OUT OF THE CRISIS

Using Profound Knowledge to Address Climate Change

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Abstract: W. Edward Deming's system of profound knowledge provides an especially cogent and effective structure from which to lead humanity "out of the crisis" of anthropogenic climate change, which is perhaps the greatest crisis facing mankind today. The problem at its core is a systems problem, and the systems approach of profound knowledge is the key to solving it.

At the dawn of the new millennium, anthropogenic climate change has emerged as one of the greatest problems facing the planet. The earth's atmosphere is being reconfigured by industrialization and in particular through the burning of fossil fuels - primarily coal, oil and natural gas. Each year the concentrations of CO_2 and other greenhouse gases increase in the earth's atmosphere, and with more greenhouse gases the planet becomes hotter. The world scientific community is extremely alarmed, as evidenced by the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC)[1] released in 2007. The assessment reflected the contribution of hundreds of scientists from the world over, and stated with 99% certainty that the earth is warming, and with 90% - 99% certainty that it is being caused by human activity. Such strong agreeement in the scientific community is rare. As James Baker, the administrator for NOAA stated, "There's a better scientific consensus on this than on any issue I know, except maybe Newton's second law of dynamics[2]."

Yet despite near unanimity from the scientific community, anthropogenic climate change has been to a great extent an invisible problem, a slow emergency. It is a crisis to which many are oblivious and whose consequences will be felt not in two, five or ten years, but rather in two or three decades and on into the next century, and centuries thereafter. If climate change is about anything, it is about long-term consequences driven by interrelationships, interconnectedness, and interdependence - the interrelationship of human development with the earth's biosphere, the interconnectedness of our biosphere to our climate, and the interdependence of all components of the bioshpere - including the human species - on each other.

Anthropogenic climate change is in some sense the first truly global problem in that it has almost no localized effect. CO_2 generated in the U.S. on a Monday is by Friday changing the atmosphere over Brasilia and Beijing as much as Boston. And given the global nature of modern industrialization, largely powered by fossil fuels, it is essential that the business community take responsibility for climate change and take the lead in addressing it. As the nation with the greatest economic power and largest carbon footprint, the U.S. needs to show leadership in both public policy and the private sector. Unfortunately, U.S. leadership on policy has been lacking for over a decade. That may be changing very soon. In the private sector, American management is under pressure to produce specific measurable results in ever shorter time horizons. This makes U.S. industry especially ill-equipped to address broad issues like climate change with its complex interdependencies and extremely long-term consequences. This was hinted at in a report released at the 2008 World Economic Forum in Davos, Switzerland which ranked the U.S. at the bottom of the Group of Eight industrialized nations on addressing climate change and other environmental issues[3]. It seems that U.S. management is not especially geared to consider a problem like climate change.

To find the best tools to address climate change, management must understand the roots of the problem. Management theory can aid in that understanding. Anthropogenic climate change is a symptom rather than a problem. The world's industrial economy is out of alignment with the carrying capacity of the planet's biosphere. This fundamental misalignment is a huge systems problem and climate change is its most serious consequence. One of the great management theorists of the 20th century who used systems theory in management problem-solving, was W. Edwards Deming. Deming was a systems thinkers and his work advanced systems-based solutions for the problems of industrial development. After a seven decade long career, Deming crystallized his thinking into a framework he called a system of profound knowledge. Profound knowledge provides a cogent and effective structure for understanding business problems from a systems perspective, but it applies beyond business and may well lead humanity "out of the crisis" of anthropogenic climate change.

Deming and Profound Knowledge

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Deming was an Iowa born, Wyoming bred, and Yale educated statistician. While working for the Department of Commerce in the late 1940's, he was asked by his superiors to go to Japan and help rebuild their economy following the devastation of World War II. Initially involved in census work, Deming eventually began giving lectures on statistical process control to groups of scientists and engineers. The students were so taken with his teachings and his direction that they wanted him to publish his notes so that the information could then be shared more widely across Japan. He made his students an offer: they could publish his notes themselves under the condition that they use any proceeds or any profits towards improving quality in Japan. That was the measure of this man that he was more interested in seeing a nation rebuild itself than personally profiting from it. In the end, the Japanese people attributed the rebirth of their industry to Deming's work there. In 1960, he was awarded the Second Order Medal of the Sacred Treasure by Emporer Hirohito, the highest possible award that can be bestowed on a foreigner.

For those interested in knowing more about Deming, a good source is the card catalog at most any public library, where one will find a long list of credits that often include his book *Out of the Crisis*, plus a technical listing of books and papers that is weighted to mathematics and statistics. It is somewhat ironic that one of Deming's most famous refrains, one he used over and over again was "the greatest gains and losses cannot be measured, but they must be managed." Perhaps only someone with a true understanding of mathematics and statistics could see that much of value within organizations is beyond measure. Deming understood not only what measuring could reveal, but also what it left out.

