CIBO Environmental Committee Meeting
September 20, 2022
Virtual

Environmental Committee Chairman
Robert (Bob) Morrow, Detroit Stoker Company

Introductions – **Alex Stoddard, CIBO**
Alex opened the meeting with around the table introductions. We have 9 speakers lined up for today. Bob Morrow, Detroit Stoker Company, is the committee chair and meeting chair. We will be covering both the regulatory side and the DOE side including the EIA forecasts.

Overview of New "IRA" Law, Tax Elements – **Jeff McMillen, Akin Gump Law**

The recently passed law is unprecedented in terms of the ideas that have been included. A number of federal agencies will have to coordinate to make this successful. Companies must include their tax departments to take advantage of the various tax credits that are in the law. There are also some new taxes that have been implemented in order to pay for the credit provisions. The EU is looking into a minimum 15% tax on international companies. This has not been finalized, but it is important to keep these provisions in mind. A number of the credits are building on existing credits. It is important to make sure that the current version has not changed the basis for applicability. Guidance on many of these credits is expected. Many regulations have not been finalized.

The investment tax credit for PTC (production tax credit) has been 1.5 cents/Kwhr. The credit applies for 10 years. There is a bonus of 2.6 cents/Kwhr for certain provisions. Job training and apprentice programs are required for the bonus. Project commencement could be within 60 days of the guidance issuance. Private companies cannot use direct pay. Some companies can sell transfer credits to bring in other companies. Domestic content rules can allow additional credits. Steel production and energy communities may qualify.

The ITC (investment tax credit) is an upfront, onetime payment. The credit applies to most renewable energy projects. The existing ITC runs to 2024. A replacement credit is anticipated thereafter. There are apprenticeship requirements as well as domestic content requirements. The level of credit can vary from 6% all the way to 70% if an energy community is involved. The 45Q credit for CO2 capture and sequestration. The prior guidance took 2 years to issue. The credit starts at $12/ton and now ranges up to $180/ton. Direct Air Capture is now included and can attract a higher level of credit. The amount of CO2 that needs to be captured has increased in order to qualify. There are prevailing wage and apprenticeship program requirements. Companies can use direct pay for this credit. The 45Q cannot be stacked with other credits. This bill was a reconciliation bill. That means that it will be difficult to fix any mistakes that may appear in the bill. Only the party that has control of the House, the Senate, and the White house can pass a reconciliation bill with only 50 Senate votes. A fix to a mistake would require 60 votes, which is unlikely.

Overview of New "IRA" Law, EPA/DOE Climate/Clean Energy Elements

Lisa Jaeger, Bracewell LLP

The DOE has included some loan guarantee provisions under the new law. Title 17 has been expanded. There is an Advanced Industrial Facilities Deployment Program that has $5.8 billion for assistance for those companies that improve or retrofit their facilities that reduce GHG emissions. There are $63 billion in DOE Industrial GHG Reduction Grants.

The DOE Advanced Manufacturing Office has an industrial emissions reduction technology program. The office will be split into two different offices. One will focus on industrial efficiency and decarbonization. The second will focus on advanced materials and manufacturing technologies.

There is a new Industrial Technology Innovation Advisory Committee that companies can join. There are at least two FOAs for decarbonization technologies totaling nearly $200 million. The DOE has issued an Industrial Decarboniztion Roadmap. This roadmap looks at 5 key industries. (iron and steel, chemicals, food and beverage, refining, and cement) There are 4 pillars of decarbonization: energy efficiency, electrification, low carbon fuels/energy resources, and CCS/CCUS.

The EPA received $41.5 billion for 24 new and existing programs. State "green banks" will get $27 billion. Climate pollution reduction at the state and local level are in line for $5 billion. Environmental Justice (EJ) and climate block grants get $3 billion. EPA OAR is in ramp up mode. Transportation and monitoring grant are included, including $5 million for states that adopt California standards for mobile sources. Monitoring activities will increase, including $117.5 million for fence line monitoring. There is $68 million for a low emissions electricity program. There is a corporate reporting program. There is $50 million to support improved air quality in schools. The bipartisan Infrastructure Law provided EPA with $100 million for emissions reduction in EJ communities.

