortality using the U.S. Environmental Protection Agency (EPA) value of a statistical life. Monetized climate benefits are calculated using the social cost of carbon for regulatory impact analysis under Executive Order 12866.

	2025	2030	2035	2040	2045	2050
Annual Avoided Premature Deaths (Thousand Lives)	6	16	28	41	52	62
Annual Monetized Health Benefits (Billion 2018 U.S. dollars)	59	144	256	383	482	577
Annual Monetized Climate Benefits (Billion 2018 U.S. dollars)	46	105	186	286	355	426

Table 1

[3] Or roughly $4 trillion (real 2018 U.S. dollars) at a 7 percent discount rate.

[4] As specified by the U.S. Environmental Protection Agency.

	Net Present Value through 2035 (3% discount rate)	Net Present Value through 2050 (3% discount rate)	Net Present Value through 2035 (7% discount rate)	Net Present Value through 2050 (7% discount rate)
Annual Monetized Health Benefits (Trillion 2018 U.S. dollars)	1.5	4.5	1.0	2.2
Annual Monetized Climate Benefits (Trillion 2018 U.S. dollars)	1.0	3.4	0.7	1.7

Table 2

MODELING DETAILS

The following table describes the assumptions going into the quantitative modeling shown above. The relative emissions contributions of each modeled policy must be considered with the important caveat that the size of any given policy's contribution would change if it were enacted in isolation or without these other policies. Unless otherwise specified, all policies are modeled beginning in 2021 and phased in linearly.

The modeling includes a subset of recommendations from the Climate Crisis Action Plan that include quantifiable benchmarks or for which existing literature could be used to make reasonable assumptions. The remaining policies were not included in this analysis. For example, the Select Committee majority staff articulated general principles for a carbon price in their recommendations but these were not modeled because they are qualitative, rather than quantitative, in nature.

Policy	Source for Policy Settings	Methodology
Electricity		
Clean energy standard	Clean Energy Standard Act of 2019 (H.R. 2597),	H.R. 2597 specifies the clean energy standard (CES) will take effect in the second full calendar year after enactment. Therefore, the CES is modeled as starting in 2022. We modify the growth rates of clean electricity growth, maintaining the quick ramp in to 60%

	modified to reach 100% clean electricity by 2040	clean, followed by a slower growth to 90% and an even slower growth to 100%. The CES grows by an additional 4.8% each year until hitting 60% in 2025. It then grows by roughly 3% each year until hitting 90% in 2034. After 2034, the CES grows by 1.8% each year, reaching 100% in 2040. Note that to hit this ambitious target, we are using a modified version of our model that lifts some deployment constraints for renewables, available here. In our business-as-usual case, we assume that roughly 40 gigawatts (GW) each of wind and solar can be built each year, in line with a recent S&P Global Market Intelligence report. This version assumes that a slightly higher maximum of 48 GW each of wind and solar can be built each year, which is only about three times the maximum U.S. build-out for those technologies in prior years. As a point of reference, the U.S. built 64 GW of natural gas in 2002.
Energy efficiency resource standard	American Energy Efficiency Act of 2019 (S. 2288)	S. 2288 specifies targets for electricity and natural gas savings through 2035, then requires successive standards to be set according to "the maximum achievable level of cost-effective energy efficiency potential." We use the U.S. Department of Energy's analysis of state level electric energy efficiency potential to implement the cost-effective electric energy efficiency potential in 2035, which we meet by specifying a percentage improvement in the energy efficiency of new building components. The Energy Policy Simulator assumes the same percentage improvement in efficiency across components of all fuel types, principally electricity and natural gas.
Extend clean energy tax credits for wind, solar, and geothermal	GREEN Act of 2020 (H.R. 7330), Sections 101, 102, and 105, with credits extended through 2050	We model an investment tax credit (ITC) worth 30% of capital costs for offshore wind, solar, and geothermal through 2050. We model 60% of the original production tax credit (PTC) for onshore wind through 2050, which amounts to $13.80 per megawatt-hour (MWh).
Expand clean energy tax	GREEN Act of 2020 (H.R. 7330), Section 102, with	Recent analysis from Wood Mackenzie projects that a storage ITC could boost battery storage deployment from 4.8 GW to 5.1 GW in 2024. We use this data to calculate an annual growth rate in battery storage, which we apply through 2050. This results in battery storage

credits for battery storage	credits extended through 2050	capacity of roughly 40 GW in 2050, compared to a business-as-usual projection of roughly 30 GW.
Extend 45Q credits	GREEN Act of 2020 (H.R. 7330), Section 103, with credits extended through 2050	We use a Clean Air Task Force study that forecasts the power sector could store 49 MMT CO_2 with carbon capture and storage (CCS) in 2030 with 45Q credits. For industrial CCS, we use a National Energy Technology Laboratory report. We assume the full potential of all industrial sources available for under $35/ton and model the equivalent tons CO_2 stored. We assume this 74 tons MMT CO_2 potential is met by 2030 and continues through 2050. Note that this policy is not coupled with the clean energy standard above, although H.R. 2597 does allow credits for power plants equipped with CCS. The effect on emissions is negligible though the power sector composition may be different.
Strengthen transmission system	Remove barriers to new transmission	We model better utilization of the existing transmission system and the addition of new transmission as a 30% growth of transmission capacity, in line with the transmission added in NREL's Reducing Wind Curtailment through Transmission Expansion in a Wind Vision Future study.
Transportation		
GHG emissions standards for LDVs and HDVs	CLEAN Future Act discussion draft, Section 401	Section 401 specifies vehicle emissions standards until 2030 for light-duty vehicles (LDVs) and 2032 for heavy-duty vehicles (HDVs), then requires standards to strengthen at levels in line with a net zero emissions by 2050 target. Because of the zero-emission vehicle (ZEV) sales standards outlined below, our modeling finds the specified emissions standards are met through 2030 for LDVs and 2032 for HDVs due to electrification alone, given the corporate average fuel economy credit manufacturers receive for sales of all-electric vehicles. Because vehicles take many years to turn over, meeting a net zero emissions by 2050 target requires a rapid phase out of gasoline and diesel vehicle sales. Starting in 2031 for LDVs and 2033 for HDVs (the years immediately following the end-date of the specified vehicle emissions standards), we rapidly increase ZEV sales standard requirements as specified below to meet net zero by 2050.

