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How the Inflation Reduction Act Opens the Door to the Implementation of Bioenergy Carbon Capture and Sequestration in the US

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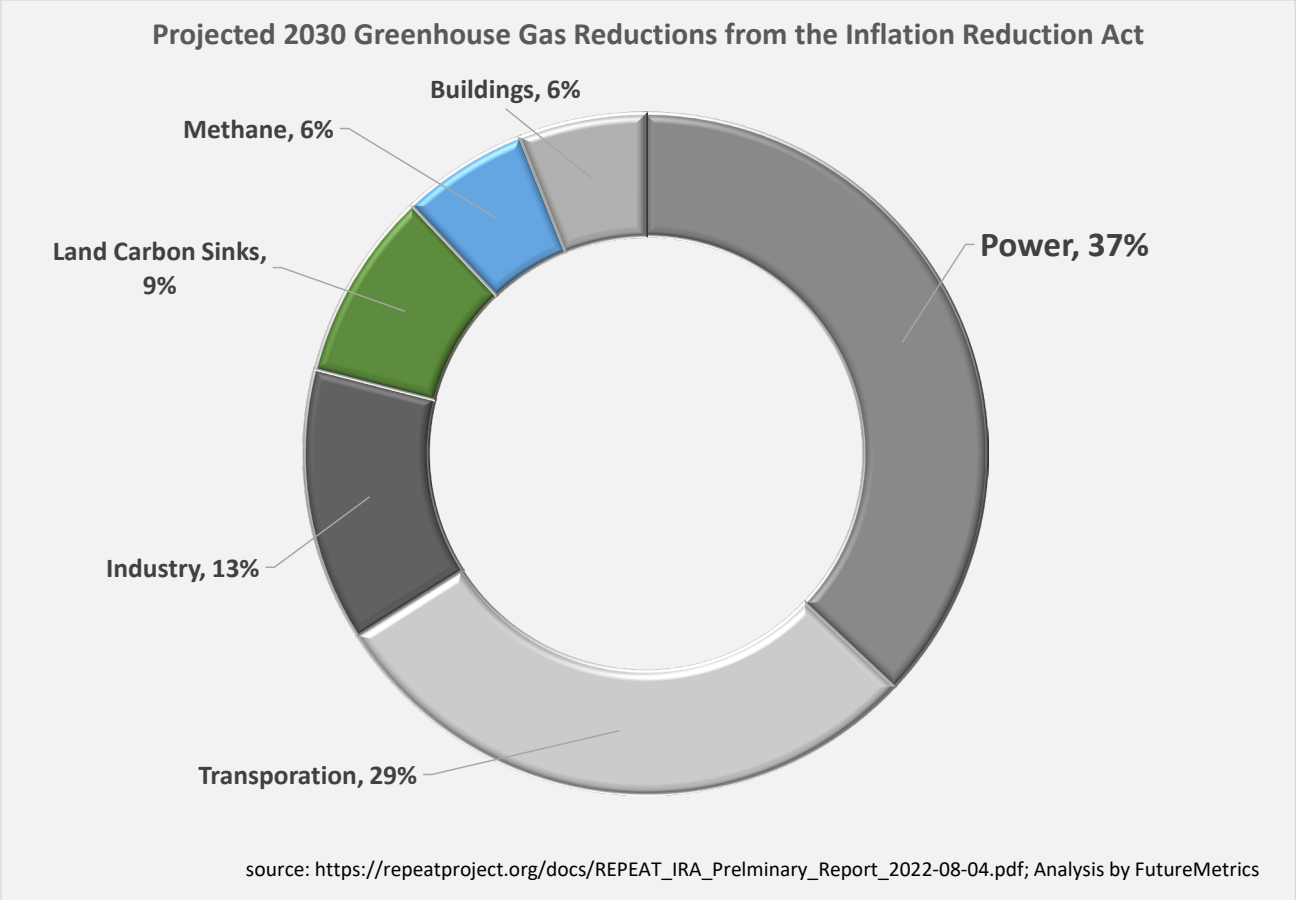
The recently implemented policy in the United States, the Inflation Reduction Act (IRA) is massive[1]. It is 273 pages long and the scope of its content is broad. Notwithstanding the name of the act, the IRA has a strong focus on mitigating climate change. Reductions in greenhouse gas (GHG) emissions from the power sector is a leading area of focus.