The Supreme Court decisions in WV v EPA went against EPA. The regulation in question was the Clean Power Plan (CCP). The CPP proposed generation shifting as opposed to Best System of Emission Reduction (BSER). The Court stated that EPA did not follow BSER and therefore exceeded its authority. The Court stated that the statute did not give EPA the authority to shift generation. The decision did not violate Mass v EPA. EPA still has the authority to regulate GHGs. The IRA restates that GHGs are considered to be pollutants under the CAA. Thus, EPA still has the authority to regulate GHGs. It just has to use the proper tools.

DOE, Direct Air Capture: Carbon Utilization – **Amishi Kumar Claros, DOE**

The DOE Office of Carbon Management Technologies has two groups: Point Source Capture and Removal and Utilization. CCUS is critical to addressing the climate challenge. Reaching net zero will be nearly impossible without CCUS. DOE FE is now DOE FECM. Carbon management seeks 50% reduction by 2030 and net zero by 2050. Carbon free electric generation is hoped for by 2035. Carbon management goes beyond fossil energy. There are 7 priority areas. A strategic vision document on carbon management has been issued.

For Direct Air Capture (DAC), $3.5 billion has been allocated to regional DAC hubs. There are also prize competitions totaling $115 million. Storage validation and verification has several billion dollars. Relative to 45Q, the DAC threshold for CO2 capture has been reduced to 1,000 ton/yr. Thresholds were reduced for electric generation and other facilities as well. There is an international mission to catalyze carbon dioxide removal worldwide. The US, Canada, and Saudi Arabia are co-leads. There are a number of international support groups. Reactive capture and conversion can comprise integration of separation and conversion using fewer steps. The idea is to make of the captured CO2 as it is captured, as opposed to releasing and purifying the CO2 and then directing it to a utilization process. There are DAC prizes for pre-commercial air capture processes. These processes are most likely bench scale and total $15 million. There is also a commercial DAC prize for projects that are large scale and total $100 million.

DOE, Direct Air Capture: Point Source Carbon – **Lynn Brickett, DOE**

There is a carbon negative shot that involves the whole DOE to capture CO2 from the atmosphere and store it at gigaton scales. Normal CO2 capture from point sources cannot get carbon negative, with the exception of using biomass and capturing the CO2 emissions. The goal is to capture and store CO2 for $100/ton.

The DOE budget for CDR has increased dramatically. There are a few generation 1 technologies, but there is a lot of interest in generation 2 technologies that are at the very early stages of development. The current estimates are $600/ton. The goal is to get to $100/ton. With appropriate qualifications, the 45Q credit can go to $180/ton. One advantage for DAC would be that the capture system could be collocated with storage without major transportation of the CO2. With potential integration, hopefully the cost can come down. Biomass is very important to CDR technology. Three studies have been initiated to study site specific conditions. Congress has instructed the DOE to go for 4 DAC hubs in the US. These hubs must capture 1 million tons/yr.

The largest DAC plant in the world is currently located in Switzerland and captures 4,000 tons/yr. The 4 hubs need to be geographically diversified. The life cycle analysis for these plants is critical

EPA – Key Air Regulations – **Kevin Culligan, EPA**

The EPA Good Neighbor Plan stems from the 2015 Ozone NAAQS rule. The EPA received numerous comments, including many from industry. These are seriously being considered. The goal is to get to a final rule so that some controls at existing facilities can be turned on next year. Then the remainder would be due by 2026. There was an oil and gas rule proposed in 2021. There will be an update shortly. The on shore upstream sources are impacted. They are mostly concerned about methane leaks. For GHG reductions at EGUs, new rules have to be proposed. Both coal and gas fired units will be impacted. A proposed rule could be out by March 2023. For the moment, these are the two main GHG rules under consideration. The PM NAAQS proposal is over at OMB for review. The ozone NAAQS are being reviewed. There are no decisions as yet. The Boiler MACT final rule was issued. For pulp and paper MACT, options are being considered. No decisions have been made and no deadlines have been established. The hazardous organic NESHAP is proposed for March 2023.

Fence Line Ambient Monitoring/Assessments –**Scott Adamson, Trinity Consultants, Inc.-MSI**

There are federal, state, and local agencies that are all looking at fence line monitoring. Right now, the federal program looks at benzene monitoring. For PSD issues, there can be requirements to get permits. For post construction monitoring for PSD could apply to any criteria pollutant at the administrator's discretion. Section 114 of the CAA has some specific requirements for particular chemicals.

