A FRESH LOOK AT CARBON DIOXIDE MANAGEMENT

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The two most significant challenges the world will face in the 21st Century are energy security/availability and environmental sustainability. How we as a global community confront and address these issues will have far-reaching implications. Our actions will affect the availability and quality of the basic necessities of life…food, water and the quality of the air we breathe. These issues also have significant geo-political implications. Energy supplies and environmental quality impact the wealth of nations. Failure to adequately manage these challenges will result in significant constraints to future economic and social development, a shift in the balance of political and military power across the globe, and lead to discontent and unrest. In short, energy shortages and deterioration in environmental quality lead to friction, conflict and war.

Our challenges are exacerbated by the current state of the world economy. We have long heard of the risks that growing energy demand, coupled with limited supplies and suppliers, could have on the financial health of the planet. For those who sounded the alarm bells, their concerns have now materialized. The financial quandary in which we now find ourselves, driven at least in small part by runaway energy costs in the first half of 2008, will limit our ability to dig our way out of the present energy mess. Without the ability to generate the significant amounts of capital necessary to invest in new equipment and technologies, we will be further frustrated in our efforts to address energy security and environmental sustainability.

The serious nature of these challenges certainly justifies the level of debate, analysis and awareness-building that is currently underway. But, while the effort being expended is significant, one must ask whether it is efficient and effective. Do we have the level of information necessary to ensure that we are improving

the situation and not actually making matters worse? Are we adequately analyzing the interrelationships between development of new energy sources and long range environmental quality? Not just greenhouse gas emissions, but all environmental factors impacting quality of life. The evidence would suggest the answer is "no".[1]

Currently there is a palpable zeal in political and policy-making circles to find the Holy Grail of green and sustainable energy. We want to invent that magic "silver bullet" that will solve our energy and environmental problems with one shot to the heart. But as with most activities conducted in haste, we may repent at our leisure.

Consider the recent crash program to develop ethanol as an alternative to petroleum-based liquid transportation fuel. At the highest levels, the U.S. failed to think through the skewed incentives and long term life-cycle impacts. The most obvious issue was that farmers redirected acreage under cultivation from growing food to supplying feedstock for transportation fuel.[2] But equally worrisome is that ethanol proponents overlooked the basic life-cycle analysis. That is, greenhouse gas emissions from ethanol production, using current processes, may actually be worse than emissions from fuel made entirely from petroleum.[3]

Ethanol's defenders claim that future production enhancements will improve ethanol's carbon footprint. Probably. But the real concern here ought to be that the nation embarked on a major policy change in both energy and agriculture without proper baseline knowledge. The political process engaged long before the overall understanding was adequate. The U.S. invested massive national

[1] See discussion of mistakes made in the name of saving the planet in Sharon Begley, "Sounds Good, But…", *Newsweek*, April 14, 2008

[2] For a quick and comprehensive summary of impact of bio fuel production on global fuel supplies see Indur M. Goklany, "Fuels Vs. Food, US Energy Policy Hurting World's Poor", *New York Post,* April 17, 2008.

[3] Keith Johnson, "More Bad News for Ethanol", *Wall Street Journal*, January 23, 2008.

credibility and treasure to "solve" a problem, but in the end may have made matters worse.

A second example illustrates how behavioral responses to policy initiatives can actually drive results in the wrong direction…in this case, global greenhouse gas emissions. We all know which countries are the largest sources of CO2 emissions. Of course, they are China and the United States. But who is number three? Surely it is another major industrial economy, or possibly a top producer of fossil fuels, right? No, actually it is Indonesia.[4] And the major source of Indonesia's CO2 emissions? Deforestation…altering land use to provide arable land to grow bio crops for energy. You know…that stuff that is suppose to save the planet.

This is not to suggest that we should abandon bio fuels as an alternative energy source. Nor, should we condemn the people of Indonesia. Indonesia is simply responding to global demand and working to develop its national economy.

Bio energy will have to play large in the 21st Century energy strategy. What these examples do suggest, and there are likely countless others, is that we need much more comprehensive data and we need to map out the behavioral responses that our initiatives will trigger…and we need to do this rapidly.