There is no doubt that Deming was a provocateur. At the age of ninety, he took time out from his very busy and well-paid consultancy to teach young business students something he called "profound knowledge." He came to America's business schools to shake things up. At a time when "B-School" students were taught to worship at the dual altars of customer and quality, Deming would espouse heresy – that customers did not determine quality; in fact customers "didn't give a hoot about quality," he would say. When conventional wisdom held that the fall of American competitiveness was due to lazy workers, he would say that quality was determined not on the factory floor but in the boardroom. When the latest buzz in the compensation arena was about using stock options to align executive pay to company performance, Deming would say that pay-for-performance was meaningless and that compensating an executive on stock performance was "like rewarding the weatherman for a nice day." He would say that we are ruined by hard work, we are ruined by best efforts – the more nonsensical he sounded, the more it reflected deep insight.

In 1986 when Deming published his book *Out Of The Crisis*, the U.S. manufacturing sector was in trouble. At one time, the label 'Made in the USA' meant excellence, the best in the world. American innovation had perfected the manufacturing of the automobile, and invented recorded sound, the television set and the transistor radio. However by the mid-1980s U.S. quality and competitiveness were falling behind; factories were closing, and jobs were being lost. Things were being made more cheaply and with higher quality in other countries, especially in Japan.

As Japanese quality and affordability dominated the electronics and automobile sectors, American management turned to Japan, and in doing so found Deming. By then, Japan's most prestigious quality award was named The Deming Prize. Japan's great success story led to the success of *Out of the Crisis*, which led to further work as Deming's teachings gained new audiences. In *The New Economics* Deming put forth a framework he called a system of profound knowledge to rescue American business from the "tyranny of the prevailing management style." Profound Knowledge had four components:

1. Appreciation for a system.
2. Knowledge about variation.
3. Theory of knowledge.
4. Psychology.

<u>Appreciation for a System</u>

Deming believed that every CEO should view his or her business as a system. A system with many interconnected, interrelated and interdependent components. Deming would say that you can't have a system without an aim, and that to be sustainable, the aim cannot be a numerical target. It must instead be the *raison d'être* of the company, the reason why a customer would buy the good or service on offer. He would also say that the aim of the system is a value judgment, implying clearly that values are part of running a successful business. Deming believed one of the most important aspects of systems, as well as the most overlooked by management, was an appreciation of all the

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interdependencies of components within a system – a necessary understanding in order to optimize the system. He also knew that the definition of system boundaries was critical to the optimization of the system, and as circumstances changed boundaries might have to be redefined.

Knowledge About Variation

To Deming, running a successful business was about understanding variation – its causes and how to control it. By variation, Deming did not mean simply variation in inputs and outputs, but also variation in people, variation in management style, variation in culture, variation in environment. Deming understood that variation in a system could be either stable or unstable. He showed how stable variation was bounded by upper and lower control limits, and he would also say that if a system were showing stable variation then one ought to look for causes that were from within the system - what he called *common causes*. If variation were not stable and were not bounded by definable control limits, then he advised looking for causes from outside the system - or *special causes*. Deming would warn that the greatest economic losses due to management had to do with mistaking *special causes* for *common causes* or vice versa, and then taking action based on that error. He called this 'tweaking the system', which he found ruinous to the system, heading management "off the Milky Way" to oblivion.

Theory of Knowledge

Deming often pointed to a quote from Thomas Edison "There's no substitute for hard work." Who could argue with that? Deming could. One of his constant refrains was "We are ruined by hard work. We are ruined by best efforts." For Deming, hard work and best efforts were not inherently bad, but coupled with a lack of knowledge they could be ruinous. Rather than making hard work the *sine qua non* of business, Deming always emphasized knowledge. "There's no substitute for knowledge," he would say.

I was a student in the MBA class Deming taught at Columbia. Once, he directed the question "Where does new knowledge come from?" to us, his graduate students. We were an elite grouping, having been accepted into one of the premiere MBA programs in the nation with many of us going on to leadership positions in industry. Yet despite all that "knowledge" we had no idea how to answer his question. So after a long silent pause Deming answered it himself, saying "New knowledge comes from those who follow their own innate curiosity, responsible to no one." He also said that there is no knowledge without theory. Some think experience is knowledge. "Experience is not knowledge," he would say. Others think information is knowledge. "Information is not knowledge." But Deming knew that if through experience, and if through information we per chance think, and if in thinking we theorize, then in proving our theory right or wrong - that is where new knowledge is born. Deming also said that organizations that have the best opportunity for new knowledge were private companies and monopolies. He always extolled the virtues of Bell laboratories, which was the think tank for the telephone monopoly. To him, Bell Laboratories was a great example of how new knowledge can come forth in an organization and what it could bring in terms of sustainable growth, innovation and improved market position.

Psychology

To a great degree Deming was a student of human psychology. He believed that for an organization - a system - to be able to achieve its aim, it had to understand human beings – their psychology and motivation. Deming was a great believer in intrinsic motivation - he used to say that it was not the job of management to motivate the individual. Every person was born motivated, and sustaining that motivation came from joy in work, and joy in learning. He thought that the extrinsic carrot and stick approach to management (which is another way of saying greed and fear) was unsustainable. These emotions were inherently destructive to the system.

