The Recently Released International Panel on Climate Change (IPCC) Report* Shows why <u>Carbon Negative</u> has to be Part of Every Decarbonization Strategy

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This Brief Analysis Shows a Pathway that the United States can Follow to join the Offramp to a Decarbonized Future

by William Strauss, PhD
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*https://www.ipcc.ch/report/ar6/wg2/

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FutureMetrics provides due diligence services, information and analysis, operations guidance, and strategic advice.

FutureMetrics combines <u>decades of experience</u> with deep operational expertise, powerful sector focused financial modeling skills, and leading market awareness.

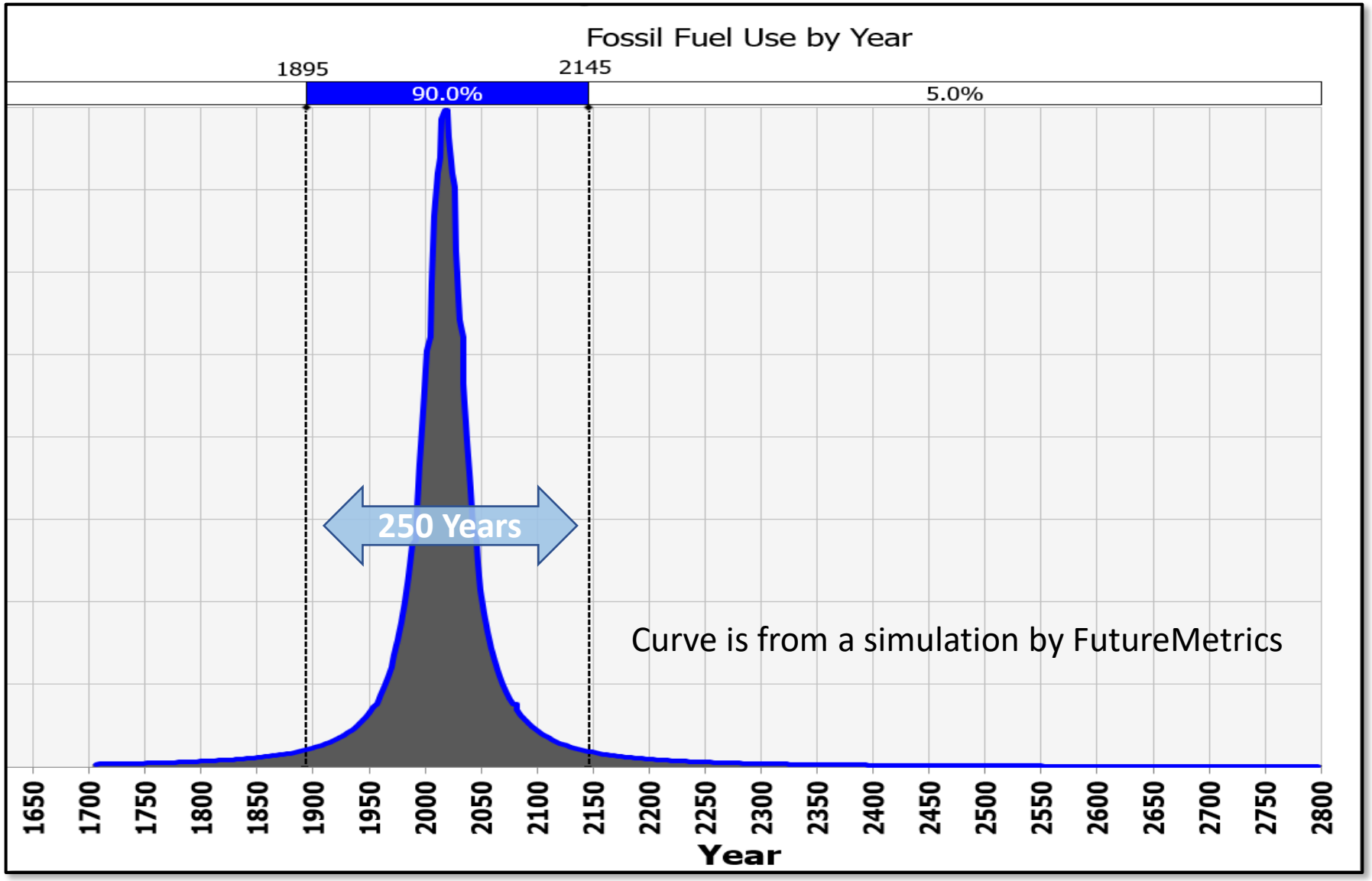
First, the reasons that
the strategy described in this brief is needed…