The solution? We need the global scientific and engineering community to come together in an effort to do a comprehensive, end-to-end, life cycle analysis of the environmental footprint of all energy sources…an effort much more granular than any effort attempted to date. This effort needs the support of national governments and the United Nations, and should be Priority One. The United Nations is certainly not well positioned to execute an effort of this size and scope in a rapid fashion. Therefore, the U.N. should support the project by way of

[4] Agus P. Sari, Martha Maulidya, Ria N. Butarbutar, Rizka E. Sari, Wisnu Rusmantoro, *Executive Summary: Indonesia and Climate Change*, Commissioned by UK Department for International Development and The World Bank, March 2007.

funding. Fortunately, there are organizations that have successfully delivered on large-scale climate change studies. The World Bank and the U.K. Department for International Development both appear to have the capabilities to undertake such a significant effort.

The results of this effort will not only provide us with a true baseline, but should also reveal what processes along each energy source life cycle generate the most CO2. That data will allow the efficient allocation of resources to address those processes with the greatest carbon intensity, thereby achieving the largest greenhouse gas reductions in the shortest amount of time.

The Annoying Reality of Energy and Environmental Sustainability

Real success in expanding clean energy supplies and improving environmental quality requires that we have a transparent debate encompassing all of the moving parts that will adversely impact our rate of success if ignored. The annoying realities of future energy demand, the sources of supply necessary to meet that demand and the related impact on environmental quality make the path ahead more treacherous and just plain harder than we currently contemplate. Ignoring these realities will lull us into a false sense of accomplishment, possibly realizing the error of our ways too far down the road to correct our missteps. These annoying realities that must be considered are:

- We live in an energy poor world.[5] Two billion inhabitants of this planet don't have access to energy as we know it. The explosive growth in China and India will likely resume in earnest as the global financial crisis sorts

[5] Philip Stott, "The World's Energy-Poor Need Hydrocarbon Fuels", *Telegraph.co.uk*, August 22, 2002 states more than a quarter of the world population is classed as "energy poor". Max Shultz, "Nuclear Power is the Future", *Wilson Quarterly*, (Fall 2006) cited United Nations data suggesting 2.4 billion people lack access to modern energy services and roughly 1.6 billion people, about a quarter of the world's population, have no access to electricity at all.

itself out. And many emerging economies, especially those in Africa, will drive continuing increases in worldwide energy demand.

- If there is no such thing as "clean coal" we are all in big trouble. Why?
    - Because global coal extraction and use is going to increase in the future, and it is naïve to deny this fact.[6]
    - Renewable energy sources, nuclear energy and conservation and efficiency efforts will help, but will not even begin to cover increasing global energy demand. This means that consumption of fossil-based energy will increase, not decrease over the foreseeable horizon.[7]

  The solution is not to "wish" coal away, but rather to commit necessary R&D dollars to perfect the in-situ extraction of coal's energy content and to continue the process of achieving significant reductions in the CO2 emissions for coal processing and consumption.
- The greatest global strategic energy vulnerability is in the area of liquid transportation fuels[8]. The fact is that there are virtually NO viable commercial alternatives to petroleum-based products, despite the current hype for new technologies. (Maybe in 50 years, but it's a long way from here to there.) Global energy security can only be achieved when viable liquid transportation fuel alternatives reach commercial scalability. Meanwhile, the world plumbing and wiring is rigged for petroleum-based liquid fuels.
- Growth in global use of fossil fuel in the coming decades will undoubtedly result in ever-increasing concentrations of CO2 in the atmosphere. So, unless we make a dramatic paradigm shift in how we deal with CO2

[6] See Study by Andrew Minchener, "Future Coal Supply Prospects", *IEA Clean Coal Centre*, http://www.iea-coal.org.uk.
[7] "International Energy Outlook 2008, World Energy Demand and Economic Outlook, *Energy Information Administration*, http://www.eia.doe.gov/oiaf/ieo/world.html.
[8] See Rod Hunter, "We Must Diversify Our Transport Fuels and Technology", Hudson Institute.

emissions, no nation will achieve anything like the predicted reductions in greenhouse gas emissions.[9]

The points outlined above may well be uncomfortable to some because they suggest that solutions tabled to date might not deliver the results as advertised, and, in some cases might even allow conditions to further deteriorate

A Manhattan Project on Energy

There are some that suggest the breadth and depth of our energy challenges need to be addressed through a global effort of the scope of the Manhattan Project or sending a man to the moon. Others say that the only way to solve this crisis is to allow a thousand flowers to bloom. Actually, both are correct. But, how can you have it both ways? How do you amass the resources to achieve both? In the same fashion that Dr. J. Robert Oppenheimer and his team focused singularly on the development of an atomic weapon while the vast U.S. war machine and industrial base successfully executed on the development, manufacture and deployment of conventional weaponry and delivery systems during World War II.

