Effect of human efforts on reversing climate change – A data model

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Brosig

Problem

How can humanity limit global warming to well below 2 degrees celsius, preferably to 1.5 degrees Celsius, compared to pre-industrial levels? / What is the optimum allocation of human efforts so we can reverse climate change?

Purpose

To develop a data science model which can accommodate various scenarios and forecast the effect of allocation of various human efforts on reversing climate change.

Hypothesis

Considering the following important climate solutions (which I have included in my data model);

1. Onshore wind
2. Offshore wind
3. Utility-Scale Solar Photovoltaics
4. Distributed Solar Photovoltaics
5. Geothermal power
6. Nuclear power
7. Reduced Food Waste
8. Plant rich diets
9. Peatland Protection & Rewetting
10. Forest Protection
11. Public transit
12. Efficient Aviation
13. Hybrid cars
14. Efficient Trucks
15. Efficient Ocean Shipping
16. Electric cars

If various factors driving these climate solutions such as investment, raw material availability, labor availability, technological maturity and public participation (or government mandates) are adequately allocated, then we should be able to reverse climate change.

Materials

- Software applications
  - Salesforce
  - Tableau
  - Google sheets
- Laptop with access to internet

Procedure

Step 1: Research (there is loads of information about this on various internet datasets) and Identify which climate change solutions may help the most in offsetting carbon dioxide in the earth's atmosphere and in turn lowering the average global temperature. **Our goal is to create one data model that, for various climate solutions, with various adjustable parameters that impact the implementation of the solution over years. We should be able to adjust the parameters so see the overall results change.**

Step 2: Research each climate solution in depth.

Step 3: Research information for the extent of effectiveness in sequestering/offsetting CO2 emissions and factors involved for each climate solution over the time period of 2020 to 2050. Make notes and gather the data.

Step 4: For each climate solution, research the factors that play a role in its implementation and any challenges to it. (See Appendix – Legend of Climate Solutions for each solution and the factors that play a role for each).

Step 5: Quantify amount of gigatons of carbon each solution could reduce and what could drive the most optimistic and the pessimistic scenarios for the implementation of the solution globally.

Step 6: Get an understanding of the current and forecasted progress for each solution.

Step 7: Research the needed amount for each factor such as investment, labor, raw material, technological maturity, public participation and any other factors for each climate solution for time period of 2021 thru 2050.

Procedure(continued)

Step 8: Based on information from Step 5 build the data tables for each climate solution.

Step 9 : Based on information from Step 7, gather the datasets (available from various government and international agencies – see references).

Note: It was found that neither of the factors alone could be taken into account to predict the effectiveness of a climate solution in its success. A combination of the factors and at the right time is necessary for the climate solution to persistently offset the most amount of CO2 from the atmosphere. Global participation would also be necessary for almost all of them. Global data is available from IEA, UNEP and other international agencies.

Step 10: Normalize(simplify) the data as much as possible into a final data model.

Step 11: Understand and create correlation equations between the forecast of CO2 expected to be offset by each climate solution (in Gigatons of CO2) and the factors (on which the climate solution is dependent) impacting each solution (in various units).

Step 12: Create free salesforce developer login at www.salesforce.com

Step 13: Login to salesforce and from the top right, go to Setup.

Step 14: Go to Object manager

Step 15: Create a new “object” to store the data for all climate solutions (I called it “Climate Solution”)

Procedure(continued)

Step 16: Under fields & relationship section, create fields for the various factors that may impact the outcome of each Climate Solution. These will depend on each solution such as technological maturity of the solution, raw material, labor, government/public participation, capital available.

Step 17 : From Step 11, create the one field which will be a calculated field based on equation developed specifically for each solution to estimate the amount of carbon dioxide that can be offset by the implementation of that climate solution.

Step 19: Load data from Step 10 for each factor for each year using Salesforce data loader into the data fields.

Step 20: Install Tableau desktop software on your laptop. This will be used to visualize the data model.

Step 21: Create a data source connection in Tableau to salesforce.com using your account and map all data fields in Tableau.

Step 22 : Create data model in Tableau using area chart to measure the gigatons CO2 expected to be offset based on assumed most likely values of the factors affecting the solution.

Step 23: Update any factors needed in Salesforce to view data model update in Tableau to reflect the resulting impact to overall contribution to climate change solution.

Independent Variable

Factors impacting each climate solution;

- Investment into the solution
- Raw material availability
- Labor availability
- Technological maturity/breakthroughs
- Extent of adoption of the solution by public participation or Government Mandates.

Dependent Variable

Total/Aggregate the amount (in Gigagtons) of CO_2 offset by the implementation of all considered climate solutions over the time period of 2021 to 2050.

Control

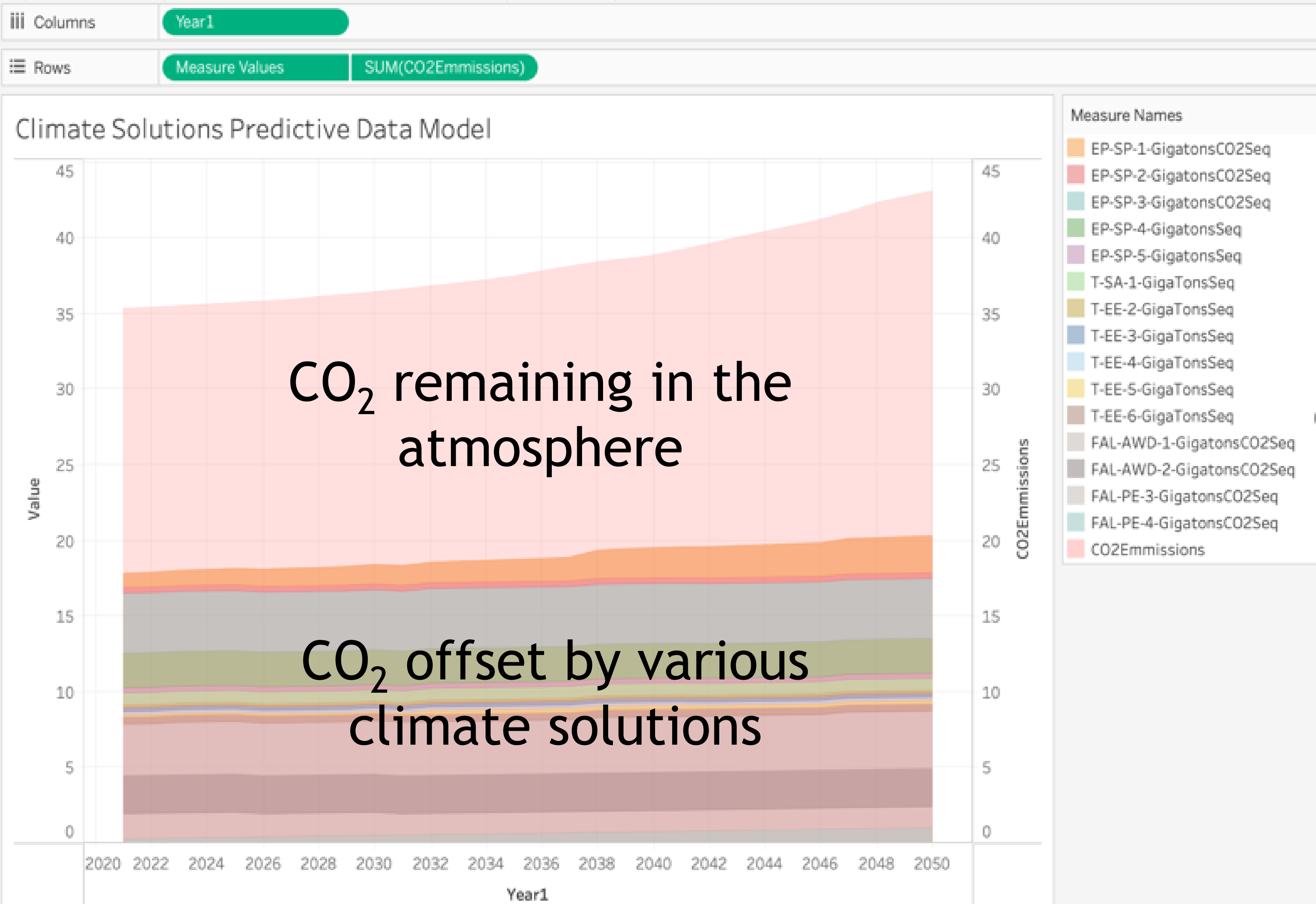
The outcome of climate change if no human efforts are invested towards solving climate change.