ZEV sales standard - LDVs	Zero-Emission Vehicles Act of 2019 (H.R. 2764) and CLEAN Future Act, Section 401	Per H.R. 2764, we set a 50% ZEV sales standard for 2030 (and assume the fraction ZEV sales ramps up linearly starting in 2021). We then set a 100% ZEV sales standard by 2035 in line with the net zero emissions by 2050 target outlined in the GHG emissions standard policy above. We assume the sales standard is met 100% with electric vehicles (EVs), i.e., no hydrogen or plug-in hybrid EVs. Note that given the average lifetime of LDVs in our model, 100% EV sales by 2035 results in 100% EVs in the vehicle stock by 2050 (in line with net zero emissions). However, achieving a 100% EV LDV stock by 2050 likely requires 100% EV sales by an earlier date, given the wide distribution of vehicle lifetimes.
ZEV sales standard - HDVs	30% ZEV standard by 2030	We model a 30% ZEV sales standard for medium- and heavy-duty trucks by 2030 (and assume the fraction ZEV sales ramps us linearly starting in 2021). By 2030, 25% of truck sales are electric and 5% are hydrogen, to reflect the fact that hydrogen technologies are likely to take more time to commercialize. We then set a 100% ZEV sales standard by 2040 in line with the net zero emissions by 2050 target outlined in the GHG emissions standard policy above. By 2040, we assume 50% of medium- and heavy-duty truck sales are electric and 50% are hydrogen. Note that we pair hydrogen HDVs with fully shifting hydrogen production to use electrolysis (separating water using electricity), which when coupled with the 100% CES results in zero carbon (green) hydrogen. In the U.S. today (and projected through 2050 in our Business-as-Usual scenario), by contrast, roughly 95% of hydrogen is produced via steam reforming of natural gas and only 5% is produced via electrolysis. The conversion to electrolysis is represented as a separate wedge in the summary graphic above.
EV tax credits for LDVs	Driving America Forward Act (H.R. 2256)	Given the aggressive ZEV standard ramp-up, setting these increases in EV tax credits has no additional emissions impact when modeled. Of course, it saves costs for consumers.
EV tax credits for heavy duty trucks	Green VAN Act of 2019 (H.R. 5162)	

<table>
<tr><td>Low carbon fuel standard</td><td>California LCFS (California Code of Regulations title 17)</td><td>We model the California low carbon fuel standard (LCFS), which applies to all vehicles (except aviation, because jet fuel is excluded). However, the Climate Crisis Action Plan does include recommendations on aviation such as including aviation fuels in the LCFS, which are not included in this analysis.

The policy requires a 20% reduction in the carbon intensity of transportation fuels by 2030. This policy is responsible for emissions reductions through about 2030, at which point the wedge for the ZEV standards pictured in the summary graphic above takes over. This reflects how the LCFS drives biofuels use in early years.</td></tr>
<tr><td colspan="3">Buildings</td></tr>
<tr><td>Homeowner investments in energy efficiency</td><td>GREEN Act of 2020 (H.R. 7330), Section 301, with credits extended through 2050</td><td rowspan="2">We use DOE's analysis of state level electric energy efficiency potential to implement the cost-effective electric energy efficiency potential for residential buildings in 2035 given incentives of $20/MWh (roughly equivalent to a $300 incentive for an electric heat pump), which we meet by specifying a percentage improvement in the energy efficiency of new building components. The Energy Policy Simulator assumes the same percentage improvement in efficiency across components of all fuel types.</td></tr>
<tr><td>Tax credits for energy efficiency in affordable housing</td><td>Affordable Housing Credit Improvement Act of 2019 (H.R. 3077), with credits extended through 2050</td></tr>
<tr><td>Commercial investments in energy efficiency</td><td>GREEN Act of 2020 (H.R. 7330), Section 303, with credits extended through 2050</td><td>We use DOE's analysis of state level electric energy efficiency potential to implement the cost-effective electric energy efficiency potential for commercial buildings in 2035 given incentives of $20/MWh, which we meet by specifying a percentage improvement in the energy efficiency of new building components. The Energy Policy Simulator assumes the same percentage improvement in efficiency across components of all fuel types.</td></tr>
<tr><td>Tax credits for builders of new</td><td>GREEN Act of 2020 (H.R. 7330),</td><td>The GREEN Act specifies credits for new homes with annual energy consumption 15% below homes constructed in accordance with the 2018 International Energy Conservation Code.</td></tr>
</table>

energy efficient homes	Section 304, with credits extended through 2050	Because of the significant code improvements modeled in the 'state and local building code adoption' below, we assume codes drive emissions reductions while tax credits make it more cost effective for consumers. Therefore, we don't assign any emissions reductions to this policy explicitly.
Rebates for home energy retrofits	HOMES Act, as included in Moving Forward Act (H.R. 2, Sections 33201 - 33207)	The HOMES Act, as included in H.R. 2, specifies $1 billion for each year from 2021 through 2025. Per the bill, we assume $4,000 per retrofit, which will go toward 250,000 home retrofits each year given the amount of program funding (note that this policy will not have a large impact without additional funding). We then take the average home retrofit cost and the cost per BTU energy saved from a LBNL study to calculate the energy savings. We extend this program through 2050.
Energy efficiency in federal facilities	Federal Energy and Water Management Performance Act of 2020 (H.R. 5650)	We approximate the fraction of energy use by federal buildings by applying the share of commercial buildings owned by the federal government and public housing to overall energy demand in buildings. This equates to 3% of commercial buildings and 2% of residential buildings. We then assume enough efficiency to decrease this demand by 2.5% each year, relative to 2018 energy use by these buildings.
Building electrification	Assume enough point of sale rebates to achieve 100% all electric new buildings and appliances by 2035	We model 100% of building component sales as electric by 2035. This applies to both new buildings and building components sold to replace equipment in existing buildings. This setting covers both point of sale rebates and net zero building requirements for new buildings – which would push a portion of states to require all-electric components in new homes by 2030, in addition to new federal buildings.
State and local building code adoption	Assume states that have adopted at least the ASHRAE 90.1-2007 or the 2009	

<table>
<tr><td></td><td>IECC for residential buildings adopt net zero emissions codes by 2030</td><td rowspan="2"></td></tr>
<tr><td>Net zero emission federal buildings</td><td>Assume new federal buildings required to be net zero by 2030</td></tr>
<tr><td colspan="3">Industry</td></tr>
<tr><td>Tradable performance standards for industry</td><td>Assume emissions intensity benchmarks in line with net zero emissions by 2050</td><td rowspan="3">We model full fuel switching from fossil fuels to electrification and hydrogen use in industry by 2050. We first estimate the potential for electrification by industry based on an analysis by the National Renewable Energy Laboratory and then converted the remaining non-electricity fuel consumption to hydrogen. The fuel switching setting incorporates both the emissions intensity benchmarks in line with net zero emissions by 2050 and the low emission heat standard, which separately requires fuel switching for the oil and gas sector.

