Energeia Home

CAER -- University of Kentucky, Center for Applied Energy Research Vol. 7, No. 2, 1996

Energeia

Global Warming - What are the Facts?

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The amount of carbon dioxide and other greenhouse gases in the atmosphere has increased in the last 100 years due in large part to the burning of fossil fuels. Since greenhouse gases act as an insulating blanket over the earth, the effect of the buildup of greenhouse gases is that the earth retains some heat that would otherwise escape into space. That added heat must cause the average temperature of the earth to rise.

"There is no scientific basis for a catastrophic global warming produced by the buildup of greenhouse gases from fossil fuel burning."

Computer programs are used to simulate the earth's climate and estimate the warming caused by the buildup of greenhouse gases. The computers say that a smooth rise of 0.5 - 2 °C in the earth's temperature should have occurred in the last 100 years. The computers further project that the earth will warm an additional 2 - 5 °C by the year 2100, if the greenhouse gases keep increasing. Two predicted consequences of a rise of 2 - 5 °C in the Earth's temperature are: (1) disruption of agricultural patterns, accompanied by starvation; and (2) flooding of coastal areas and low-lying islands as glaciers and polar ice melt and the sea level rises. Such possible outcomes due to dramatic and rapid climate change deserve serious study. But at the same time, the economic impact of policy decisions to limit future greenhouse gas emissions will be extremely costly. What are the scientific facts behind global warming? First, are the computer programs that predict a major temperature rise reliable?

How do we know the forecasts of 100 years into the future are believable? We start by noting that the increase in greenhouse gases from human activities over the last 100 years, added together, is equivalent to nearly a 50 % buildup in carbon dioxide alone. The 50 % buildup in carbon dioxide gives a way to test the accuracy of the forecasts. First, we compare the computer predictions to the temperature record of the last 100 years. Then we compare the forecasts to very accurate temperatures measured by satellites over the last 17 years, in particular, to the temperature changes in the Arctic.

According to the computer forecasts, the last 17 years are very important because this is the period in which CO_2 is pouring into the atmosphere and so the earth's temperature should be rapidly rising. The Arctic is important because the forecasts say that Arctic temperatures rise fastest of all and thus provide a stringent test of the greenhouse warming theory.

Comparison with the temperatures actually observed shows that the forecasts are exaggerating the warming by a large factor, perhaps as much as a factor of 3-5.

No evidence can be found in the temperature measurements to support the theory of catastrophic global warming caused by human activities. Three major tests of the climate forecasts, and the failure of those forecasts to explain measurements of the climate, will be reviewed in order to show why the predictions of a large temperature rise are wrong.

(continued, page 2)

Lignite: A Novel Material for Low-Cost Removal and Disposal of Heavy Metals and Radionuclides from Waste Water

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The goal of this study is to develop new and inexpensive technologies for the removal of contaminant heavy-metal species and radionuclides from large volumes of groundwater and other aqueous systems containing low-to-moderate levels of contamination (<1000 ppm), and their subsequent stabilization for long-term storage.

One of the most important environmental issues facing scientists and engineers today is the removal of heavy-metal pollutants from aqueous systems and the prevention of contaminant re-release into the environment. In response to this need, researchers at the CAER, in collaboration with the University of Kentucky Depart-

(continued, page 3)

Global Warming, (continued)

Test 1. *Temperature from 1880 to present* – The ground-based records show that the global average temperature warmed 0.5 °C since 1880. But most of the warming occurred before 1930, while most of the anthropogenic greenhouse gases entered the atmosphere after 1930. i.e., most of the temperature rise of the last 100 years occurred before the greenhouse gases from human activities existed in the atmosphere.

After 1940, the buildup of greenhouse gases in the atmosphere accelerated, but the temperature dropped. One thing the greenhouse gases cannot do is cause cooling as they increase. So the buildup of greenhouse gases cannot be the cause of most of the 0.5 °C warming that occurred between 1880 and 1930. The computer forecasts are exaggerating the warming that should have already taken place due to the 50 % buildup of greenhouse gases. The greenhouse warming to date must be considerably less than 0.5 °C.