Climate change

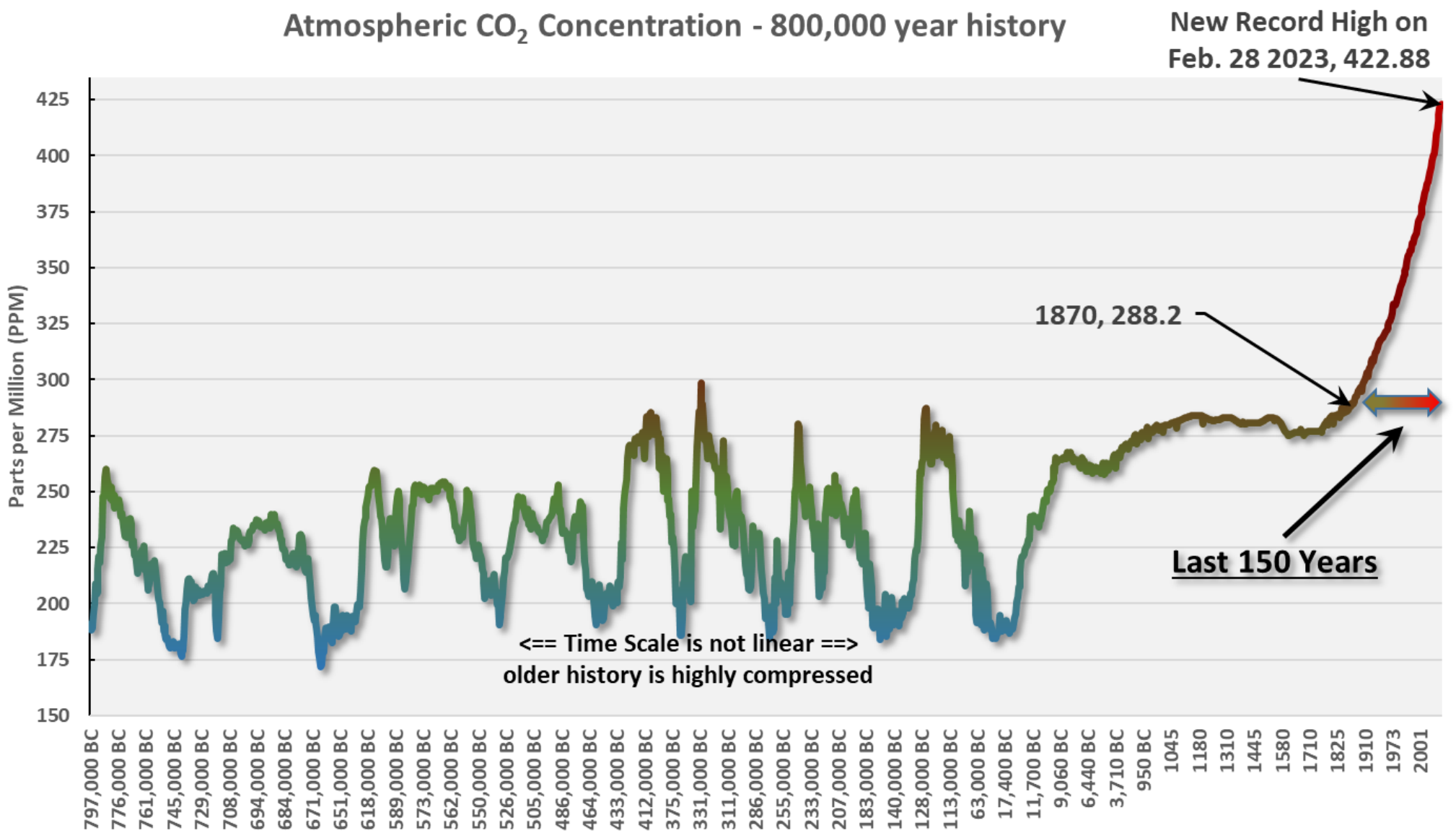
and the need to mitigate CO_2 emissions

And part of the solution for replacing depleting energy sources with renewable energy sources

We will release most of the geologic carbon <u>sequestered over hundreds of millions of years</u> over a <u>span of about 250 years</u>.



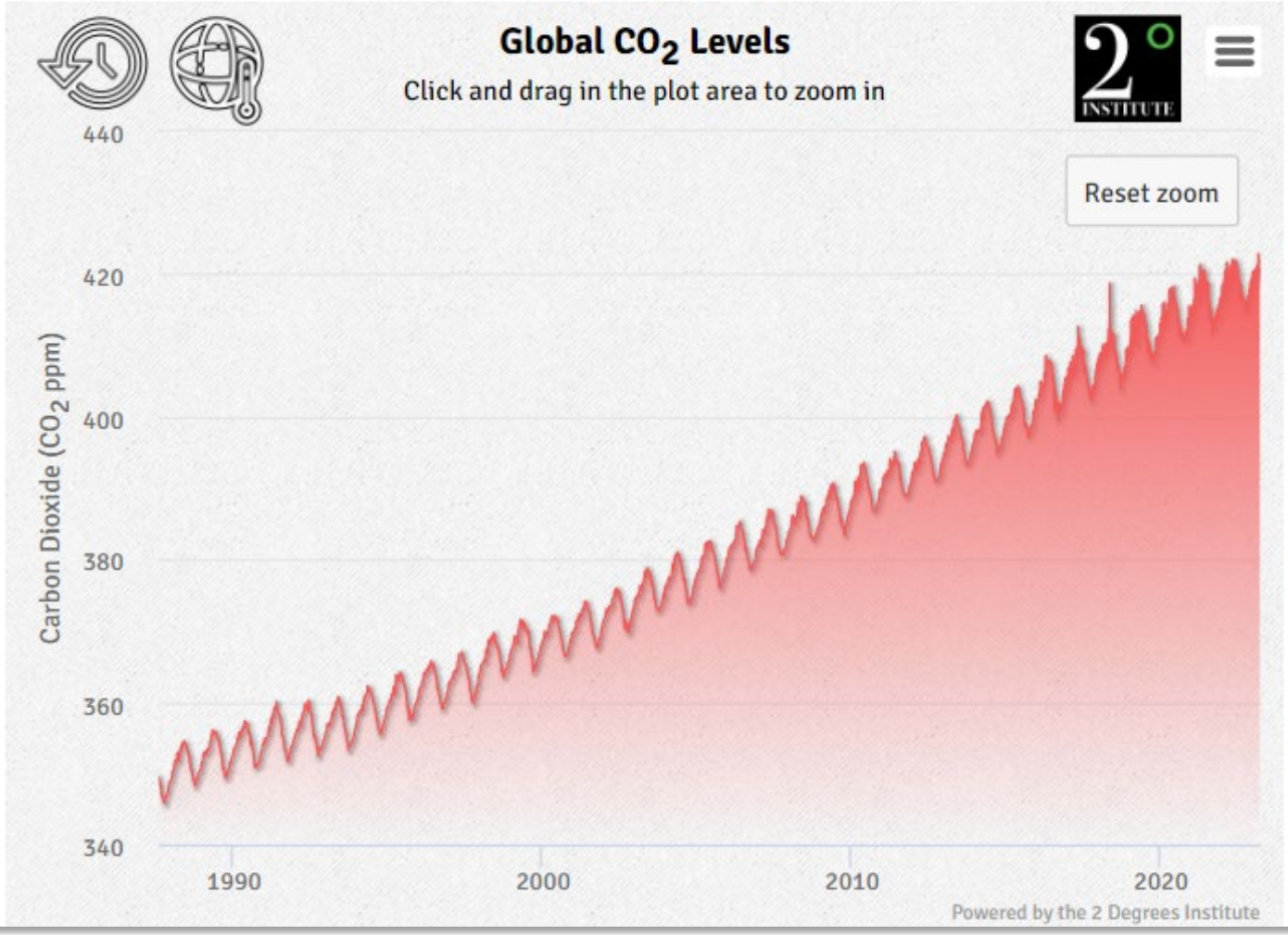
Almost every year in recent history in the late winter and spring, atmospheric CO_2 concentrations hit new record highs!