While the IRA has only been law in the US for less than a few weeks (as of the writing of this white paper) it appears that there is no direct policy in the IRA that will incentivize existing utility scale coal-fueled power station to co-fire pellet fuel and coal. ***With one exception***…

[1] 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"[2]. 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.

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.

FutureMetrics has written several white papers on the topic of using sustainably sourced pellet fuel to replace coal in power generation as a rational and pragmatic component of decarbonization strategies because pellet fuel is carbon neutral in combustion[3]. Replacing coal with pellet fuel to lower carbon emissions for power generation is a strategy that is supported by policy in a number of nations. But, so far, not in the US.

That may have changed with the IRA.

Sequestration of CO_2 from the combustion of sustainably sourced biomass derived fuel[4] is the only pathway to negative CO_2 emissions while producing baseload or on-demand load-following power[5].

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.

Is BECCS Real?

The short answer is yes. CCS is an essential component in carbon emissions mitigation strategies. CCS allows on-demand generation from fossil fuels without the CO_2 emissions from combustion entering into the atmosphere. Governments across the globe, including the US, are supporting the scaling up of the technology.

DACCS removes CO_2 permanently from the atmosphere. But there is another way to accomplish the same outcome: replacing some or all of the coal used in a utility scale pulverized coal (PC) power station with pellet

[2] See HERE for a summary.
[3] These and other free to download white papers are at the FutureMetrics website: https://www.FutureMetrics.com.
[4] See FutureMetrics' white paper on carbon accounting for sustainably sourced pellet fuel. HERE.
[5] See FutureMetrics' white paper on why wind and solar generation are complimented by the on-demand generation of power from renewing carbon emissions beneficial biomass derived fuels. HERE.

fuel and then sending the by-products of combustion to a carbon capture module and then into permanent sequestration. In other words, BECCS.

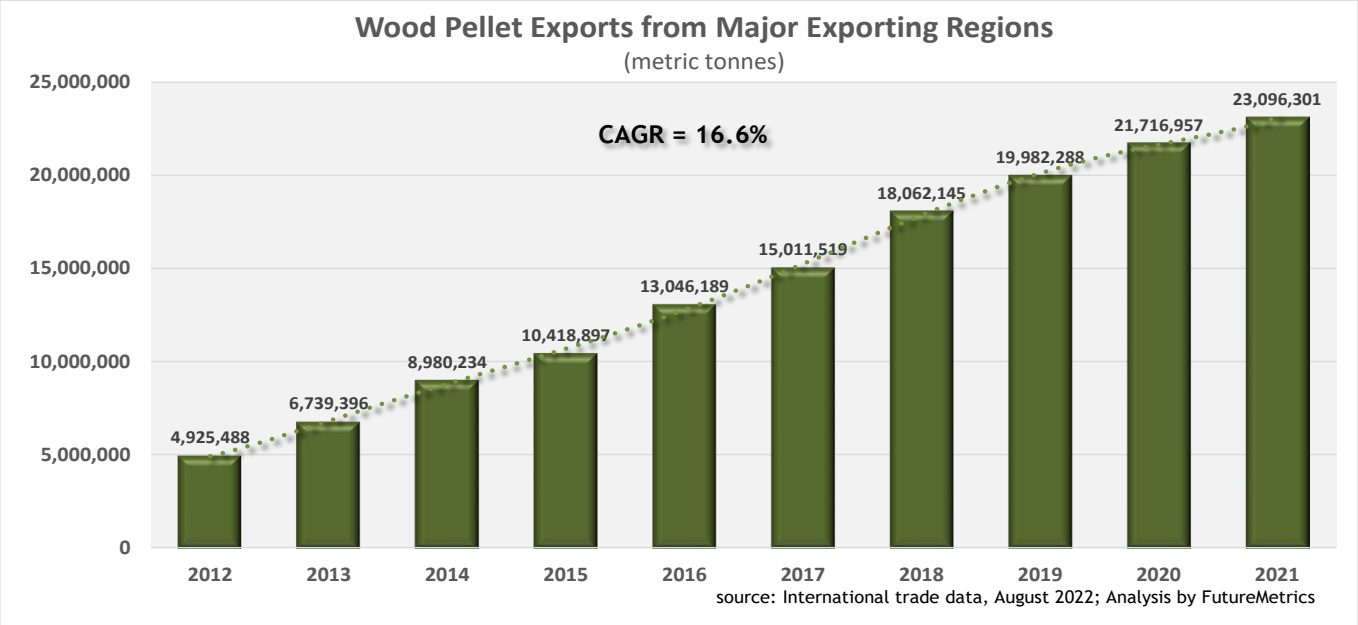
There are two major differences between BECCS and DACCS.