We pair industrial fuel switching with fully shifting hydrogen production to use electrolysis (separating water using electricity), which when coupled with the 100% CES results in zero carbon (green) hydrogen. In the U.S. today (and projected through 2050), by contrast, roughly 95% of hydrogen is produced via steam reforming of natural gas and only 5% is produced via electrolysis. This is modeled as a separate wedge in the summary graphic above.

The “Industry performance standards” wedge pictured above also includes an efficiency component. A DOE report suggests industrial facilities could double their rate of energy efficiency improvement, which would cut cement energy use by roughly 23% by 2050, steel energy use by roughly 8%, and other industry roughly 16%. We take this as the maximum improvement for the covered industries.</td></tr>
<tr><td>Low emission heat standard</td><td>Assume same policy stringency as in the Insights from the California Policy Simulator report</td></tr>
<tr><td>Federal Buy Clean and industrial</td><td>CLEAN Future Act discussion draft, Section 521, but applied to all</td></tr>
</table>

performance-based standard	domestic manufacturing facilities for covered products	The CLEAN Future Act specifies that in certain years, targets will be set that must be achievable by a certain fraction of covered industries (80% of facilities in 2025-2029, 70% in 2030-2034, 60% in 2035-2039, and 50% in 2040 and beyond). We assume that products' embedded carbon values are distributed across a range, with some facilities showing no improvement and other facilities able to meet our calculated maximum rate of improvement. We can therefore exclude the lowest-performing facilities by assuming the covered industries as a whole only achieve a portion of the maximum improvement. For example, 80% of covered products must meet the target in 2025-2029. We therefore multiply the maximum energy savings in 2025-2029 by 20%, to represent that the lowest-performing 20% of products are excluded. For the cement industry, we also assume CO_2 reductions from substituting inputs such as fly ash for a portion of the clinker in cement. We assume the maximum identified potential for cement clinker substitution by 2050.
Product recyclability	Assume new regulations enacted	"Sustainable Materials Without the Hot Air: Making Buildings, Vehicles and Products Efficiently and with Less New Material," by Allwood and Cullen and a report from Industrial Transformation 2050 identify the potential for better product efficiency, recyclability, and reuse to cut product demand by up to 65%, depending on the specific industry. We model a 10% demand reduction in iron/steel and chemicals by 2050, as well as a 5% demand reduction in cement.
Tax credits for CHP and WHP	Renewable Energy Extension Act of 2019 (H.R. 3961) and Waste Heat to Power Investment Tax Credit Act of 2019 (H.R. 5155)	To model the impact of expanding tax credits for combined heat and power (CHP), we use EIA data for CHP projections, which incorporate tax credits through 2022. We find the average growth rate through 2022 and apply this through 2050. For waste heat to power, we assume tax credits will result in the uptake of all potential projects with a payback period of less than five years. We assume a 100% capacity factor of collection for these projects. Together, these measures equate to 28% of the potential for industrial cogeneration and waste heat recovery by 2050 in the EPS, taken from a study by Rocky Mountain Institute.
Oil and Gas		

Methane emissions from oil and gas	CLEAN Future Act discussion draft, Section 701	We model the maximum potential for abatement of methane from the oil and gas sector, as projected by the EPA, by 2030 and continue the maximum abatement through 2050. Note that decreased natural gas use due to other policies in this policy package leads to additional emissions reductions. Together, this equates to annual emissions reductions of nearly 360 MMT in 2050. Although this is less abatement than specified by the CLEAN Future Act, we opt to use the EPA data as an objective source for the maximum level of ambition.
HFC phase down in line with Kigali	American Innovation and Manufacturing Leadership Act of 2020 (H.R. 5544)	We recreate the analysis from Velders et al. with current emissions projections to determine hydrofluorocarbon emissions reductions resulting from the Kigali phase-down schedule.
Agriculture		
Implement climate smart agricultural practices	Assume climate smart practices which can abate 200 MMT per year according to World Resources Institute	We model 100% of the potential to abate non-CO_2 greenhouse gases from crop and rice lands by 2050, as identified by the EPA. Note that this equates to roughly 70 MMT emissions reductions in 2050, less than the 200 MMT projected by World Resources Institute.
Implement livestock measures	Assume advanced grazing management and support for anaerobic digesters	We model the maximum abatement potential for intensive grazing and various feed practices by 2050, as projected by the EPA. To represent financial support for large-scale anaerobic digesters, we also model deployment of the fraction of these technologies available for under $50 per MMT CO_2e abated.
Natural Climate Solutions		

<table>
<tr><td>Reforesting /restoring forests</td><td>Assume reforestation and restoration of 330 million acres of forest by 2040</td><td rowspan="2">Our model caps the land area available for reforestation based on research from the Congressional Research Service. It assumes the maximum acreage available for reforestation in any one year is equal to 0.1% of the contiguous 48 states’ land area. Using this maximum setting is not enough to reforest the entire acreage specified by these proposals. Therefore, we assume the remaining acreage covered by these policies is forests enrolled in best management practices. By 2040, these policies equate to 40 million acres of land reforested and 335 million acres brought under best forest management practices.</td></tr>
<tr><td>Reforesting historically forested lands</td><td>Assume reforestation of 40 to 50 million acres of federal and nonfederal land by 2030</td></tr>
<tr><td>Forest Legacy Program and Community Forest and Open Space Program</td><td>Assume enrollment of 1 million acres of private forestland in the Forest Legacy Program and the Community Forest and Open Space Program by 2030</td><td>We model 1 million acres of forested land set aside under these conservation programs by 2030.</td></tr>
</table>