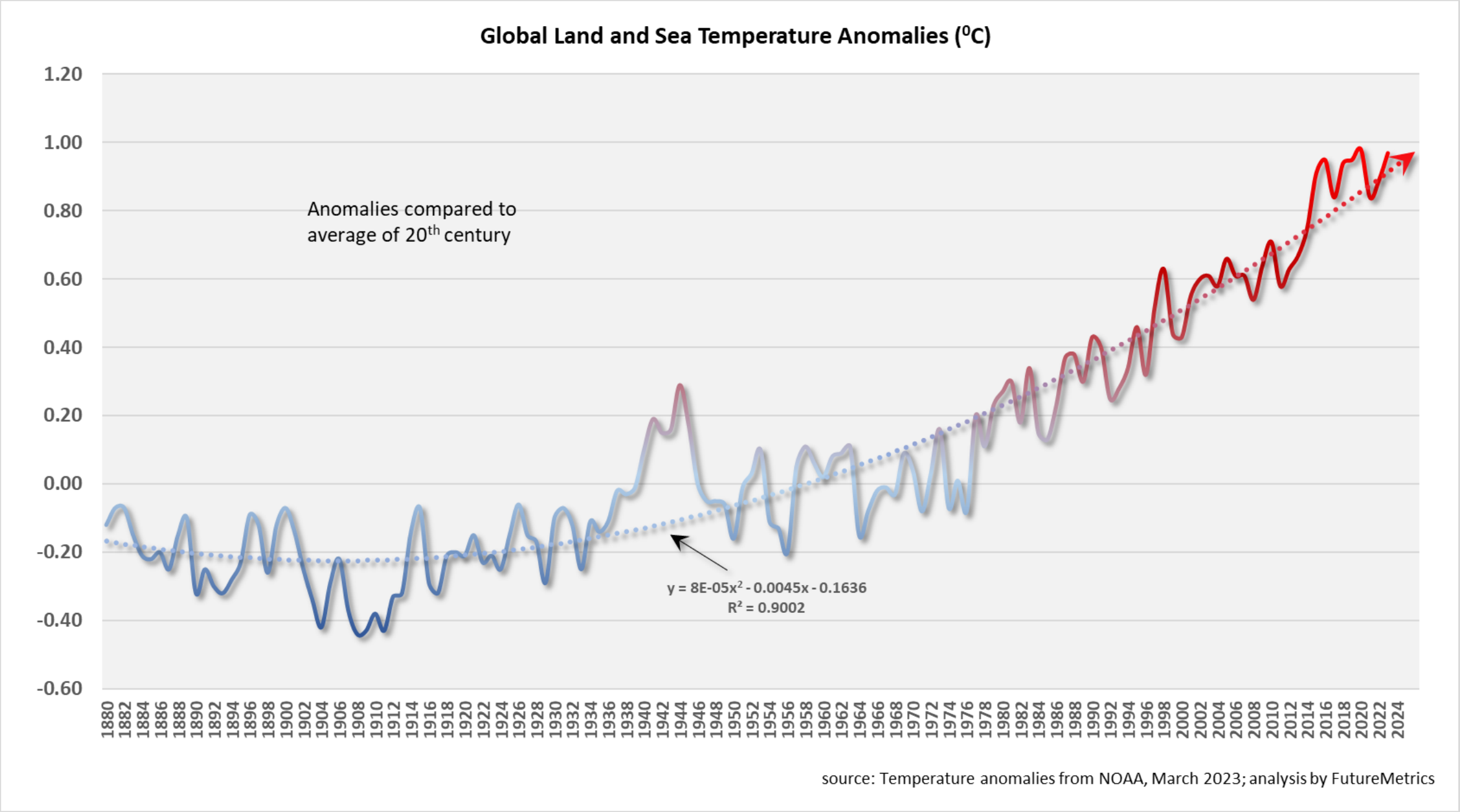
Source: EPA's Climate Change Indicators in the United States: www.epa.gov/climate-indicators; NOAA for recent data; March 2023, analysis by FutureMetrics

Historic and Current Atmospheric Greenhouse Gas Concentrations (and other data)

Data updated daily – The chart is interactive

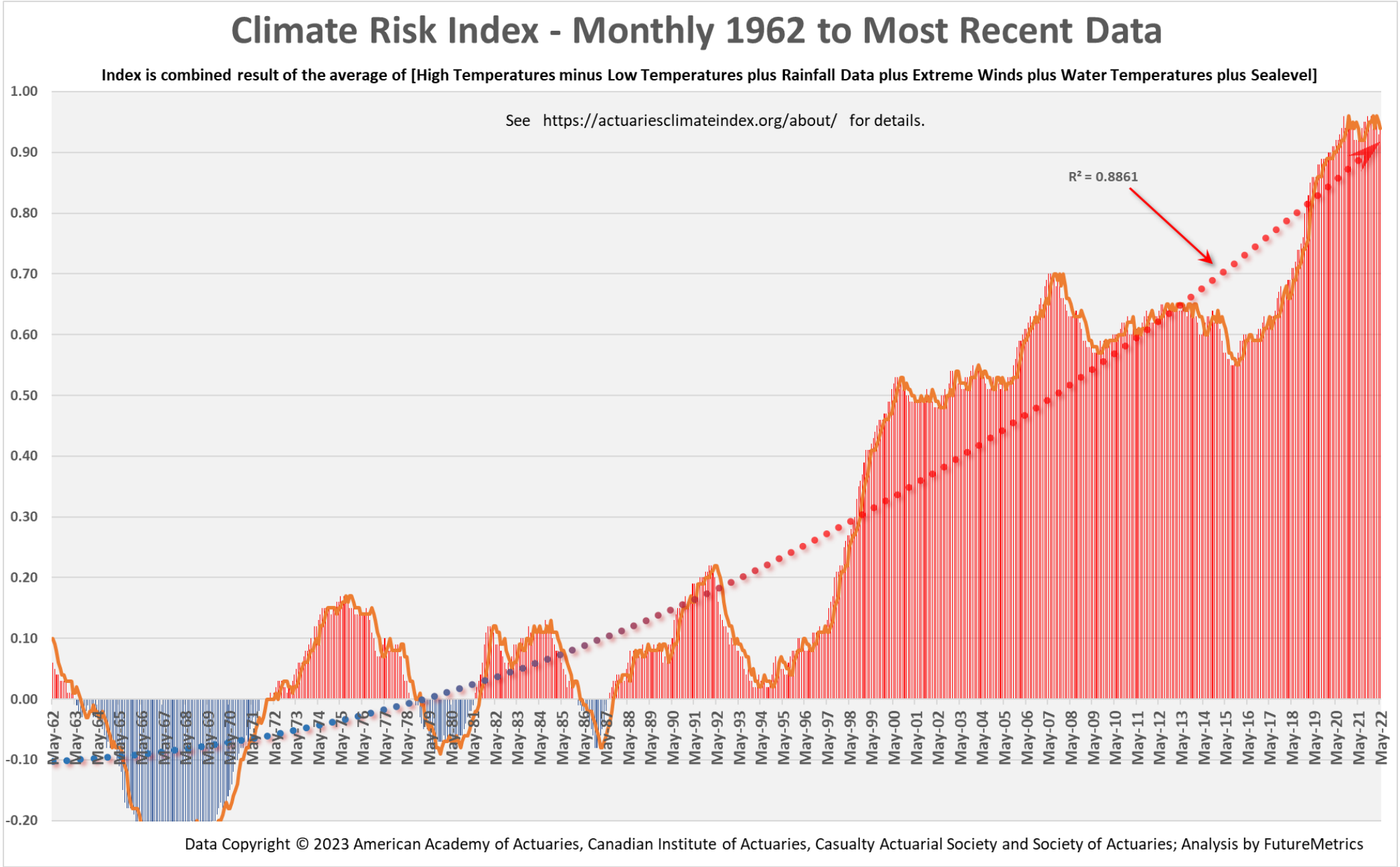


This chart is on the FutureMetrics homepage and is interactive on time span, greenhouse gases of interest, and global temperature.



Not only increasing, but increasing at an increasing rate (exponential curve)

The consequences are not only Environmental and Ecological but are also Economic!



The cost of doing business is increasing due to the increasing costs of insurance against the more frequent and more severe consequences of climate change.

Another exponential curve!

Action is Needed!

The IPCC report is a strong call to action.

This brief describes a strategy that should be included in every decarbonization road map.

The Strategy is based on Carbohydrates replacing Hydrocarbons

Using sustainably produced upgraded biomass fuel to substitute for coal in power generation is a pragmatic and rational component of a strategy for the transition to a decarbonized power sector.

- Leverages existing coal power stations and can be deployed NOW.
- Produces baseload or load-following renewable power.
  - Compliments and supports the variability and intermittency of wind and solar power.
- Creates many more jobs per MWh than any other renewable power source.
- Is ***carbon neutral in combustion***.