Test 2. *Global temperatures from satellites* -- In the last 17 years very precise readings of temperature over the entire earth have become available from satellites, which made measurements globally. The computer forecasts say that the buildup of greenhouse gases is now so large that the global temperature should be warming 0.2 - 0.5 °C per decade. But the satellite readings show that the temperature has not changed at all in the last 17 years in response to the buildup of greenhouse gases. The satellite readings prove again that the computer forecasts are exaggerating the global warming.

Test 3. *Arctic temperatures from satellites* -- The Arctic, according to the computer forecasts, is very sensitive to the man-made greenhouse effect. The forecasts say that the Arctic region should have warmed by as much as 5 - 8 °C in the last 50 - 100 years. And the Arctic should have warmed by 1.5 °C in the past 17 years, during the period of satellite monitoring. No sign of this warming is in the data. Again, the satellite readings prove the computer forecasts are exaggerating the global warming by a very large amount.

Some researchers argue that aerosol pollution -- smog and haze -- has masked a large greenhouse warming. Pollution shades the surface from the sun and keeps the land cooler. So increased cooling by pollution might just counterbalance the increased warming due to the buildup of greenhouse gases. Recent arguments have been forwarded that the combination of greenhouse gases and aerosols in the computer simulations have at last produced agreement between the observed and projected global temperature, especially over the last 20 years. This agreement has been interpreted to mean that the human component of the greenhouse signal has now risen above the natural fluctuations in climate. But such claims do not agree with the measurements in two important respects. First, the simulations predict large warming in the Arctic over the last 50 years. But the temperature records show that the Arctic has not warmed in that interval. The second problem is that the regional forecasts of North America and Europe, where the temperature and aerosol records are well documented, contradict the global results. The temperature projection for North America and Europe has been significantly worsened by including the aerosol effect. Other estimates show that worldwide pollution is masking at most only one-fourth of the predicted warming. And in any case, pollution in the Arctic is so small that it cannot be the explanation for the lack of warming there.

Even though the satellite record is more precise than the ground-based temperatures, and is truly global in coverage, it is sometimes dismissed because it samples the troposphere at several kilometers altitude, not the surface. Where the ground-based data overlap in coverage with the satellite records, the agreement is a nearly perfect correlation, arguing that the satellite data have validity in use.

Exaggerated warming -- If the computer forecasts are exaggerating the greenhouse warming, what is the maximum amount of warming due to increased greenhouse gases that can be expected to occur, if we lower the forecasts to the limits allowed by the temperature measurements? The answer is that the corrected warming in the next century, at present rates of increase in the greenhouse gases, will be less than 0.5 °C. Spread over a century, that warming will be insignificant and indistinguishable from the natural fluctuations in the earth's temperature.

Why are the predictions so far off? The computer simulations which generate these forecasts lack knowledge of the physics of the action of water vapor -- the major greenhouse gas -- and clouds on climate change. The simulations assume that water will amplify increases in carbon dioxide and other minor greenhouse gases, so the projections are guaranteed to produce a significant warming -- but the assumption may be unjustified.

But what if we are wrong? Despite the evidence from the temperature records, what if a major global warming is occurring, but we cannot yet observe the fingerprint? The penalty paid in the increase of temperature in the next century by delaying reductions of greenhouse gas emissions is small. For example, assume the global warming will cause a temperature rise of 3 °C by 2100 (a warming we know to be exaggerated). In that case, the extra temperature rise that will result from a delay of ten years in action on policies

(continued, page 3)

Global Warming, (continued)

to limit greenhouse gas emissions is less than 0.2 °C. This penalty of an extra few tenths of a degree, spread over a century, will be entirely negligible against the backdrop of natural fluctuations. It would be a very small price to pay while waiting to obtain better information on whether the man-made global warming is of any practical consequence.

There is no observed change in mean temperature or variation in temperature extremes that is outside the bounds of natural variability. There is no scientific basis for a catastrophic global warming produced by the buildup of greenhouse gases from fossil fuel burning. Policy makers are considering fossil fuel and carbon dioxide restrictions that will be devastating to the U.S. economy. The catastrophe lies in the squandering of resources that could be better used for real problems.

