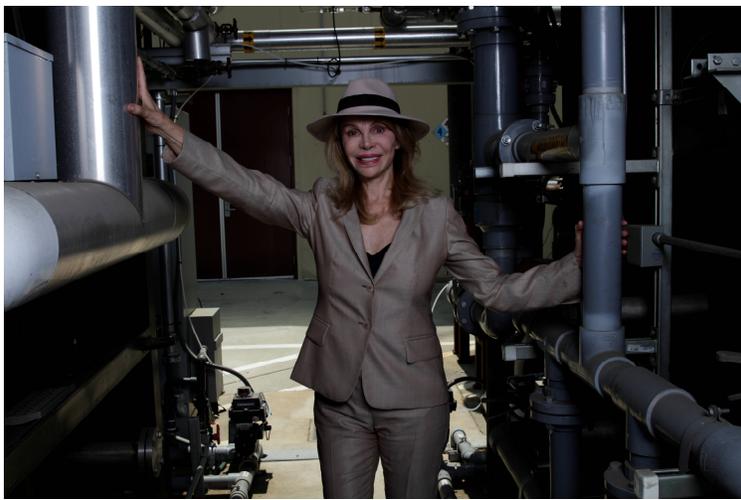


Reversing Climate Change: Interview with Graciela Chichilnisky

Marcus Rolle – September 1st 2016



Has humanity reached an irreversible stage with regard to climate change? If not, can we halt the phenomenon of global warming from fulfilling a catastrophic scenario which will cause inestimable damage to the global economy, destroy entire cities and island states, cause mass human migration waves that will disrupt irreversibly the fabric of Western civilization and even threaten with extinction the human species? World renowned economist Graciela Chichilnisky, author of the Carbon Market of the Kyoto Protocol and creator of the formal theory of Sustainable Development, thinks there is a way out of the

climate change conundrum but it requires adopting both a long-run and a short-run strategy as well as changing our overall attitudes towards the Earth's resources and producing new economic values. In the exclusive interview that follows for Global Policy Journal, Professor Chichilnisky shared her views about how to reverse climate change, which is the subject of her latest and forthcoming book. She is also the author, among many other books and scores of academic articles, of Saving Kyoto: An Insider's Guide to the Kyoto Protocol.

Marcus Rolle: Professor Chichilnisky, your latest and soon to appear book titled Reversing Climate Change: Carbon Negative Technologies and the Carbon Market (World Scientific, 2016) deals with new technologies and the carbon market. First, I'd like to start by asking you a basic question: namely, how much of climate change is caused by human activity and how exactly our economic activities are impacting planet Earth?

Graciela Chichilnisky: We need to understand and come to terms with the fact that, for the first time in history, humans are dominating completely planet Earth. We are changing the basic metabolism of the planet: the composition of gases in the atmosphere, its bodies of water, and the complex web of species that makes life on Earth. The result of this is disruptions in climate and global warming. Both the North and the South Poles are melting. Water expands when it is heated. Since the seas are warming, sea level is rising all over the world. This irrevocable upward trend is well documented: slowly but surely the rising waters will sink most island states. There are 43 island states in the United Nations representing about 23% of the global vote and most or all could disappear soon under the warming seas. In addition, the current shift in climate patterns threatens many species. It has allowed for the spread of insects that are migrating to areas they did not previously inhabit, bringing with them a variety of vector-borne illnesses. For example, new outbreaks of malaria in Africa are on the rise. Humans are also shifting ground. The UN reports that 21 million people are reportedly migrating due to drought and other climate change induced conditions, and the numbers are increasing rapidly. The 2014 migration of one million people into the EU is causing considerable political stress leading to anti-immigration candidates in German, UK, and US elections, and Brexit, and some anticipate that it could damage the fabric of Western democracy.

In the U.S., the consequences are less extreme but still evident: the mighty Colorado River is drying up, prompting orders to turn off farm water in several states. Lake Mead's waters in Nevada are exhibiting record lows, threatening the main supply of water to Las Vegas. Wild fires from drought conditions have multiplied and have spread rapidly around the region and in California since 2006.

MR: While what you have described seem to be irrevocable facts, has the connection between climate change and fossil energy entered fully the world's consciousness?