Carbon Neutral?

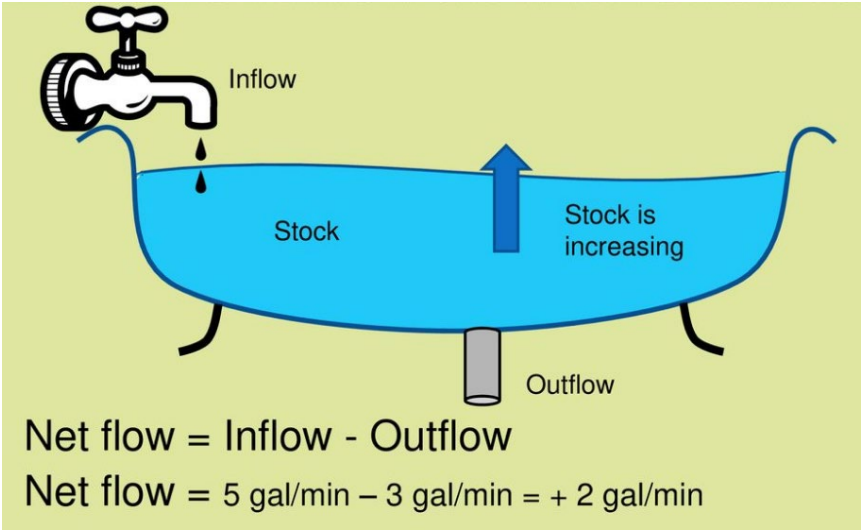
If sourced from the harvest residuals of sustainably managed forests and the residuals from sawmill operations,
wood pellets are carbon neutral in combustion*.

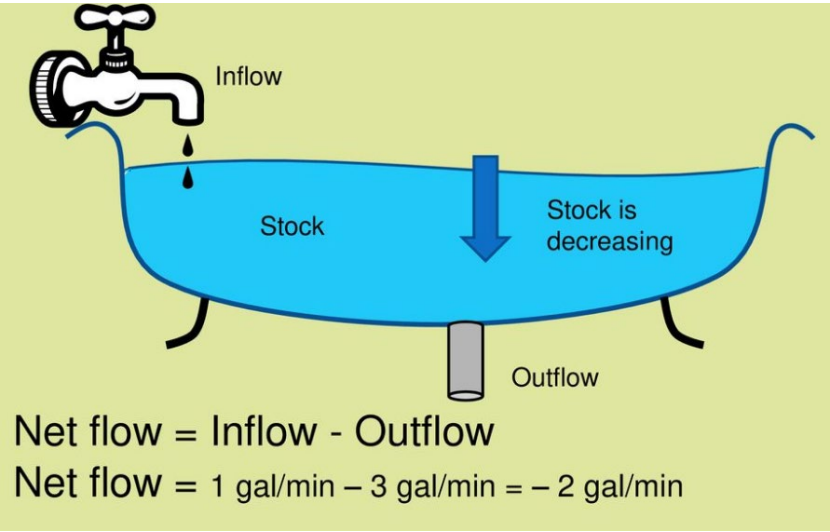
ABSOLUTELY NECCESARY CONDITION:
If the annual harvest rate across the managed forest landscape is less than or equal to the annual growth rate, then the stock of carbon held in the forest is not shrinking.

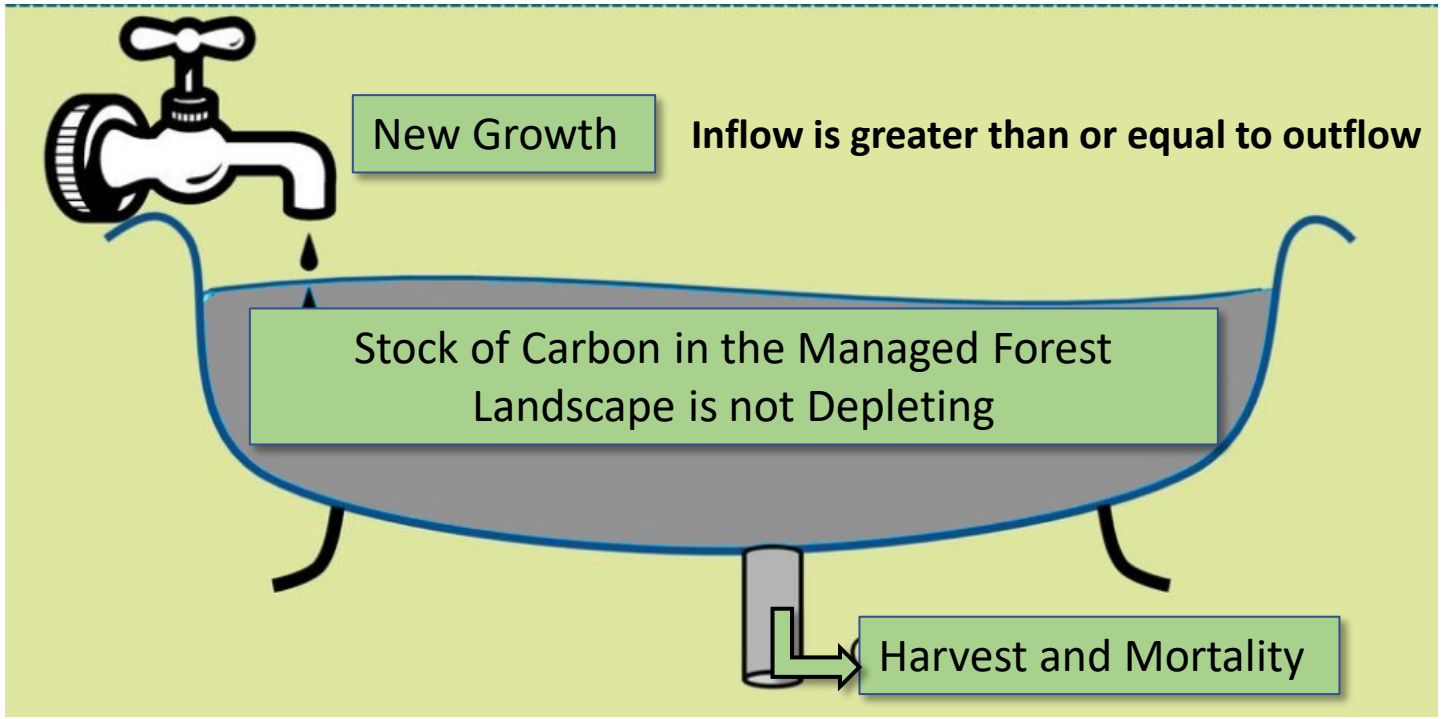
Thus, every molecule of CO_2 that is emitted in combustion is absorbed by the new growth contemporaneously.
There is no carbon debt.

*As with any fuel that must be mined, refined, and transported, there is a carbon footprint associated with the fossil fuels used within the supply chain.

The basics of net carbon steady state in a dynamic system…







If the growth rate equals or exceeds the drain rate, the net carbon held in the forest is not decreasing.