Constants

- The heat and energy reaching the earth from the sun
- The heating trapping affect of carbon dioxide

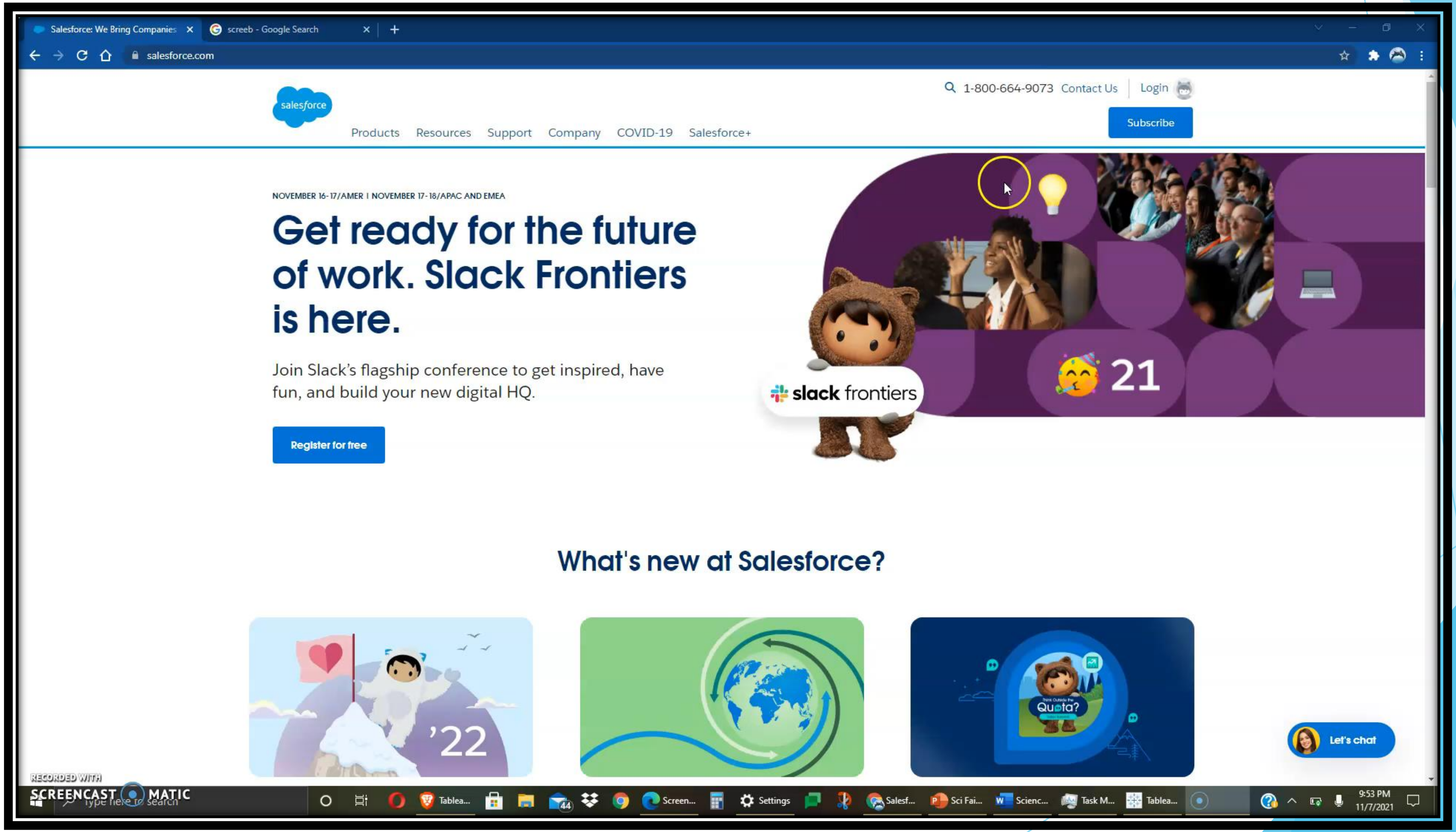
Data (Quantitative)

Visual area chart of CO2 emissions (Global) and CO2 offset (climate solutions) forecasted from 2020 to 2050.



Data (Qualitative)

Click to play the video below for a visual explanation of the data model



Data - Scenario #1

For climate solution – Utility-scale solar photovoltaic, IF raw material availability dropped by 50% from 2025 - 2035 from 0.3497 to 0.1749 – how would the carbon offset contribution change impact the overall outcome for Climate change?

Climate Solutions

EP-SP-3-Utility-SolarPV

New | Import | Change Owner | Printable View

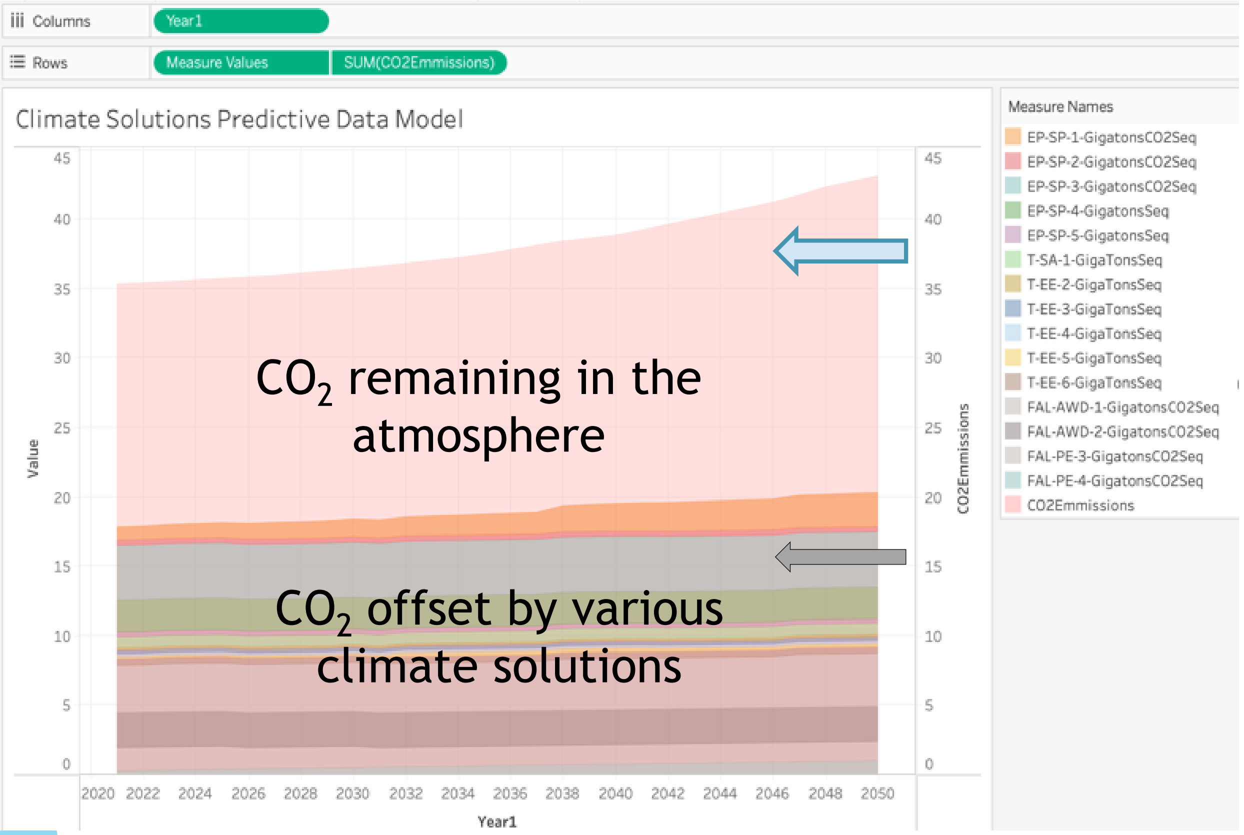
30 items • Sorted by Climate Solution Name • Filtered by All climate solutions - Climate Solution Name • Updated 3 minutes ago

Search this list...