GC: The world is clearly aware of the connection that scientists postulate between climate change and the use of fossil energy. The largest segment of carbon emissions, about 45% of the global emissions of CO₂, originate in the world's power plant infrastructure, 87% of which are fossil fuel plants that produce the overwhelming majority of the world's electricity. This power plant infrastructure represents a value worth \$45-55 trillion according to the International Energy Agency (IEA), which is about the scope of the world's economic output. Moreover, new forms of clean energy are emerging, such as wind farms in Scotland and solar farms in Spain and the US, in an attempt to forestall carbon emissions. But the process is necessarily slow since the world's fossil power plant infrastructure is comparable in monetary value to the world's entire GDP, and changing this infrastructure can take decades. Transforming the power plant infrastructure is too slow to avert the potential catastrophes that are anticipated in the next 10-20 years.

MR: Before I ask you about a solution to the climate change threat, aren't there other environmental crises facing us today?

GC: Climate change is indeed just one of several global environmental areas that are in crisis today. Biodiversity is another; industrialization and climate warming threaten the world's ecosystems. Endangered species include sea-mammals, birds such as cockatoos, polar bears, and marine life such as coral, saw-fish, whales, sharks, dogfish, sea turtles, skates, grouper, seals, rays, bass, elephants, and even primates, our cousins in evolution. Scientists know that we are in the midst of the sixth largest extinction of biodiversity in the history of our planet, and that the scope of extinction is so large that 75% of all known species are at risk today. The UN Millennium Report documents rates of extinction at 1,000 times higher than fossil records. The current extinction event is the largest following the dinosaurs' extinction that took place 60 to 65 million years ago. But today's extinction event is unique in that it is caused by human activity. And it puts our own species at risk. There is a warning signal worth bringing up: all major recorded planetary extinctions were related to changes in climate conditions. Through industrialization we have created environmental conditions that could threaten our own species' survival. 99.9% of all species that ever existed are now extinct. Are we next? Will humans survive? These are the critical questions facing us and the issue is none other than how to avoid extinction.

MR: In your forthcoming book, where I had the privilege to have seen some of the chapters you have worked on, you discuss the need for humans to develop survival skills based on altruism. Can you elaborate on this fascinating theme?

GC: It has become quite clear to me that if we are to avoid extinction, we have to develop survival skills for a changing environment. This seems reasonable and natural; yet the social skills that are needed are not here and are not obvious either. These skills could be quite different from what human societies have achieved, such as the individual survival skills that we are familiar with. A simple but somewhat unexpected experimental finding involves colonies of bacteria, which are one of the world's oldest living species. They have been around for billions of years and have shaped the planet's geology and atmosphere to suit their needs. Bacteria are champions of survival. They needed appropriate survival skills, and developed unexpected skills based on what can be described as "altruism." Since bacteria are some of the oldest species on the planet, much older than relatively recent humanoids, we need to take their skills seriously as a model of survival. Bacterial colonies know how to avoid extinction. Here is new data: findings indicate that *Escherichia Coli*, and indeed most known bacteria colonies, when exposed to a pathogen or stressor such as antibiotics not only mutate and evolve to develop resistance but the evolved members produce specific resistance tools that they do not need in order to share with the rest of the (non-evolved) members of the colony. In other words -- when exposed to stress, mutant bacteria use some of their own energy -- altruistically -- to create a chemical called "indole" that protects non-mutants from the pathogen. This way the entire group survives. A way to

summarize this finding is to say that altruism is an effective survival tool and bacteria -- those champions of survival -- have developed and mastered altruism for this task.

This finding is quite different from what we believe to be effective survival skills in human colonies or societies. Until now human survival skills have focused on avoiding natural risks and confronting successfully the threats posed by other species that preyed on us, species that are dangerous to us. Altruism has been considered to a certain extent to be a weakness in human societies; it is considered to be a desirable ethical trait rather than a survival skill. Yet, it is a survival skill. Aggressive and individualistic behavior may have been a useful survival tool until now. The war society that humans have created has become an efficient killing machine. But when things change, as they are changing right now, strengths can turn into weaknesses. And things have fundamentally changed and they continue to evolve quickly. Indeed, physical strength and aggression matter much less today for human survival than does intelligence. Some of the worst risks we face today are caused not by other species that prey on us, but by traits that evolved to succeed against our predators -- for example, extracting energy and burning fossil fuels in order to dominate nature and other species. In other words, we are now at risk due to the impact of human dominance on the planet. Our success as a species has become the source of our main risks. Humans are causing some of the worst risks that we are facing. The situation is somewhat unusual and is new for our species, and it is also new for the planet itself. As the situation changes, the rules we used to follow for survival must change too.