California is looking at refineries in particular, but there are District level rules as well. Underground gas storage has ambient monitoring for methane. Colorado has requirements for ozone precursors, particularly VOC monitoring. Chicago has requirements for fugitive dust and toxic metals, especially in EJ communities. Passive sampling includes Method 325A and Method 325B for VOC concentrations. The samplers are placed along the fence line in a hooded installation to protect against the elements. The sampling period is 14 days. Generally 12 samplers are required, but more can be required for large facilities. Equal spacing or special placement, depending upon size and shape, can be used. The device is simple and the sample tube is removed and analyzed in the lab. The disadvantage is that the data only comes back after the lab analysis. Short term detection can be a problem. Time integrated samples can be done with Summa canisters. A flow controller draws the sample over a fixed period of time. A sorbent captures the VOCs of interest. The collected samples are still sent to a lab for analysis. Costs are somewhat higher. However, the time frame could be as low as 1 hour. The detection limits are much lower. The data is still lagged due to lab analysis requirements. Continuous monitoring can also be installed. These provide near real time data. The number of continuous monitors has been increasing significantly. There are federal reference methods. There are near reference monitors at lower cost. Data validity might be an issue.

EPA does not particularly like the use of low cost sensors and does not really use that data. Data resolution is better. For EPA use, strict performance criteria are set by EPA. A climate controlled shelter is typically required. The results are verifiable. Line power is required. The low cost sensors do not meet the EPA requirements. Open path monitoring is required in some states. A laser system is used with FTIR analysis. Continuous measurements across the fence line can be obtained. As a general rule, if data is available for 75% of the time, it is considered continuous. Thus, 45 minutes out of any hour or 18 hours out of any day would satisfy the requirement for continuous ambient monitoring. These are the most expensive. Annual calibration is typical. Community based monitoring is supported by EPA. Both mobile and stationary systems can be deployed. EPA has developed an Air Sensor Tool Box. In order to get good data, there is a need for QA/QC, as opposed to just a number. In many cases, an alarm system is being required. An agency has to be notified of any alarm condition within a specified time frame. Data has to be kept for at least 2 years. The EPA is continuing to focus on fugitive emissions. EJ considerations are taking on higher importance. Local regulations are increasing. Being involved is getting more important. Comments on proposed regulations are helpful.

NSR and Possible Changes – **Amy Marshall, All4**

The last administration got some good things done on NSR. Thus far, the changes are still in place. The Pruitt Memo on projected actual emissions was one of those. Project emissions accounting guidance became a rule. This allowed netting for shutting down a coal plant and changing to gas. A project aggregation reconsideration was issued. There were also some site specific decisions that were helpful.

The PAL guidance encouraged states to take a flexible approach to PALs. Also, there were some language cleanups that were done. Biogenic CO2 was not addressed. Begin actual construction guidance did not go through. States had some objections. A court case was won on routine maintenance, repair, and replacement. Guidance on debottlenecking was not forthcoming. Recently, with the new administration, a guidance rule was eliminated. The project emissions accounting rule petition was denied.

The John Deere memo on removing avoidance limits when a source reclassifies asked about such a removal. Some guidance has been issued on ozone and PM2.5 modeling. This is now required when PSD is triggered for NOx or SO2. EPA issued a BACT memo to TCEQ to define a BACT limit on what is achievable. EPA stated that a limit is achievable if it is in a permit. On fugitive emissions, the original rule required inclusion to determine if a modification was a major modification only if the industry was included in a particular listing. This went back and forth a few times. The last time, EPA went back to the original. Environmental groups objected. EPA has made a new proposal that has not issued yet. EPA is looking at “improvements” on the project emissions accounting and the improvements to major MACT. EPA is looking at notice requirements for minor NSR permits. The primary concern is synthetic minor permits. The Pruitt memo may be under review.

Further NSR reform is not a priority for this administration. Those memos that did not get finished will not likely be addressed. EJ is a key priority for the current administration. Different states are taking different approaches. Some recent permit applications have been denied on EJ grounds, even if all regulatory requirements have bene met. There will likely be increased use of the Civil Rights Act to object to permit actions. That means interaction with neighbors prior to submittal of a permit application is becoming more important.