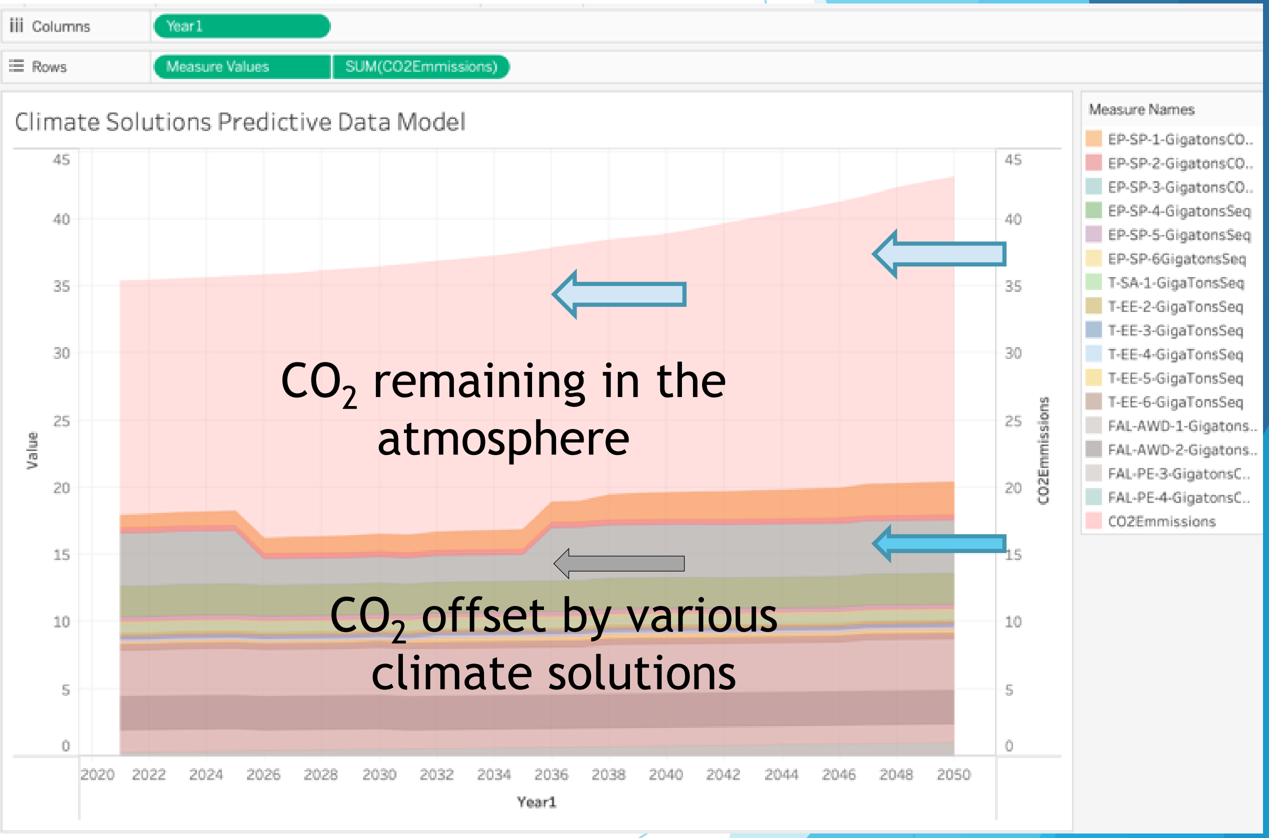
rs	EP-SP-LaborAvailable	EP-SP-LaborNeeded	EP-SP-Labor Impact Factor	EP-SP-Raw Material Available	EP-SP-Raw Material Needed	EP-SP-Raw Material Availabi
	527.21	527.21	1.0000	0.3497	0.3497	1.0001
	527.21	527.21	1.0000	0.3497	0.3497	1.0001
	527.21	527.21	1.0000	0.1749	0.3497	0.5002
	527.21	527.21	1.0000	0.1749	0.3497	0.5002
	527.21	527.21	1.0000	0.1749	0.3497	0.5002
	527.21	527.21	1.0000	0.1749	0.3497	0.5002
	527.21	527.21	1.0000	0.1749	0.3497	0.5002
	119.38	119.38	1.0000	0.1167	0.2331	0.5006
	119.38	119.38	1.0000	0.1167	0.2331	0.5006
	119.38	119.38	1.0000	0.1167	0.2331	0.5006
	119.38	119.38	1.0000	0.1167	0.2331	0.5006
	119.38	119.38	1.0000	0.1167	0.2331	0.5006
	119.38	119.38	1.0000	0.2331	0.2331	1.0000
	119.38	119.38	1.0000	0.2331	0.2331	1.0000
	119.38	119.38	1.0000	0.2331	0.2331	1.0000

Result of Scenario #1

Base Case – Less Carbon Dioxide remains in the atmosphere



Note the blue shaded region dipped - More carbon dioxide remains in the atmosphere (More Light orange shaded area)



The gigatons that were being offset in the base case was 21 gigatons per year for 2025 - 2035. The gigatons being offset in scenario #1 changes to 16.5 gigatons during those years due to decreased implementation of solar farms by power utility companies (blue shaded region) leaving more orange shaded area (Carbon dioxide remaining produced but not offset)

Data - Scenario #2

Scenario 2 - If due to a (hypothetical) technology breakthrough the technological maturity improved 10 times (1 is default – incremental multiplication factor used – 9) for nuclear power from 2040 to 2050, what would its effect be on solving climate change?