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Lignite, (continued)

ment of Chemistry, are developing a novel inexpensive coal-based process for the remediation of metal and radionuclide contaminated systems. A schematic representation of the Metal Recovery, Stabilization And Disposal (MERSAD) process is presented in Figure 1. The proposed process utilizes the natural cation exchange capacity of low-rank coals to adsorb heavy metal and radionuclide species from solution via an ion exchange mechanism. The cationic species noted above are complexed from solution through the formation of stable metal-carboxylate bonds with carboxylic acid functional groups naturally present on the coal surface.

The unique aspect of the proposed system, however, lies in the complete utilization of the coal. The use of traditional ion exchange resin-based systems for heavy metal and radionuclide treatment requires periodic regeneration of the resin column producing an acidic/corrosive secondary waste stream. The MERSAD process is unique in that the integrated treatment system will produce a vitrified, non-leachable product. Whilst the normally deleterious organic oxygen content naturally present in low-rank coals is used as the adsorption site, both the calorific content and mineral matter will be exploited in a thermal treatment system to produce a stabilized product for long-term storage. The calorific content of the metal-loaded coal is used to fuel the combustion system with any excess energy being used to supplement the electrical power requirements of the associated pumps and filters of the remediation site.

Ion Exchange Properties of Lignites

Lignites are characterized by low specific energy, as well as high oxygen and moisture contents. The high moisture content of the lignites retards efficient combustion and must be removed by energy consuming processes prior to combustion. A combination of these and other factors make low-rank coals generally unacceptable as fuel sources for conventional electric utility plants, although geographical factors can dictate the use of low-rank coal fired power plants in certain regions.

The high oxygen content of low-rank coals allow, however, the unique capability for lignite to remove cations from solution via ion exchange with carboxylic acid and phenolic hydroxyl functional groups on the coal's surface. The ion exchange properties of several North American lignites have already been characterized at the CAER. Earlier experiments showed that metals with a high charge density are preferentially adsorbed.

Moreover, the adsorption selectivity of lignites for first order transition metal groups follow that of an Irving-Williams order indicating that the group involved in the metal adsorption contains either a nitrogen or oxygen atom, and is most likely a carboxylic site. The equilibrium pH of the coal/

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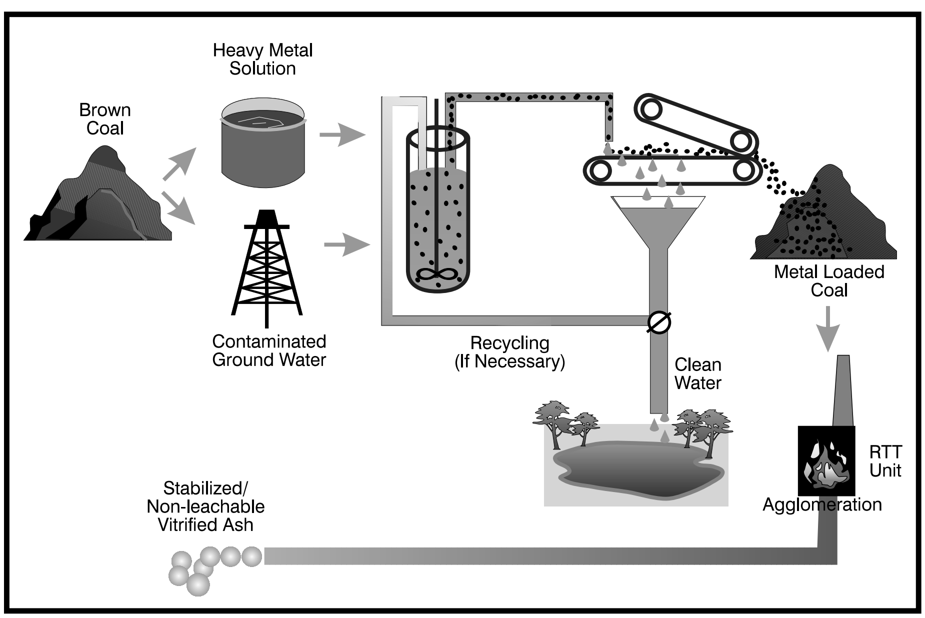

Figure 1. *Metal Recovery, Stabilization and Disposal (MERSAD) process*

Lignite, (continued)

solution mixture has been shown to be the principal factor controlling the extent of metal exchange from solution. Maintaining the equilibrium pH of the lignite/metal solution above a value of 4 will ensure that the majority of the carboxylic acid functionalities on the coal surface dissociate, producing a negatively charged site capable of forming a stable complex with the metal cations in solution.

