ENGINEERING DRAFT -- ENGINEERING DRAFT -- ENGINEERING DRAFT

January 18, 2023

Revised January 30, 2033

By: Howard Phillips

www.PhillipsExport.com

Title:

Use of coal to produce heat for large power plants, with virtually no CO_2 production

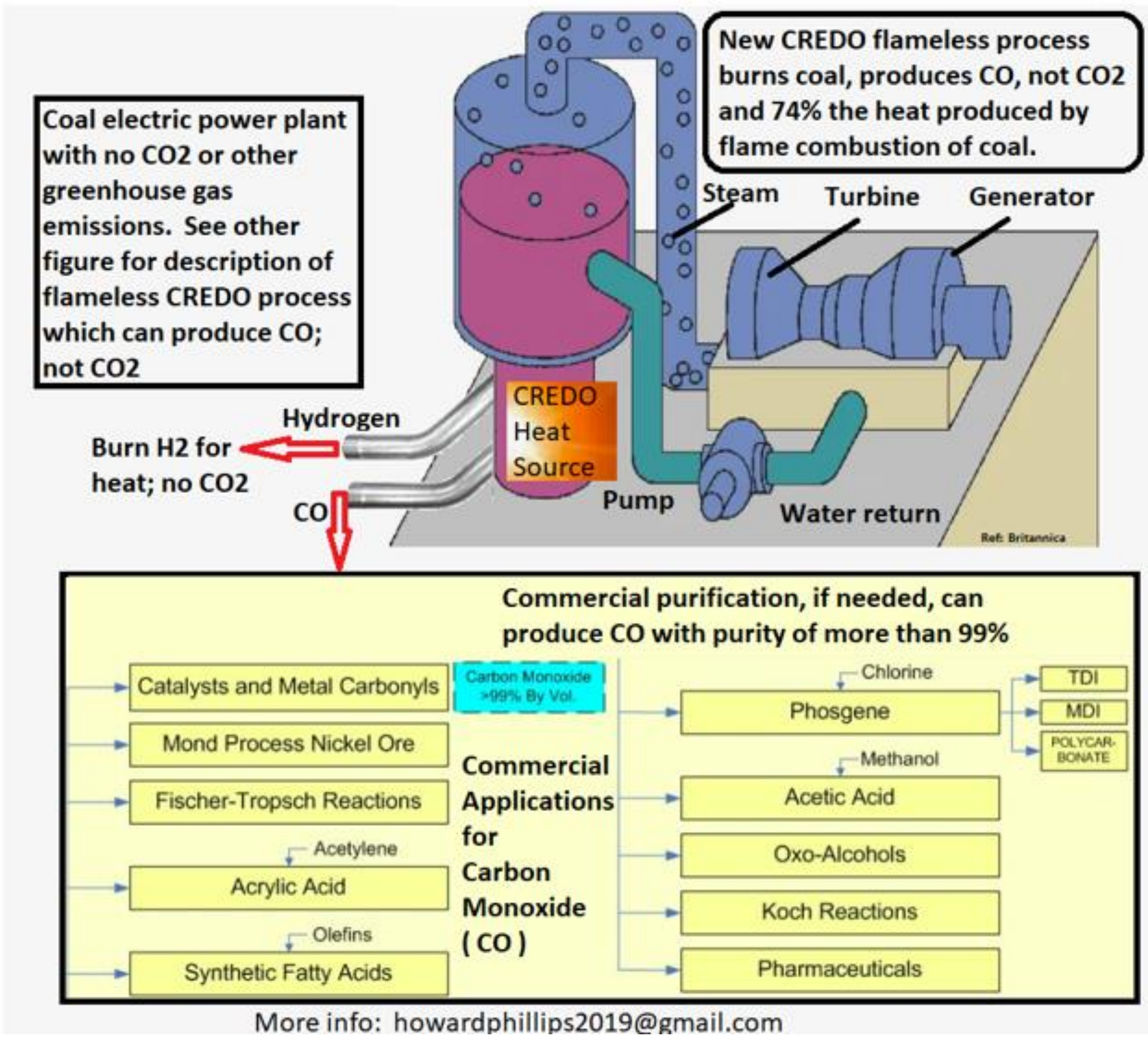
Abstract

Coal can be used to produce heat for large power plants, with virtually no CO_2 production, using the CREDO process for the combustion of coal.

CREDO is defined as Coal Rich Electrolytic Depleted Oxygen process.

At a temperature of 2000C, if coal is oxidized to carbon monoxide (CO) using the CREDO process, the heat output can be about 74% of the heat that would be produced by the oxidation of the same amount of coal to produce carbon dioxide, CO_2.

CREDO does not require a flame or a fire box, yet this process can produce large amounts of heat at elevated temperatures. If this novel process is used, the heat output can be about 74% the heat that would be produced by the combustion/oxidation of the same amount of coal to produce CO_2.



Introduction. CREDO -- Coal Rich Electrolytic Depleted Oxygen process

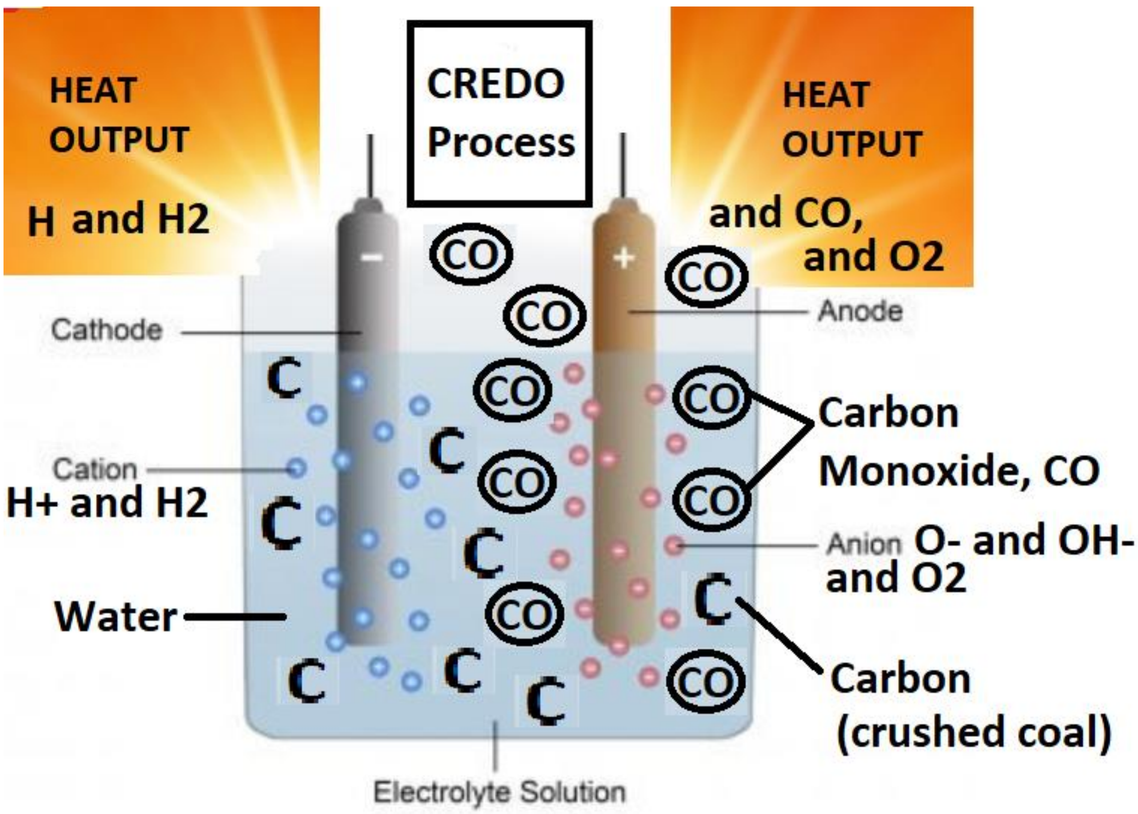
Problem: Flame combustion, used to produce heat, produces carbon dioxide. CO2 is undesirable. How can combustion be used to produce heat and not produce CO2 ?

Solution: Combustion using CREDO at elevated temperatures, can be used to produce large amounts of heat and not produce CO2 .

This technology is called CREDO -- Deprived Oxygen Carbon monoxide Electrolysis.

Novel combustion process: CREDO can be used to initiate and produce incomplete combustion, thereby providing a method for using coal to produce heat and power, with a minimum production of CO2 .

CREDO does not require a flame or a fire box, yet this process can produce large amounts of heat at elevated temperatures. If this novel process is used, the heat output can be about 74% the heat that would be produced by the combustion/oxidation of the same amount of coal to produce CO_2.



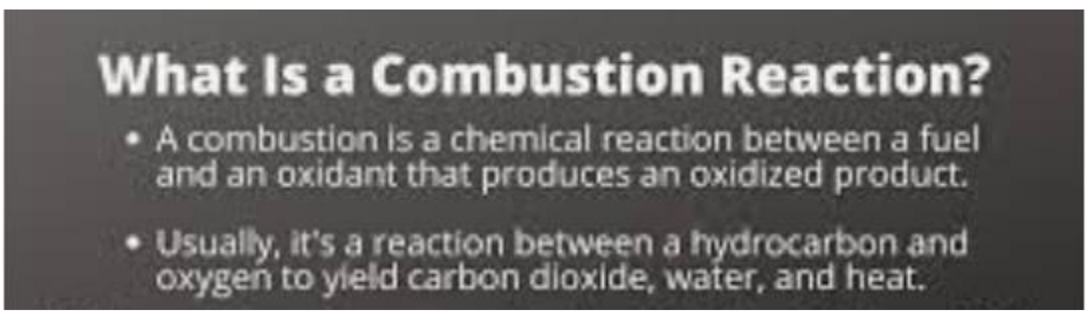
CREDO Process. Under oxygen-starvation conditions, outputs are hydrogen from the cathode and mostly carbon monoxide (CO) from the anode, and much heat at elevated temperatures. This system can be pressurized for operating at high temperature.