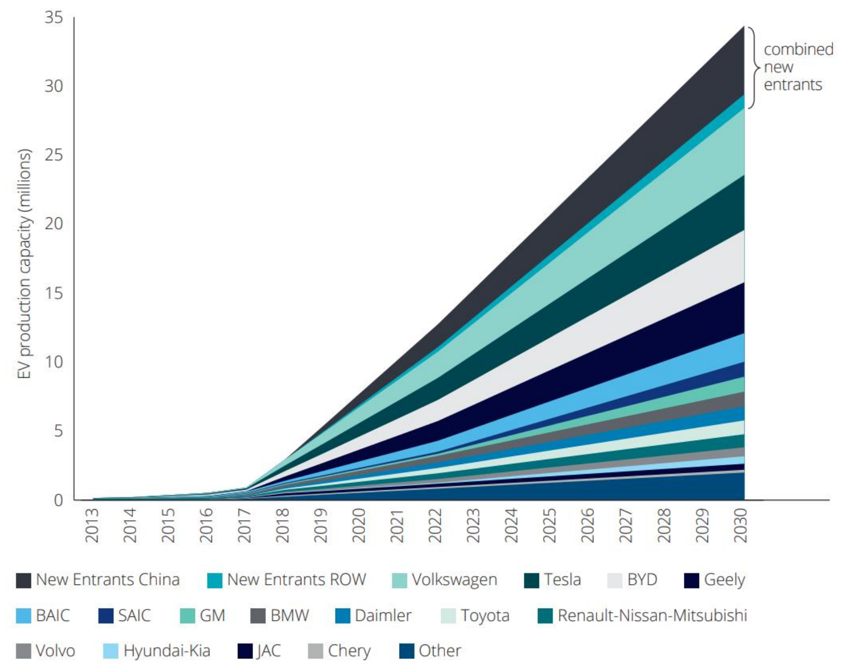
APPENDIX I: NOTES ON AMBITIOUS POLICIES

TRANSPORTATION ELECTRIFICATION

In order to fully decarbonize passenger vehicle travel given the average lifetime of vehicles, all newly sold passenger cars need to be electrified by around 2035. However, hitting this target presents challenges to scaling electric vehicle (EV) production. Global EV manufacturing capacity is currently limited but is expected to grow significantly in the next decade – from fewer than 10 million EVs per year to roughly 35 million in 2030, as pictured below. However, this projected capacity will be spread across the world and potentially cater to other markets (for example, several of the most prominent manufacturers are focused on the Chinese market). Other countries are also expected to set aggressive electric vehicle goals. As with any rapid scale-up of a new industry, supply chain issues could present delays.

For context, we project nearly 22 million light-duty EVs sold in the U.S. in 2035 in this modeling scenario. Given today's projections, this would be a significant share of global EV manufacturing capacity in that year. Even if the U.S. were to drastically ramp up its EV manufacturing capacity, increased output would likely meet only a portion of vehicle demand. The Select Committee's recommendations recognize the need to increase U.S. manufacturing of EVs and identify key policies to do so.

Figure 6. Electric vehicle production forecast of major OEMs and new entrants



Source: Deloitte analysis, IHS (2018), CAAM, IEA, wattev2buy, evobsession, Gasgoo AutoNews, Cleantechnica, SinaAuto, Xinhuanews, Yiche, ifeng

Source: Deloitte. *New market. New entrants. New challenges. Battery Electric Vehicles.*

BUILDING ELECTRIFICATION

The Energy Policy Simulator suggests it is *very challenging* to achieve 100 percent market transformation with only incentives. While efficiency subsidies are an effective and demonstrated policy mechanism, there is much less published research on the effectiveness of subsidies for fuel switching/electrification. For example, consider that existing federal and state EV tax credits[5] have not driven significant vehicle electrification in most states despite the fact they often cover at least a quarter of the vehicle cost. We recommend a combination of incentives like rebates with performance standards, which help capture savings where economic signals fail due to market barriers. The Select Committee's recommendations include building performance standards, but they were not included in the modeling.

INDUSTRIAL FUEL SWITCHING

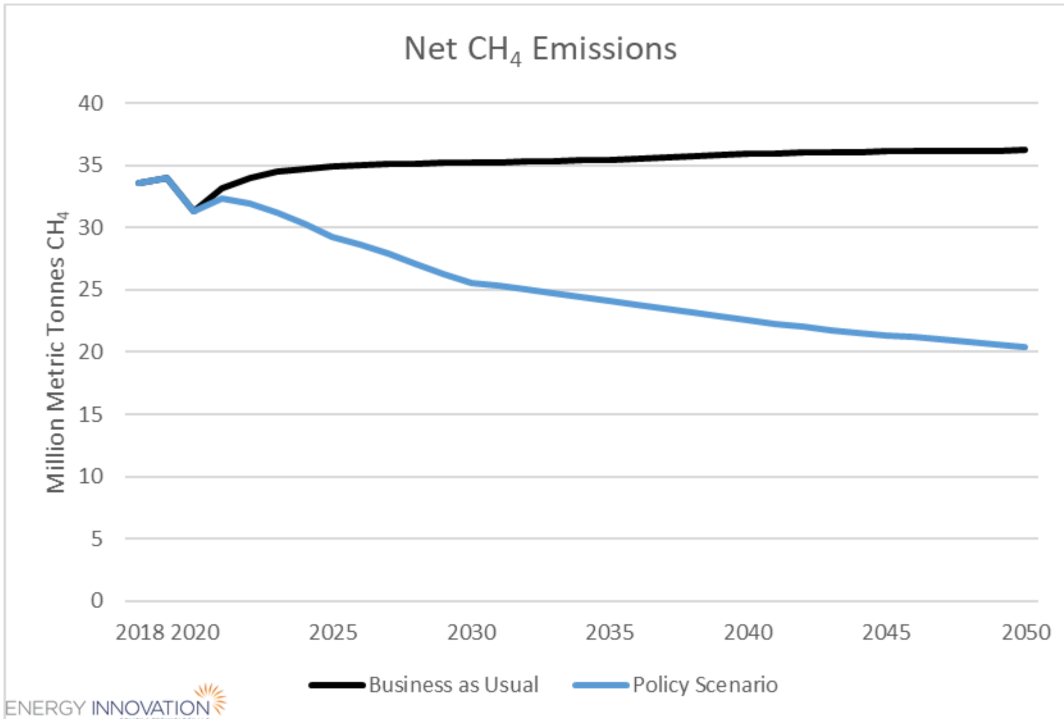
Federal options for industrial decarbonization are less established than in other sectors of the economy, where the path to zero emissions is clearer. Much more research is needed on the exact pathways to net zero industry. Driving emissions from industrial fuel consumption to zero will likely take a combination of policies and new technology options, and we are not aware of any proposed legislation or examples from other countries that would bring the U.S. close to this goal. We strongly support emissions intensity standards that ramp up to zero emissions by 2050, but recognize the inherent challenges given today's technology and economics. Strong standards like these would need to be complemented with support for R&D, demonstration facilities, and subsidy programs to support the industrial transition. The Select Committee's recommendations include these policies.