Climate Solutions

EP-SP-6-Nuclear Power

New | Import | Change Owner | Printable View

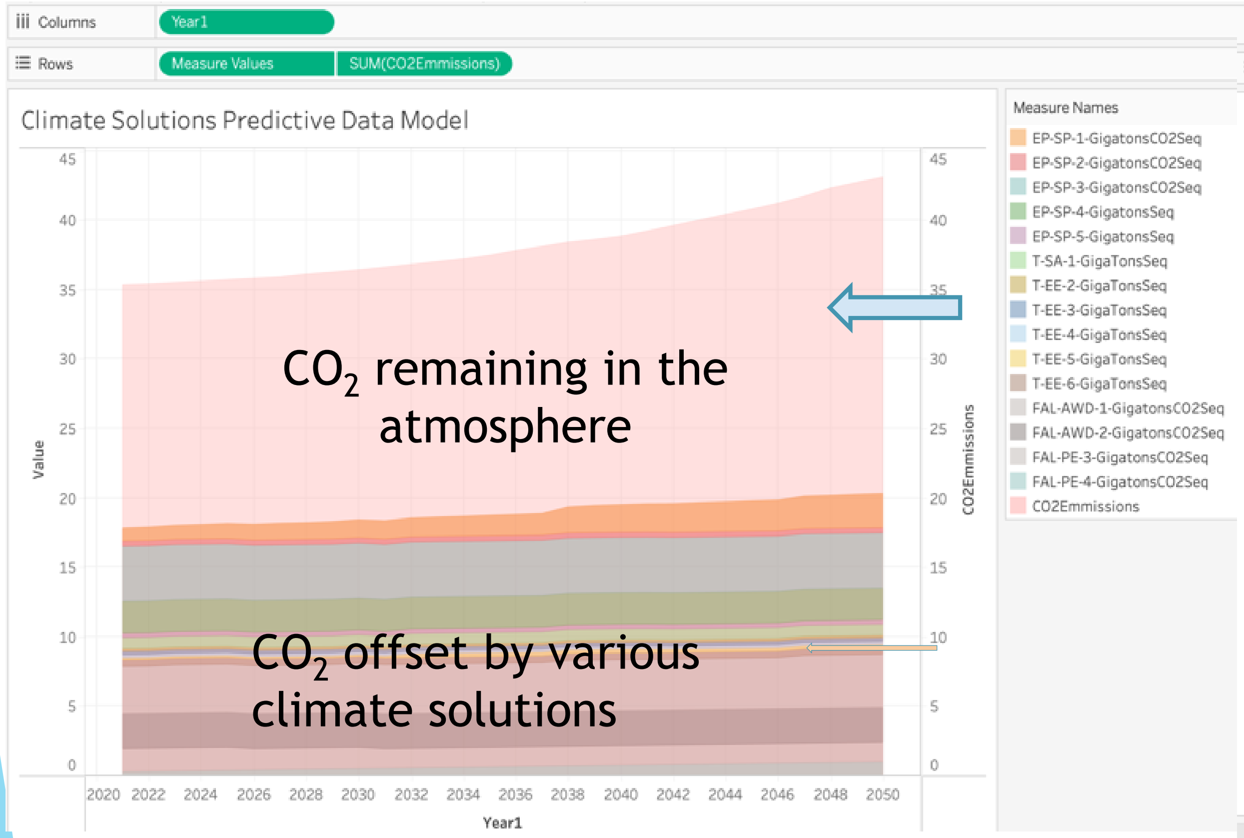
30 items • Sorted by Climate Solution Name • Filtered by All climate solutions - Climate Solution Name • Updated 18 minutes ago

Search this list...

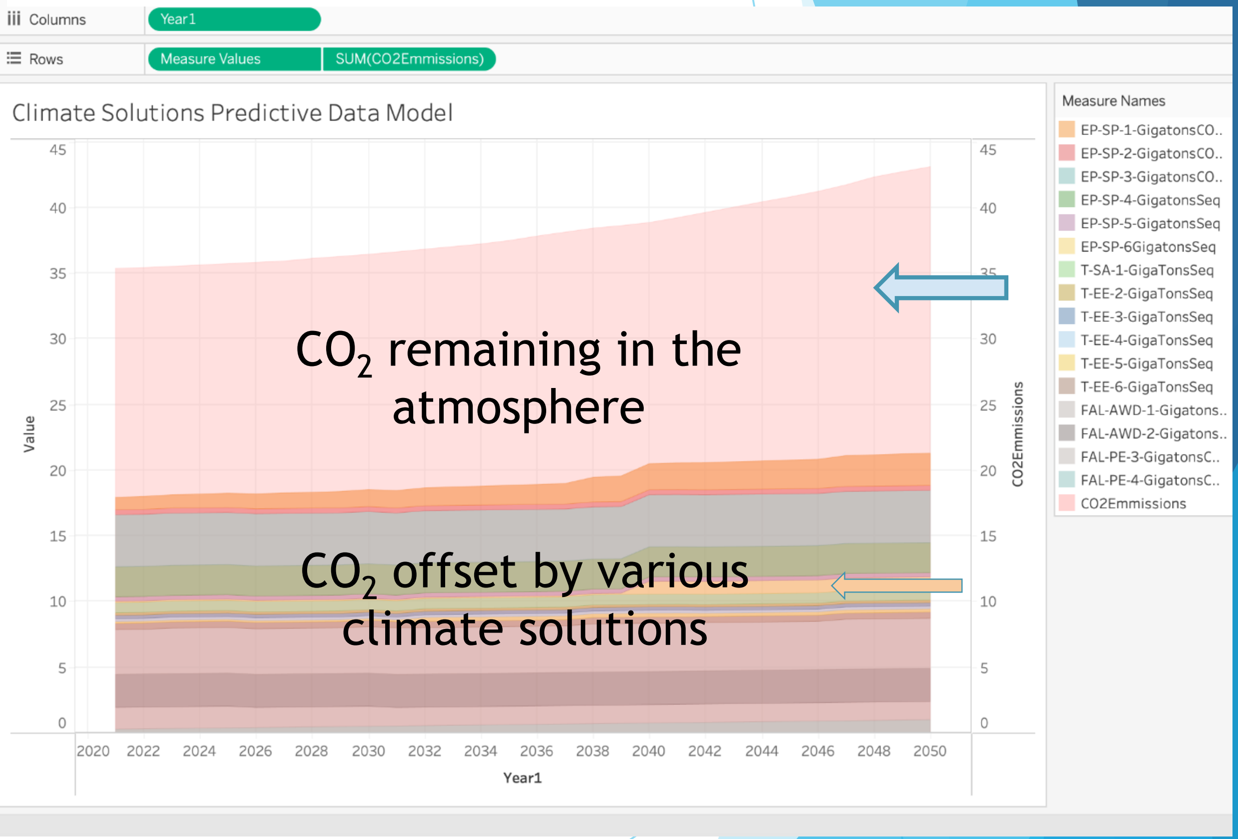
Material Needed	EP-SP-Raw Material Availability Fa...	EP-SP-Technological Maturity	EP-SP-Government ...	EP-SP-6GigatonsSeq	EP-SP-6GigatonsSeqCalc
	1.0000	0.0000	1.0000	0.0980	0.0980
	1.0000	0.0000	1.0000	0.0980	0.0980
	1.0000	0.0000	1.0000	0.0980	0.0980
	1.0000	0.0000	1.0000	0.0980	0.0980
	1.0000	0.0000	1.0000	0.0980	0.0980
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800
	1.0000	9.0000	1.0000	0.9800	0.9800

Result of Scenario #2

Base Case – More Carbon Dioxide remains in the atmosphere



Lesser carbon dioxide remains (more is offset) to the atmosphere (Lesser Light Orange shaded area)



The gigatons that were being offset in the base case was 21 gigatons during years 2040 -2050. The gigatons being offset in scenario #2 changes to 21.5 gigatons due to higher efficiency of Nuclear power plants (Yellow shaded region) leaving less orange shaded area (carbon dioxide produced but not offset) in comparison.