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[6].

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 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.

A utility's PC power station that would be carbon neutral with CCS can easily be modified for a relatively insignificant cost to either co-fire pellet fuel with coal or use 100% pellet fuel. This is not bleeding edge fantasy. In 2021 about 23 million metric tonnes of pellet fuel was exported into nations that support the substitution of pellet fuel for coal in utility power stations to lower carbon emissions.

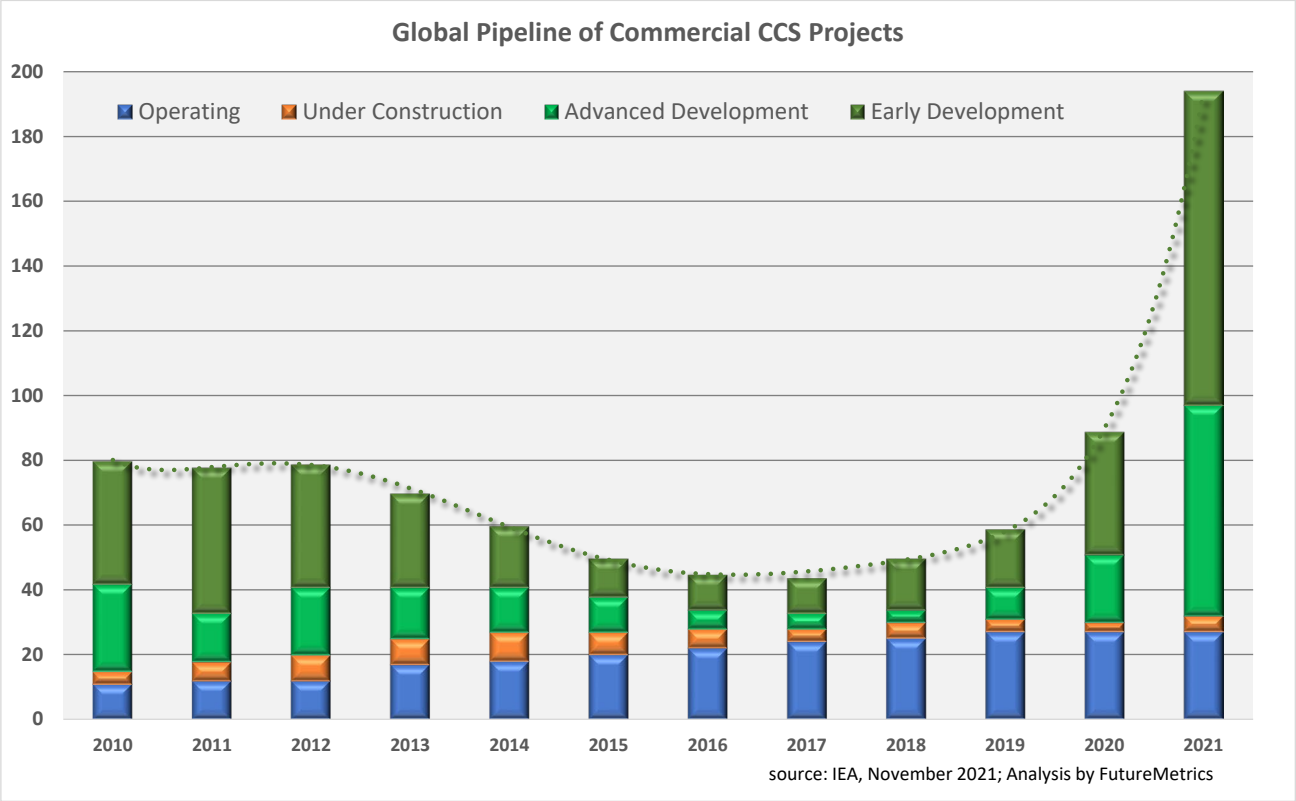


Deployment of BECCS at scale is already in the strategic plans for England's largest power station, Drax. That station currently produces about 8% of the UK's power. Drax power station is a baseload supplier that

[6] National Academies of Sciences, Engineering, and Medicine, 2019.

generates electricity from 100% sustainably sourced pellet fuel (capacity is 4 x 650 = 2,600 megawatts). By 2030, they expect to one of the world's largest carbon negative projects[7].

Development of CCS is accelerating dramatically. The Drax power station may be one of the largest BECCS plants in 2030 but it will not be alone in 2030.