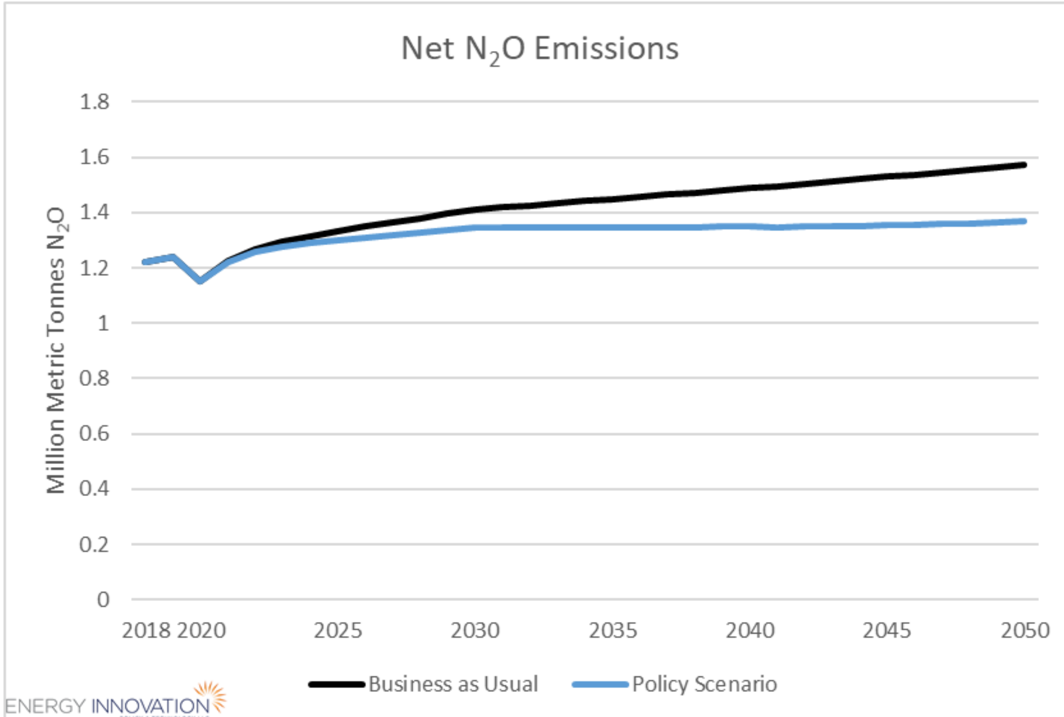
Note that this modeling scenario assumes fuel switching to electricity and green hydrogen, as those are widely considered promising options for industrial decarbonization. However, if other technologies or fuel sources becomes commercially available, these could be used instead. In that case, the Green Hydrogen Production for Industry wedge pictured in the summary graphic above would be smaller and the size of a different wedge would grow.

[5] $7,500 federal tax credit, with higher credits in some states

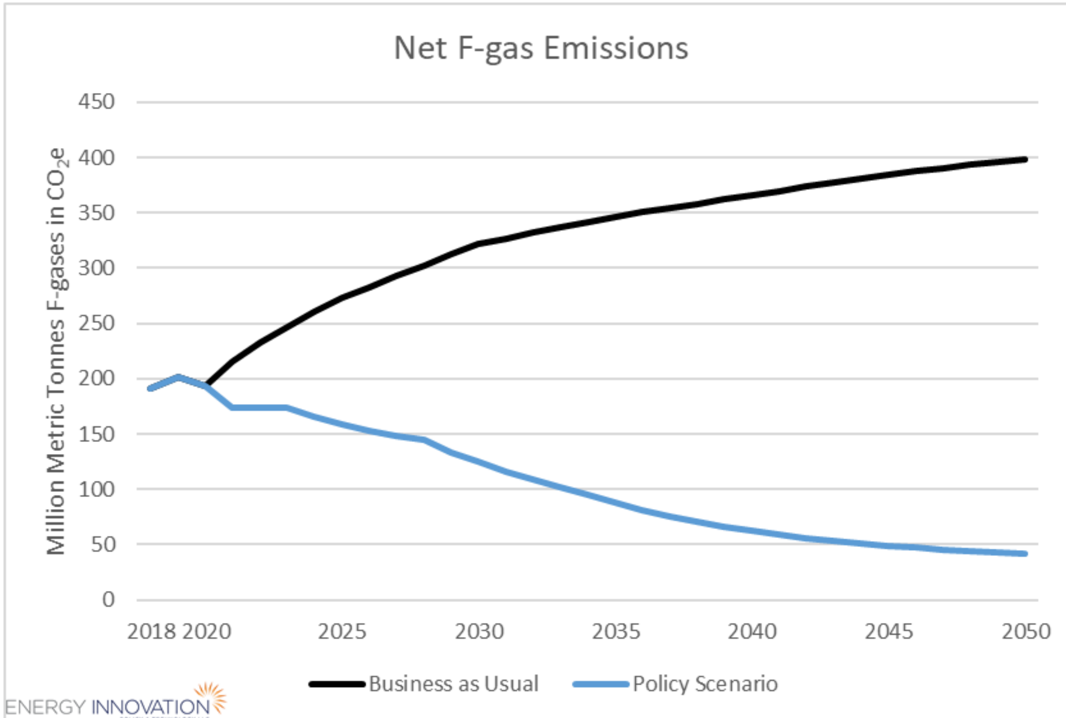
APPENDIX II: ADDITIONAL EMISSIONS BY POLLUTANT

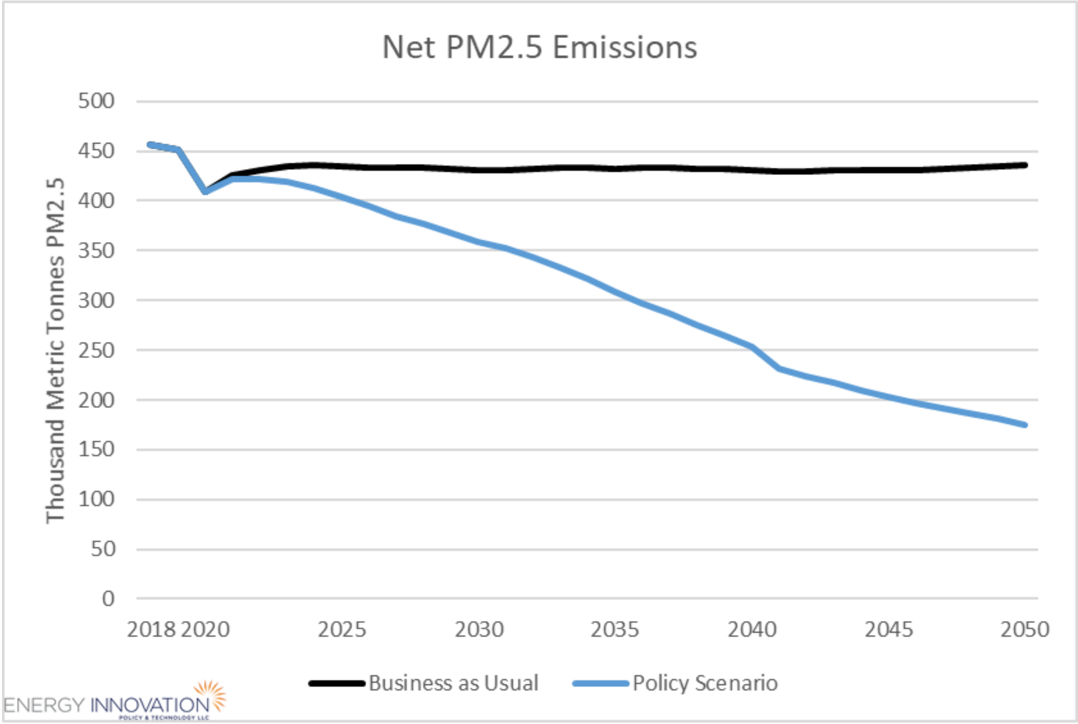
Emissions of CO_2e and CO_2 and presented in Figures 1 and 2. Here, we present emissions reductions by all other pollutants tracked in the EPS.