CO from the CREDO process is a valuable by-product. CO can (and should be) captured and used in the manufacture of other products that have commercial value. Section 5 of this document includes a list of CO-containing products that have commercial value.

EPA is primarily concerned with flame-combustion processes that emit CO and CO2 into the environment. So long as CREDO or other processes meet the NAAQS standard, EPA has historically not been concerned with the production of CO resulting from processes that produce and capture CO for use in commercial applications which produce non-harmful products containing CO. The NAAQS standard is explained in Appendix H of this document.

Section 1. Description of combustion in a CREDO vessel

Discussion: In this paper, the word "combustion" means oxidation. A flame, causing burning is not the only form of combustion. In this paper, "incomplete combustion" means flameless oxidation of coal (carbon) under oxygen starvation conditions. In the field of combustion chemistry, this condition is often called "fuel rich" combustion or "fuel rich" oxidation.



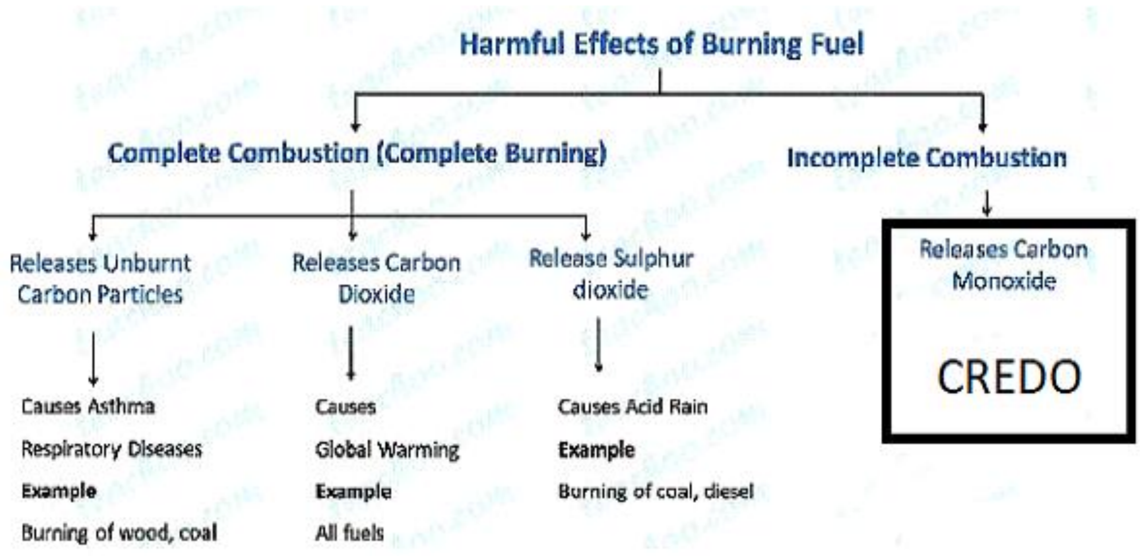
1. "Incomplete" combustion is a misnomer. Incomplete combustion means combustion in an oxygen-starved environment, such as a water-coal electrolysis environment. Incomplete combustion does not mean that some per-cent of the coal can not be used for fuel to produce heat.

2. Incomplete combustion can be very efficient, because combustion of the all of the coal (fuel in the combustion chamber, vessel) can be achieved using incomplete combustion, thereby wasting no coal and produces no solid "unburned waste." This novel process produces no fly ash.

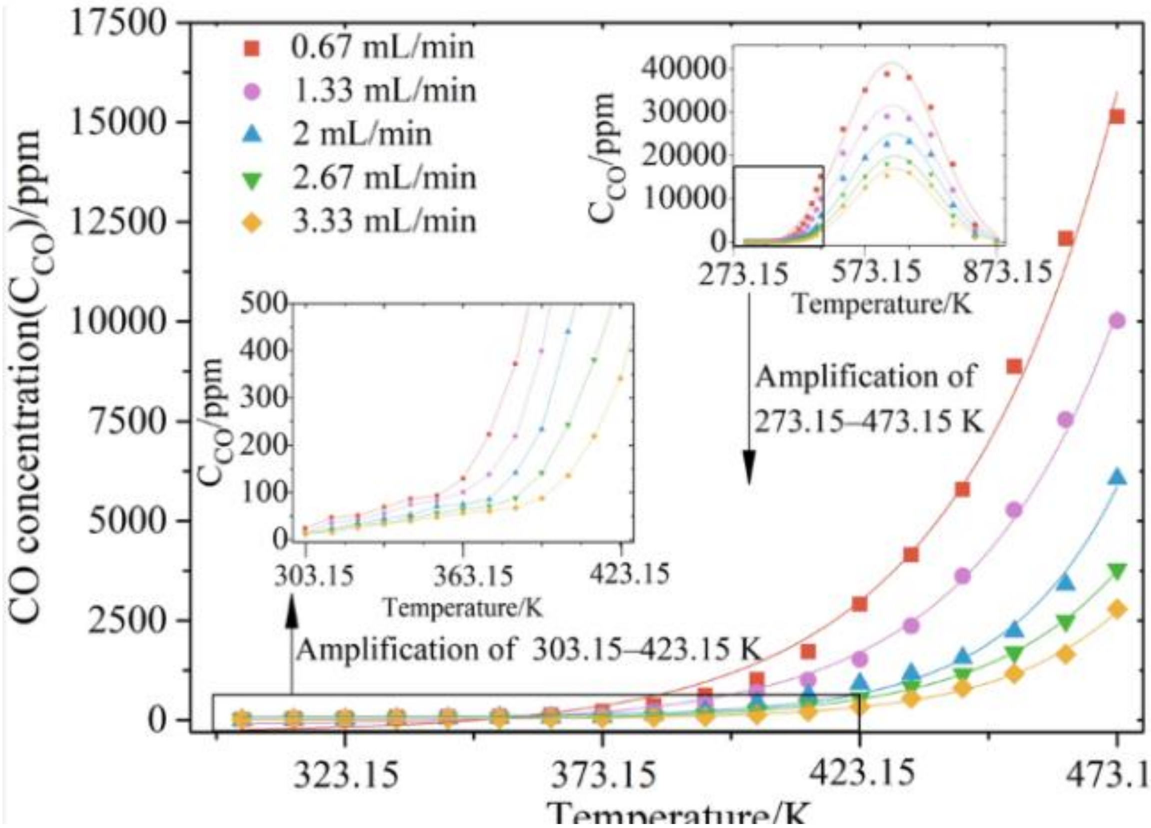
3. Incomplete combustion can be used to produce heat without a flame. This is important, because flame combustion always produces a lot of CO2 .

4. The use of coal-water incomplete combustion can make possible the design and fabrication of lower-cost equipment to produce heat, because coal-water electrolysis can be used to produce heat without a fire box and without a flame.

5. Incomplete combustion can reduce the harmful effects of burning fuel.



6. Spontaneous coal combustion must be prevented and controlled in a CREDO vessel. Spontaneous coal combustion occurs in stages, as implied by the time required for the "Amplification" described in the graph below.



Spontaneous combustion of coal can be prevented by preventing the concentration of CO from exceeding 2000 PPM. Carbon Monoxide characteristics are described in Appendix A.

Incomplete combustion using water-coal electrolysis can be used to minimize risk of spontaneous coal combustion (flame, explosion).

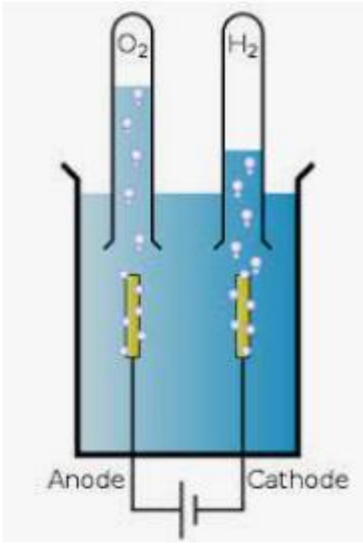
Spontaneous coal combustion (flame, explosion) is unlikely in an oxygen-starvation environment, because a rapid supply of oxygen is required for an explosion and an oxygen-rich supply is required to sustain a flame.

7. <u>Carbon Monoxide Ignition</u>. Notwithstanding the mostly-correct statements in the above paragraphs, a low-level "poof" (mini explosion) is possible under rare conditions. This rare phenomenon has been observed by a group of researchers (Moore, Phillips, Pike). More discussion of this rare phenomenon is described in Appendix B.

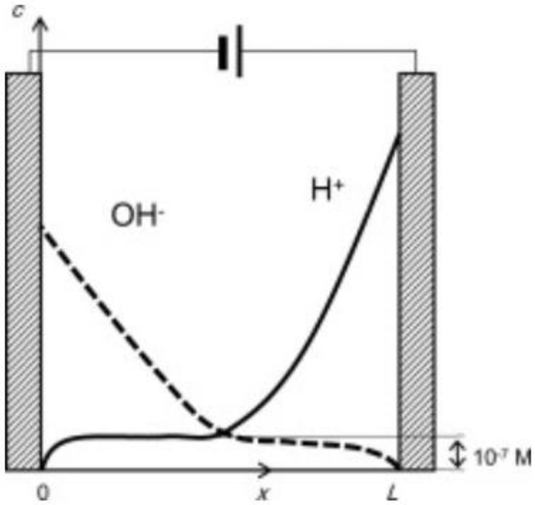
The following section describes a thought experiment. A thought experiment is a hypothetical situation in which a hypothesis is laid out for the purpose of thinking through its consequences.

Section 2. Oxygen starvation

Following is a thought experiment to describe incomplete combustion using water-coal electrolysis.



The figure above describes the most simple configuration for water electrolysis. For our experiment, the water contains 50% crushed coal (not shown) and an electrolyte, baking soda (not shown). The electrodes can be any metal.



Electrolysis will split the water into H^+ and OH^- ions. The concentration profile is shown above. At the anode, the electric field can be strong enough to split the

OH into O^- and H^+ ions, both highly reactive. Most of these ions can combine to form O_2 and H_2 .