What is the Potential in the US?

There are 458 operating coal fueled power stations in the US with a total capacity of about 217,895 MWs[8]. As of July 2022, 216 have planned retirement dates. The average age of the US coal power generating fleet is 43.7 years.

Of those operating units, there 27 large PC generating units with a total capacity of 18,717 MWs that are 15 years old or less.

There may be other large generating units in the US that would be good candidates for co-firing or full-firing pellet fuel with BECCS, but for this analysis, only those newest generation assets are analyzed. The 15-year cutoff is entirely arbitrary; but certainly, closure of those plants relatively early in their normal life would

[7] See HERE for a summary of Drax's strategy for BECCS.
[8] Data is from "Global Coal Plant Tracker," Global Energy Monitor, July 2022. Database under license to FutureMetrics.

represent the classic definition of a stranded asset[9] which will ultimately cost the ratepayers or taxpayers (or both).

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. The table below lists the plants considered in this analysis in alphabetical order of the state they are in.

Station Name	Capacity (MW)	Age (Years)
Arizona - Springerville Generating Station - Unit 4	458	13
Arkansas - John W. Turk Jr. Power Plant - Unit 1	609	10
Arkansas - Plum Point Energy Station - Unit 1	720	12
Colorado - Comanche Generating Station - Unit 3	857	12
Illinois - Dallman Station - Unit 4	230	13
Illinois - Prairie State Energy Campus - Unit 1	883	10
Illinois - Prairie State Energy Campus - Unit 2	883	10
Iowa - Walter Scott Jr. Energy Center - Unit 4	923	15
Kentucky - Spurlock power station - Unit 4	329	13
Kentucky - Trimble County Generating Station - Unit 2	834	11
Missouri - Iatan Generating Station - Unit 2	914	12
Missouri - John Twitty Energy Center - Unit 2	300	11
Nebraska - Nebraska City Station - Unit 2	738	13
Nebraska - Whelan Energy Center - Unit 2	248	11
North Carolina - James E. Rogers Energy Complex - Unit 6	910	10
South Carolina - Cross Generating Station - Unit 3	591	15
South Carolina - Cross Generating Station - Unit 4	652	14
Texas - J. K. Spruce Station - Unit 2	878	12
Texas - Oak Grove Plant - Unit 1	917	12
Texas - Oak Grove Plant - Unit 2	879	11
Texas - Sandy Creek Plant - Unit 1	1008	9
Virginia - Virginia City Hybrid Energy Center -	668	10
West Virginia - Longview Plant - Unit 1	808	11
Wisconsin - Elm Road Generating Station - Unit 1	701	12
Wisconsin - Elm Road Generating Station - Unit 2	701	11
Wisconsin - Weston Power Plant - Unit 4	595	14
Wyoming - Dry Fork Station - Unit 1	484	11
TOTAL ==>	**18,717**	**11.8** **<== Average Age**

The analysis does not consider how the location may impact the optimization of the carbon dioxide sequestration. 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 from 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 a new interactive dashboard.

A screenshot of the dashboard is on the next page. Discussion of the dashboard's content begins on the page following.

[9] See description of stranded asset HERE.

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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)

Arkansas - John W. Turk Jr. Power Plant - Unit 1

Capacity (MW)	Age	Combustion Technology	Coal Type	Assumed Efficiency
609	10	ultra-super	sub-bituminous	43.3%

Click Here for More Info about this Power Station

Change the Heat Rate / Efficiency ==> 7,880

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 sub-bituminous Coal (GJ/Tonne) 23.5 = 6.53 MWhs = 10,124 BTU/lb.

Price of Coal = $150 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

60% <== Carbon Content of Black Pellets Yields 2.20 Tonnes of CO2 per Tonne of Fuel Combusted

22.5 Black Pellet Energy Density = 22.5 GJ/Tonne which is 6.25 MWh's/T

Apply CCS and the Inflation Reduction Act Benefit?