EPA is reconsidering the last administration's decision to retain the ozone NAAQS as is. EPA is expected to propose a lower annual standard for PM2.5. The current standard is 12 ug/m3. Numbers from 8 – 11 have been suggested. Background is 8. Companies should improve the confidence in their emissions inventory. For expansions plans, the time to apply for a permit is now before the standards are lowered. Engage with the community now. Understand geographic impacts, as well as cumulative impacts. Engage with your industry associations (CIBO) to maintain your understanding or the rules and make comments on these proposed rules.

DOE-STEO Natural Gas Markets Outlook & Electricity Markets Update

Lori Aniti and Kathryn (Katy) Fleury, DOE EIA

Katy provided the short term natural gas outlook. Henry Hub price is expected to average $7/MMBTU in 2022 and $6/MMBTU in 2023. Pricing has been volatile. Consumption is expected to increase this year with a potential slight decline next year. Net exports will increase.
Working gas inventories are expected to remain below the 5 year average at the end of October. Natural gas provides 37% of generation, but may drop slightly due to increased renewables. Export LNG will increase.

Pipeline exports to Mexico are expected to increase. Gas production is expected to increase. Recent production hit 100 BCF/day. Production is primarily coming from the Permian Basin (associated gas). Right now, LNG production in the US is pretty much maxed out. There are a couple of projects under construction, but they will not come on line until 2024.

Lori presented on the electric generation forecast. The share of renewables is expected to increase. Coal generation increased in 2021, but labor shortages, rail shortages, and some mine closures prevented coal from increasing in 2022. Some areas could not get coal to their plants during the heat wave. Gas prices are expected to rise somewhat into 2023, but decline after the summer of 2023, as normal temperatures are expected and the economy may not be as robust. Industrial consumption is expected to continue to increase.

Renewables in PJM are around 4% (not counting hydro). Gas prices tend to increase in the winter. Industrial electric prices are high in New England, but more modest in rest of the country. In the midcontinent ISO, coal is the dominant fuel.

The Southwest Power Pool is higher on natural gas. ERCOT has a lot of wind. Wholesale prices are lower than in the Northeast. Industrial prices are about 2/3 of New England. California has

a large amount of solar. Natural gas provides most of the rest. Coal, nuclear, and others are small. Western hub prices are between midcontinent and New England.

September 21, 2022
Virtual Energy/Sustainability Minutes

Energy/Sustainability Committee Chairman
Robin Mills Ridgway, Purdue University

Introductions – **Alex Stoddard, CIBO**

Alex opened today's meeting noting that this session will focus on energy issues. The agenda was reviewed. Robin gave the antitrust admonitions.

EPA – PFAS – **Chuck Chaitovitz, US Chamber of Commerce**

Chuck noted that there were a couple of issues that have come up, including a revised definition of waters of the US (WOTUS). The need for more certainty with regard to these issues has been pointed out. The Sackett case is coming up before the Supreme Court. A request for extension has been submitted. One of the issues is the use of CERCLA authority for a water deposition limit. The EPA estimated costs look to be underestimated and incomplete. The Chamber is working on comments and requested CIBO to weigh in on this issue. Issues include disposing of waste waters generated by EPA research projects and standards levels below non-detect levels.

Cornell Campus Energy Update – **Cheryl Ann Brown, Cornell University**

The Cornell campus is pushing 15 million ft2 in upstate New York. The power plant supplies steam for heat, plus electric power and water services. Peak load is 35 Mw. Energy conservation activities improved overall efficiency which reduced carbon emissions. Two gas turbines with HRSGs provide cogeneration and allowed for the shutdown of the two coal boilers. Pressure from the student community, the state, the faculty, and some eNGOs drove the elimination of the coal units.

The university adopted the Paris Accords. There are state regulations that will impact the university. Building codes may require renewable energy credits. The state is pushing for all buildings to be electric. The university has a Climate Action Plan which calls for carbon neutrality by 2035. Renewable energy use is only a part of the plan. One approach is earth source heat (like geothermal). The alternative is ground sourced heat pumps. Nuclear power can also be considered. The last alternative is carbon credits. Solar PV and wind power can be deployed for

electricity supply. Earth source heating involves drilling down about 10,000 ft to where the temperature can support heating water to 190 F. That hot water can then be brought to the surface for use as building heat. A test well has been drilled. Hot water has been verified. There were no seismic or fracture issues. Community involvement has been promoted. Of course, this approach requires a shift from steam distribution to hot water distribution. Backup and emergency power and heat need to be evaluated. Energy conservation programs will continue. The university would like to be able to generate some carbon offsets

University of Cincinnati Campus Energy Update – **Sheri Bussard, University of Cincinnati**

The University of Cincinnati campus covers nearly 8 million ft2. The campus is landlocked and in the middle of a built up urban area. They are subject to EJ considerations.