Climate Change An... | Climate Solutions | EVRawMaterial | Reports | Dashboards

Climate Solutions
T-EE-3-HybridCars

New | Import | Change Owner | Printable View

30 items • Sorted by Climate Solution Name • Filtered by All climate solutions - Climate Solution Name • Updated 23 minutes ago

	Climate Solutio...	Year	EP-SP-InvestmentinTrillionDollars	EP-SP-Technological Maturity	EP-SP-Government ...	T-EE-6-ECAdoption-Factor	T-EE-6-ECS
1	T-EE-3	2,021	0.1187	0.0200	1.0000	1.0000	0.0400
2	T-EE-3	2,022	0.3740	1.0000	1.0000	1.0000	0.0400
3	T-EE-3	2,023	0.7480	1.0000	1.0000	1.0000	0.0400
4	T-EE-3	2,024	1.4960	1.0000	1.0000	1.0000	0.0500
5	T-EE-3	2,025	1.4960	1.0000	1.0000	1.0000	0.0500
6	T-EE-3	2,026	1.4960	1.0000	1.0000	1.0000	0.0100
7	T-EE-3	2,027	1.4960	1.0000	1.0000	1.0000	0.0100
8	T-EE-3	2,028	1.4960	1.0000	1.0000	1.0000	0.0120
9	T-EE-3	2,029	1.4960	1.0000	1.0000	1.0000	0.0120
10	T-EE-3	2,030	1.4960	1.0000	1.0000	1.0000	0.0120
11	T-EE-3	2,031	1.4960	2.0000	1.0000	1.0000	0.0120
12	T-EE-3	2,032	1.4960	2.0000	1.0000	1.0000	0.0120
13	T-EE-3	2,033	1.4960	2.0000	1.0000	1.0000	0.0120
14	T-EE-3	2,034	1.4960	2.0000	1.0000	1.0000	0.0120
15	T-EE-3	2,035	1.4960	2.0000	1.0000	1.0000	0.0120

Climate Change An... | Climate Solutions | EVRawMaterial | Reports | Dashboards

Climate Solutions
T-EE-3-HybridCars

New | Import | Change Owner | Printable View

30 items • Sorted by Climate Solution Name • Filtered by All climate solutions - Climate Solution Name • Updated 24 minutes ago

	Climate Solutio...	Year	EP-SP-InvestmentinTrillionDollars	EP-SP-Technological Maturity	EP-SP-Government ...	T-EE-6-ECAdoption-Factor	T-EE-6-ECS
15	T-EE-3	2,035	1.4960	2.0000	1.0000	1.0000	0.0120
16	T-EE-3	2,036	1.4960	2.0000	1.0000	1.0000	0.0215
17	T-EE-3	2,037	1.4960	2.0000	1.0000	1.0000	0.0215
18	T-EE-3	2,038	1.4960	2.0000	1.0000	1.0000	0.0215
19	T-EE-3	2,039	1.4960	2.0000	1.0000	1.0000	0.0215
20	T-EE-3	2,040	1.4960	2.0000	1.0000	1.0000	0.0215
21	T-EE-3	2,041	1.4960	3.0000	1.0000	1.0000	0.0215
22	T-EE-3	2,042	1.4960	3.0000	1.0000	1.0000	0.0215
23	T-EE-3	2,043	1.4960	3.0000	1.0000	1.0000	0.0215
24	T-EE-3	2,044	1.4960	3.0000	1.0000	1.0000	0.0215
25	T-EE-3	2,045	1.4960	3.0000	1.0000	1.0000	0.0215
26	T-EE-3	2,046	1.4960	3.0000	1.0000	1.0000	0.0215
27	T-EE-3	2,047	1.4960	3.0000	1.0000	1.0000	0.0215
28	T-EE-3	2,048	1.4960	3.0000	1.0000	1.0000	0.0215
29	T-EE-3	2,049	1.4960	3.0000	1.0000	1.0000	0.0215
30	T-EE-3	2,050	1.4960	3.0000	1.0000	1.0000	0.0215

Data - Scenario #3

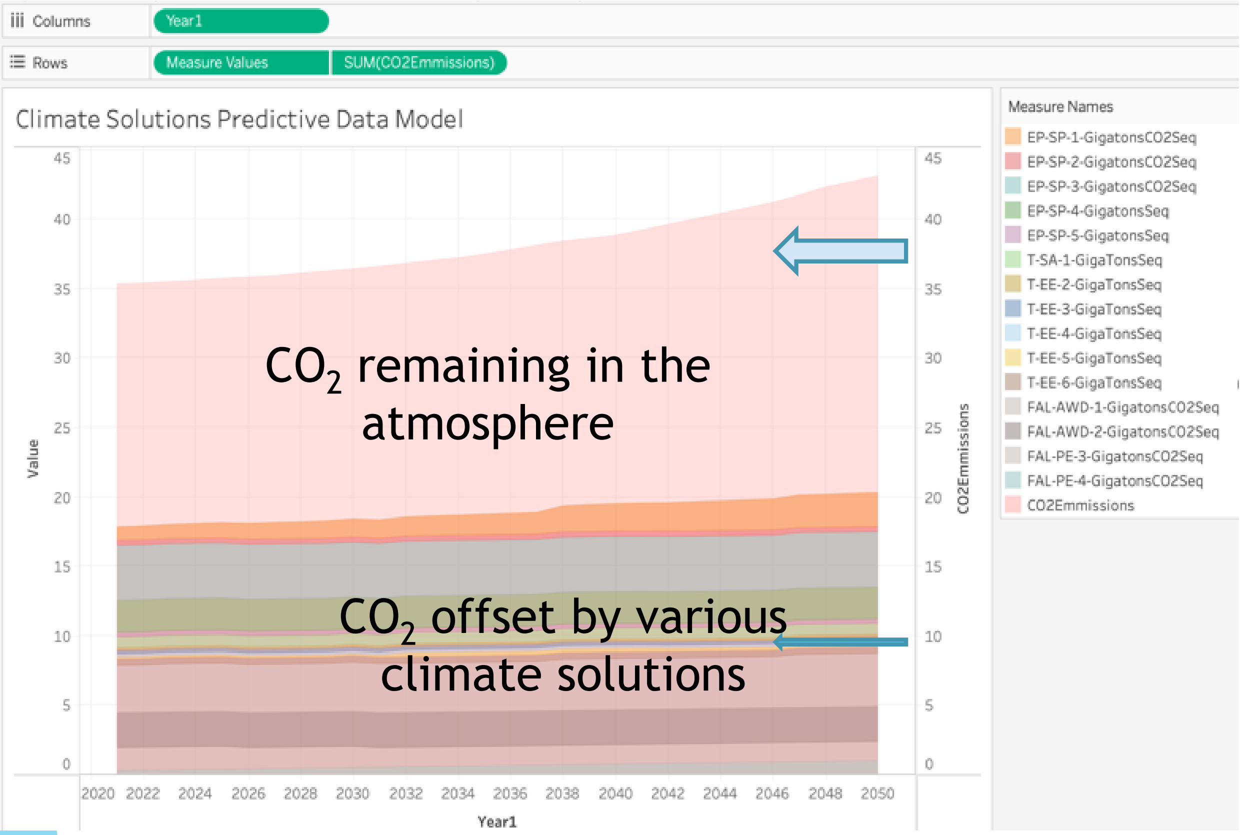
In an extremely utopian scenario, if for Hybrid cars,