Consider the coal-water mixture when the electrical power is applied and the very first O^- and H^+ ions are formed. The H ion will attach to a C atom, forming CH, and the O ion will attach to a carbon atom, forming CO, or carbon monoxide. No CO2 will be formed because, at the initial startup of electrolysis, there is only one O ion in the coal-water mixture.

As long as the mixture is oxygen-starved, the major oxide product will be CO (and not CO2), while continuing to produce heat.

In summary, the following compounds are expected to be produced by oxygen-starved coal-water electrolysis:

Mostly the following:

O_2

H_2

CO

Only small amounts of the following:

CO_2

OH^- ions

H^+ ions

O^- ions

H^+ ions

CH_1 (not stable)

CH_2 (not stable)

CH_3 (not stable)

CH_4 (stable)

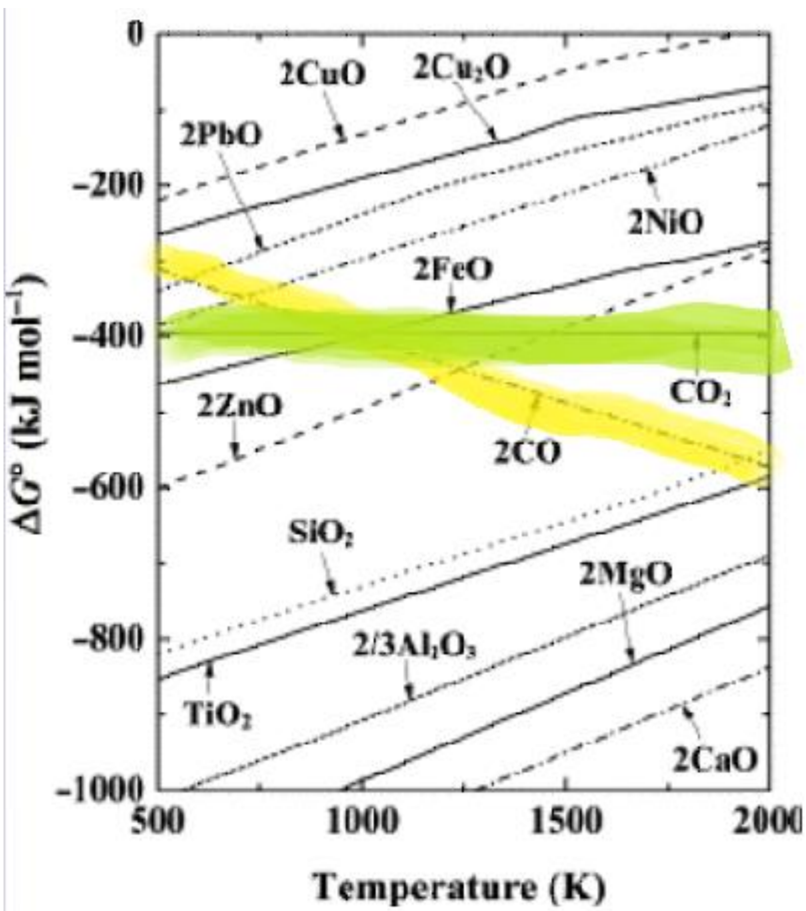
The chemistry leading to the above listings of chemical compounds and ions is described in Appendix C.

Section 3. Heat produced from CREDO at high temperature

Incomplete combustion is described in Appendix D.

Using CREDO to produce heat, the oxidation will produce mostly CO instead of CO2.

$$2C + O_2 \rightarrow 2CO \qquad \Delta G_{1000^\circ C} = -432kJ/mol$$
$$\Delta G_{1900^\circ C} = -624\mathrm{kJ}/\mathrm{mol}$$



Verification needed: As I read the published data,

ΔG for 2CO, CO and CO2 can be summarized below.

	RT	1000C	2000C
2CO	274	400	590
CO	**137**	**200**	**295**
CO_2	**394**	**400**	**400**

Conclusions:

At room temperature, if coal is oxidized to CO, the heat output will be about 35% of the heat that would be produced by the oxidation of the same amount of coal to produce CO_2.

At a temperature of 1000C, if coal is oxidized to CO, the heat output will be about half the heat that would be produced by the oxidation of the same amount of coal to produce CO_2.

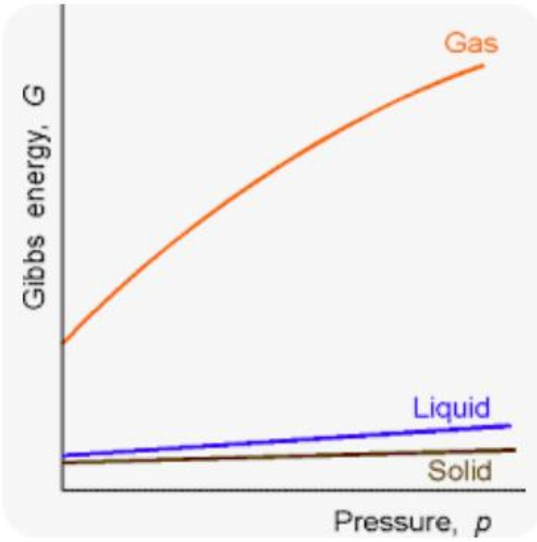
At a temperature of 2000C, if coal is oxidized to CO, the heat output will be about 74% the heat that would be produced by the oxidation of the same amount of coal to produce CO_2.

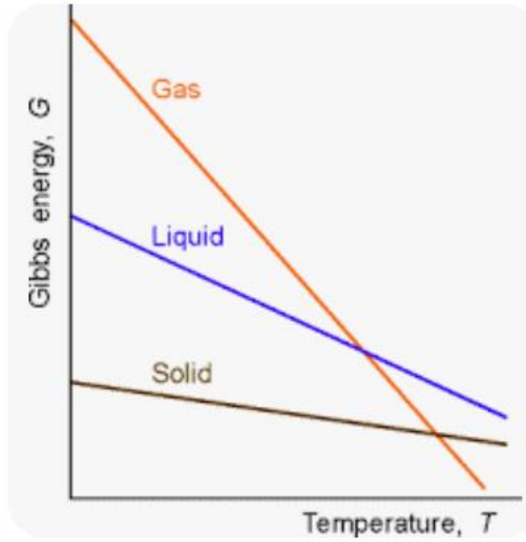
The above conclusions do not include the effects of pressure in the vessel during formation of CO and CO_2.

Section 4. Effects of pressure on ΔG

For gas materials, such as CO and CO2, the expectation is that increases in temperature will result in decreases in ΔG, as described above.

For gas materials, such as CO and CO2, the expectation is that increases in temperature will result in increases in ΔG, as described below.



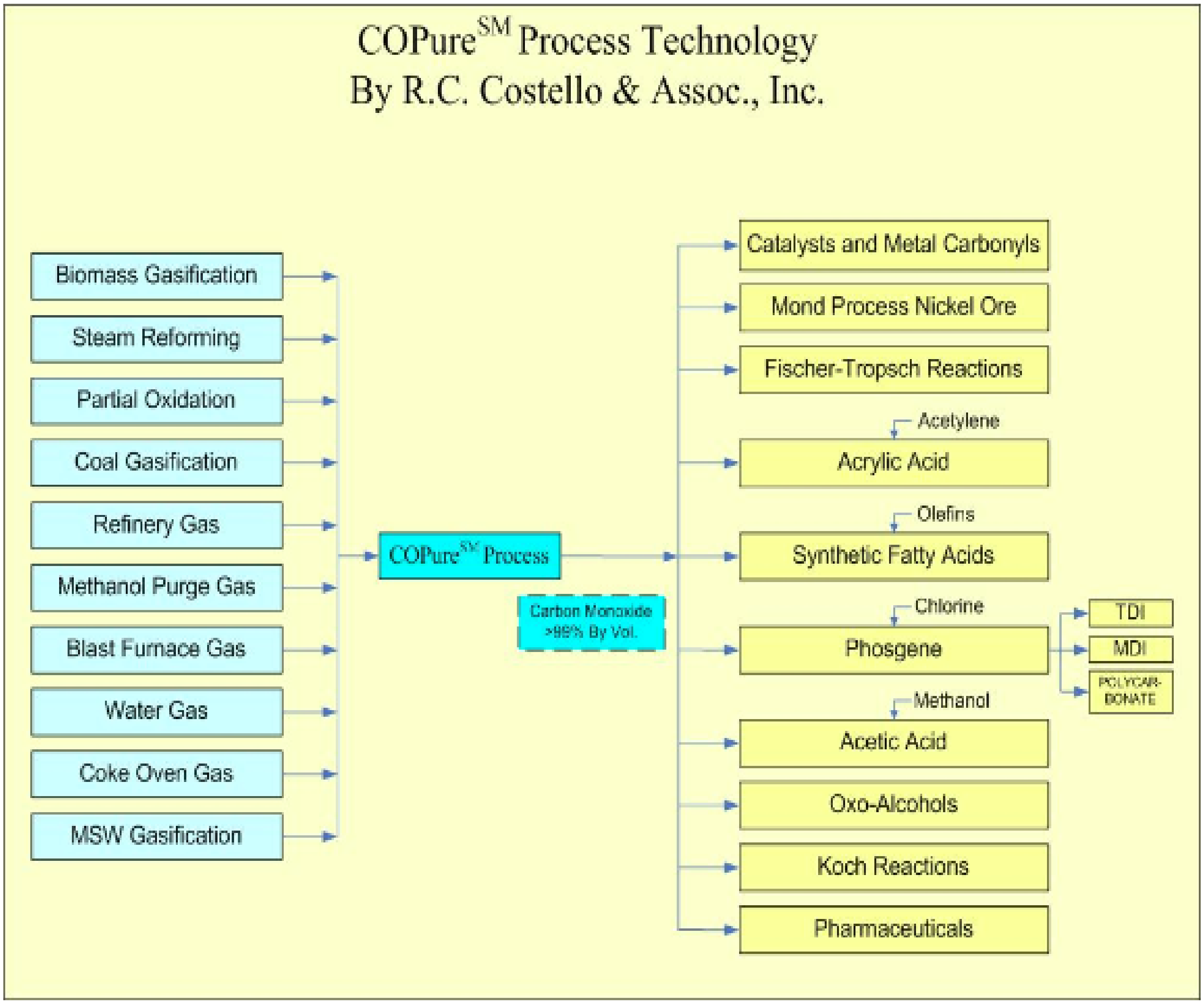


An optimized design of the pressure vessel would consider both temperature and pressure in the search for operating conditions that optimize the production of heat per ton of coal.