The equivalent quantity of molecules of CO_2 emitted from the biomass from that managed landscape that is used for energy are absorbed by the new growth.

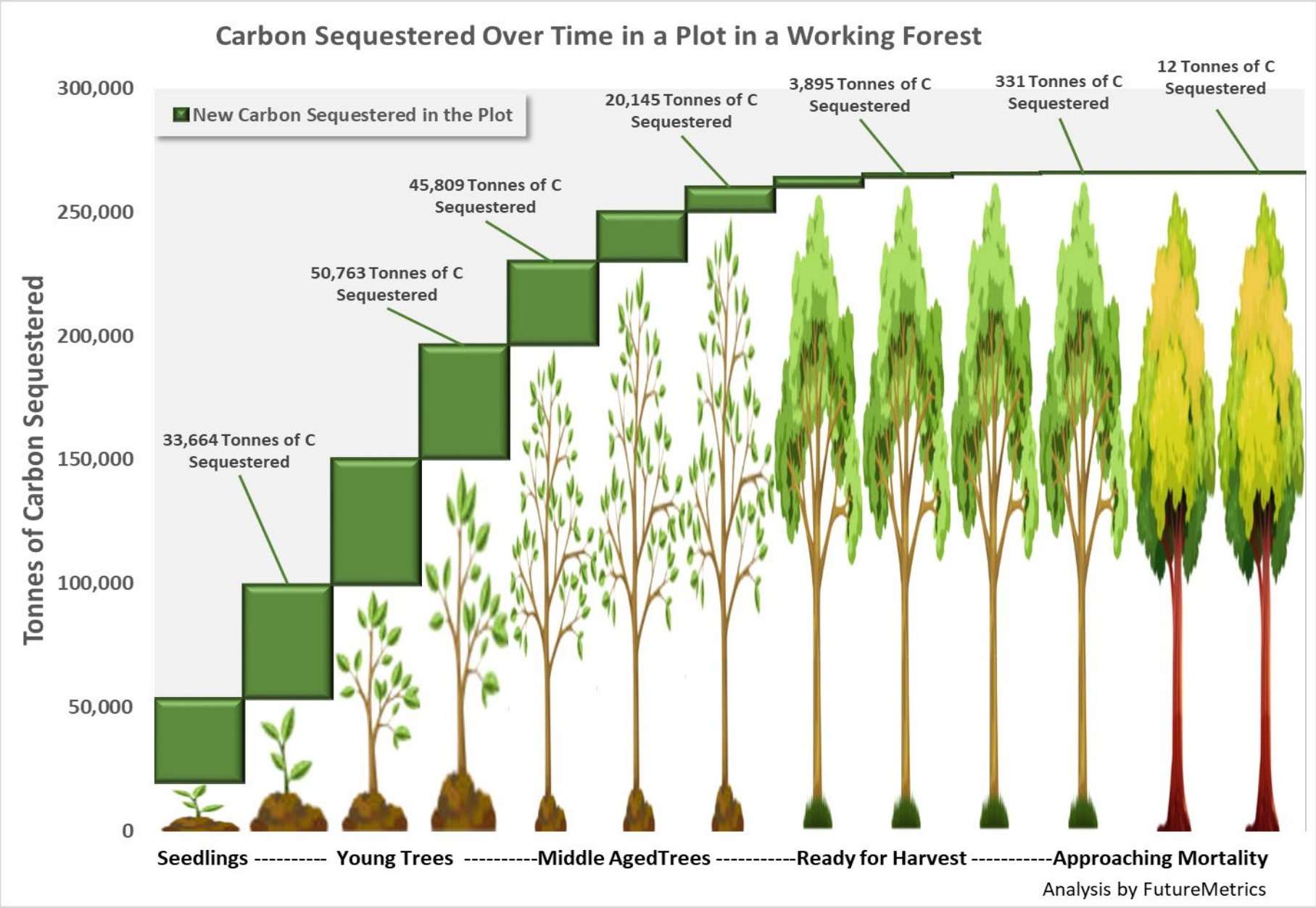
The atmosphere sees no net new CO_2.

Carbon neutral in combustion!

The "bathtub" has a limit to what it can hold.

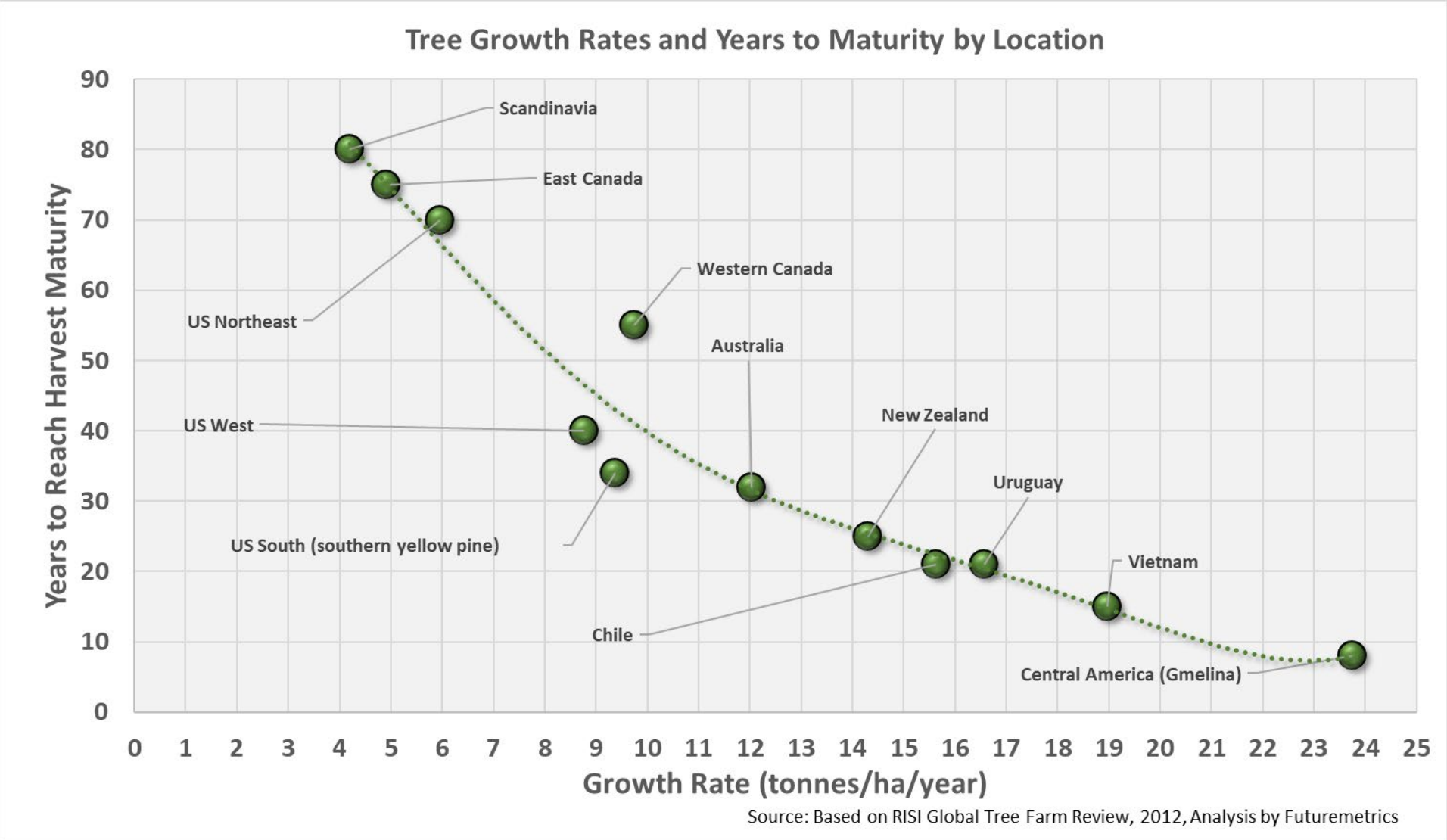
<u>Plots in a managed forest reach a carbon stock equilibrium</u>.