These basic studies into the ion exchange properties of low-rank coals have been recently extended to include an evaluation of the possibilities of using low-rank coals for acid mine drainage remediation.

Mining operations in hard-rock formations create porosity and permeability for groundwater flow. Water-soluble inorganic-sulfates, formed during mining operations by exposure of sulfide minerals to air, are transported from the mines as dissolved and suspended solids. This phenomenon is referred to as acid mine drainage because of the relatively low pH of the water due to the presence of sulfates. Levels of metals in these streams can vary from zero to several thousand parts per million. For optimum adsorption results using low-rank coal, the pH of the acid mine water should be raised to a value approaching 4.0 or greater. One of the reagents investigated for use in pH control/adjustment was a sample of calcium carbonate sludge formed as a waste stream during the process of sugar refining. We are studying the feasibility of adding calcium carbonate sludge to raise the water's pH, which seems to be the most economical solution, as this material is available in relatively large quantities from sugar refining facilities.

We have obtained recent results by treating a sample of mine drainage water from Colorado (Argo mine) with a Na-rich lignite from North Dakota (table 1). Only the concentrations of the most environmentally significant heavy metal contaminants, and sodium, are reported. Two sets of sample-solution mixtures were prepared. The first consisted of 0.6 g of lignite in 40 mL of mine water (ratio of 1 g/100mL dry weight), and the second of 3 g in 40 mL (ratio of 5 g/100mL dry weight). The mixtures were shaken for 18 hours and then filtered through a 0.45 µm filter. The pH of the solutions was measured and the concentrations of the cations were determined using DCP/ICP-AES. The amount of Cd, Cu, Fe, Ni, Pb and Zn were significantly reduced in the mine water while the Na concentration increased, indicating that Na is being exchanged with heavy metal contaminants on the lignite.

Table 1. *Analysis of a Colorado mine water, prior and after treatment with North Dakota lignite (concentrations in ppm).*

Analysis	Water as received	Treated with 1g/ 100mL	Treated with 5g/ 100mL
pH	2.66	3.15	4.88
As	<0.04	<0.04	<0.04
Cd	0.124	0.118	0.03
Cr	<0.004	<0.004	<0.004
Cu	5.67	3.04	0.261
Fe	140.5	38.5	2.8
Na	21.9	68	167
Ni	0.164	0.155	0.057
Pb	0.033	0.032	<0.016
Zn	41.5	36.5	16.9

The effect of adding calcium carbonate sludges in the Argo mine water to optimize the ion-exchanged process was also investigated. Mixtures of Argo mine drainage water with lignite, in a ratio of 1 g/100mL were prepared and different concentrations (from 0.1 to 1 g/100mL) of dry calcium sludges were added. The results are presented in Table 2. As expected, the addition of calcium-rich sludge to the lignite resulted in an increase of metal adsorption, especially for Cd, Cu, Fe, Ni and Zn. The adsorption of Fe goes through a maximum at a calcium carbonate sludge ratio of 0.1 g/100mL, as more sludge is added, the pH of the solution is increased, due to an increase in the extent of dissociation of the carboxylic acid functional groups with pH.

Thermal Treatment of Exchanged Lignites

The second, and most important step of the MERSAD process, is the immobilization of the metals contaminant within the ion-exchanged coal. The vitrification reactor investigated to date in this continuing study is a scaled-down model of the AGCOMM combustor developed by the Institute of Gas Technology. The AGCOMM unit is a patented two-stage fluidized bed/ cyclonic agglomerating combustor. When contaminated systems are fed into the fluidized bed, the combustible part undergoes rapid combustion to produce gaseous components and the solid fraction containing inorganic contaminants is chemically transformed in the hot zone and agglomerated into glassy pellets.