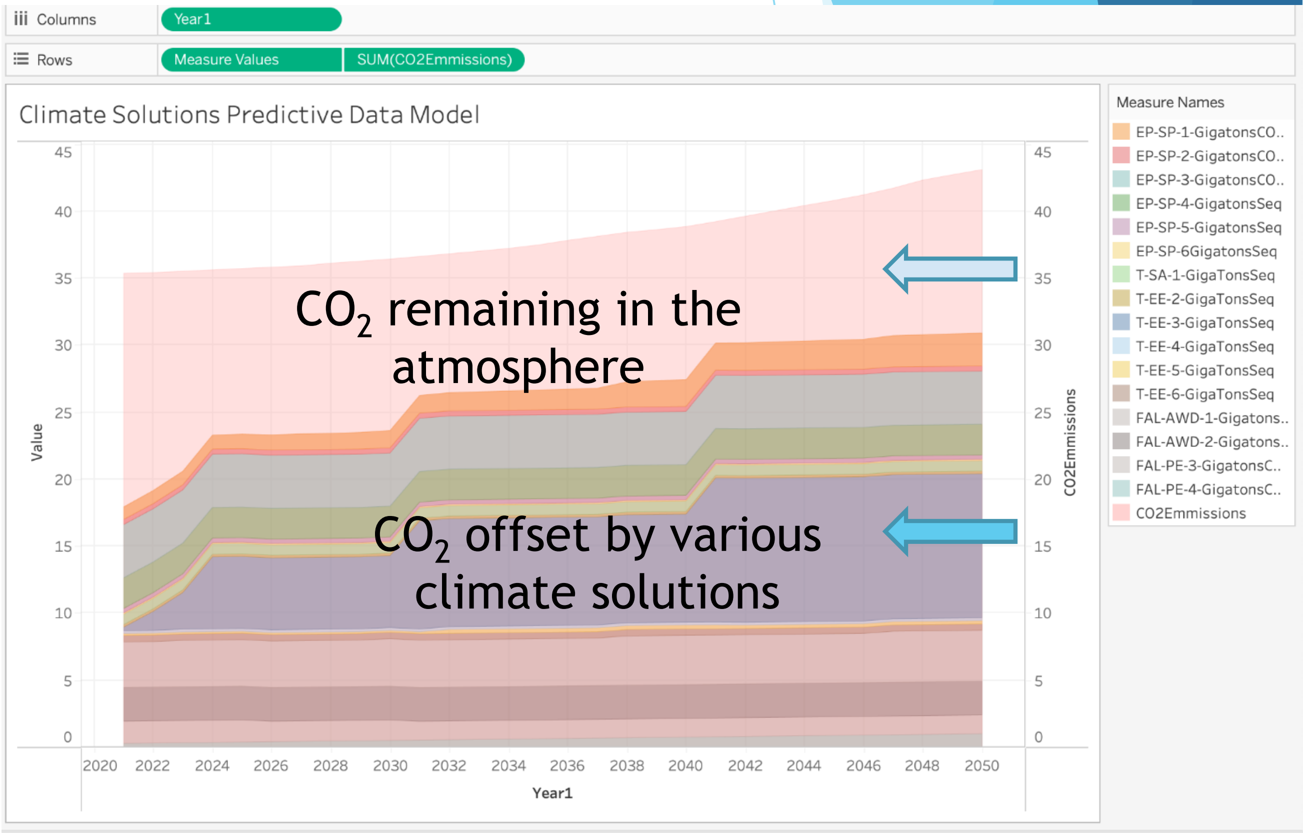
1) An increase in funding happened to double from 2021-2024 and then became stable at $1.496 trillion globally AND technological maturity became twice of what it was in 2021 to 2022 and remained at that level through 2030.
2) Then on average tripled from current in years 2030-2040, then quadrupled from current in years 2040-2050, how would the carbon offset from this climate solution impact the overall climate change problem?

Result of Scenario #3

Base Case – More Carbon Dioxide is added to the atmosphere (Current plan)

Lesser carbon dioxide is added to the atmosphere (Lesser Orange shaded area in comparison)





The total gigatons that were being offset in the base case was approximately 21 gigatons. The gigatons of CO2 offset from increased use of hybrid cars shown by the larger size of the blue shaded region left much less orange shaded area (Carbon dioxide emitted but not offset)

Conclusion

Users of this predictive data model are able to update the value of factors affecting each climate solution (in Salesforce – Data store) see how the contribution of that climate solution towards the overall goal of CO2 reduction will change (in Tableau – Data visualizer).

e.g. if there is an increase (or decrease) in global availability of uranium as a raw material for nuclear power how may it impact the contribution of nuclear power as a climate solution. Nuclear power being one of the climate solutions and raw material for nuclear power being one of the factors. Multiple factors can be changed for a solution or multiple solutions at a time to see the combined results.

Also the data model can be posed questions regarding the most optimum combination of investment, labor efforts, raw material allocation to devise sound environmental and government policy globally across different climate solutions. This can enable the best outcome to preventing climate change.

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Appendix : Legend for Labels of climate solutions in my data model

Legend for Climate Solution Codename in Database	
EP-SP-1	Onshore wind
EP-SP-2	Offshore wind
EP-SP-3	Utility-Scale Solar Photovoltaics
EP-SP-4	Distributed Solar Photovoltaics
EP-SP-5	Geothermal power
EP-SP-6	Nuclear power
FAL-AWD- 1	Reduced Food Waste
FAL-AWD- 2	Plant rich diets
FAL-PE-3	Peatland Protection & Rewetting
FAL-PE-4	Forest Protection
T-SA-1	Public transit
T-EE-2	Efficient Aviation
T-EE-3	Hybrid cars
T-EE-4	Efficient Trucks
T-EE-5	Efficient Ocean Shipping
T-EE-6	Electric cars

EP-SP-1 Onshore Wind Turbines

Wind energy is one of most promising forms of energy which can help us get rid of dirty fossil fuel-based energy generation. Electricity is needed now and its demand in the future will only increase as the world population increases. Onshore wind turbines are strategically placed in mountain valleys inland or sometimes close to the ocean to harness the power of the wind to generate electricity. Cost wise, this climate solution is now competing with coal-based energy power plants in. “Wind farms” are a collection of many turbines which all operate to generate electricity with no need for fuel and no pollution and have very low running costs.

Factors which drive the speed and effect of this climate solution;

Building wind turbines at scale requires;

1. A plethora of raw material which includes steel, aluminum and concrete,
2. People that are skilled at engineering, technicians, builders and investment of funds.
3. Government incentives or mandates to build wind farms at large scale.
4. Technological advancements are continuously being made with wind turbines to make them more efficient and less expensive.
5. Investment capital to build the farms.

EP-SP-2 - Offshore wind turbines

The only difference between onshore wind turbines and offshore wind turbines is that offshore wind turbines are not on land instead they are on big bodies of water like lakes or oceans. Wind speeds over sea are tend to be faster than wind speeds over land which makes offshore wind a dependable source of energy. In most places wind energy is cheaper than the coal alternative. Wind turbines are projected to grow from its current 60 TWh to 1918-2256 TWh by 2050. Wind turbines generate electricity by using wind to rotate turbines which in turn generate electricity.

Building offshore wind turbines at scale requires;

1. Labor expertise may require personal skilled in engineering, technicians, builders, and more
2. Raw materials may include steel, aluminum and concrete
3. Technological advancements are constantly being made and influenced into new and old wind turbines alike
4. Investment to make wind turbines at scale
5. Government Participation is vital to offshore wind power

EP-SP-3 Utility Scale Solar Photovoltaics

Solar is a key factor in overcoming climate change. Utility scale solar photovoltaics means that there are a lot of solar panels put in one place. Solar farms may contain up to a thousand solar panels. Currently, it costs sixty-five cents per watt generated by solar. Solar PV is now cheaper than conventional power generation in most places.

Building solar farms at large scale requires;

1. Labor must be proficient in one or more of these fields, electrical engineering, engineering, chemistry, material science, and more
2. Raw materials may include aluminium, steel, thin film, monocrystalline, and polycrystalline
3. Technological advancements are constantly being made and are constantly being influenced into new and old solar panels
4. Investment is needed to make solar farms
5. Government Participation is vital to utility scale photovoltaics

EP-SP-4 Distributed Solar Photovoltaics

Distributed solar photovoltaics means that solar will be separated around the globe powering individual homes and other buildings. Distributed solar photovoltaics will be necessary to overcoming climate change since it gives people clean power without transporting electricity to them from solar farms or other clean climate solutions.