And we would be wise to heed the lessons learned from the Manhattan Project…lessons that illustrate the structure and level of accountability for an organization tasked with such a significant responsibility. President Roosevelt's initial approach to developing the atomic weapon was to establish a committee to oversee the process. It probably comes as no surprise that progress under the committee was slow. Then, in August of 1942, Roosevelt changed direction, placing the initiative under the oversight of a single agency's jurisdiction. It was reorganized as a stand alone effort and accountability was assigned to a single

[9] David Adam, "Scientists Fear Worst on global Warming", *The Guardian*, April 14, 2009. See also "Key Messages from Copenhagen Climate Conference", University Of Copenhagen, March 12, 2009, http://climatecongress.ku.dk/newsroom.

leader with almost unlimited ability to tap military, industrial and scientific resources. The change resulted of delivery of the desired effect in an amazingly short period of time. Does this experience show the way to structuring an organization to undertake this enormous energy effort? It certainly seems that it does.

However, in order to employ a Manhattan Project strategy for energy, that one massive single focus effort must be defined.

So let's see…we live in an energy starved world that is acutely aware and concerned about increasing concentrations of carbon dioxide in our environment, a gas that is made up of almost 30% carbon. Since carbon is currently the world's primary energy source, the answer is obvious. The single focus project should be to perfect a process to effectively harvest carbon dioxide from our environment and convert its carbon content into energy. Since the top strategic energy vulnerability across the planet is liquid transportation fuel, the project focus ought to be augmenting the liquid fuel supply.

Of course, carbon reuse technologies are in their infancy stages. These technologies are energy intensive and expensive. It will be some time before we see a commercial-scale, "carbon-reuse" alternative ready to deploy. Then again, the proposed processes to capture and store CO2 underground are also alternatives fraught with risk and uncertainty. Large-scale CO2 sequestration will take decades to perfect, if it can even work at all over the long term. So why not focus our efforts on recycling the carbon from CO2, rather than focus solely on the monumental task of "perpetual" waste storage?

Carbon Dioxide Reduction, Capture and Reuse (CO2RCR)

Today, the carbon management debate centers around treating CO2 as a waste, carries with it the costs normally associated with the collection, transportation and handling of waste, and creates potential liabilities and environmental risks that may not be fully understood for centuries or millennia. The challenges that lie ahead require true revolutionary ideas…ideas that not only address a problem, but turn a problem into an opportunity. Reversing the trend of ever-increasing CO2 levels in the environment will require turning current thinking on its head, re-characterizing CO2 from a costly waste into a commercially valuable industrial material.

As Bill McDonough, of William McDonough + Partners illustrates in his book Cradle to Cradle: Remaking the Way We Make Things, waste constantly recycles as food, or fuel in this case, in the natural world. Waste is consumed and reused.[10] Why is the same not possible in the manmade industrial world? Well, it is, but will require a paradigm shift in thinking and a focused effort equal to the Manhattan Project.

So what are the options? Well…there are several. Which of these options are scalable to commercial size and scope? That, of course, will be the focus of the CO2RCR initiative. Fortunately, we are not starting from scratch on these options. Several of the U.S. Department of Energy Research Labs, university research teams and private industry have been working these alternatives. So, we have a jump start to find real, permanent and productive solutions to greenhouse gas emissions.

Current efforts surrounding the management of manmade CO2 emissions focus primarily on the concept of geologic sequestration. This process requires

[10] William McDonough & Michael Braungart, *Cradle to Cradle, Remaking the Way We Make Things*, (New York: North Point Press, 2002), p.92.

identifying large storage locations for carbon dioxide deep underground or out at sea. Depleted oil wells, abandoned coal mines and saline aquifers all offer opportunities for long term storage of CO2. Small scale short term tests suggest that carbon dioxide storage has potential, but longer term tests are necessary to ensure that commercial scale sequestration can be done safely and effectively. Most experts suggest several decades of research and analysis is necessary to clearly understand the long term impact of geologic storage of greenhouse gases.