There is no sequestration benefit after XX years of growth as the forest plot reaches its maximum density.



The reader can experiment with this model using the free dashboard produced by FutureMetrics [HERE](#).

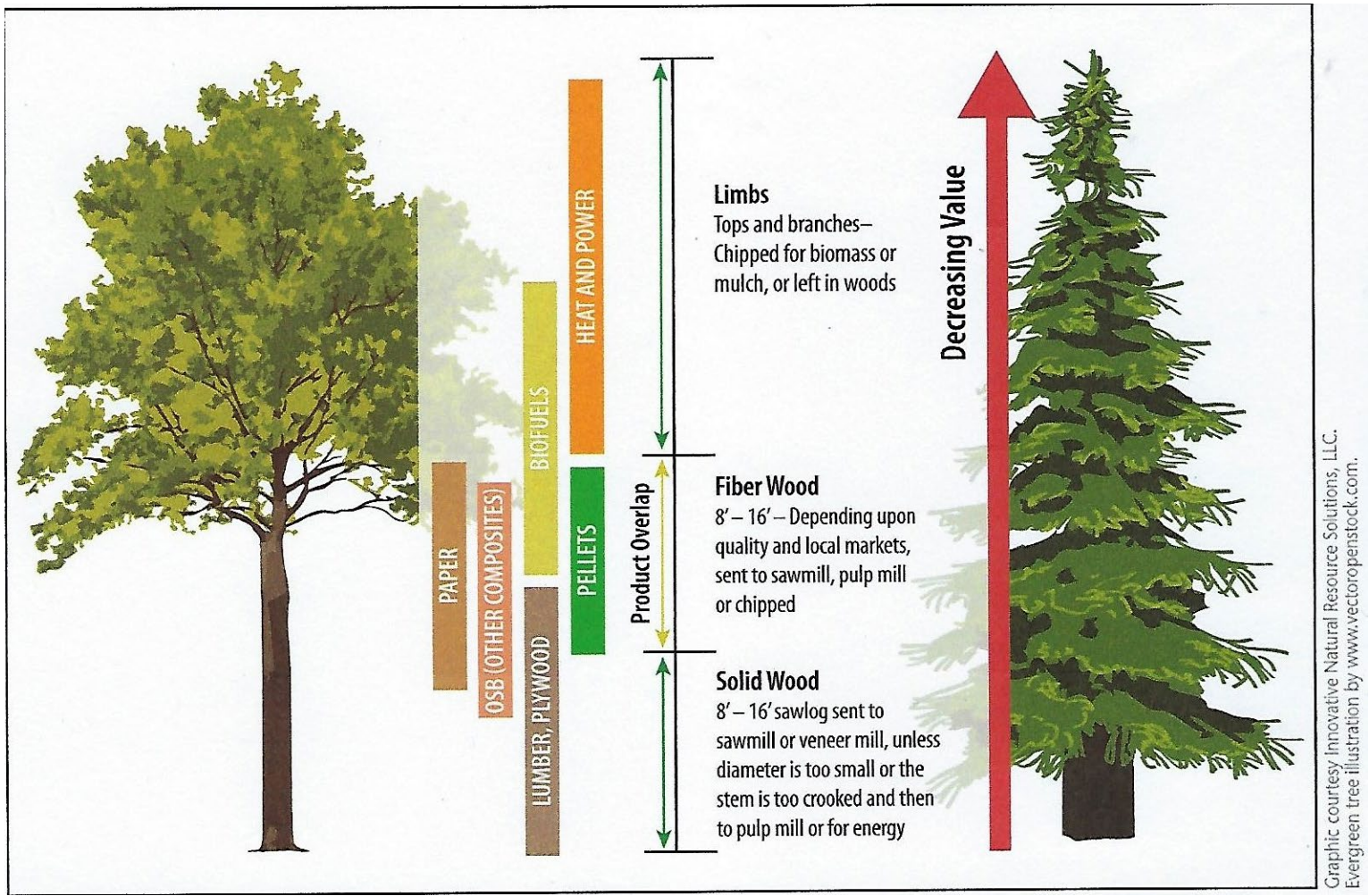
The farther north (northern hemisphere) you go, the more patient the tree farmer must be before reaching optimum harvest conditions.



And remember that most of the harvested timber does not end up as pellet fuel.

"Forest Residuals" are the parts of the harvested tree that are not suitable for primary industries such as lumber, flooring, furniture, paper, packaging, and tissue production.

Every tree is unique in its potential. Some that are crooked, rotten in the middle, or have other defects and thus may not be suitable for primary use. Those may find their way to pellet factories.
The small diameter upper portions of the tree that have no other use may find their way to pellet factories.



Graphic courtesy Innovative Natural Resource Solutions, LLC.
Evergreen tree illustration by www.vectoropenstock.com.

The highest value parts from the harvest from working forests (think tree farms) becomes lumber, furniture, cabinets, windows, and flooring.

The "sawmill residuals"* (around the edge of the sawlog and sawdust) may become feedstock for pellet manufacturing.

*30% to 60% of the incoming wood in a sawmill becomes residuals.

To make something round into square products will result in residuals!

It makes no sense to think that forests are being raped by users of woody biomass…

From a business point of view, a working forest's purpose is to supply the raw material for the production of building materials, paper, packaging, tissue, biochemicals, and many other products including wood pellets.

From a business perspective, the major investment in a new sawmill or a pulp and paper mill or a pellet mill requires that it receive feedstock ***every day*** at a ***stable price*** for decades.

This means that the mill's demand for feedstock cannot exceed the ability of the nearby forests to generate new wood at a rate that is equal to or greater than the needs of the mill.

Pellet factories are bottom feeders!

They take the left-overs from forestry operations and sawmills.
They cannot afford to pay the high value prices for the parts of the tree that are suitable for the primary forest products industries (lumber, etc.).

As long as the source of woody biomass is renewing at a rate that is equal to or greater than the rate of removal, there is no way that any rational thinking person can say that the use of wood pellets for heat and power is not carbon beneficial.

The United States' "Inflation Reduction Act" supports the use of sustainably sourced pellet fuel in power generation.