One of the things that Deming personally felt was injurious to human motivation was ranking systems. He did not like ranking people, and thought it one of the most damaging and tyrannical aspects of the prevailing management style. But beyond that, it was also ineffective. The best way to keep underachievers in an organization, he would say, was to have a ranking system, because the higher-ranked individuals were then motivated to keep the lower-ranked around in order to help maintain their status. With a purer system, however, where high expectations exist and performance is observed informally by one's peers, the best performers are motivated to have everyone else also perform to their best ability and to see that underperformers either improve or leave. Deming felt that a system that relied on a formal ranking system was much more likely to retain underachievers than one that did not.

While listing the four aspects of profound knowledge separately, Deming said "The various segments of Profound Knowledge proposed here can not be separated. They interact with each other.[4]"

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An Example of Profound Knowledge

In the early 1990's, when I was introduced to profound knowledge, Arthur Andersen had one of the premiere brands in the world. Arthur Andersen had been using the Deming framework of profound knowledge even before Deming articulated it. Arthur Andersen the man had a keen appreciation of a system. The Arthur Andersen system had one aim, and that non-numerical aim was the protection of the shareholders of the companies Arthur Andersen audited. The Arthur Andersen firm very carefully built a system of hiring practices, training, controlled expansion, and watchful selection of clients, that was informed by and was in pursuit of that aim. For example, the firm only hired people they felt they could train the Arthur Andersen way. This was very important because when these new trainees went out in the field, clients might try to influence them. This made the choice of client very important as well. Andersen looked for clients that they felt would not likely corrupt their auditors. In a way, being selected as an Arthur Andersen client became a point of pride for many corporations because it indicated that they had been vetted for honesty, openness, and transparency by the prestigious Arthur Andersen. How fast the firm expanded was also informed by the aim. In fact, everything that Arthur Andersen did was in pursuit of the organization's aim of protecting shareholders of public companies. Arthur Andersen himself knew the power of interdependencies – and by carefully managing them he created one of the top brands in the world.

But something happened at Arthur Andersen, something that took the focus away from the original aim and put it elsewhere. Steve Duggan started out at Arthur Andersen back in 1961 when Leonard Spacek was still the head of the firm. Spacek was a protégé of the founder, and only the second person to lead the firm, which he managed much in the same way Mr. Andersen had done. Duggan did three weeks of boot camp as a new CPA hire and at the end of training, he and his classmates were addressed directly by Mr. Spacek. Duggan told me that one of the first things Spacek said to them was that if they were joining Arthur Andersen to become rich, they should stand up right then, turn around and walk out the door - because they were not there to get rich, but rather to protect the shareholders of the companies Arthur Andersen audited. In Deming-speak, they were there to service an aim, a non-numerical aim that was the *raison d'être* of the firm. All of those new hires would have the opportunity to do very well financially, but rather than making it a personal target, their own financial success would become the consequence of optimizing the overall system.

Duggan was very successful at Arthur Andersen, eventually becoming a partner. But late in his career, he began having doubts about the direction in which his firm was headed. He shared with me that he felt he would never have succeeded at Arthur Andersen if it were run in the 1960's as it was being run in the 1990's. "I just don't have the personality for it," he said. By the end of 2001, the firm imploded from the scandals related to Enron, Waste Management, and Sunbeam, which capped a long list of controversial engagements where Arthur Andersen was supposed to be keeping public shareholders protected but was instead advising their own corporate clients on how to protect themselves. So I asked Duggan about how the company went from having Leonard Spacek call new recruits to serve a higher aim, to seeing the manipulation, shady practices and shredding of documents for which Arthur Andersen became infamous. He paused for a short time, and then he said to me, "I think it all started to change when we began measuring things." All I could hear was Deming's voice echoing in my head "The greatest gains and losses cannot be measured." Arthur Andersen became obsessed with earnings growth. They implemented management by objective (MBO), which encouraged companies to partition their enterprises into measurable business units, set numerical goals for each, and have each manager run his area of responsibility with the sole purpose of meeting his individual targets. With MBO, Arthur Andersen changed the aim from its *raison d'être* to a numerical target, and in the bargain created a new growth obsessed culture. The old Arthur Andersen system based on hiring, training and carefully selecting clients, the old way of thinking and many of the old employees did not fit in with the new culture. What eventually ensued from this was something that Arthur Andersen the man had been concerned about from the very beginning – a lack of control. The new culture abandoned its appreciation of the system that had created a world-class accounting firm. The new culture introduced competition within the system and a myopic focus on "making the numbers", which as Deming predicted, was unsustainable. Arthur Andersen was once a firm that leveraged profound knowledge to great success. In abandoning it, it destroyed itself.

Profound Knowledge and Another Kind of Crisis

In some ways, Deming's profound knowledge seems simple – perhaps it might be called a system of common sense. But, unfortunately, the way Deming approached problem solving was all too uncommon. As important as it was to change American management thirty years ago and to lift America "out of the crisis" that bad management was

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causing, there is an even greater danger looming today. Anthropogenic climate change threatens the very habitability of our planet.

Surprisingly it is problem that has been largely ignored in the U.S., but which must be addressed rapidly if dire consequences are to be avoided. For civilization to address a problem with long-term effects and complex interdependencies, profound knowledge is an especially cogent and effective structure. Each of the four steps of profound knowledge can be used as a window into why climate change must be addressed, and how to address it.