Section 5. Carbon Monoxide purity and commercial use

<u>Section 5.1 If needed, Carbon Monoxide can be purified</u>.

COPure is one company that provides this service.



CO produced by CREDO will not be 100% pure, but this CO by-product may be commercially useful for many applications without the need for purification.

For example, blast furnace gas collected at the top of blast furnace, still contains some 10% to 30% of carbon monoxide, and is used as fuel on Cowper stoves and on Siemens-Martin furnaces on open hearth steelmaking. Ref: Wikipedia

Section 5.2 If needed, Carbon Monoxide has many commercial uses.

CO produced by the CREDO process is a valuable byproduct. This is less so in the case of conventional coal-fired byproducts, primarily fly ash.

The following is from Wikipedia:

Carbon monoxide is an industrial gas that has many applications in bulk chemicals manufacturing. Large quantities of aldehydes are produced by the hydroformylation reaction of alkenes, carbon monoxide, and H2. Hydroformylation is coupled to the Shell higher olefin process to give precursors to detergents.

Phosgene, useful for preparing isocyanates, polycarbonates, and polyurethanes, is produced by passing purified carbon monoxide and chlorine gas through a bed of porous activated carbon, which serves as a catalyst. World production of this compound was estimated to be 2.74 million tonnes in 1989.

Methanol is produced by the hydrogenation of carbon monoxide. In a related reaction, the hydrogenation of carbon monoxide is coupled to C—C bond formation, as in the Fischer–Tropsch process where carbon monoxide is hydrogenated to liquid hydrocarbon fuels. This technology allows coal or biomass to be converted to diesel.

In the Cativa process, carbon monoxide and methanol react in the presence of a homogeneous Iridium catalyst and hydroiodic acid to give acetic acid. This process is responsible for most of the industrial production of acetic acid.

Carbon monoxide is a strong reductive agent and has been used in pyrometallurgy to reduce metals from ores since ancient times. Carbon monoxide strips oxygen off metal oxides, reducing them to pure metal in high temperatures, forming carbon dioxide in the process. Carbon monoxide is not usually supplied as is, in the gaseous phase, in the reactor, but rather it is formed in high temperature in presence of oxygen-carrying ore, or a carboniferous agent such as coke, and high temperature. The blast furnace process is a typical example of a process of reduction of metal from ore with carbon monoxide.

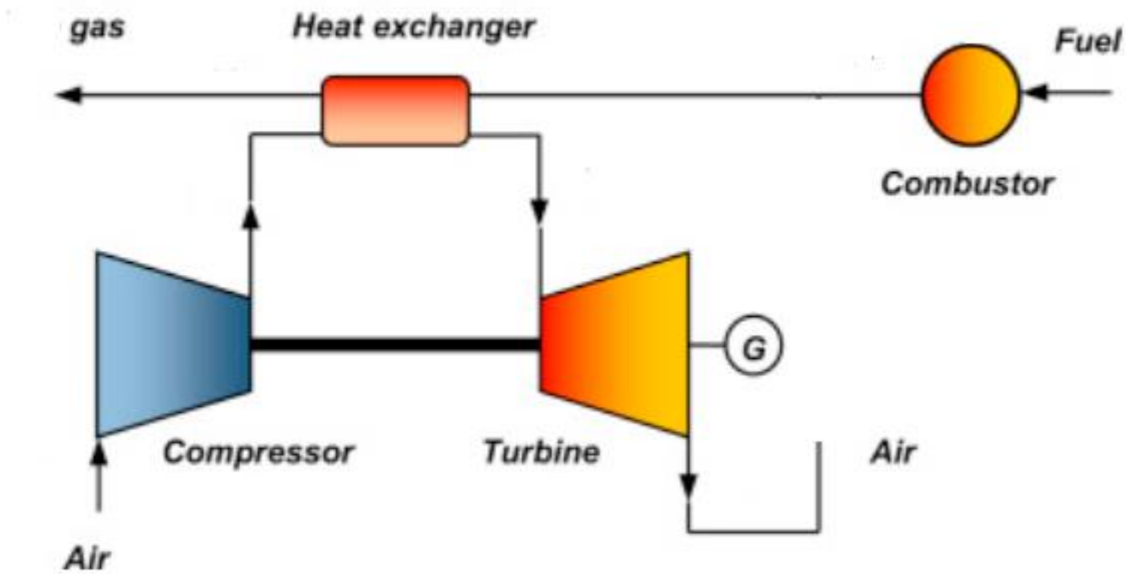
Carbon monoxide has also been used as a lasing medium in high-powered infrared lasers.

Carbon monoxide has been proposed for use as a fuel on Mars. Carbon monoxide/oxygen engines have been suggested for early surface transportation use as both carbon monoxide and oxygen can be straightforwardly produced from the carbon dioxide atmosphere of Mars.

Section 6. System design concepts

A CREDO system would use a heat exchanger, similar to conventional power plants.

The "gas" output will contain CO, a byproduct which can be commercially valuable. Safety considerations make the handling of the gas output more complex than the handling of the non-volatile gas output from a conventional coal-fired power plant.



The combustor for CREDO system would be a flameless vessel and the fuel would be water and crushed coal.

Because no flame or firebox is required, the system cost can be less than for a conventional power plant.

There is no firebox and there are no steam pipes, so no steam pipe cleaning is needed. No shooting the steam pipes with shotguns, to dislodge the solid buildup on the steam pipes. 

For a CREDO system, the "Air" output from the turbine would <u>not</u> be fed back to the combustor. The "Air" in this system would be exhausted, as a flue gas.

Another design concept is illustrated below.

A gas separator can be used to provide an extra benefit.

Gas separator. Water electrolysis always produces oxygen, O_2, and hydrogen, H_2. These two gases can be separated from the CO in the output from the coal-water electrolyzer. The gas separator can be located either at the input or the output of the heat exchanger. The gas separator can provide three outputs: CO, oxygen, O_2, and hydrogen, H_2.

The oxygen and hydrogen can be used to increase the temperature of the CO when burned ahead of the heat exchanger. This is the only place a flame is used. Burning of the oxygen and hydrogen produces a pure water product, with no CO2, and no nitrogen oxides that are most relevant for air pollution.

The result of burning the O_2, and H_2 can be an increased temperature of the gas input to the heat exchanger.

CREDO can benefit from other processes, such as steel production, that need gas separators. Worldwide steel production is still mainly achieved from primary manufacturing by carbon-intensive processes in integrated steel mills, making this industry the first in terms of direct CO2 emissions. Both carbon capture and storage (CCS) and carbon capture and utilization (CCU) approaches are currently considered. Design of available or development of new gas separation-purification technologies are at the heart of these strategies. The gas separator for use by CREDO must have the ability to separate existing gas streams into the two main carbon-bearing species, CO2 and CO. Recovery of H2, available in important quantities, is also a requirement. Ref.
https://www.sciencedirect.com/science/article/abs/pii/S1383586617315071

Summary and conclusions

Coal can be used to produce heat for large power plants, with virtually no CO_2 production, using CREDO for the combustion of coal.

At a temperature of 2000C, if coal is oxidized to CO, the heat output can be about 74% of the heat that would be produced by the oxidation of the same amount of coal to produce CO_2.

CREDO does not require a flame or a fire box, yet this process can produce large amounts of heat at elevated temperatures. If this novel process is used, the heat output can be about 74% the heat that would be produced by the combustion/oxidation of the same amount of coal to produce CO_2.

Appendix A. Carbon Monoxide characteristics

Appendix B. Carbon Monoxide autoignition

Appendix C. Compounds produced by the coal-water electrolysis process.

Appendix D. Incomplete combustion produces mostly Carbon Monoxide (CO) -- especially in a CREDO environment

Appendix E. Background -- Where did this come from? What led to the CREDO process?

Appendix F. Research plan

Appendix G. Patents and intellectual property

Appendix H. Regulatory matters

Appendix I. PRESS RELEASE -- First public disclosure of CREDO

Appendix J. Planned Hydrogen Press Release DRAFT

Appendix A. Carbon Monoxide characteristics

Carbon monoxide is a colorless, odorless, toxic and highly flammable gas with the formula CO.

It reacts with steel at temperatures above 800°C and imparts carbon into its surface.

The Autoignition Temperature for carbon monoxide is 1148˚F (620˚C). Because of this, Carbon monoxide is shipped and stored in high-pressure cylinders, tube trailers or ISO modules.

1. Flammable Properties: EXTREMELY FLAMMABLE GAS. Can easily ignite. Can readily form explosive mixture with air at room temperature.

2. Heating will cause rise in pressure with risk of bursting if in a pressurized vessel. Gas/air mixtures are explosive. NO open flames, NO sparks and NO smoking.

3. Properties:

Melting point	-205°C
Boiling point	-192°C
Relative density	1 (Air = 1)
Flammable at all temperatures	
Auto-ignition temperature	620°C
Explosive limits	12 to 74% in air

Appendix B. Carbon Monoxide autoignition

Autoignition can happen in a CREDO environment, but it is a rare event and it can be prevented.

CREDO produces an oxygen-starvation environment. Oxygen-depleted environments are known to produce mostly CO (and very little CO_2) when the coal is combusted (oxidized).