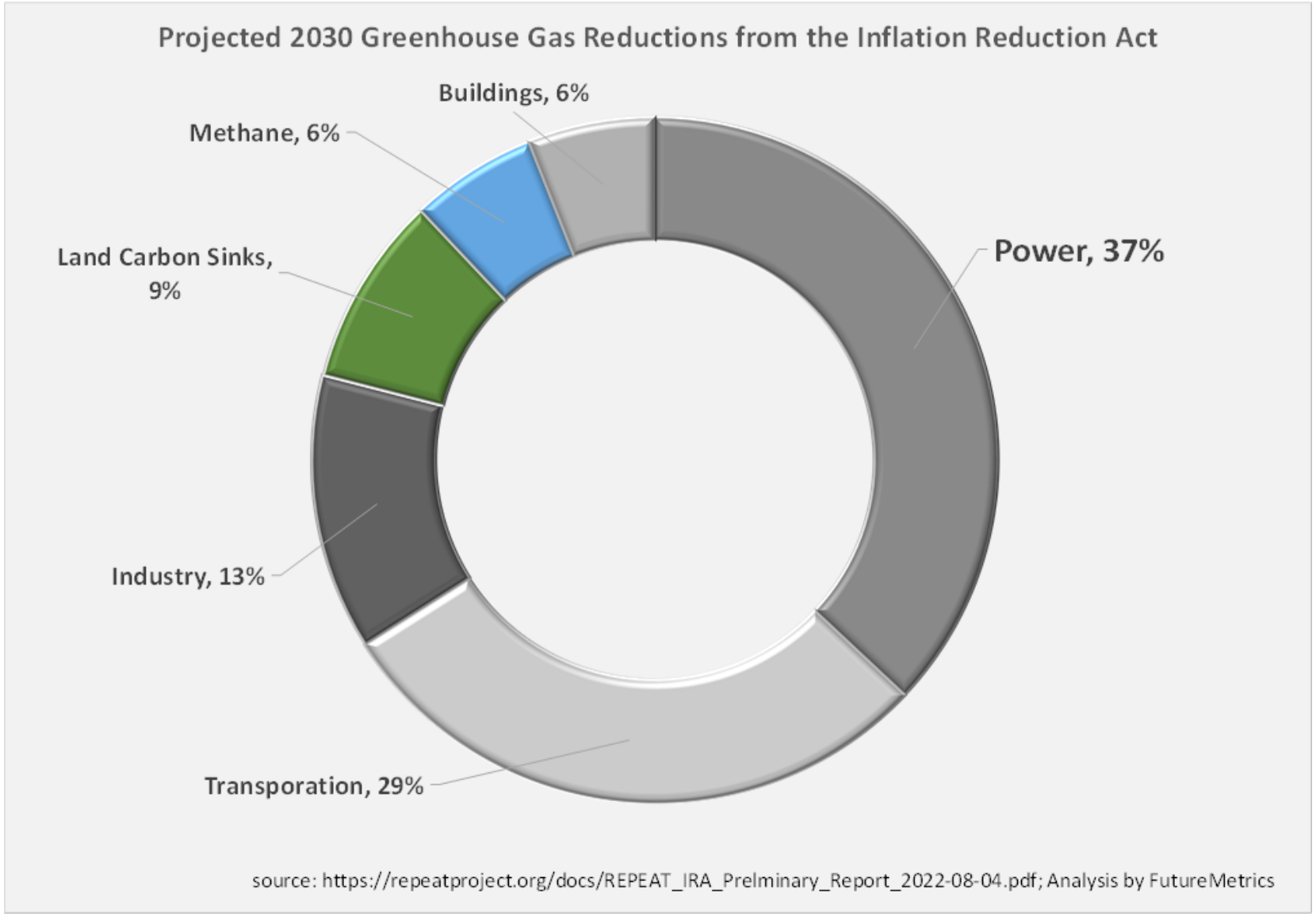
Keep reading to find out how.

The Inflation Reduction Act (IRA) is massive*. It is 273 pages long and the scope of its content is broad.

Notwithstanding the name of the act, **<u>the IRA has a strong focus on mitigating climate change</u>**.

Reductions in greenhouse gas (GHG) emissions from the power sector is a leading area of focus.

*https://www.congress.gov/bill/117th-congress/house-bill/5376



Deep in the IRA is section 13104: “extension and modification of credit for carbon oxide sequestration”.

This extension and modification of existing policy (in section 45Q of the internal revenue service code) significantly elevates support for carbon capture and sequestration from combustion gasses (CCS) and from direct air carbon capture and sequestration (DACCS).

Any new CCS facility built within the next 10 years that permanently sequesters CO_2 will receive $85 per US short ton (equivalent to $93.50 per metric tonne) for every ton sequestered.

DACCS will receive $180 per ton (about $198 per metric tonne) of CO_2 removed from the atmosphere and sequestered.

At best, CCS from fossil fuels is carbon neutral.

DACCS is by definition carbon negative.

CCS prevents the CO_2 from fossil fuel combustion from adding to the net CO_2 concentrations in the atmosphere.

DACCS removes CO_2 from the atmosphere (carbon negative).

The higher price per ton of CO_2 subtracted from the atmosphere via DACCS demonstrates that the IRA explicitly provides a higher monetary value to carbon negative over carbon neutral.

Carbon negative bioenergy carbon capture and sequestration (BECCS) is how the IRA opens the door for pellet fuel use in US coal-fueled utility power plants.

There are **two** major differences between BECCS and DACCS:

First, capturing carbon oxides from combustion emissions is orders of magnitude more efficient and economical than carbon capture from ambient air.

In contrast to DACCS where atmospheric CO_2 concentrations are in the parts per million range (400 ppm = 0.04%), post-combustion BECCS is supplied with CO_2 levels in the range of 8% to 15%. That is 200 to 375 times more concentrated than ambient air. This results in much higher CO_2 capture per unit of input energy.

The second distinction between BECCS and DACCS is that while both subtract CO_2 from the atmosphere,

BECCS simultaneously supplies the grid with utility scale power.

Both DACCS and BECCS are carbon negative solutions and thus BECCS, along with DACCS, should be qualified under the IRA policy to receive the same treatment in terms of the 45Q tax credit accounting:

$198/metric tonne removed!

Think of BECCS as “indirect” air CCS!

That is, the renewing forests that supply the residuals that become pellet fuel are doing the hard work of concentrating carbon from atmospheric air.

What is the Potential in the US?

There are 396 operating coal fueled units greater than 100 MWs in the US with a total capacity of about 209,000 MWs*.

As of January 2023, 202 have planned retirement dates.

The average age of the US coal powered generating fleet is 44.7 years.

Of those operating units, there 27 large generating units with a total capacity of 16,988 MWs that are 15 years old or less.

*Data is from "Global Coal Plant Tracker," Global Energy Monitor, January 2023. Database under license to FutureMetrics.

There may be other large generating units in the US that would be good candidates for full-firing pellet fuel with BECCS. The 15-year cutoff is entirely arbitrary; but certainly, closure of those plants relatively early in their normal life would represent the classic definition of a stranded asset which will ultimately cost the ratepayers or taxpayers (or both).