◉ Yes ○ No

Price of Pellet Fuel = $8.50 per GJ which Equals $191.25 Per Tonne

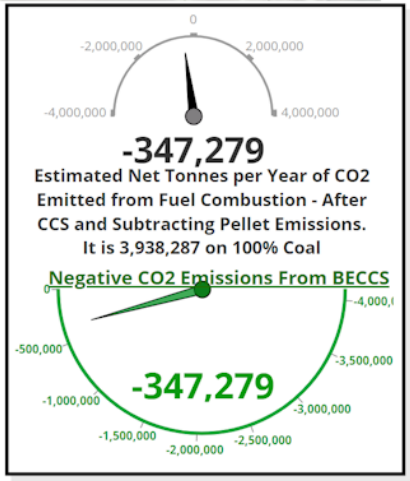
Co-Firing Ratio - MWh Pellets/MWh Coal = 10%

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
1,358,995	157,711	$203,849,264	$30,162,141	$17.84

Net BECCS Benefit is Subtracted from the Generation Fuel Cost

Tonnes of CO2 per MWh	Net CCS Benefit per MWh
1.153	$50.69

This scenario is less costly by $48.49 per MWh than 100% coal

Dashboard Created by FutureMetrics

FutureMetrics Website

+ Save scenario

View all scenarios

The dashboard allows the user to select any of the 27 stations listed above and perform an experiment on the impact on the cost of generation of several potential scenarios. The example on the previous page is for Unit 1 of the John W. Turk Jr Station in Arkansas. The map of the selected power station in the upper right is interactive and can be opened full screen.

By default, the CCS tax credit benefit of the IRA (and thus CCS) is applied to the selected station. It is assumed that all of the CO_2 produced by the station is captured and sequestered.

Under the new and modified 45Q §13104 rules, the amount of the tax credit benefit for the CO_2 captured and sequestered from the coal generated portion of the MWh's is equal to the IRA's value for the carbon neutral CCS solution: $85/short ton. The default assumption in the dashboard is that the CO_2 captured and sequestered from the portion of the MWh's generated from sustainably source pellet fuel is equal to the IRA's value for the carbon negative DACCS solution: $180/short ton.

Both of those defaults can be switched off. Turning off the IRA CCS benefit also switches off all carbon capture. Under that scenario, zero carbon emissions from combustion is only possible with 100% pellet fuel. Negative CO_2 is not possible without BECCS. Turning off the BECCS-equals-DACCS assumption sets all of the CO_2 captured and sequestered at the CCS rate of $85/short ton.

The dashboard displays basic data on capacity, age, combustion technology, reported coal type, and the assumed efficiency. Assumptions on efficiency (heat rate), the energy density of the coal type, and the power stations capacity factor can be changed by the user[10].

Most other critical input assumptions can also be adjusted by the user.

The example has higher energy density "black" pellets selected. So-called black pellets have an energy density that is closer to coal. They do not lose their mechanical characteristics when wet. However, they are typically more costly per gigajoule than white pellets. A cost/benefit analysis may result in concluding that there is a net benefit with black pellets. The analysis, among others, would consider the cost of building dry storage for the white pellets, of modifying the pulverizers and burners to handle higher volumes of fuel to get the same energy into the boiler, and it would consider the potent loss of revenue due to lower output (derating) from using a lower energy density white pellet fuel if sufficient modifications to the power boiler cannot be made.

The dashboard example shows that with the input assumptions on cost per tonne for coal and pellets, and co-firing at a ratio of 10% pellet generated MWh's and 90% coal generated MWh's, the cost of generation per MWh is significantly lower than it would be with 100% coal. The generating unit would use about 158,000 tonnes per year of black pellets to achieve this outcome.

The significant net CCS and BECCS benefits per MWh essentially lowers the realized "fuel cost" per MWh.

[10] Assumed heat rates (and thus efficiencies) are based on data from an MIT study HERE and data from the Global Energy Monitor database. **FutureMetrics can insert the exact values for any power station in the US upon request**.

Based on the input assumptions in the example, the utility would lower its cost to produce a MWh and lower its CO_2 emissions not to just zero but to a negative 347,000 metric tonnes per year.

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.

Experimenting with the dashboard shows that if the IRA benefit for the carbon negative BECCS portion is equal to the carbon negative value for DACCS, the net average effective fuel cost per MWh becomes negative at higher co-firing ratios!

This is a win-win for all.

- ✓ The project achieves the same outcome that direct air carbon capture and sequestration produces.
- ✓ The utility avoids a stranded asset.
- ✓ There is baseload power to compliment the intermittency and variability of wind and solar generation.
- ✓ The portion produced from pellets is 100% renewable baseload power.