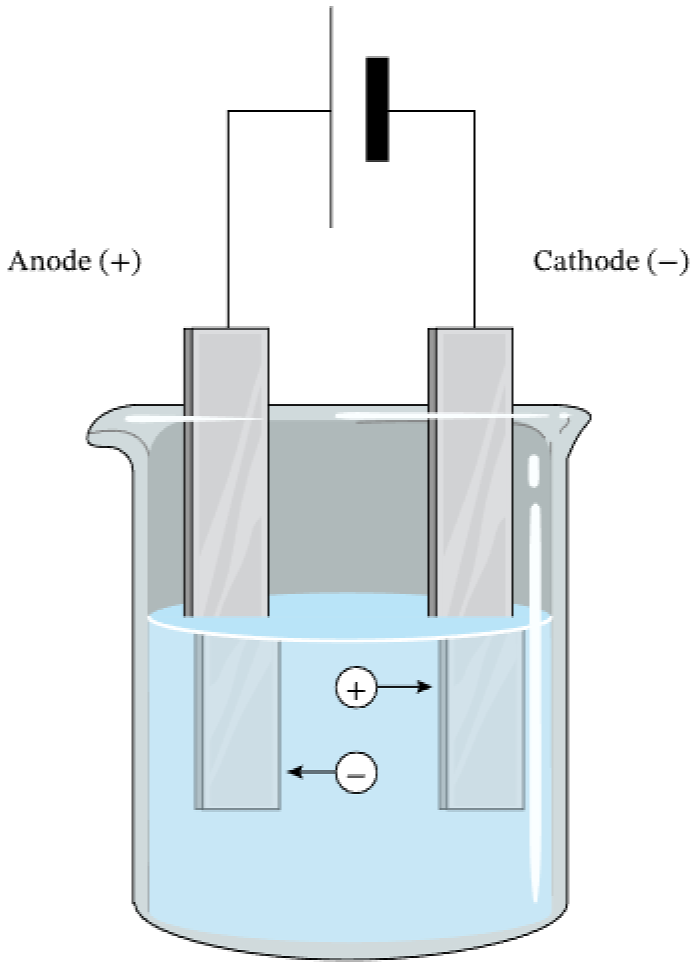
Carbon monoxide is a colorless, odorless, toxic and highly flammable gas with the formula CO.

Properties:

Flammable at all temperatures	
Auto-ignition temperature	620°C

Explosive limits 12 to 74% in air

Our research team has produced CO autoignition only rarely and only when lead anodes have been used. In our experiments a parallel-plate CREDO cell was used.



The water in our cell was tap water, with 10% dissolved baking soda (electrolyte). The vessel was filled with crushed coal with an approximate 50% coal and 50% liquid mixture. A voltage of 12 VDC and a current of 10 Amperes, dissipating a power of approximately 120 watts, was used to initiate and sustain electrolysis.

When electrolysis proceeded over time:

> Because oxygen is attracted to the anode, CO concentration probably increased near the anode (where it was formed). The CO concentration increased because it was partially trapped by the semi-solid mix of coal and liquid. Also, the temperature of the mixture was less than 100C, so the

agitation of boiling was not effective in liberating the trapped CO.

Temperature increased but only up to about 95°C. This is much lower than the autoignition temperature of approximately 620°C.

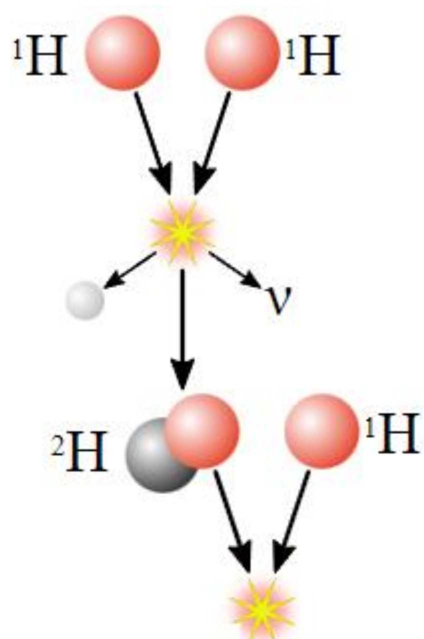
Eventually an ignition event occurred. We reason that the ignition event was a brief but intense temperature spike at the surface of the anode where the concentration of CO was highest.

The formation of the temperature spike, we believe, can be described as follows:

The lead (Pb) anode forms a thin oxide. PbxOy is electrically conductive, so the electrolysis current continues to flow even after the lead oxide is formed.

During electrolysis, OH^- ions are attracted to the anode surface, where dissociation removes the H^+ from the OH^- ions. The H^+ becomes entrapped at or near the surface of the anode. (Hydrogen embrittlement is well known as a condition that occurs because hydrogen can move freely in metals, especially at the metal surface. This process is called "hydrogen loading" of the anode surface.)

Eventually, we believe the possibility of a H-H fusion event may have occurred, releasing enough energy to cause a temperature spike sufficient to ignite the CO. This type of known LENR event is illustrated in the top half of the figure below.



Another LENR possibility may exist. Low concentration deuterium ($^2H = D$) is known to exist in water and also in coal, to a lesser degree.

Eventually, during electrolysis, a deuterium atom may be loaded into the anode surface. Eventually, we believe the possibility of a D-H fusion event can occur, releasing enough energy to cause a temperature spike sufficient to ignite the CO. This kind of LENR event is illustrated in the bottom half of the above figure.

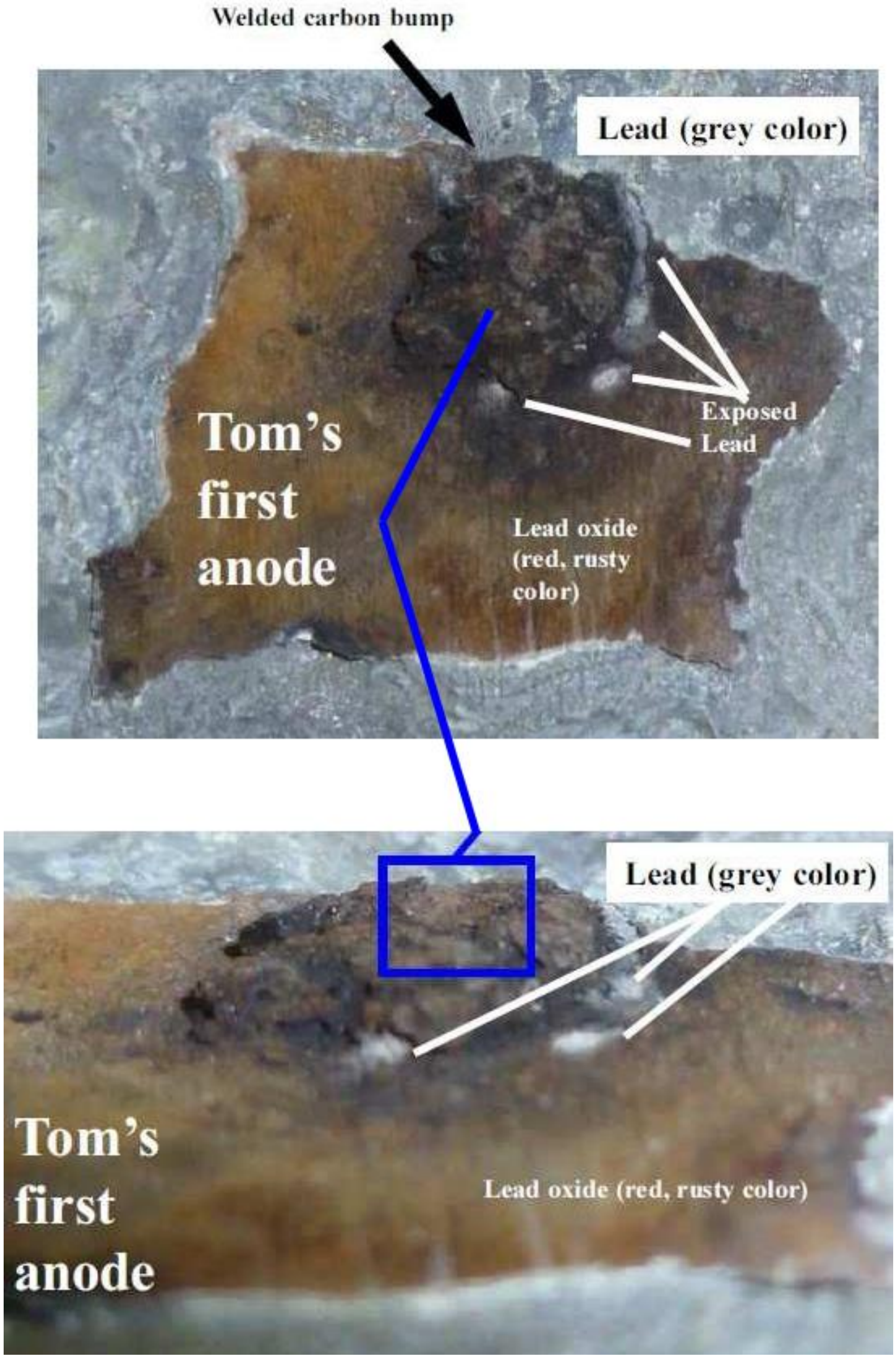
We have found evidence of a temperature spike on the surface of the lead anode. The evidence is in the form of a melt zone, in the form of a crater or a bump as shown in the photo below. The bump/crater is never seen before, but always seen after a CO ignition event.

<u>First temperature spike</u>

Below is the site of a temperature spike which caused a melt zone, much like a crater.

Second temperature spike

Below is a photograph of another type of a temperature spike which caused a melt zone, much like a bump. In this case, the melted lead seems to have welded the anode to a carbon particle.


Welded carbon bump
Lead (grey color)
Exposed
Lead
Tom's
first
anode
Lead oxide
(red, rusty
color)
Lead (grey color)
Tom's
first
anode
Lead oxide (red, rusty color)

In our experiments, the CO ignition event stops the electrolysis process, because both water and crushed carbon are blown out of the vessel at the time of the CO ignition event.

We have found evidence of only one temperature spike (bump or crater) on the surface of the lead anode following CO ignition events. If multiple craters had been observed, that would suggest that the temperature spikes causing the melted lead crater may NOT be the cause of the CO ignition event.