Distributing solar panels requires;

1. Labor must be proficient in one or more of these fields, electrical engineering, engineering, building
2. Raw materials may include aluminum, steel, thin film, monocrystalline, and polycrystalline
3. Technological advancements are constantly being made and are constantly being influenced into new and old solar panels
4. Investment is vital to Utility solar power
5. Government Participation is vital to Utility solar photovoltaics

EP-SP-5 Geothermal power

Taps into underground reservoirs of steamy hot water, which can be piped to the surface to drive turbines that produce electricity. Prime geothermal conditions are found on less than 10 percent of the planet, but new technologies dramatically expand production potential. Production can take place at all hours and under almost any weather conditions. Geothermal is reliable, abundant, and efficient.

Building Geothermal power plants requires;

1. Labor must be proficient in one or more of these fields- engineers (electrical and mechanical) and construction workers—along with electrical technicians, electricians, electrical machinists, welders, riggers, and mechanics

2. Technological Maturity is increasing and is being influenced in new geothermal power plants

3. Investment is required to make power plants

4. Government Participation is vital to geothermal energy

EP-SP-6 Nuclear Power

Boils water and creates steam which powers steam turbines that generate electricity. Nuclear is expensive, and the highly regulated industry is often over-budget and slow. Greenhouse gas emissions are calculated to be ten to a hundred times higher for coal-fired plants than for nuclear. The current percentages will go from 10.5 percent to 8.6-13.2 percent depending on the support nuclear gets

Getting energy made by Nuclear powerplants requires;

1. Labor must be proficient in one or more of these fields- carpenters, accountants, chemists, electricians, chemical engineers, Radiation protection specialists, Reactor operators, and many more.
2. Governments should promote the building of nuclear power plants.
3. Investment is required to pay for the labor and raw materials needed to make nuclear power plants.
4. Technological advancements will drastically improve the amount of energy produced by nuclear power plants.
5. Nuclear power plants need a steady supply of water and uranium to sustain themselves.

FAL-AWD-1- Reduce Food loss and wastage

Producing uneaten food squanders, a whole host of resources—seeds, water, energy, land, fertilizer, hours of labor, financial capital—and generates greenhouse gases at every stage—including methane when organic matter lands in the global rubbish bin. The food we waste is responsible for roughly 8 percent of global emissions.

Factors which drive the speed and effect of this climate solution;

1. Government incentives or mandates would encourage people to reduce food waste.
2. Capital investment may help to fund the companies distributing the food to print the right expiration date on their food.
3. Raw materials wouldn't make much of a difference because this climate solution relies on people taking the responsibility to reduce food waste.
4. Technological advancements may allow for food to be okay to eat for longer, which may prolong the expiry dates on food.
5. Raw materials wouldn't make much of a difference because it relies on the people to reduce food waste.

FAL-AWD-2 Switch to Plant Rich Diets

Instead of a meat rich diet, if we were to switch to plant rich diet, we would be able to make a significant dent in the world's carbon emissions. Currently the meat-centric diet is on the rise all over the world. As people's standard of living increases more people are able to afford and so consume meats. This diet is harmful to the climate. It is estimated that this diet is responsible for one-fifth of global emissions. Plant-rich diets can help reduce emissions and also make us less prone to disease.

Factors which drive the speed and effect of this climate solution;

1. Government incentives may incentivize people to switch to a meat less diet.

2. Capital investment may be helpful to this climate solution in funding events that help make the public aware of this climate solution. Investment may also go to farmers so that they reduce the amount of meat they distribute to the public.

3. Technological advancements won't help much because this solution relies on the people to switch to plant rich diets.

4. Raw materials wouldn't make much of a difference because it relies on the people to switch to plant rich diets.

5. Farmers would be vital for this solution because plants would need to be grown more than ever before.

FAL-PE-3 - Peatland Protection

Peatlands are marsh like lands on the surface of the earth. Peat is usually dead decaying plant matter. These lands develop over many hundreds of years, these are unique ecosystems which cover about 3 percent of the earth's land area. Peatlands are very powerful as a carbon sink. They are twice as effective as forests to store carbon, protecting peatlands through land preservation and fire prevention is a big opportunity to help provide a sink for carbon emissions.

Factors which drive the speed and effect of this climate solution;

1. Government or incentives or mandates.
2. Capital investment

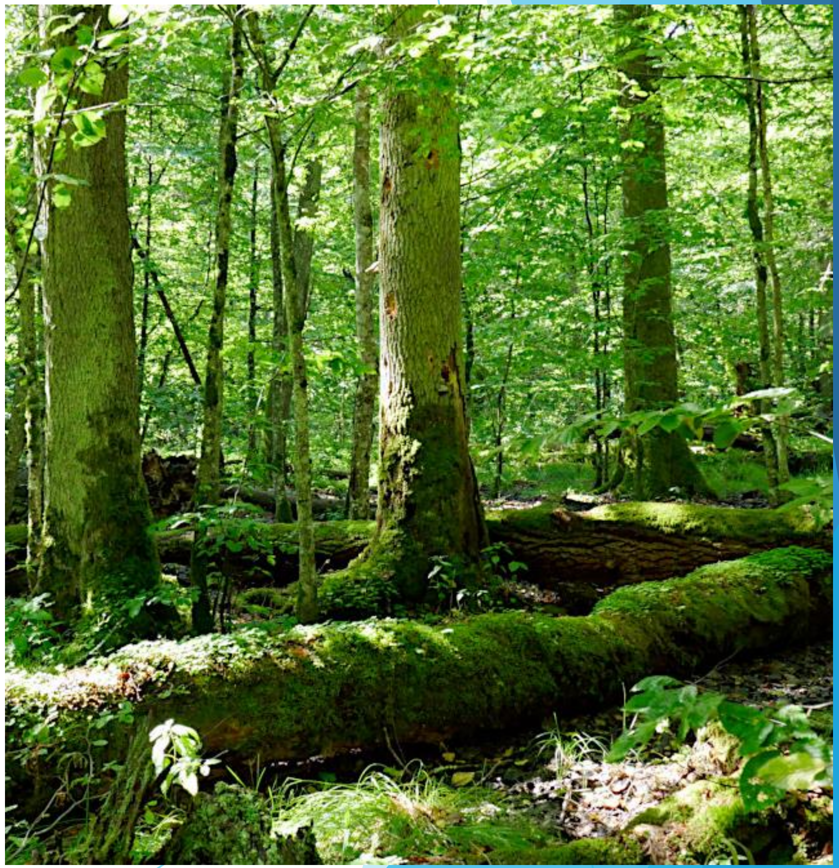
FAL-PE-4 - Forest Protection

Strategies to stop deforestation and protect forests include:

- public policy and the enforcement of existing anti-logging laws;
- market-driven mechanisms, primarily eco-certification programs that inform consumers and affect purchasing decisions; and
- programs that enable wealthy nations and corporations to make payments to countries and communities for maintaining their forests.