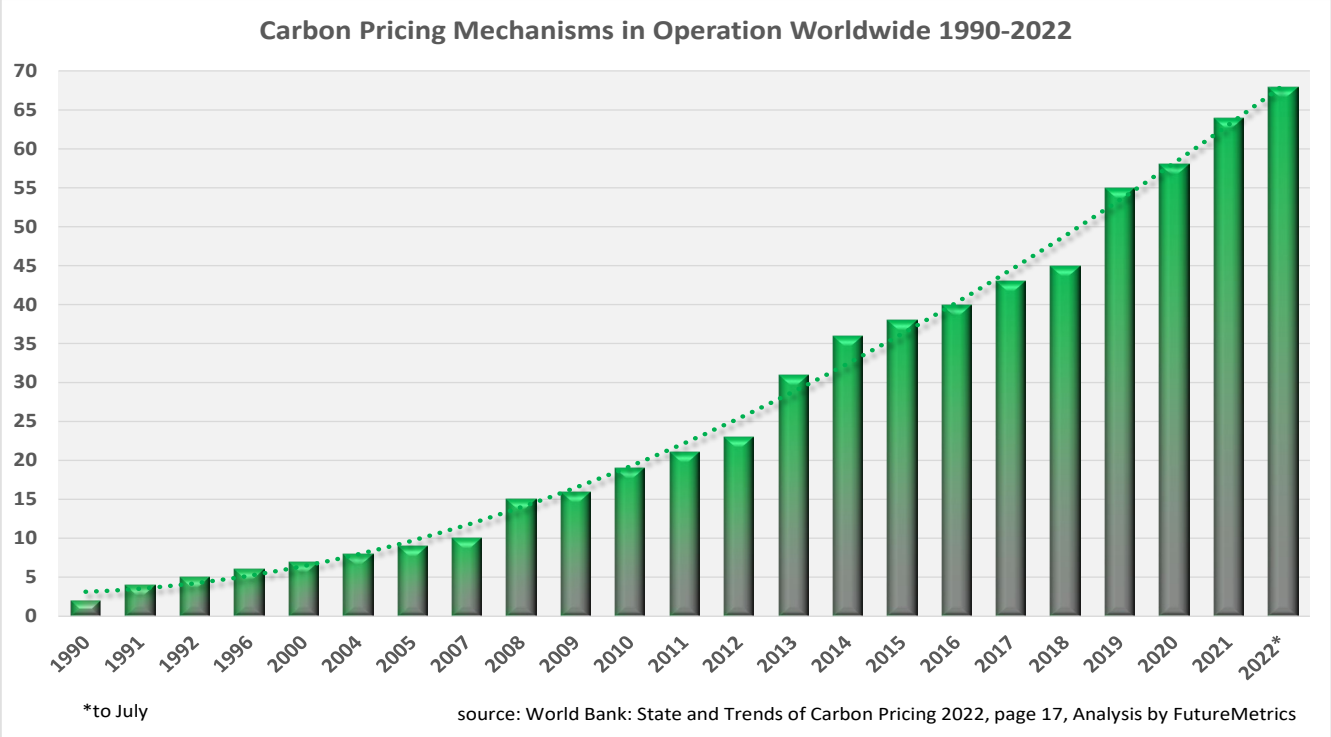
Is this Possible in the US?

Pellet fuel is currently exported from the US primarily to England, western Europe, and Japan[11]. If the fuel is used in the US, the delivered cost for fuel that does not have to be stored at a port, loaded on ships, and shipped across oceans would be significantly lower for US power stations than it is for power stations in different parts of the world. The cost of pellet fuel produced in the US and delivered directly via rail, barge, or short truck haul will be highly competitive.

What about the cost to capture and sequester a tonne of CO_2? With the intense R&D that is underway and with real-world experience, the cost should be low enough for the gap between the IRA support and the capture and sequestration cost to be sufficiently beneficial. A sufficient gap is without doubt if BECCS receives the same support as DACCS.

Will coal prices stay high? That depends on supply and demand, but also on policy. The chart below shows the trend in carbon pricing mechanisms around the world. The US is still an outlier in terms of putting a direct cost on carbon dioxide pollution.

[11] In 2021 the US exported 7,523,000 tonnes. The US can increase the sustainable supply of pellet fuel many times over. See this FutureMetrics White Paper for details.



The IRA support for CCS indirectly puts a price on carbon. It does not penalize carbon emissions. It rewards the emissions that are prevented from entering the atmosphere.

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 managed forests 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 (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[12].

The IRA provides a strong foundation for the implementation of BECCS as part of a US environmental protection strategy.

[12] https://direct.argusmedia.com/NewsAndAnalysis/Article/2364094