Appreciation of a System

Industrialization used to see itself as disconnected from the ecosystem, and drew boundaries around itself very narrowly, defining externalities as unallocated costs that had no impact internally. Through the impact of climate change, business is beginning to realize that there are no "externalities", and that the actions a business takes ultimately impact back on that business, and in ways that are unforeseen and unintended. Industrialization is out of alignment with the earth's ecosystem. To be prepared to address climate change and its impact, industrialization must see itself as a subsystem of earth's ecosystem and serve the AIM of the overall system.

The Caspian Sea was once a beautiful and vibrant body of water. It supported marine and human ecosystems for thousands of years. But now it is controlled by systems not aligned with natural ecosystems. The gas and oil industries have dominated the Caspian region for decades and the sea is now dying. Fish counts in the Caspian are down 99% from historic levels.

Not very far from the Caspian lies the Aral Sea which was once the sixth largest inland sea in the world. It was the lifeblood of the region, supporting the livelihoods of many in Central Asia for thousands of years. But in its search to expand its industrial base, and to improve the lives of its people, the Soviet Union decided to build up agriculture. In the 1930's and 40's, the central planners began tapping into the source waters of the Aral to develop a cotton industry in the region. Today, with its source waters diverted, most of the once mighty Aral Sea is a desert.

Our business decisions and even our consumer decisions impact our environmental quality, and one of the most powerful examples of the consequences of a misalignment between the economic system and the ecosystem is made clear in a story I call "The Case of the Cashmere Sweater."[5]

This is the story of the price being paid in Asia's land and in America's air in order for us to have cheap sweaters. It also teaches the lesson that what happens in China does not stay in China. It truly reflects the interconnectedness, interrelationships and interdependencies that world trade – and in this case trade between the US and China - bring. It also heralds the end of "externalities" – because it makes clear that actions not only affect others, but eventually they affect the actor as well.

In order to meet the exponentially increasing demand in the United States for cashmere sweaters, China is literally raping its land, polluting its air and affecting the ecosystem of which we are all a part. In 2005, the United States imported fifteen times as many cashmere sweaters as it imported ten years earlier. And prices have plummeted – in 2005 a cashmere sweater cost about ⅓ of what it did in 1995. Cashmere, which was once available only to customers of Lord & Taylor, Saks Fifth Avenue and the like, has now become a sale item at Kmart and Costco. This is the way capitalism is supposed to work – providing more goods for more customers at lower cost. This is a good thing. However, there is more to this story.

It turns out that cashmere is only available from sheep that graze in a very particular part of China, called the Alashan Plateau. The Alashan Plateau is the size of Arizona and Colorado put together, and it was once a very lush and green ecosystem, populated mostly by camels and some sheep. The system was sustainable for thousands of years. But ten years ago, when camel herders saw how much money could be made getting into the cashmere sweater business, they sold their camels, replacing them with sheep, and started cultivating and harvesting the fine wool found on the sheep's underbellies. This was good business for them, and they earned more money than they had ever earned before, helping to lift them and their families out of poverty. But slowly a problem revealed itself – the carrying capacity of the prairie was being exceeded for the first time in thousands of years, and a once lush prairie was being turned into a dust bowl.

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This example is just one that demonstrates that China's economic boom has become ecological doom. In 1949, there were 2.4 million sheep on the Alashan Plateau. By 2004, the number was 25.8 million. The result of this shift from camels to sheep has destroyed the grasslands of the plateau. Not only are sheep more voracious than camels, but their hooves are very different – camel hooves are actually very flat and smooth and do little damage as they tromp around the plateau, while sheep on the other hand have very sharp stiletto-like heels that tear up the grasslands of the Alashan.

A dust bowl is being created by this phenomenon, and one that is not just affecting China. For example, one particular dust storm in April 2004 that started in the Alashan was so intense that by the time it hit the Pacific, the Korean government reported that 1.8 million people got sick enough to seek medical care, and $7.8 billion in damage was done to the semiconductor and airline industries. That was one dust storm, but it didn't stop there – the dust continued to travel across the Pacific Ocean on a high altitude air stream called the Transpacific Transport, and by the time it hit Denver, the midday sun was so dimmed that it made national news. This dust storm even made it all the way over to the Atlantic coast.

And what of the sheepherders of the Alashan Plateau? They are now in desperate financial condition, because there is no grass for their sheep to graze, they must import feed, which is costing them a fortune and ruining their once comfortable profit margins. The Alashan Plateau may not recover for decades from this devastation. "Our life depends on nature," one of the sheepherders was quoted saying. "Things are getting worse year by year."

The case of the cashmere sweater is a lesson in the appreciation of a system. This is a story of interconnectedness and interdependencies within a system that are hard to measure but which must be managed. It is a story of system boundaries and how in global markets drawing boundary lines seems almost meaningless. Rather than considering waste or pollution as an “externality”, this example makes clear that the overall system has no “externalities”- in the system everything is connected .