The melting point of lead (anode) is 327°C. We estimate that the temperature spikes reached temperatures in the range of

m.p.	Pb	327 °C
b.p.	Pb	1744 °C

For CO, the autoignition temperature is approximately 620°C.

The electrolysis time required to cause our CO ignition events has varied from a few hours to a few days. This is consistent with other researchers' reports of LENR onset times, for different experimental configurations.

More research is needed to clarify the hypotheses described herein.

<u>Prevention of CO ignition events</u>

> Anode metals other than lead can be used. We have used steel anodes, with no sign of CO ignition events.
>
> Mechanical mixing can prevent the buildup of CO that is trapped among the crushed carbon particles.
>
> The CREDO process can be operated at temperatures greater than 100C, so that agitation caused by boiling can liberate the trapped CO.

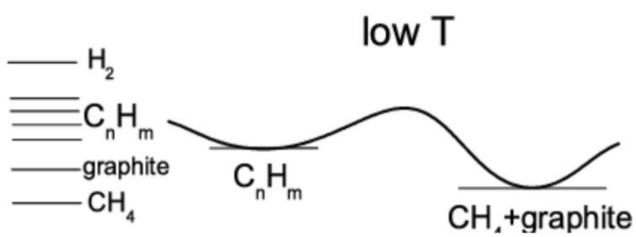
Appendix C. Compounds produced by the coal-water electrolysis process.

Hydrogen (H and H_2) will form in any water electrolysis environment.

In addition to H and H_2 , a group of C_nH_m compounds are expected to form to a lesser degree. These compounds are described as part of the following thought experiment to describe phase 2 of incomplete combustion using water-coal electrolysis.

As electrolysis proceeds, the concentration will increase for both OH and H ions.

<u>What happens to the C_nH_m ions</u>?



Gibbs' free energy for carbon, hydrogen and hydrocarbons at low temperatures (condensed phases). At low temperatures the equilibrium state is the methane-graphite mixture, and all other hydrocarbons are in metastable state.

In other words,

CH_1 is not stable.

CH_2 is not stable.

CH_3 is not stable.

CH_4 <u>is</u> stable.

Substance	State	$\Delta_f G°$(kJ/mol)
NO	g	87.6
NO_2	g	51.3
N_2O	g	103.7
H_2O	g	-228.6
H_2O	l	-237.1
CO_2	g	-394.4
CO	g	-137.2
CH_4	g	-50.5
C_2H_6	g	-32.0
C_3H_8	g	-23.4
C_6H_6	g	124.5
C_6H_6	l	129.7

Heads up. The above data is for near room temperature. The Gibbs free energy (energy of formation) is known to be temperature dependent for all materials, including CO. For accurate calculations of heat production, accurate values for the Gibbs free energy must be known (and used in calculations) for the design operating temperature of the CREDO system.

Near room temperature, under oxygen-starved and hydrogen starved conditions, the most likely compounds to be formed are the compounds with low number of oxygen and low number of hydrogen per molecule.

Substance	State	$\Delta_f G°$(kJ/mol)
H_2O	l	-237.1

CO	g	-137.2
CH_4	g	-50.5
C_2H_6	g	-32.0
C_3H_8	g	-23.4

1. A water-electrolysis environment is expected to be water rich, carbon rich, oxygen starved and hydrogen starved.

2. In a water-splitting CREDO environment, recombination to form water is good, because it provides heat to the coal-water mixture.

3. In an oxygen starvation environment, CO will tend to form, whereas CO2 may form to a much lesser concentration.

4. In a hydrogen starvation environment, the following hydrocarbons will probably form at a higher rate than more complex hydrocarbons:

Substance	State	$\Delta_f G°$(kJ/mol)
CH_4	g	-50.5
C_2H_6	g	-32.0
C_3H_8	g	-23.4

5. All of the above compounds are formed under exothermic conditions, thereby providing heat to the CREDO environment. The heat of formation is given in the $\Delta_f G°$(kJ/mol) column of the above table. This is heat ADDED to the environment in addition to the heat provided by the electrical energy for electrolysis.

a. In an oxygen-starved environment, methane is expected to oxidize to CO, not CO2.

b. In an oxygen-starved environment, C2H6 is expected to oxidize to CO, not CO_2.

c. In an oxygen-starved environment, C_2H_8 is expected to oxidize to CO, not CO_2.

What happens to the OH ions?

Electrolysis is expected to dissociate some portion of the OH ions to produce a mixture of O, H and OH ions.

Recombination of some portion of the H ions will produce H_2 gas. Some portion of the H ions will combine with carbon to produce C_xH_y as described in the previous section.

Recombination of some portion of the O ions will produce O_2 gas. Some portion of the O ions can produce CO.

Summary of this Appendix: In an oxygen-starved environment, specifically a carbon-water electrolysis environment, most chemical reactions are expected to produce CO.

Appendix D. Incomplete combustion produces mostly Carbon Monoxide (CO) -- especially in a CREDO environment

Incomplete and complete combustion has been studied extensively.

Incomplete	Complete
Combustion that occurs when oxygen is limited.	Combustion that occurs when there is plenty of oxygen.
Produces carbon (soot/smoke) and CO	Produces CO_2 and Water

Carbon Monoxide	Carbon Dioxide
Doesn't occur naturally in the atmosphere	Occurs naturally in the atmosphere

In an oxygen-starved environment,

C + O --> CO

As temperature increases, CO formation becomes more exothermic

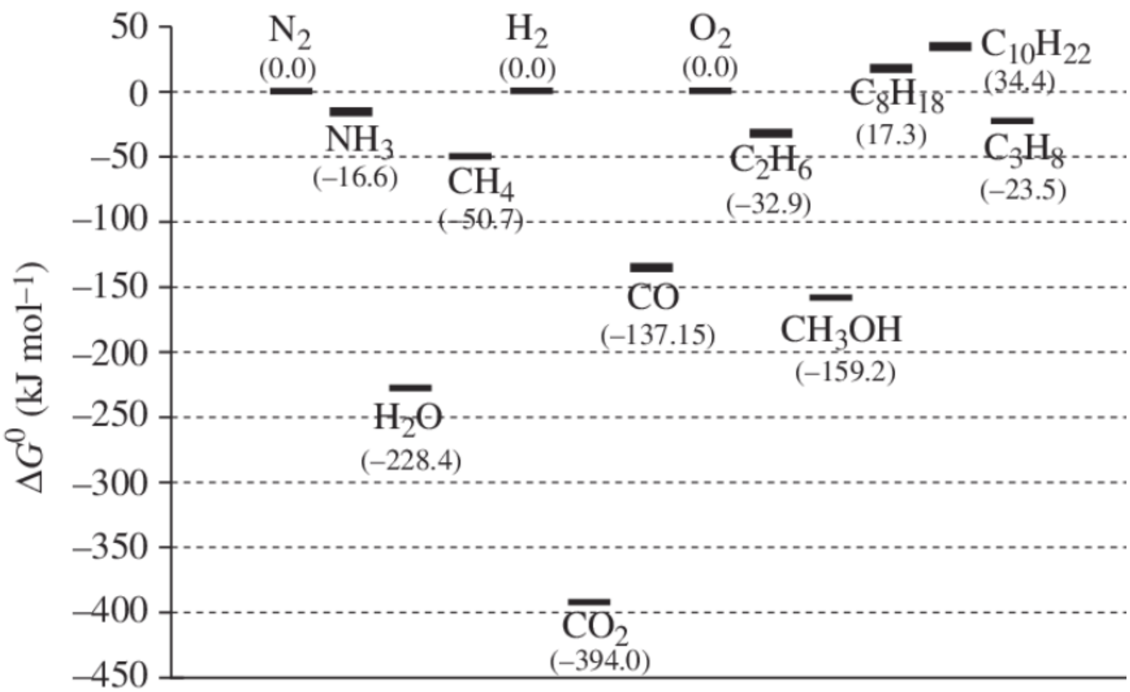
$$2C + O_2 \rightarrow 2CO \qquad \Delta G_{1000^\circ C} = -432kJ/mol$$
$$\Delta G_{1900^\circ C} = -624\mathrm{kJ/mol}$$

Temperature dependence of Gibbs free energy of formation

	ΔG (kJ mol^{-1})	
T (K)	Methane	Carbon Monoxide
298.15	-50.33	-137.17
300	-50.38	-137.33
400	-41.83	-146.34
500	-32.53	-155.41
600	-22.69	-164.48
700	-12.48	-173.51
800	-1.99	-182.49
900	8.68	-191.42
1000	19.48	-200.28
1100	30.36	-209.08
1200	41.29	-217.83
1300	52.26	-226.15

Note that methane formation produces heat at low temps and requires heat to form at higher temperatures.

At room temperature, the energy of formation is greater for CO2 than for CO, as shown below.



Gibbs free energy of formation for selected chemicals (data compiled and calculated from NIST database, http://webbook.nist.gov/chemistry/name-ser.html). Here, DG 0 for the constituent elements is taken as the reference point.

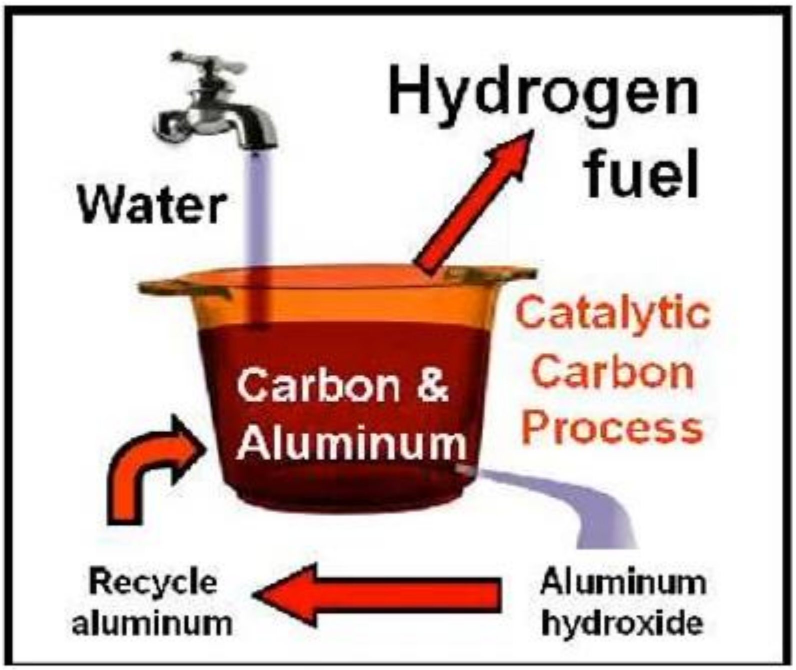
Because of the oxygen-starved environment, using CREDO to produce heat, the oxidation will produce mostly CO instead of CO2.