MR: Of course, this is not how we understand survival today. Isn't it true?

GC: True. In our culture, the essence of survival is viewed differently. It is generally viewed as the ability to conquer, dominate, and kill. Research shows that men tend to think of life skills as those skills that allow them to win the battle for survival. War is an example. Surveys asking men what characterizes life find that they are likely to say "the survival of the fittest" or "dog eat dog." This may be because of the evolutionary role that males originally had in human societies, a role that is somewhat outdated. The reality is that humans could not live -- and indeed could not be part of the chain of life -- if they did not have the nurturing skills needed to reproduce. Women understand that reproduction requires altruism. Women donate their physical substance such as eggs, blood, and milk, and they do so voluntarily for the sake of reproduction. This is what reproduction is all about: the most voluntary donation of one's substance. Most living beings, animals and plants, do the same. They donate their substance voluntarily to the next generation, sometimes at the cost of their own welfare and even their own lives. Observe that voluntarily donating one's own substance, one's flesh and body fluids, is the very essence of altruism. This altruistic donation is the key to the survival of the species.

MR: Can you talk a bit more about women and survival?

GC: Women understand altruism because their evolutionary role is to protect the weakest of all: children at birth. Women are of course critical to human survival: they are the key to reproduction and they voluntarily provide their substance and energy to give birth and protect babies for the survival of the human species. Men miss this important aspect of survival because their evolutionary roles appear to value physical strength more than anything else. However, this is a role that seems increasingly out of date. In this context, it is fitting to raise the issue of "avoiding extinction" within a male-dominated world and a culture that is focused on violence, economic competition, and wars. We need to assure a changing role for women so the entire ethos of destruction and dominance that permeates our society is balanced out by a modicum of altruism. Nurturing and protecting the weakest is critical and necessary if we are to avoid extinction.

It is true that there have been changes in the role of women, most of all their rapid entrance into the market for labor in industrial societies. But this change has not been fast enough. Modern societies, such as the U.S., still witness abuse of women at home and elsewhere, both physically and economically. For example, the U.S. has a 30% gender difference in salaries, which seems not to be narrowing. These are the salaries that are paid to men and women even when comparing men and women with equal training, age, and experience. The gender inequality is prevailing, persistent, and systematic. In any given society, there is a statistical correlation between the amount of housework a woman does at home and the difference between male and female salaries in the economy as a whole. These two different statistics -- two indices of abuse -- are seemingly unrelated, but they are indeed related, because when women are overworked and underpaid at home this leads them to be overworked and underpaid in the marketplace, an issue I have analyzed in some of my writings. Gender inequality in salaries is in reality legally sanctioned. Research shows that men are admired for traits that prevail in negotiating salaries, while the same traits are considered too aggressive for females. Indeed, the

U.S. still does not have an Equal Pay Act. Unequal pay for women and men is still legal in the U.S.A.

Is there a reason to pay women less than men? If so, what is it?

The persistent unequal situation is based on a rationale of "genetic inferiority" of women. Even a former president of the oldest University in the U.S., Harvard University, Larry Summers, presented this suspicion in public as a plausible hypothesis to explain the persistent >30% difference in salaries between women and men in our economy. Furthermore, when he was subsequently voted out by Harvard University faculty, he went on to become an economic advisor of President Barack Obama. One wonders whether Mr. Summers would have been selected as an economic advisor of the president of the U.S. -- the first black U.S. president -- if he had presented in public his suspicions about the genetic inferiority of blacks, rather than the genetic inferiority of women. I venture to say he would not have been selected by President Barack Obama if he had said in public that blacks are genetically inferior. But saying this about women is acceptable, and he went through and indeed was rewarded by President Obama with the economic advisory role. This was a discouraging event for many, but not for the men who secretly or openly believe that women are indeed genetically inferior to men. One cannot but draw a somewhat distant but illustrative connection between this situation and the excuses that the Nazis used to explain the most savage Holocaust in memory, namely, they explained Nazism as based on the supposed genetic inferiority of Jews. This illustrates the implications of claiming the genetic inferiority of some groups in our society.