But, there are alternatives…alternatives that not only leverage processes in nature, but could also increase the energy yield from our limited fossil resources, while reducing the environmental footprint of using these fossil resources. In those decades necessary to research the safety of carbon dioxide storage, wouldn't it be to our benefit to identify methods for effective utilization of CO2 to support environmental sustainment efforts and expand energy alternatives for an energy-starved world? The objective of these carbon reuse initiatives is simple. The desire is to make carbon dioxide a valuable commodity rather than a costly and risky waste product.[11]

One set of alternatives comes from the concept of biologic sequestration…the natural process by which plant life absorbs CO2. Regrettably, the planet's natural ability to absorb carbon dioxide has been diminished by massive deforestation, much accomplished in the name of providing arable land to grow feedstocks for bio fuels. A bit counterintuitive, isn't it? As world leaders contemplate alternatives to combat rising greenhouse gas levels in the environment, forestation and reforestation on a grand scale needs to play a significant role.

[11] For a discussion of CO2 direct utilization technologies see Howard Herzog, Elizabeth Drake and Eric Adams, "CO2 Capture, Reuse and Storage Technologies for Mitigating Global Climate Change", Energy Laboratory, Massachusetts Institute of Technology, January 1997.

Natural biologic sequestration can be augmented via the assistance of new technologies. Efforts are currently underway beta testing the enhancement of growth of oil-rich algaes via injection of manmade CO2. Scalable projects currently in operation should yield sufficient data early next decade to provide a roadmap to the development of commercial scale operations of algae to fuel facilities.

Bioengineering offers great promise in the search for new methods of carbon dioxide management. Specifically, adapting microorganisms to be capable of consuming CO2. Bacteria are “fed” carbon dioxide produced from industrial processes such as coal burning power generation to produce a carbon-neutral energy source. Essentially, a solar power factory is created, combining light, bacteria, CO2 and water to yield a bug with high energy content. Initiatives like one underway at Arizona State University utilize microorganisms called cyanobacterium that can be directly converted into high energy bio fuels that will not compete with food production.

Physical transformation of carbon dioxide into valuable sources of energy provides an additional suite of opportunities. Direct conversion of CO2 to ethanol yields an energy source in current demand. The technology is proven but is presently quite expensive, thus requiring additional effort to drive down cost of production. Co-electrolysis combines CO2 with water that is passed through an electrolysis cell. The process yields hydrogen and carbon monoxide…both sources of energy. Finally, CO2 destruction also yields the energy sources hydrogen and carbon monoxide. Presently, CO2 destruction requires extremely high temperatures, making it an energy intensive process. Co-electrolysis and CO2 destruction require significant additional research of the scale of a Manhattan Project to develop a commercially viable process.

What will it take to achieve rapid and effective results? It will require leadership, money, global reach, and an organization stripped of bureaucracy and not

beholden to any political agenda. It will require an organization similar to Dr. Oppenheimer's Manhattan Project team.

The lessons learned from the Manhattan Project give us insight as to the way ahead. Management by committee is a non-starter….this effort, at least in the U.S., will have to be placed under the control of one single Federal agency…one with a history of successful operational execution of complex initiatives on a grand scale. That organization would logically be the U.S. Department of Defense…not the organization one might naturally think of in the energy or environmental arenas. But, this is not a policy exercise. It is an effort that requires strategic identification of an objective, developing tactics necessary to achieve stated milestones, and mobilizing vast resources to achieve that stated objective. These are activities quite similar to a military campaign…activities for which the military is best suited. But it is not the Department of Defense that should actually lead the charge. It is each branch of the military that has the capabilities and personnel to execute on such an undertaking. So, one of the Services should be tasked with the responsibility to carry this effort forward. The U.S. military has, over many years of working in coalition settings, developed close relationships with counterparts across the globe. International cooperation in achieving stated objectives can be facilitated via these long-standing relationships. And, like the Manhattan Project, one individual must me empowered to draw upon the government, private sector and academic resources necessary to complete the assigned task.

This effort will require an organization completely focused on one single, clearly defined deliverable…reuse of carbon dioxide for the purpose of creating energy for an energy starved world But, with energy and environmental sustainability the most significant challenges of the 21st Century, this is an effort we can't afford not to get right.

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