> <u>Formation of carbon monoxide at room temperature</u>:
>
> 1 Kg of Carbon, when oxidized <u>at room temperature</u> to form CO, produces 2.55 kWh of energy, or a power of 2.55 kW for an hour, using CREDO (incomplete combustion). CO is the waste product. CO has much more commercial value than fly ash.

<u>Heads up</u>. The above data is for near room temperature. The Gibbs free energy (energy of formation) is known to be temperature dependent for all materials, including CO. For accurate calculations of heat production, accurate values for the Gibbs free energy must be known (and used in calculations) for the design operating temperature of the CREDO system.

Appendix E. Background -- Where did this come from? What led to the CREDO process?

Hydrogen on demand: In addition to our former business (pharmaceuticals), we have used our catalytic chemistry capability to create a new catalyst which efficiently splits water, retains the oxygen in the liquid, and releases pure hydrogen for use as a fuel or for use as a fuel supplement.



This new catalyst, called CATALYTIC CARBON, has been invented, and the process that uses this new invention is called CC-HOD, or Catalytic Carbon - Hydrogen On Demand.

What has recently come out of this process is a new process, called CREDO, Depleted Oxygen Carbon Monoxide electrolysis. The CREDO process incorporates the CC-HOD process described in the figure above. The COCOE process can use coal as a fuel with the production of CO, and minimal amounts of CO2.

The COCOE process can be developed to allow coal-fired electrical power plants to be redesigned so that coal can be used to produce large quantities of heat without the production of CO2.

The technology is available for non-exclusive licensees who want to develop the COCOE technology for other applications or in other parts of the world.

Appendix F. Research plan

To develop and qualify the CREDO for use in coal-fueled power plants, the following research plan is has been developed. It is a low-cost R&D project to verify the concepts in this document.

		Est M Months
Start date: ___________		
Customer engineers review this document	xxxxxx	1
Customer coordinate with Phillips	xxxxxxxxxxxxxxxxxxxxx	1
Design/build/ demonstrate small CREDO vessel		
Purchase equipment / supplies	$10,000	
Engineering	xxxxxx	2
Machine shop build	xxxxxxxxx	3
Characterize and Report (Publish?)	xxx	1
Collaborate with coal-fired power plant	xxxxxxxxxxxxxxx	1
Design/build/ demonstrate medium-size CREDO vessel		
Purchase equipment / supplies	$20,000	
Engineering	xxxxxxxxxxxx	1.5
Machine shop build	xxxxxxxxx	4
Characterize and Report (Publish?)	xxxxxxx	1
Patent applications TBD	xx xx	1.5
Technology transfer to customer and others	xxx 3	

Totals: **$30,000 equipment/supplies**

20 man-months @ $10K/MM = $200K

This estimate does not include travel or consultants

Appendix G. Patents and intellectual property

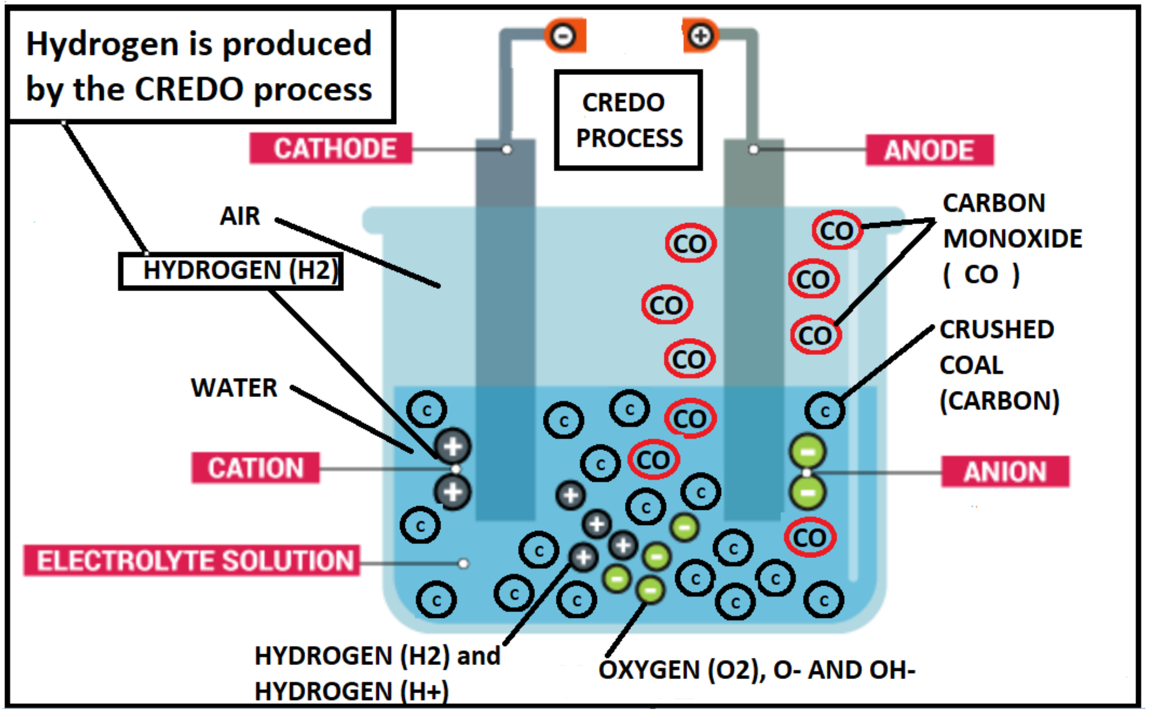
Section G1: Is the CREDO process already covered by patents?

One of our patents is described in Appendix E. An excerpt from this existing patent follows:

> http://www.google.com/patents/WO2013016367A1?cl=e
>
> Claim 6 of that patent is:
>
> 6. A method of producing hydrogen, comprising:
>
> combining electro-activated carbon with a liquid composition; and
>
> generating a chemical reaction between the combination of electro-activated carbon and the liquid composition to produce hydrogen.

The research in the above-referenced patent was the precursor to the development of the current invention, a process to **use coal to produce heat for large power plants, with virtually no CO_2 production.**

The current invention does produce hydrogen, as shown in the description of the CREDO process.



It seems likely that the USPTO examiner will rule that the CREDO process "could be developed from previously-patented information by those sufficiently schooled in the art."

<u>Section G2</u>: The CREDO process has produced engineering knowledge (and IP) that goes beyond the published patent

The development of the CREDO has produced engineering knowledge (and IP) that goes beyond the published patent. Those elements of the CREDO invention that may be patent worthy are:

1. Anode design (both restrictions and enhancements)
2. Safety provisions regarding the safety of large volumes of CO.
3. Systems design related to operation of the CREDO process at high temperature and under high pressures.

It seems that there are elements of the CREDO invention that may be patent worthy.

Phillips Export does not want to patent the CREDO process with the ownership and licensing opportunities owned by Phillips Export or the inventor.

Section G3: The CREDO process can be patented by other companies or universities or inventors

May other companies want to patent the above "new" elements of the CREDO invention? If so, the inventor is willing to assist in the preparation of the patent application, but with provisions. Those provisions are:

1. All interested companies and universities shall be encouraged to engage in the development or the CREDO process with no need for the establishment of administrative constraints, except for those beneficial to both parties and those which will not deter other companies from developing the CREDO process.

2. The first 10 companies to use the CREDO process to generate 10 MW for 24 hours (or more) electrical output shall earn the freedom to operate commercially with guarantees that no patent royalties or other hinderances shall hinder their use of the CREDO process. This provision shall apply to all patents traceable to the inventor (Phillips).

3. The CREDO invention has been donated to the people of Ukraine and therefore worldwide patents cannot apply to Ukraine. This donation was made (free) because much of the electrical power infrastructure has been destroyed/damaged by the war. Coal-fired power plants are less expensive and can be built in less time than nuclear power plants. Ukraine is the third largest coal producer in Europe.

Appendix H. Regulatory matters

Carbon monoxide is an industrial gas that has many applications in bulk chemicals manufacturing. Large quantities of aldehydes are produced by the hydroformylation reaction of alkenes, carbon monoxide, and H2. Hydroformylation is coupled to the Shell higher olefin process to give precursors to detergents. Ref. Wikipedia

EPA has historically not been concerned by the production of CO resulting from processes that produce CO for use in commercial applications which produce non-harmful products containing CO.

The CREDO process is designed to maximize the production of CO, with the goal of capturing the CO for industrial uses. See Section 5 of this document for a more complete listing of the industrial uses for CO.

EPA has historically been concerned by the emission of CO resulting from **flame combustion** of coal and other primary fuels. The incomplete combustion of carbon produces CO. Operationally, this is used to optimize the combustion process as it indicates that there is a non-optimum mixing of combustion air with the fuel. Traditionally, on large multi-burner plants, getting the fuel and air right has been one of the ongoing problems. For this reason, most large plants operate with a level of excess air. The level of CO that can be achieved on biomass-only plant is strongly dependent on the chosen technology, with grate technology often giving high CO, while on circulating fluid bed the levels can be very low. The 'BAT ref' document sets an emission limit of 50 mg Nm^{-3} for good combustion. Ref. https://www.sciencedirect.com/topics/engineering/incomplete-combustion

EPA has defined the national ambient air quality standard (NAAQS) for carbon monoxide as nine parts per million averaged over an eight-hour period, and this threshold cannot be exceeded more than once a year or an area would be violating the standard.