Location / Station / Unit	Capacity (MW)	Age (years)	
Arizona - Springerville power station - Unit 4	458.1	14	
Arkansas - John W. Turk Jr. Power Plant - Unit 1	609	11	
Arkansas - Plum Point Energy Station - Unit 1	720	13	
Colorado - Comanche power station - Unit 3	856.8	13	
Illinois - Dallman Station - Unit 4	230.1	14	
Illinois - Prairie State Energy Campus - Unit 1	883	11	
Illinois - Prairie State Energy Campus - Unit 2	883	11	
Iowa - Archer Daniels Midland Clinton Power Plant - Unit 2A	105	14	
Kentucky - Spurlock power station - Unit 4	329.4	14	
Kentucky - Trimble County power station - Unit 2	834	12	
Louisiana - Brame Energy power station - Unit 3	704	13	
Missouri - Iatan Generating Station - Unit 2	914	13	
Missouri - John Twitty Energy Center - Unit 2	300	12	
Nebraska - Nebraska City Station - Unit 2	738	14	
Nebraska - Whelan Energy Center - Unit 2	248	12	
North Carolina - James E. Rogers Energy Complex - Unit 6	909.5	11	
North Dakota - Spiritwood Industrial Park -	106.2	9	
Texas - J. K. Spruce Station - Unit 2	878	13	
Texas - Oak Grove Plant - Unit 1	916.8	13	
Texas - Oak Grove Plant - Unit 2	878.6	12	
Texas - Sandy Creek Plant - Unit 1	1008	10	
Virginia - Virginia City Hybrid Energy Center -	668	11	
West Virginia - Longview Plant - Unit 1	808	12	
Wisconsin - Elm Road power station - Unit 1	701.3	13	
Wisconsin - Elm Road power station - Unit 2	701.3	12	
Wyoming - Dry Fork Station - Unit 1	484	12	
Wyoming - Wygen III power station -	116.2	13	
TOTAL ==>	**16,988**	**12.3**	**<== Average Age**

Some of the units in this list may not have good geology for sequestration or access to potential pipelines to carry the CO_2 to sequestration fields.

And there may be other older units not included in this analysis that are better suited for BECCS.

Even with the potentially incorrect top candidates list, this analysis does provide an insight into the potential for BECCS.

To illustrate what is possible, FutureMetrics has produced an interactive dashboard.

FutureMetrics has produced a Google Map HERE of those 27 units. Clicking on the map pins show supporting data. The data includes a hyperlink to a wiki page with details about the selected generating unit.

How the Inflation Reduction Act Supports Bioenergy Carbon Capture and Sequstration at Selected Power Stations

Interactive map of all 27 units

Select Power Station from this Drop Down List (alphabetical order by state)

Texas - Oak Grove Plant - Unit 1

Capacity (MW)	Age	Combustion Technology	Coal Type	Assumed Efficiency
916.8	13	supercritical	lignite	38.5%

Click Here for More Info about this Power Station

Change the Heat Rate / Efficiency ==> 8,870

80% <== Power Station Assumed Capacity Factor

For a full description of this dashboard, click on this link to read the FutureMetrics white paper

Change the Energy Density of lignite Coal (GJ/Tonne) 18.0 = 5. MWhs = 7,755 BTU/lb.

Price of Coal = $125 per Tonne

Click Here for Current Price of Coal (US Spot)

Click Here for Current Price of Coal (CIF ARA)

72% <== Carbon Content of Coal Yields 2.64 Tonnes of CO2 per Tonne of Coal Combusted

White Pellets **Black Pellets**

50% <== Carbon Content of White Pellets Yields 1.84 Tonnes of CO2 per Tonne Combusted

17.5 White Pellet Energy Density = 17.5 GJ/Tonne which is 4.86 MWh's/T

Price of Pellet Fuel = $8.50 per GJ which Equals $148.75 Per Tonne

Co-Firing Ratio - MWh Pellets/MWh Coal = 10%

Apply CCS and the Inflation Reduction Act Benefit?

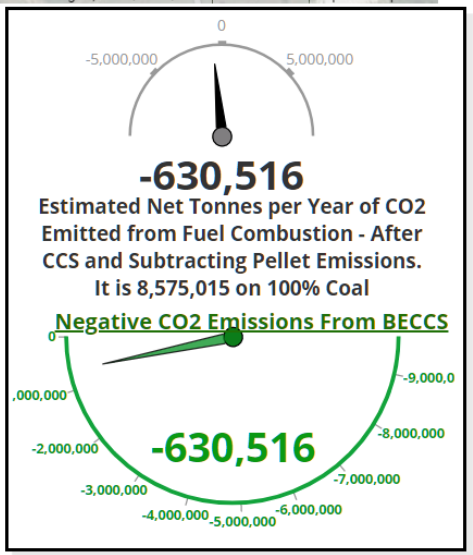
Yes No

Apply DACCS benefit to the BECCS portion of CCS?

Yes No

$180.00 per short ton = $198.00 per metric tonne

Assumed Cost of CCS per Tonne of CO2 is $60



Annual Coal Use (Tonnes)	Annual Pellet Use (tonnes)	Cost of Coal	Cost of Pellets	Avg Cost of Fuel per MWhe minus Net CCS Benefit
3,006,547	343,605	$375,818,343	$51,111,295	$9.74

Net BECCS Benefit is Subtracted from the Generation Fuel Cost

Tonnes of CO2 per MWh	Net CCS Benefit per MWh
1.668	$73.32

This scenario is less costly by $71.50 per MWh than 100% coal

Dashboard Created by FutureMetrics

FutureMetrics Website

+ Save scenario

View all scenarios

In this example, co-firing is at 10%, and the IRA DACCS benefit is applied to the BECCS portion of CCS.

With the assumptions (all of which can be changed by the user), the scenario shown lowers the cost per MWh by about $71.50 versus 100% coal.

Under the assumptions in the dashboard example, the utility would make a rational business choice to implement BECCS and co-fire or full-fire pellet fuel that meets strict sustainability criteria.

This is a win-win-win for all.

- ✓ The project achieves the **same outcome that direct air carbon capture** and sequestration (DACCS) produces.
- ✓ But with **the benefit of generating power rather than using power**.
- ✓ The utility **avoids a stranded asset**.
- ✓ The project produces **baseload or load following power** to compliment the intermittency and variability of wind and solar generation.
- ✓ The **power produced is from 100% renewable fuel**.

Conclusion

- The Inflation Reduction Act has opened the door for what may be the most efficient and pragmatic approach to actively lowering atmospheric CO_2 concentrations. Combining the use of fuel produced from the by-products of continuously growing forests that are already supplying high value primary products with carbon capture results in the same outcome as direct air capture.
- The interpretation of the rules and the application of the tax credits should be consistent with the intent of the IRA's different levels of support for carbon neutral (CCS) and carbon negative (DACCS and BECCS) results.
- **CCS will become a common and ordinary component in national decarbonization strategies. BECCS will be implemented in a subset of power stations and thus will also become part of decarbonization strategies and policies.**
- ***The IRA provides a strong foundation for the implementation of BECCS as part of a US environmental protection strategy.***

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Dashboards of Interest:

Carbon sequestration dynamics

How the IRA Supports BECCS at Selected Power Stations

How to Subtract CO2 from the Atmoshpher and Produce Baseload Power

Many Other Dashboards HERE.

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