The Central Utility plant was constructed in 1993 to house the combined cycle plants, which allowed the shutdown of their coal units. There are two gas turbines that feed HRSGs, which in turn feed a steam turbine for power generation. There are 4 gas/oil fired boilers to provide steam, as well as backup diesel generators for summer use. The university has committed to 50% carbon reduction by 2035 and carbon neutrality by 2075. There is a climate action plan, but there is limited accountability in terms of reaching those goals. Implementing some of the ideas to actually achieve these goals is a major challenge.

The combined cycle plant was installed in 2003 and has generated renewable energy credits. An underground chilled water plant was installed in 2008. One of the peaking generators can used biodiesel. The two coal fired boilers were converted to wood pellets. However, problems with the feed systems and fuel supply led to the shutdown of these units. Chilled water systems are being upgraded with smart, multi compressor systems. Some green power is being purchased from the utility. Wind power is the primary source. A real time data system is being installed to provide complete system data to identify potential opportunities for energy savings. A 1.5 Mw solar array is planned. Biodiesel blending is being considered when oil firing (backup fuel) is needed. Hydrogen blending with natural gas is being considered for the gas turbines. Hydrogen supply is currently an issue. The PEMS system would have to be modified for such blends. Small modular nuclear reactors are being studied. The “nuclear battery” concept appears to be more attractive (shop assembled, 10 year life, plug and play). These units might be a long term solution.

DOE – Renewable Energy Guidance Report – **Anne Hampson, DOE**

Anne pointed out that there are a number changes going on with the Advanced Manufacturing Office. One of the groups covers technical assistance. The AMO is splitting into two offices assistance. The AMO is splitting into two offices: Industrial Efficiency and Decarbonization and Advanced Materials and Technologies. The split will occur on Oct. 9. The Industrial

Decarbonization Roadmap has been issued. The roadmap is focused on the 5 sectors that account for the majority of industrial GHG emissions. (chemicals, iron and steel, refining, food & beverage, and cement) There is no silver bullet. Multiple solutions will be needed, as well as integration of processes. There is a funding opportunity announcement out that is under a $104 million funding effort. Proposals are due in December. The AMO has a number of institutes and is now setting up a 7th institute on industrial electrification.

The DOE has a Better Climate Challenge that aspires to reduce GHG emissions by over 50% in 10 years. A renewable guidance document for industry has been released. There is a summary document and a supplemental document (more detailed). Energy efficiency underpins the major resource for these efforts. By reducing energy needs, the requirements for the remaining equipment and processes (including renewables and storage) are also reduced. The CHP program will be expanded to include all types of onsite energy. There is also an Industrial Technology Validation program. Phase 3 of that program is coming soon. The Infrastructure Law has provisions for providing grants and aid to smaller businesses for GHG reductions. There is also a state manufacturing leadership program. There are several manufacturing related provisions in the Inflation Reduction Act.

High Temperature Heat – New Technology Overview – **David Bierman, Antora Energy**

David pointed out the off peak power from renewables in SPP causes the wholesale price of electricity to go to zero or less (with incentives). In that area, the incentives drive the generation of power when it is not necessarily needed. However, this generation is intermittent. Effective and reliable storage of such energy in the form of heat can provide the needed reliable heat for industrial use. The Antora process uses resistance heating of carbon blocks to drive up the temperature of the blocks. The blocks then radiate heat to the desired process. Carbon blocks are used because it can be heated to high temperatures in a stable manner. It is generally low in cost and highly scalable. There is an existing supply chain. The material has a high thermal conductivity and a high specific heat. The technology has been used in graphitization furnaces for many years. The use of radiation to move the heat allows large quantities of heat without circulating a fluid through the system. The system is modular. Shutters can be used to modulate the amount of energy being delivered to an industrial process. A pilot system is being deployed at a site in California. The system is a 5 Mwhr storage system. It is intended to be the foundation for a single module. Success of this system would allow industrial thermal heat to be supplied by renewable electric power.