Summary: EPA is primarily concerned with processes that emit CO and CO_2 into the environment.   So long as CREDO or other processes meet the NAAQS standard, EPA has historically not been concerned with the production of CO resulting from processes that produce and capture CO for use in commercial applications which produce non-harmful products containing CO.

Appendix I. PRESS RELEASE -- First public disclosure of CREDO

Coal combustion without producing Carbon Dioxide

Use of coal to produce heat for large power plants, with virtually no CO_2 production

Hugo, Oklahoma Jan 23, 2023 (Issuewire.com) - Coal can be used to produce heat for large power plants, with virtually no CO_2 production, using the CREDO process for the combustion of coal, said Howard Phillips, the General Manager of Phillips Export.

The new process, called CREDO, can be pressurized for operation at high temperatures. CREDO is defined as Coal Rich Electrolytic Depleted Oxygen process. The process can fully oxidize coal (flameless combustion/oxidation) and produce no greenhouse gas.

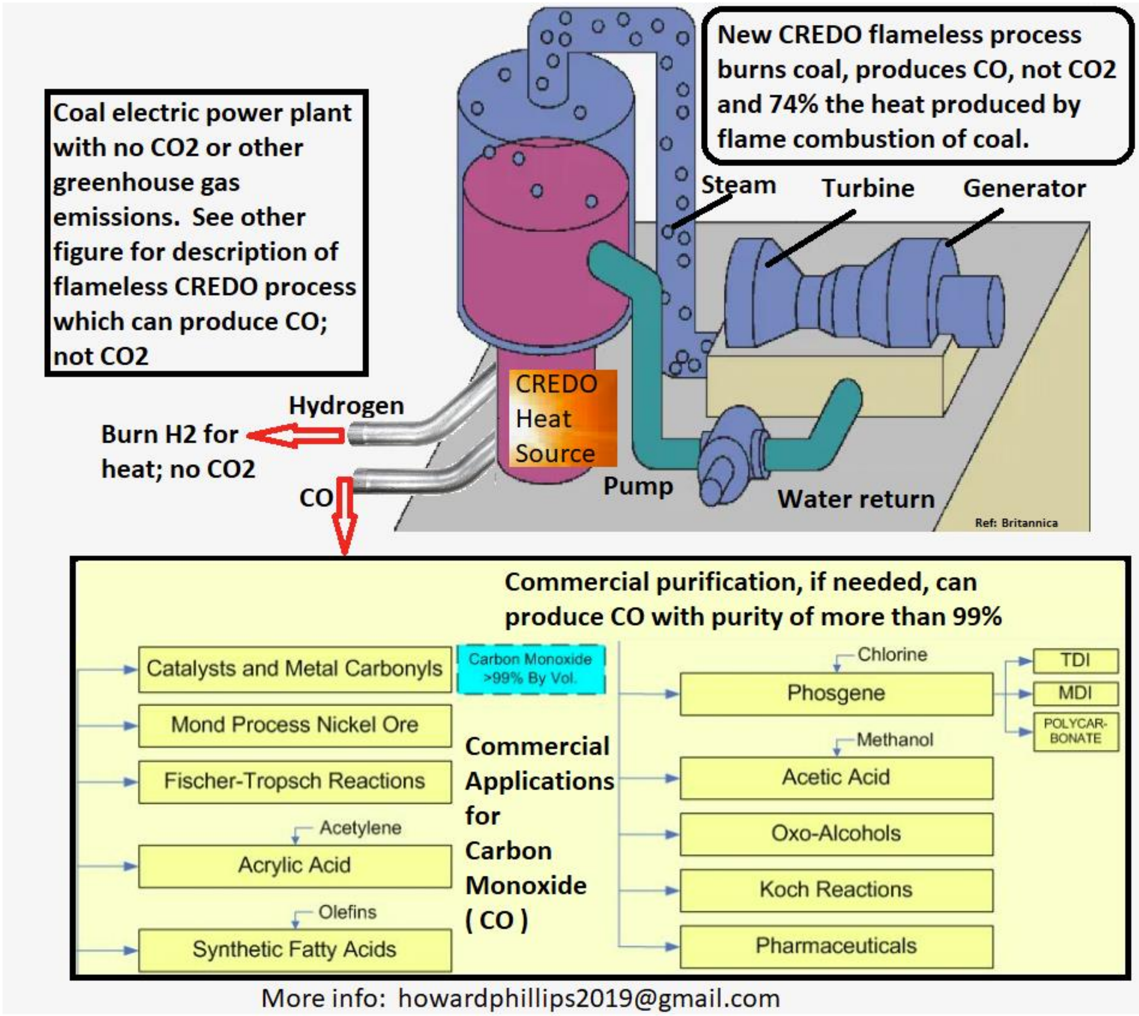
At a temperature of 2000C, if coal is oxidized to carbon monoxide (CO) using the CREDO process, the heat output can be about 74% of the heat that would be produced by the flame oxidation of the same amount of coal.

The CREDO coal combustion process does not require a fire box and does not produce fly ash or CO_2 or other greenhouse gas, yet this process can produce large amounts of heat at elevated temperatures. If this novel process is used, the heat output can be about 74% the heat that would be produced by the flame combustion/oxidation of the same amount of coal to produce CO_2.

For more information, contact the inventor via email: howardphillips2019@gmail.com

Media Contact

— Phillips Export
— howardphillips2019@gmail.com
— 580 746 2430
— 311 Chickasaw St. Millerton, OK 74750



Categories : Energy , Engineering , Environment , Government , Mining

Tags : coal , energy , power plants , carbon dioxide , greenhouse gas , coal mining , carbon monoxide , CO , CO2

Appendix J. Planned Hydrogen Press Release DRAFT

Hydrogen high volume production

Use of coal to produce hydrogen as a low-cost byproduct, and heat for large power plants, with virtually no CO2 production

Hydrogen can be a low-cost high-volume output when coal is used to produce heat for large power plants, with virtually no CO_2 production, using a new invention / discovery called the CREDO process, said Howard Phillips, the General Manager of Phillips Export.

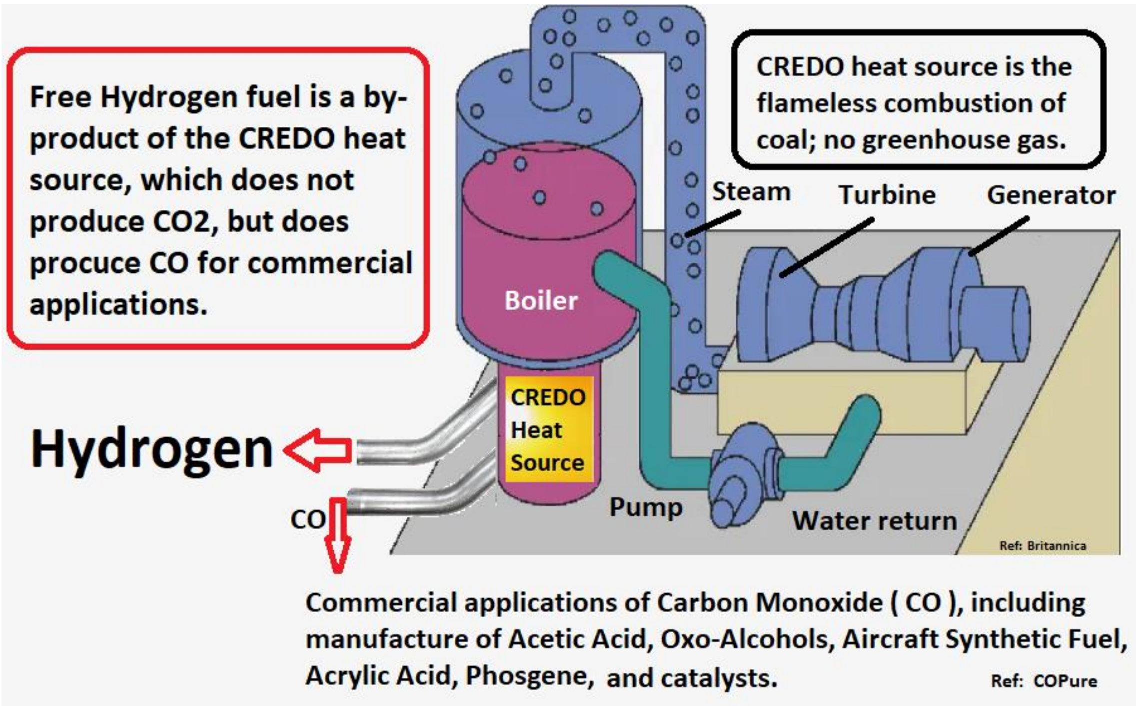
The new process, called CREDO, can be pressurized for operation at high temperatures. CREDO is defined as Coal Rich Electrolytic Depleted Oxygen process. The process can fully oxidize coal (flameless combustion/oxidation) and produce no greenhouse gas.

At a temperature of 2000C, if coal is oxidized to carbon monoxide (CO) using the CREDO process, the heat output can be about 74% of the heat that would be produced by the flame oxidation of the same amount of coal.

The CO output from the process can be used for the manufacture of many commercial products, including synthetic aircraft fuel,

The CREDO coal combustion process does not require a fire box and does not produce fly ash or CO_2 or other greenhouse gas, yet this process can produce large amounts of hydrogen and heat at elevated temperatures. If this novel process is used, the heat output can be about 74% the heat that would be produced by the flame combustion/oxidation of the same amount of coal to produce CO_2.

Phillips Export has offered to provide full disclosure of the CREDO process to anyone interested in the low-cost high-volume production of hydrogen for use as an alternative fuel. For more information, email:
howardphillips2019@gmail.com



Note to editor: the above figure is available as a PNG file, entitled Hydrogen production from coal no greenhouse gas.png

Categories : Energy , Engineering , Environment , Government , Mining

Tags : hydrogen, coal , energy , power plants , carbon dioxide , greenhouse gas , coal mining , carbon monoxide , CO , CO2