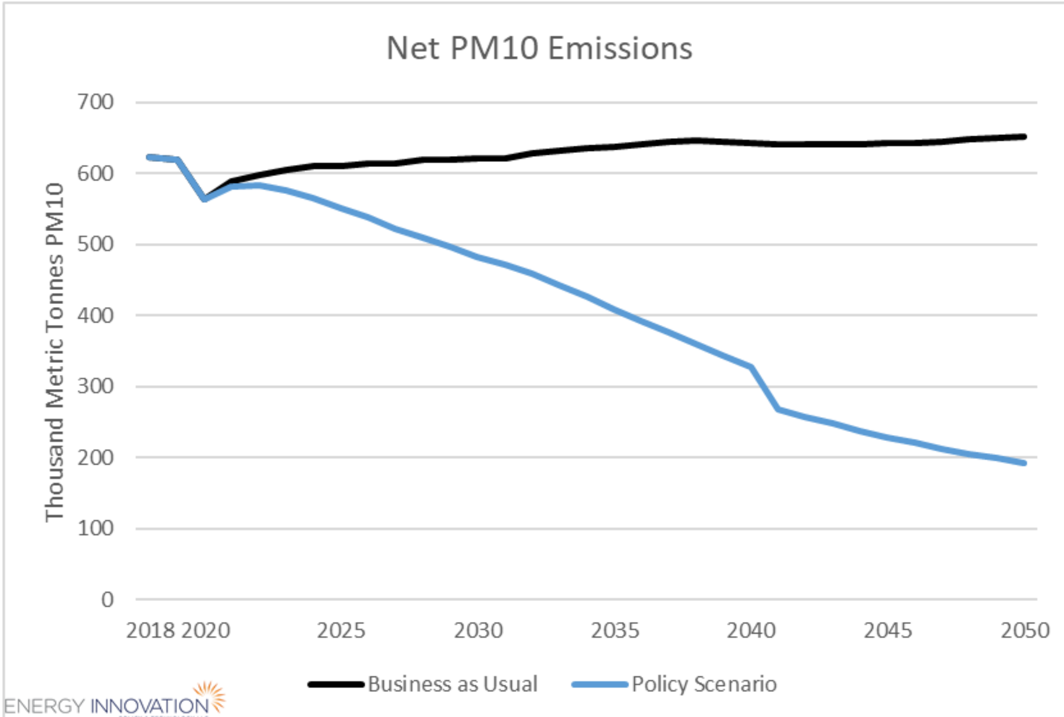


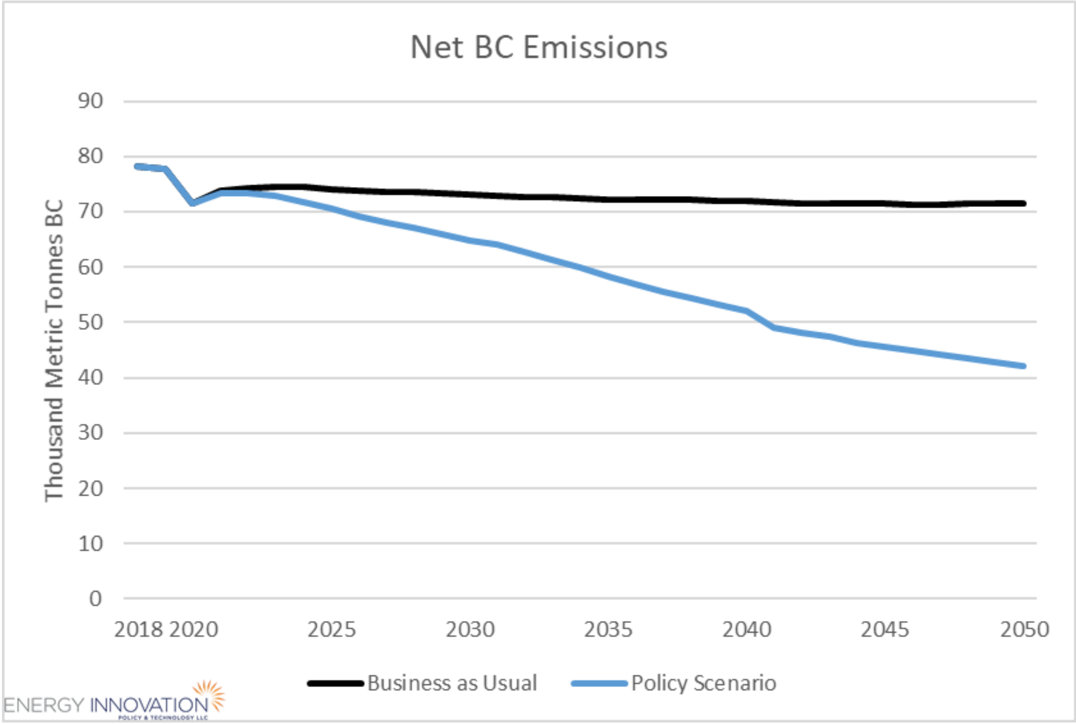


Net N_2O Emissions
Million Metric Tonnes N_2O
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION

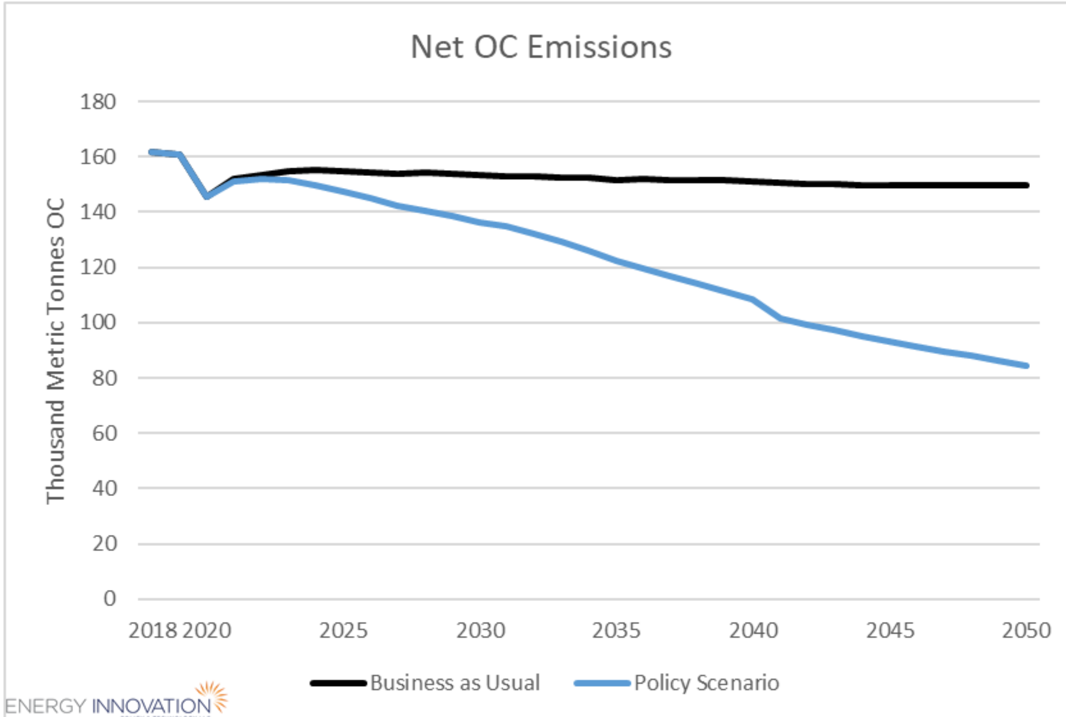

Net F-gas Emissions
Million Metric Tonnes F-gases in CO2e
450
400
350
300
250
200
150
100
50
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION


Net PM2.5 Emissions
Thousand Metric Tonnes PM2.5
500
450
400
350
300
250
200
150
100
50
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION

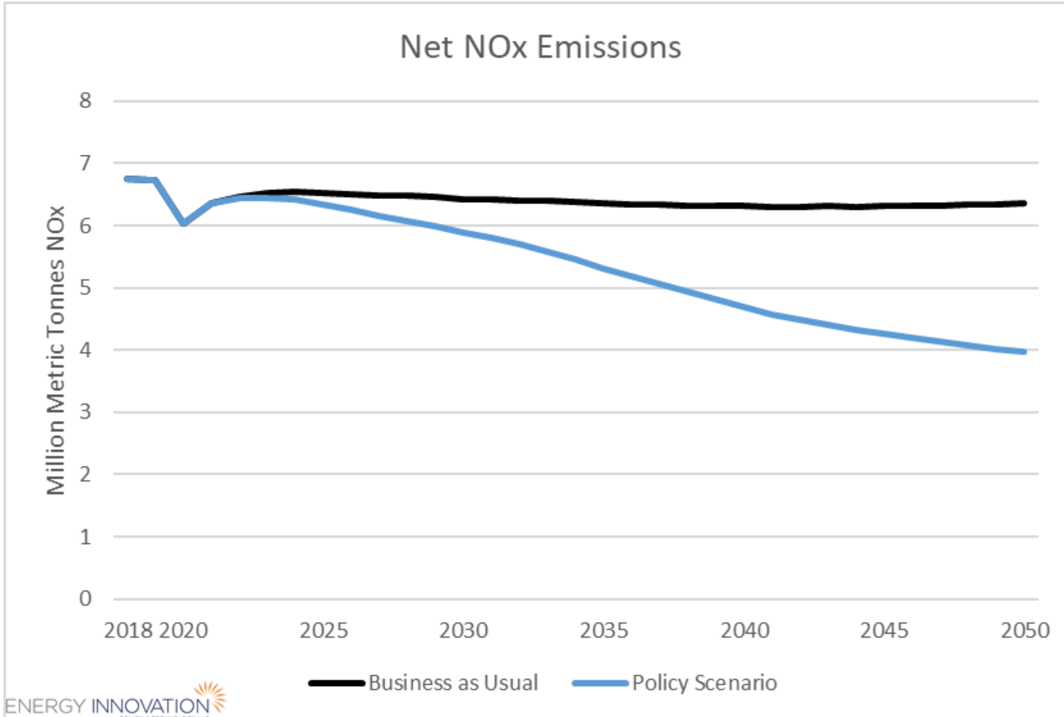

Net PM10 Emissions
Thousand Metric Tonnes PM10
700
600
500
400
300
200
100
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION

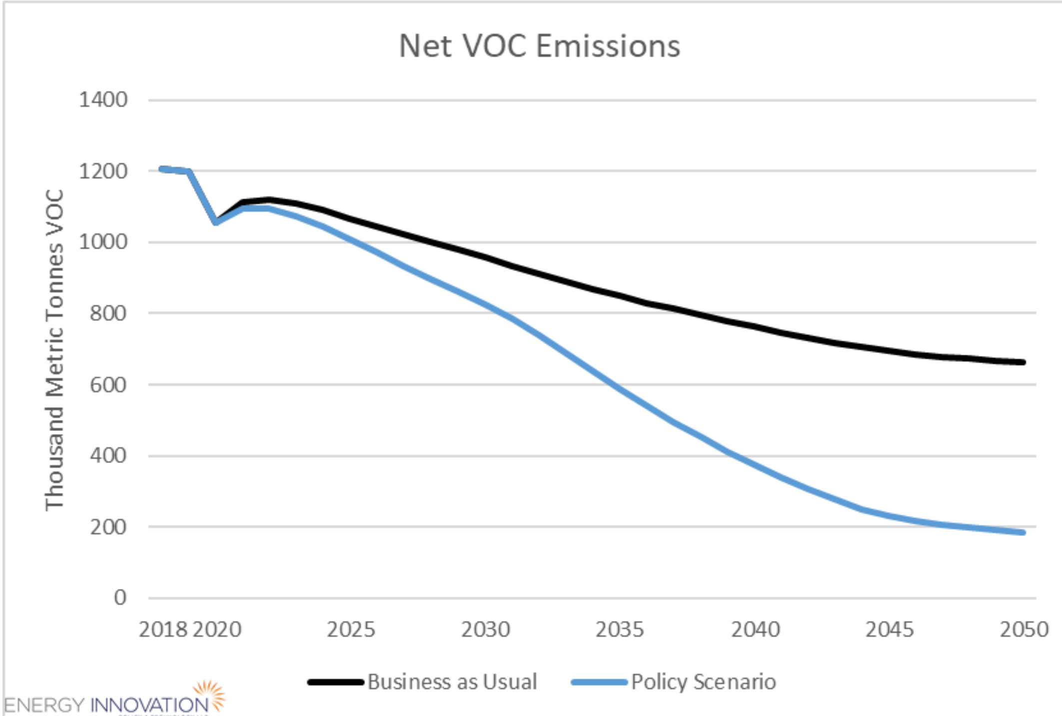


Net BC Emissions
Thousand Metric Tonnes BC
90
80
70
60
50
40
30
20
10
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION

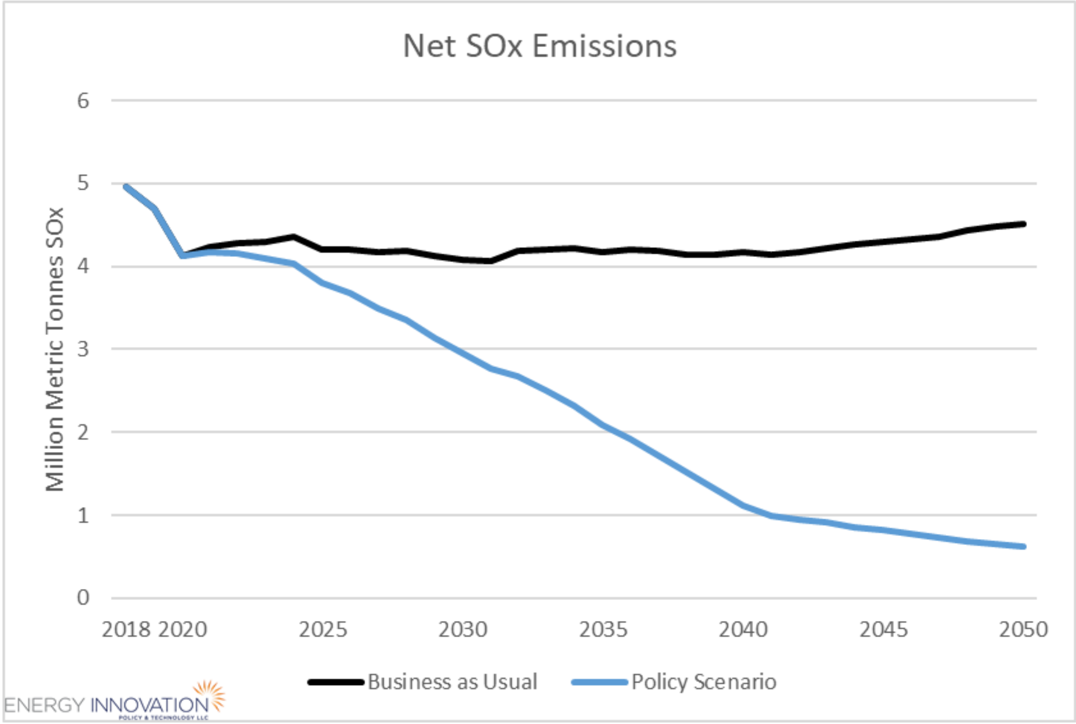


Net OC Emissions
Thousand Metric Tonnes OC
180
160
140
120
100
80
60
40
20
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION

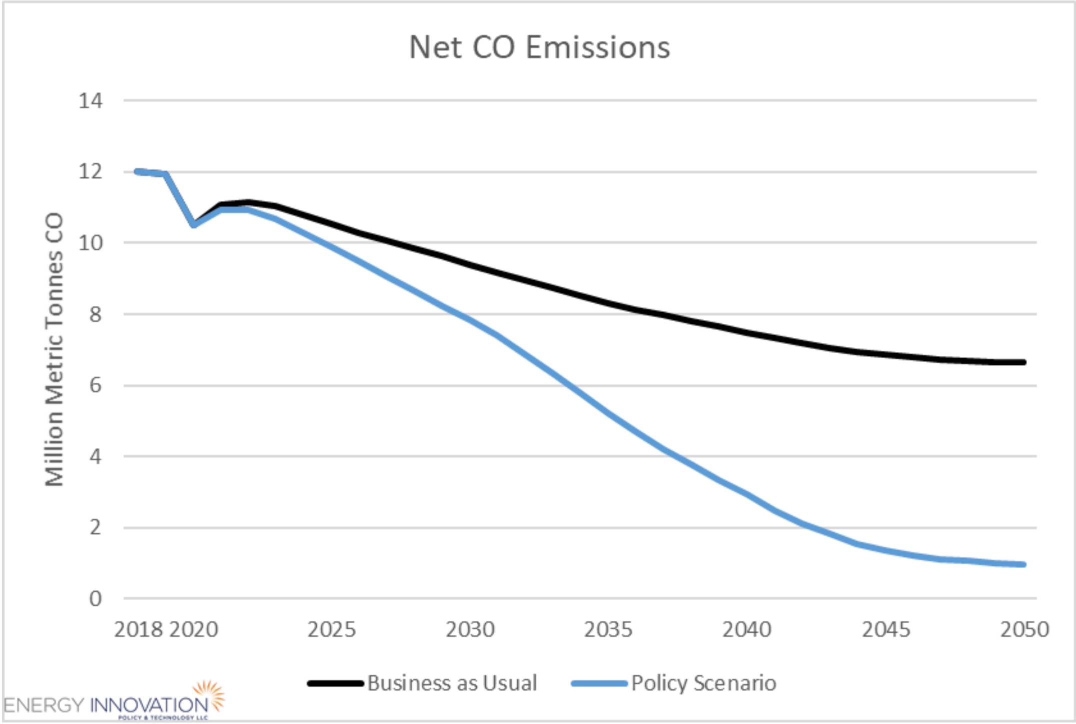

Net NOx Emissions
Million Metric Tonnes NOx
8
7
6
5
4
3
2
1
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION



Net VOC Emissions
Thousand Metric Tonnes VOC
1400
1200
1000
800
600
400
200
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION



Net SOx Emissions
Million Metric Tonnes SOx
6
5
4
3
2
1
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION


Net CO Emissions
Million Metric Tonnes CO
14
12
10
8
6
4
2
0
2018 2020
2025
2030
2035
2040
2045
2050
Business as Usual
Policy Scenario
ENERGY INNOVATION