Wrapped in this story is also a warning about climate change. In 2008, China may already be the largest emitter of greenhouse gases, certainly not on a per capita basis, but as a nation as a whole. Their desire to improve the lives and living standards of their citizenry is a noble one. China will develop and must develop. The only question is, as Dr. Deming would ask, by what method ? China is currently firing up a new coal-fired power plant every week. The implications for global climate if such plans continue unabated are catastrophic. In order that China's development does not become an ecological disaster for the planet, it is essential to understand the system and use new knowledge to optimize the system. The world economic system can not be separated from the planet’s ecosystem. The economic system must serve the aim of the overall ecosystem – which is sustainability and life – otherwise it will lead to the destruction of the system. China, nor any other nation or people, wants to commit ecological or climatological suicide. The international community must work together to develop and share new technologies for creating sustainable and clean energy sources and for increasing energy efficiency. All countries must work together to develop a global system of energy generation and usage that is aligned with the ecosystem.

Knowledge of Variation

In terms of climate change, knowledge of variation means understanding variation in the earth’s climate, and the impact that a variable climate can have on the earth’s ecosystem as well as the suitability of that ecosystem for human habitation. An understanding of where climate variation comes from, and how can it be controlled, if indeed it can or should be controlled, is necessary. Variation in climate has been the story of planet Earth for 4 billion years – and over the last million years the world has experienced significant variation marked by a continuing series of ice ages and interglacial periods. So how is climate change today different from the previous million years? Are the causes of contemporary climate change related to historic climate change? Are the causes coming from within the system or outside the system, *common causes* or *special causes*? How does understanding the origins of variation affect our ability to deal with climate change?

The scientific community has gathered ice data going back at least 650,000 years. In looking at this data, it is clear that while there is a substantial variation in the level of CO_2 going back hundreds of thousands of years, it is also clear that variation is stable with an upper control limit of 280 ppm CO_2 and a lower control limit of 180 ppm CO_2. One can also see that temperature is very closely correlated to CO_2 levels. In two plots: one for CO_2 and one for

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temperature, the rise and fall in CO_2 and temperature levels over this 650,000 year period are so closely correlated that they appear to be the same data set.

When a system is exhibiting variation that is stable, Deming would recommend looking for a cause that is from within the system – what he called a common cause. What might that cause be? What has caused the stable variation in CO_2 and temperature for over the last million years or more? It turns out that that question puzzled nineteenth century scientists when the existence of the "Ice Age" was discovered in the early part of that century. The term "Ice Age" is somewhat of a misnomer as there have been many "Ice Ages" in the last million years (seven in the last 650,000 years.) CO_2 concentrations which have dipped down to 180 ppm correlate to what we know as an Ice Age. What is bringing about these Ice Ages, and this variation in CO_2 concentrations? Is the cause from within the system as Deming would suggest?

The system here is not just the earth's ecosystem alone, but the earth as a subsystem inside the solar system. The cause of the Ice Ages (and the cause of variation in atmospheric CO_2) is due to changes from within the earth-sun system. This was revealed through the research of Milutin Milankovich, who he published his findings on the origins of the Ice Age in 1941 in a paper written in Serbian and only translated into English in 1969[6].

What Milankovich learned was that there were three cycles that brought about the Ice Ages, each with a differing period length and effect. The first and most powerful cause is due to the Earth's orbit around the sun which shifts on a 100,000 year cycle. The more elliptical the Earth's orbit, the greater the difference between summers and winters, and the less overall solar energy hits the earth. The second cause is the tilt of the earth on its axis, which varies on a 40,000 year cycle, and the third cause, the wobble of the earth's axis as it rotates, varies on a 20,000 year cycle. These three effects combined have given the planet seven periods of advancing ice as well as seven "interglacial" periods in the last 650,000 years. The system has been stable and the cause, as Deming might have predicted, came from within the system.

When today's level of CO_2 concentration is examined, it is apparent that it has moved outside the bounds of stability as defined by the prior 650,000 years of atmospheric history. It is now at 385 ppm of CO_2, which is almost 35% above natural levels of 280 ppm. This is outside historic control limits, and if business continues as usual, by the middle of this century, we will reach and almost certainly exceed 600 ppm of CO_2, which pushes us even further outside the stable region. If this variation is indeed outside the control limits, and if it is unstable, Deming advised looking outside the system for the cause. Clearly digging up material from the earth's crust and systematically burning it into the atmosphere is "outside the system" of natural history. It is in fact a large scale geophysical experiment that human beings have been undertaking for the last 200 years whose consequences are not at all clear.

We humans have taken a stable climate system and through special causes created an unstable climate system. To address this, some are suggesting "geo-engineering", i.e. putting up large scale satellite umbrellas, or perhaps seeding the atmosphere with particulates to cool down the planet quickly. I think Deming would see the geo-engineering approach to climate change as "tweaking the system", introducing potentially even more variation into the system without addressing the real cause of the current variation – i.e. the burning fossil fuels on a large scale.

Theory of Knowledge

Is the concern about global warming based on knowledge or on a political agenda? What is the history of the understanding of climate change? In fact, anthropogenic climate change is a theory, but as Deming said "There is no knowledge without theory."

The understanding of anthropogenic climate change comes from the work of dedicated scientists at places like NASA's Goddard Institute for Space Studies and the National Oceanographic and Atmospheric Administration. The climate scientists of today sit on the shoulders of giants whose work in understanding anthropogenic climate change dates back to the early 19th century.