*The conclusion of this article will appear in the Vol. 7 #3 issue of E**nergeia**.*

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Table 2. *Effect of the addition of calium-rich sludge on the adsorption of a Colorado mine water on 1 g/100mL of North Dakota lignite (concentrations in ppm).*

Analysis	no sludge added	0.1 g/100mL	0.5 g/100mL	1 g/100mL
pH	3.84	7.20	7.67	7.95
As	<0.04	<0.04	<0.04	<0.04
Cd	0.118	0.0287	0.0161	0.0089
Cr	<0.004	<0.004	<0.004	<0.004
Cu	3.04	0.037	0.052	0.071
Fe	38.4	0.062	0.496	1.39
Na	68	62	67	62
Ni	0.155	0.055	0.034	0.019
Pb	0.032	<0.016	<0.016	<0.016
Zn	36.5	10.3	2.09	0.435

COMMENTARY

What Drives Research - Ideas or Funding?

Burt Davis, Center for Applied Energy Research

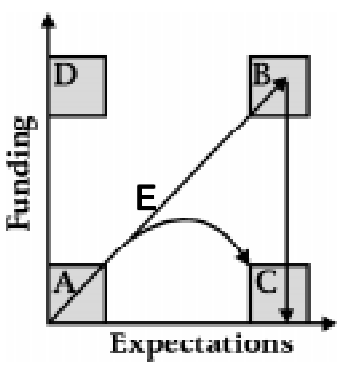
An advantage of attending a meeting that features research other than your own discipline is that you are presented some of the same material but in a different wrapping, and this gives you pause for thought. So it was with the invited lecture presented by Dr. Richard Brook, professor at Oxford University and chief executive, Engineering and Physical Sciences Research Council, United Kingdom, at a recent meeting held during September 24-27 at The Pennsylvania State University. The following is based upon notes taken during Dr. Brook's presentation and, as frequently happens, there is always the likelihood of an incorrect attribution and/or the tainting of Dr. Brook's comments with the writer's own biases.

Professor Brook presented a provocative look at the state of funding for research, leaving the listener wondering how we got here and is there hope for the future? Dr. Brook looked back to 1637, providing his translation of Descartes that states, in effect:

- There are so many explanations offered that all which were proposed as probable must be false.

- A person appears to receive all the more credit the more his/her ideas deviate from common sense (implying that the person will need more wit and cunning to make the ideas seem probable).

Dr. Brook presented a look at the expectations and the funding for research, and reduced this complex issue to the figure shown below:



In region A, the LOW PROFILE region, a person receives little or no funding and is therefore allowed almost complete freedom of action - limited only by creativity and ability to turn ideas into reality - to create a silk purse from a sow's ear, to transform lead into gold. Region D, PARADISE, where the funding is abundant and the expectations approach zero, was dismissed quickly by Dr. Brook; only a few limited groups attain this lofty position - e.g., particle physicists, large instrument astronomers, NASA space flights.

Obviously scientists and engineers strive to attain PARADISE, and on occasion, such as in the 1970s energy crisis, fuel scientists may approach this lofty position. When denied PARADISE, scientists and engineers strive to attain region B, and the shorter the expectation line the better. Logic does not apply to the drive to attain regions B or D. During the 1960s "golden era of science," a University of Florida administrator made a plot showing that if the rate of increase in scientists and engineers was to continue, by about 2040 every man, woman and child in the U.S. would be either a scientist or an engineer. This plot did not deter the University of Florida from making an intense drive to expand their sphere of influence in science and engineering, and to strive to place UF in PARADISE. Most scientists and engineers, however, possess some degree of reality, and accept that the best STEADY STATE CONDITION that they can hope for is region B, a region of HIGH PROFILE and therefore one that demands HIGH EXPECTATIONS.

Dr. Brook indicated that region C was the STEADY STATE CONDITION envisioned by politicians, the POLITICAL REGION. Those of us in science are certainly being made aware of the fact that industrial management members are becoming more and more like politicians: they expect more and more results for lesser and lesser expenditures. Historically we have become accustomed to following the pathway depicted as A → B → C; recent events indicate that management will accept only pathway A → E → C and that E should not be very expensive.