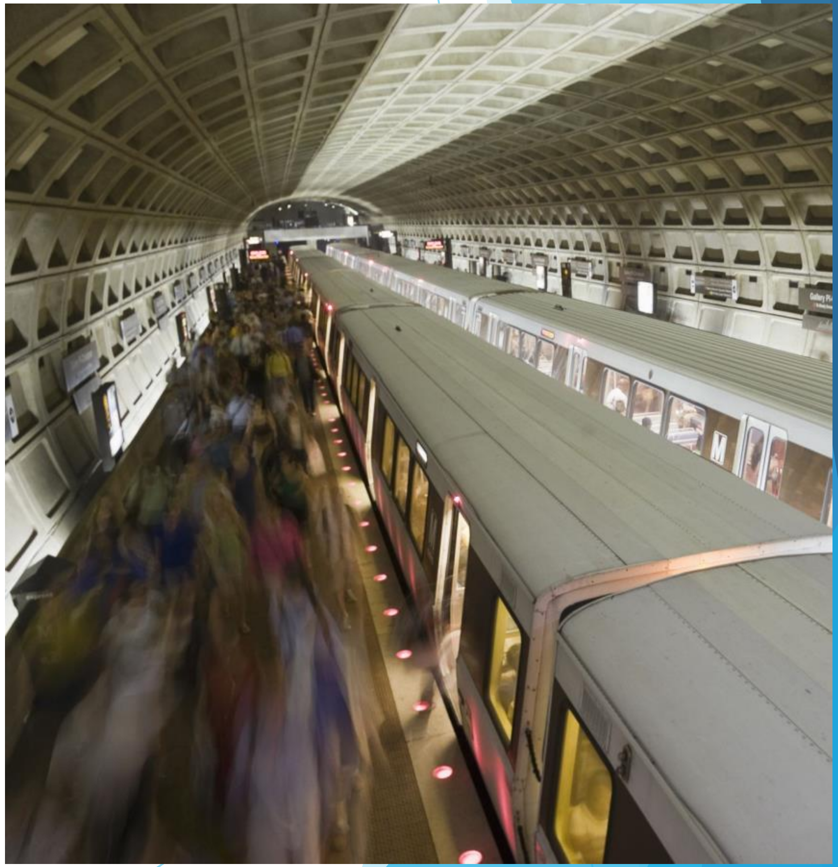
Factors which drive the speed and effect of this climate solution;

1. Government or incentives or mandates.
2. Capital investment



T-SA-1 - increased use of Public Transport

Use of public transport by the masses instead of individual vehicles can have a huge impact on reducing carbon emissions per capita. There are many advantages of this to all city residents, not just those who use mass transit. By reducing the volume of cars, mass transit traffic congestion can be reduced. With fewer people driving, there may be lesser accidents. Individual city transport is a large source of transportation-related emissions and is increasing. Modern public transit should be built and support by energy efficient electric buses/trams. A model example of this is currently being implemented in many cities around the work.



Factors which drive the speed and effect of this climate solution;

1. Government or incentives or mandates.

2. Capital investment

3. Technological advancements to further improve efficiency and alternative fuels for aviation and hybridization

4. Abundant availability of electric vehicle battery raw materials such as Lithium, Nickel and Cobalt.

5. Extent of electrification of public transit vehicles.

T-EE-2 - Efficient Aviation

There are about 20,000 airplanes currently in use around the globe. They are estimated to be producing at least 2.5% of annual carbon emissions. It is estimated that this number will double by 2040. Planes can be made more efficient by taking several measures including:

1. Making aircrafts more fuel-efficient.

2. Introducing aerodynamic winglets, better engines, and lighter interiors

3. Hybridization/Electrification of aircrafts (over short flights)

4. Operating existing aircraft with fuel-saving practices.

Factors which drive the speed and effect of this climate solution;

1. Adoption of efficient aviation by the general public

2. Government or incentives or mandates.

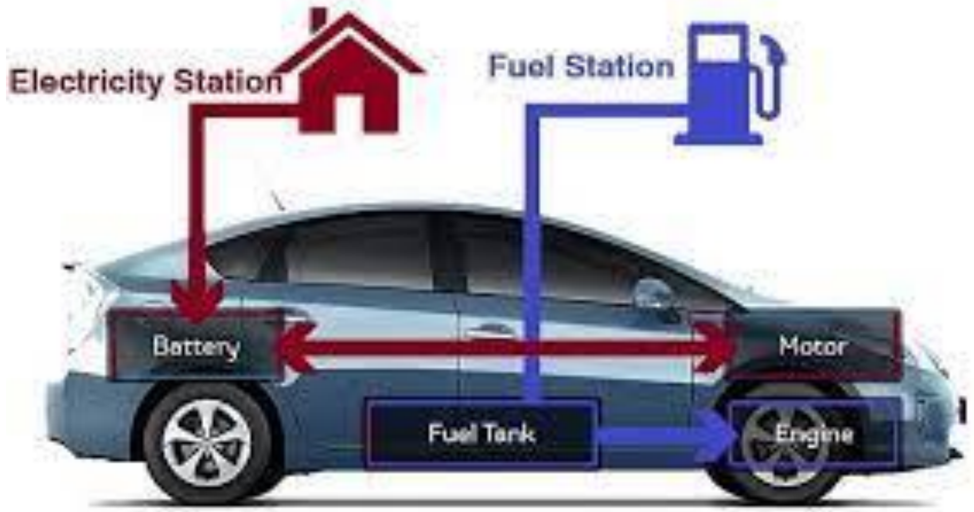
3. Capital investment

4. Technological advancements to further improve efficiency and alternative fuels for aviation and hybridization

5. Abundant availability of electric vehicle battery raw materials such as Lithium, Nickel and Cobalt.

T-EE-3 - Hybrid Cars

Hybrid cars contain an electric motor and battery, as well as an internal combustion engine—hybrid cars hardwired for better fuel economy and lower emissions. Hybrid cars provide a unique combination of electric motor which is more efficient for city driving while the gas powered combustion engine helps power the car for high-way speeds. 5.4 million hybrid vehicles were sold in the US alone in 2019.



Factors which drive the speed and effect of this climate solution;
1. Adoption of hybrid cars by the general public

2. Government or incentives or mandates to reduce sale of fuel-inefficient vehicles.

3. Capital investment

4. Technological advancements to further improve efficiency and alternative fuels.

5. Abundant availability of electric vehicle battery raw materials such as Lithium, Nickel and Cobalt.

T-EE-4 - Increase efficiency in trucking

Trucks are used to transport goods all over are land and use a much 25 of the total gasoline fuel each year. They are responsible for 6 percent of global emissions of carbon into the atmosphere. Trucks can be made more efficient by making their engines more fuel-efficient engines, improvising on aerodynamics, making them lighter weight, decreasing the rolling resistance for tires, hybridization (i.e. by introduction of electric battery power apart from fuel), automatic engine shutdown when stopped.

Factors which drive the speed and effect of this climate solution; Increasing Ocean shipping efficiency at scale requires;

1. Participation by international organizations, industry alliances and requirement or incentives from the government to control this source of pollution.

2. Capital investment

3. Technological advancements to further improve efficiency and alternative fuels for shipping

4. Abundant availability of electric vehicle battery raw materials such as Lithium, Nickel and Cobalt.

T-EE-5 - Increase efficiency in Ocean Shipping

Ocean shipping is currently responsible for 3% of the world's global carbon emissions. As we sit home and order more products from countries across the globe, this pollution could increase three-fold. Energy Efficiency Operational Indicator (EEOI) is an indicator that tells us about how efficient an ocean vessel is. There is a set of 17 measures identified by the Global Maritime Energy Efficiency Partnership (GloMEEP) project by the International Maritime Organization (IMO) to increase efficiency of ships. These include slow steaming (literally slowing down the speed of the ship), better maintenance and cleaning of propellers, better coating of the hull of the ship, compressed air lubrication technology among others.

Factors which drive the speed and effect of this climate solution; Increasing Ocean shipping efficiency at scale requires;

1. Participation by international organizations and industry alliances.

2. Capital investment

3. Technological advancements to further improve efficiency and alternative fuels for shipping

4. A least required measure of needed improvement in efficiency is at least 4 % each year.

T-EE-6 - Electric Cars

There are now more than 1 million electric cars on the road in the US and 4 million in China. Using an electric car drops emissions by 50%. Electric cars are simpler to make, having lesser need for maintenance or parts replacement. The only current limitation for an electric car is how far it goes on one charge and the availability of charging stations for these cars. Factors which drive the speed and effect of this climate solution;

1. Adoption of electric cars by the general public

2. Government or incentives or mandates to reduce sale of fuel-inefficient vehicles.

3. Capital investment

4. Technological advancements to further improve efficiency and alternative fuels for shipping

5. Abundant availability of electric vehicle battery raw materials such as Lithium, Nickel and Cobalt.