As long ago as 1827, the term "greenhouse effect" was coined by Jean-Baptiste Fourier. Any student of advanced mathematics knows of the Fourier Series and Fourier Transforms. Fourier's contributions to mathematics were enormous. Self-educated and innately curious, he wondered why the earth was a stable, hospitable 58°F. He theorized that it should actually be much colder and that something was happening to make the earth warmer than a black-body heat balance would lead one to conclude. Then he theorized that it was because our planet's atmosphere

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acts like the glass of a greenhouse - it lets solar energy in, but it doesn't let all the heat out. He published a paper in 1827 discussing the greenhouse effect. Later that century, in the 1860's, John Tyndall, who was known as the invisible scientist because of all the work he did for which he got little or no credit, advanced the understanding of the greenhouse effect by actually measuring the absorption of radiation by carbon dioxide and water vapor. While Fourier understood that the greenhouse effect existed, it was Tyndall who showed the mechanism by which it occurred. Then at the very end of the 19th century, Svante Arrhenius, a Nobel prize winning chemist, actually spent years in his attic calculating the effects of increasing concentrations of CO_2. He was tickled to find that given the rate at which the world was burning coal, his cold homeland of Sweden would someday become a tropical paradise like Hawaii. But based on his calculations it would take 3000 years, and that was entirely too long as far as he was concerned.

After the work of giants like Fourier, Tyndall and Arrhenius, the conventional thinking from the scientific community by the twentieth century was that:

1. The greenhouse effect was real.
2. CO_2 was the main greenhouse gas.
3. Mankind was adding CO_2 through industrialization.
4. Anthropogenic CO_2 was too small to measure.

There were a few intellectually curious men and women who were not quite satisfied with item 4. One of those was Roger Revelle, a professor at Harvard and the Director of the Scripps Institute for Oceanography in San Diego. Revelle was "responsible to no one" as Deming might have said. He could work on anything he wanted. He could fund or get funding for just about any scientific research that interested him. But the thing that interested him most was finding out whether indeed CO_2 was building up in the Earth's atmosphere. So together with his colleague and young protégé Charles Keeling he set up an observatory at the Mauna Loa volcano in Hawaii, and began measuring carbon dioxide. This was in the mid-1950s. By 1958 they had their first results - and the findings were stunning, because not only was the difference in CO_2 measurable, but it was significantly above the natural level of carbon dioxide for the last 10,000 years. Their conclusion was that without knowing it, humanity was carrying out a large-scale geophysical experiment on the earth's atmosphere.

The story of the knowledge of the greenhouse effect is the story of scientists who pursued their own innate curiosity, responsible to no one. They used theory, and in proving their theories right or wrong, they advanced human knowledge. Anthropogenic climate change could very easily have gone undetected if not for the work of a few curious giants. That work continues today as the leaders of modern science try to gain further knowledge about the course of this "geophysical experiment" and advise policy makers on its implications.

Psychology

When looking at business systems, Deming understood the power of human psychology and human motivation in supporting the aim of the system. When competition and politics enter in, he warned, it leads to the destruction of the system.

Unfortunately, scientists have been put in the position of having to deal with the politics of climate change. In some instances, scientists have been directly intimidated by their own government. In 1998, the journal *Nature* published a report by Michael Mann, Raymond Bradley and Malcolm Hughes[7]. This report was based on a new methodology to combine data from a variety of sources to estimate temperatures in the Northern Hemisphere for the last 1000 years. It received wide attention and one of its graphs showed a simple figure of the Northern Hemisphere temperature and came to be known as the "hockey stick." This was given much attention and many took it as a "smoking gun" – hard evidence of climate change.

Senator James Inhoufe (at that time, chair of the Senate Environment and Public Works Committee) called Mann's work a hoax, and Congressman Joe Barton of Texas, Chairman of the House committee on Energy and Commerce, took it even further by requesting information from Mann and his co-authors NOT just about their data gathering for this report but also about their ENTIRE work history. Mann's report is only one of many rigorous peer-reviewed scientific studies that have found over the last decades that global warming is happening and that it is caused by human activities. But rather than looking to other peer-reviewed work on this subject, or scientific papers from leading scientific bodies like the National Academy of Sciences or the American Association for the Advancement of Science, Rep. Barton chose instead to begin a witch hunt. This did not go unnoticed in the scientific community.

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In a letter to Rep. Barton, Alan Leshner, the head of the American Association for Advancement of Science and publisher of the magazine *Science,* referred to this request as "a search for some basis on which to discredit these particular scientists and findings, rather than a search for understanding. " Continuing, he said "…we are concerned that establishing a practice of aggressive congressional inquiry into the complete professional histories of scientists whose findings may bear on policy in ways that some find unpalatable could have a chilling effect on the willingness of scientists to conduct work on policy-relevant scientific questions.[8]"

Mann wasn't the only scientist having a difficult time. Dr. James Hansen of NASA's Goddard Institute of Space Studies has spent most of the last thirty years researching global warming and speaking out. NASA's mission statement began with the words "to understand and protect our home planet." When asked why a NASA scientist was working on climate change, Hansen would always point directly to the mission statement – as if to say "I'm just doing my job." But in late 2005, he was told by a junior political appointee in the federal government to stop speaking publicly about climate change "or there may be consequences." Hansen was stunned, but he knew that he was just doing his job "to understand and protect our home planet" and would continue to do it. Two months later, in February of 2006, the NASA mission statement was changed and the words "to understand and protect our home planet" were dropped[9].