Lessons that those of us concerned with science should learn are illustrated in an article by Ralph Landau (*Research-Technology Management* May-June, 1992). In 1946, Landau was a co-founder of Scientific Design Co., Inc. (later Halcon International and Halcon SD Group). During the 1946-1966 golden years of America's postwar dominance of the international economy, the company made rapid growth from within. In 1966 they formed a joint venture (Oxrane) with Atlantic Richfield Co. to exploit a new technology that they had developed for the manufacture of propylene oxide. The joint venture flourished, and grew during 1969-1979 to revenues of $1 billion per year.

Going off the gold standard, the energy crisis of 1973, and soaring inflation that raised the U.S. prime interest rate to 21% all contributed to Halcon finding themselves in the position where all of their cash flow was going to the banks. Suddenly the technologically successful Halcon had to turn its attention from technological strategy to sheer survival in the business world and to finding a way to make the next interest payment.

Discussions were underway with Arco to renegotiate some of the terms of the original financing arrangement. Landau recalls vividly one of Arco's financial executives saying, "I'll teach you the value of money [vs. technology]." Halcon's rapid growth and technological innovation did not impress Arco's financial wizard, and Halcon sold their half of the partnership to Arco. In the real world, there always seems to be a "deep pocket around to help out" such an unfortunate individual or company. In hard times many suffer while a select few prosper.

The health of science in general, depends critically upon the length of the line ABC and upon the height of the line CB. Today many would contend that the length of ABC is even longer, and that CB is even shorter, than when Landau learned the cruel lesson of the rapidly changing values of technology and finance.

(Continued, page 6)

Commentary, (continued)

Politicians in the U.S. are, by the nature of their existence, directed to the short-term result: a U.S. Senator has only six years before re-election decides success or failure, and other elected officials have even fewer years. Politicians are therefore always on the lookout for successful happenings, and especially those they can share in or for which they may claim the entire credit. Unfortunately, scientists and engineers have raised expectations that too frequently fall far short and these have led to an erroneous model that is dear to most politicians: **all problems will go away with time so why waste money funding research?**

There has always been a residual hostility to mechanistic studies by those who control the purse strings. Furthermore, the open expression of this hostility ebbs and flows, always in concert with the real or perceived threat. The Manhattan Project could not cost too much in 1944. Likewise, the pressure of WWII was great enough so that the development of fluid catalytic cracking by Exxon could not cost too much. Twenty years later President Kennedy decided that the race to put a person on the moon could not cost too much. If, in the pursuit of these lofty goals, some “long-haired professors” had ‘fun’ doing mechanistic studies, that was a part of the cost of success.

In spite of the residual hostility to mechanistic studies, it must be recognized that nothing injects more life into a discipline than the drive to understand, to explain. The most certain way to extinction of a discipline is to remove mechanistic studies. Dr. Brook emphasized the need to be far-reaching in mechanistic studies by stating that Friedrich Schuler indicated that the potential for error keeps a subject alive.

What is needed for science is simple: imaginative ideas and the mechanistic studies that flow from them and; sponsors to accept the potential for error. The solution would seem simple: an approach must be developed that will teach the “Arco financial award” that the value of money exists only if technology is developed. When no technology is for sale, money has no value.

The problem is that technology has become much more sophisticated and has become so difficult to understand that even active practitioners find it difficult to comprehend. A busy CEO, even if technically trained, does not have the “time to be taught.” It would therefore seem that the only viable approach is to develop trust between management and the technologists. In short, those of us in science must somehow become more conversant with the language and the problems of the financial wizards of management so that the development of trust can begin.

Energeia is published six times a year by the University of Kentucky's Center for Applied Energy Research (CAER). The publication features aspects of energy resource development and environmentally related topics. Subscriptions are free and may be requested as follows: Marybeth McAlister, Editor of **Energeia,** CAER, 3572 Iron Works Pike, University of Kentucky, Lexington, KY 40511-8433, (606) 257-0224, FAX: (606)-257-0220,

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