Congressional GOP Perspective and Plans for 2023

Marty Hall, Citizens for Responsible Energy Solutions (CRES)

Marty ran the Republican policy task force on climate in the US House in order to prepare for a potential Republican majority following the November elections. The goal is to have a plan ready.

For energy and environment, energy independence, lower costs, faster permitting, cleaner, and American produced will be the major themes. The US is the most efficient producer in the world. A product produced in China generates 3 times the emissions as the same product produced in the US. The US has reduced GHG emissions since 2005 more than the next 5 reducers in the world. A similar analysis applies to natural gas that comes from Russia compared to US natural gas. If lower GHG emissions are desired, production in the US should be optimized. That also means that obstacles to US production should be removed. Permitting should be made easier. American resources should be unlocked to provide security at home as well as abroad. Reliance on /China needs to be reduced. China controls 90% of rare earth minerals, which are needed for renewable energy systems. Replacing OPEC with China is not the way to solve our energy problems. Yet opening a new mine in the US is nearly impossible. Innovation will be critical to reducing costs (and thus emissions). That also requires changes to the permitting system. This will be required across the board. We need to beat Russia and China. We need to make ourselves more competitive. Conservation technologies will also be needed (for example in farming and forest management). Finally, a more resilient society will be needed. Spending money on disaster mitigation ahead of a disaster will pay in reduced cost and resiliency going forward.

Decarbonizing Industrial Steam & Power with Chemical Looping and Oxygen Combustion Technologies – **Brian Higgins, The Babcock and Wilcox Company**

Green energy can be thought of as renewable power, energy storage, synthetic fuels (particularly sustainable aircraft fuels), and industrial steam/heat. The energy transition involves a number of technologies, but in particular, carbon capture. The first question becomes whether or not sequestration is available. If not, renewable fuels and energy will be the primary path. If sequestration is available, carbon capture will likely be deployed. Renewable fuels include green hydrogen, biomass, biowaste, and renewable natural gas.

The EU is not allowing growing a crop to convert to fuel. In the EU, there is a waste hierarchy which leads to energy recovery after reduce, reused, and recycle. For a boiler, the most straight forward approach is to substitute hydrogen for natural gas. The DOE target is $1/Kg hydrogen. That translates to about $ 7/MMBTU. However, transportation and delivery of hydrogen is more difficult. Delivered cost can be much higher. Some hydrogen will be made from grid power, but currently grid power is more carbon intensive than natural gas. Methanol may turn out to be a better solution for transportation fuels. Low cost solar or wind is usually “behind the fence”. However, they are still intermittent. Distribution is still a significant cost. To get “green steam”, an electric boiler driven by renewables could be applied. Intermittency is still a problem. Heat pumps can also be applied, but that doesn’t change the intermittency problem. Thermal storage can smooth out the problem. B&W is using sand as the storage medium. With carbon sequestration being available, carbon capture technologies become applicable. There will likely be a capture business, a transportation business, and a sequestration business.

For capture, there is post combustion capture (amine scrubbing), oxygen firing, and fuel processing. Amine scrubbing is essentially commercial (although the largest unit is around 100 MW). Oxygen firing has been demonstrated. However, the boiler has to be essentially leak proof. A package oxyfired boiler. These small boilers are already slightly pressurized, so leakage is not as much of a problem. Electric power can be generated to drive a small ASU as well as the CO2 compression station. The usual fuel can be used and the CO2 sequestered. Finally, B&W is developing a chemical looping system called BrightLoop. The system consists of 3 vessels. The lower vessel is a fluid bed that has a solid particle that is an oxygen carrier. Air is introduced in which the particle absorbs oxygen. The depleted air exhausts. The particles are separated and sent to a moving bed. The particles are transported to a higher vessel where fuel is introduced. The fuel takes the oxygen from the particle and produces a relatively pure stream of CO2. The CO2 can be sequestered. The system can also be operated to produce hydrogen. A pilot plant was built at the DOE/Southern Co test center combined with KBR on the gasification side. A 15 ton/day hydrogen plant is planned. The oxygen carrier is an iron oxide particle that is engineered to operate between two oxidation states of iron. There are other substances that are added to help control the oxygen uptake and oxygen pickup by the fuel.