Deming understood the importance of psychology in any system that involved human beings. He knew the destructive power of fear in a system. We have been seeing the intimidation of science over the last seven years because of political pressure on what should be a pure search for answers and for truth. Deming presaged this when he stated in one of our classes that the natural inclination of scientists was "to get to the bottom without bias or agenda, and that the more political an issue became the more science suffered."

Profound Knowledge, Climate Change and Biomimicry

Industry and business need a framework to address climate change. With its appreciation of a system and respect for sources of new knowledge, profound knowledge points the way forward to a transformation of industrialization. Profound knowledge naturally leads to a process of aligning the industrial system with the aims of the ecosystem. This means looking to nature and then emulating it. A new field of science is emerging along these lines called biomimicry.

Pioneers of biomimicry are shaping the future by analyzing nature to understand its secrets and apply them to human industry. Some are studying the signaling power in proteins to speed up and cool down computers, while others are learning about super strong and super resilient materials from spiders. Some study how cells in leaves convert sunlight to fuel in thousandths of a nanosecond, while still others are discovering miracle drugs by observing what animals eat[10]. Biomimicry taps into the vast information that is embedded in our planet's biosphere, and, through theory, creates new knowledge for business, so that industrialization may operate as a genuine subsystem of the ecosystem, serving the aim of the ecosystem.

Yet our current industrialization does not look to nature for any guidance or answers. In fact, it is built on a resource-hungry path of least resistance. In one day, the industrialized world uses twenty-seven years of solar energy that has been stored in coal, oil and natural gas[11]. Nature, however, runs off solar income. The planet's ecosystem does not look for energy sources outside of the daily income that it gets from our sun.

Our industrialized system is based on a linear system, and a linear way of thinking; it is a system characterized by "take, make and waste". Material is removed from the earth's lithosphere, some of which is transformed into a product of inorganic and non-biodegradable matter of limited usable lifespan, while the remainder is wasted and dumped back into rivers, landfills or the atmosphere where it can not be reabsorbed for - in some cases - tens of thousands of years. In our industrialized system products have a beginning and an end; it is a "cradle-to-grave" model of industrialization. Yet this is imbedded in an ecosystem that is a "cradle-to-cradle" system, where waste equals food and output from one process is input to another. Everything left by one species or natural process is used by another and converted into something that is then used again by another. Species that dominate, that take everything for themselves and that foul their own nest - these species eventually die off, and do not make it to the next round of evolution. This is what four billion years of evolution has taught.

Stages of Ecosystems

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In Paul Hawken's book *The Ecology of Commerce*, he explains how ecosystems are characterized by three significant stages: pioneering systems, intermediate systems, and mature systems. Pioneering systems are characterized by aggressive, competitive, resource hungry behaviors pursuing untrammeled growth that are by their nature unsustainable. Only if a pioneering system evolves into an intermediate stage typified by increasingly complex organisms can it survive. Eventually if it makes it to becoming a mature system, it will be comprised of highly efficient processes that are resource-conserving, robust, self-sustaining and highly complex[12].

If the industrialization of tomorrow had the characteristics of a mature ecosystem, it would look like yesterday to some extent. The old Arthur Andersen was like a mature ecosystem – a highly complex organization with critical interdependencies that were understood and carefully managed. The old Arthur Anderson was efficient, robust, sustainable and complex, but it was not driven by growth. Eventually this changed, as interdependencies and complexities were sacrificed, and Arthur Andersen became more like a primary ecosystem devoted to growth at any cost, which made it vulnerable and ultimately unsustainable.

As industrialization mimics mature ecosystems, the result will be nothing short of revolutionary. The change will be characterized by renewable clean energy, closed loop recycling, zero waste, harmless emissions, efficient transport, sensitized people – in short: reinvented commerce. This way of doing business is very much in line with what profound knowledge would point us towards. And thankfully, examples of this type of industrialization are already in practice today.

Interface Corporation

Ray Anderson is the chairman and founder of Interface Corporation[13]. In 1994 he was asked by his sales staff about the company's position on the environment. The sales staff was headed to a conference where they knew they were going to be asked questions about Interface's environmental impact. So Anderson's reply was that Interface complied with the law – their environmental policy was that they followed orders. But for some reason this conversation got Anderson thinking. He started to study his company and learn about its environmental impact. Interface is one of largest industrial carpet makers in the world. Their business has historically been a highly petrochemical-intense and fossil fuel-intense business that also pollutes a lot of fresh water. After only a month of research into his company's environmental impact, Anderson was stunned. To make one ton of industrial carpet, Anderson found out that his company Interface threw away into landfills, into rivers and streams, and into the atmosphere thirty-three tons of waste. He concluded that although today he might be a hero to Wall Street, or to the 7000 people he employed, someday he would end up in jail for what he was doing to the ecosystem. At that point, he made a decision to undertake a revolution within his company. And the revolution he undertook is very similar to the type of change Deming advocates through profound knowledge – a complete transformation of the organization, involving every employee in the transformation, and aligning every process, every action, every initiative in service of the aim.

Anderson had an advantage that the CEO's of many public companies don't have. He was fortunate enough to have controlling interest of his company. So in some sense he could do whatever he wanted and was "responsible to no one." In fact he was responsible to the board, but he held a lot of sway. He approached his company as a system, and he redefined the aim of his company to work towards that aim. He involved all his employees, and gave them a sense of a higher purpose and esprit de corps. He involved his customers, and he said that the goodwill that came from his clients was nothing short of " astonishing." While some in his company were concerned that he had "gone around the bend," he remarked "That's the job of a leader - to go around the bend and see what's coming."

His first concrete step was to create the new aim for the company. The aim was to make Interface, firstly a sustainable, then a restorative enterprise. His first initiative was one called Ecosense: whose mission was to reduce, reuse, reclaim, recycle, and redesign -- and the entire organization was put to work in pursuit of that initiative. He pioneered the Evergreen lease, whereby customers never quite own the carpet they buy from Interface, but instead use it until it is no longer usable, and then Interface will be responsible for taking it back and making it into something usable again. This is what is known as "closed loop" recycling, and it is probably the most powerful idea today aligning industry to the ecosystem and addressing industrial waste. In the United States, local and municipal governments spend far too much of their budget getting rid of things like industrial carpet and other solid waste, when instead they should be spending that money on education, putting out fires, and security. Getting rid of solid waste should be the responsibility of the manufacturer, and that's the position of Interface, even though they are a huge manufacturer of solid waste. The idea of closed loop recycling also brings us closer to the natural way, and the

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idea that there is no waste, or that waste equals food. In this way worn-out Interface carpet can become the raw material (i.e. the food) for the next generation of carpet. With closed loop recycling, industry is actually providing itself with a new source of raw material that is a lot easier to work with, and a lot easier to procure, while encouraging new design techniques that consider a product's use and reuse in perpetuity.

Since 1994, Ray Anderson has done much, but he is only halfway to his goal of becoming a completely restorative enterprise by 2020. He still needs to find a recyclable nylon, to substitute carbohydrates for petroleum products, and to solve the transportation problem. But the results so far have been quite impressive. After 13 years of revolutionary change, use of fossil fuels is down 45%, use of water is down 67%, greenhouse gases are down 60%, contribution to landfills are down 80%. The hard cash savings for Interface since 1995 is $336 million. Revenues of Interface are up 49%, with increased profit margins. They have $1.1 billion in annual sales and represent 37% of the global market share.

I met Ray Anderson at a conference in Chicago in November of last year. When I asked him if he was familiar with Dr. Deming or his teachings, he first said that he was not a follower of Deming and that the implementations that he put forth in his company were of his own initiative. But then he began to speak about Deming, and talked about how Deming had powerful ideas that were ahead of their time, and that he wasn't listened to in his home country. Anderson appreciated Deming's systems approach to problem solving, and how his teachings had a message beyond serving the bottom line. The more he spoke about Deming, it seemed to me the more he began to see the application of Deming and his teachings to what Anderson himself had been doing at his company for the last thirteen years. Ray Anderson's actions and leadership are very closely aligned with Dr. Deming's teachings of understanding the system, understanding variation, understanding the power of new knowledge, understanding human motivation and ultimately involving the entire enterprise in pursuing a common purpose. This is exactly what Ray Anderson has done, and it was exactly Deming's purpose in articulating the framework he called profound knowledge.

Conclusion

Climate change has emerged as one of the greatest problems facing our world today. It is a problem which on the surface seems to be about a build up of greenhouse gases in the earth's atmosphere due to industrialization. Yet from another perspective, climate change is the symptom of a larger problem – a misalignment of systems. The world economic system, powered by fossil fuels, is fundamentally out of alignment with the earth's ecosystem. This urgent "systems" problem requires U.S. leadership. Unfortunately American management is being asked to address a problem with long-term consequences and ill-quantifiable complexities, when it usually emphasizes short-term results that are easily measurable.

W. Edwards Deming has shown American management the way out of crisis before, and through his system of profound knowledge he can guide us out of the crisis that is climate change. Profound knowledge provides a framework that focuses on four essential aspects of industrialization to address the fundamental causes of climate change – (1) viewing business from a systems perspective, (2) understanding variation, (3) the importance of new knowledge, and (4) an appreciation of human psychology. The business leader of today needs to be thinking of her enterprise as a system inextricably linked to and dependent upon the ecosystem. Climate change has made that link undeniable. Deming's profound knowledge not only helps management recognize that link and but also points directly to solutions such as clean renewable energy, closed loop recycling and biomimicry.

Footnotes

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[12] "*Ecological succession* must be mirrored by *economic succession* …business doesn't need criticism, it needs a plan" – Paul Hawken, Ibid
[13] Anderson, Ray, *Mid-Course Correction*

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