Publicly declaring the genetic inferiority of women to explain their economic exploitation is not an innocent remark even if the genetic inferiority is about performance in the sciences. It is a way to justify a systematic way in which male-dominated societies perpetrate economic and cultural abuse, violence and brutality against women, pornography, torture of women, and rape that represents a form of social control and intimidation. Ultimately it is a deep social rejection of altruism, protection of the weak and the essential reproductive role that women bring to society, which is a necessary precondition for the survival of the human species. Our society's manifested hate and violence against women is critically connected with the self-destructive aspects of our society and the problem of avoiding extinction that we face now.

MR: What is the link between addressing the problem of climate change and extinction and Sustainable Development?

GC: Reversing climate change and avoiding extinction is the ultimate goal of Sustainable Development. While we are still climbing up from the depths of a global financial crisis that started its deadliest stages in 2008, the world knows that the game is not over. Judging by the threats from the Eurozone, including Brexit, it could all re-start next year. For the first time in history, the U.S. was downgraded to a debtor nation a few years ago, and the shocks to its financial markets underscore these points. At the same time, within a larger historical context, the financial crisis takes second place. We have seen such a crisis before. What we have never seen before is the global threat to human survival that is developing in front of our own eyes. We are in the midst of a global environmental crisis that started in a small way with the dawn of industrialization and accelerated with the onset of globalization, ever since the Bretton Woods Institutions were created after WWII to provide a global financial infrastructure for spreading the role of markets and industrialization across the world economy. In both cases, financial mechanisms are at work. The global financial crisis and the environmental crisis are essentially two aspects of the same problem. Also consider the fact that fundamental causes of extinction such as overfishing, pollution, and climate change are attributable to the industrialized world who consumes the majority of the marine life used as seafood, 80% of which is believed to be discarded after removing it from the ocean, who generates over 60% of the global emissions of carbon dioxide and who uses 70% of the world's energy, all this while housing only 20% of the world's population. Industrialization is at work, contributing to the impending destruction and mass extinction in the earth's seas.

The complexity of the problem is baffling scientists. The Earth self-regulates its atmosphere, but right now we are tying the Earth's hands in self-regulating itself. There is no quick fix. A standard way that the planet uses to regulate carbon, for example, is to sequester carbon from the atmosphere in its mass of vegetation, which breathes CO₂ and emits oxygen. Animals, such as humans, do exactly the opposite. Animals breathe oxygen and emit CO₂. In balance, the two sets of realms -- flora and fauna -- maintain a stable mix of CO₂ and oxygen in the atmosphere. Since CO₂ in the atmosphere regulates its temperature, this cycle maintains a stable climate. But the enormous use of energy by industrial societies is tipping the scales, and our widespread destruction of the mass of vegetation prevents the planet from adjusting.

Again, note that it is not the developing nations with 80% of the world's population that are causing this problem. This is because over 70% of the energy used in the world today is used by 20% of the world

population that lives in industrial nations, who emit 60% of the CO₂. These are the same industrial nations that created the Bretton Woods Institutions in 1945 and have consumed an overwhelming amount of the Earth's resources since then. Financial markets are the core of industrial societies and are operating globally. One can say that the financial crisis and the environmental crisis are two sides of the same coin. They are at the foundation of the current model of economic growth in industrial nations and of its voracious use of the Earth's resources. Indeed, one can pinpoint precisely which part of our economic model destroys the environment and creates financial crisis: it is the practice of "discounting the future" which was introduced by the famous economist Tjalling Koopmans, who gave it the name of "impatience" in financial markets. It is also called "short termism" and can lead to Ponzi schemes. When "discounting the future" comes into play in environmental and natural resource issues, we ignore the future needs of the planet and our species. Sustainable development requires an equal treatment of the present and the future, an axiom that I introduced when I defined the formal theory of sustainable development. In a nutshell: both the world's financial crisis and the global environmental crisis stem from a flawed financial mindset and both require a new model of economic growth that is characterized by sustainable development.

MR: So, what is the solution? What exactly needs to be done?

GC: The task in front of us is nothing less than building a human future. In the midst of the sixth largest extinction on planet Earth, we face potentially catastrophic climate change and extinction of life on land and in the world's seas, the basis of Life on Earth. It seems fair to say that there is a global emergency. We have come so close to the brink with the current economic perspectives that it appears right now that only a new, more innovative generation can help. As Albert Einstein said: "the mindset that created the problem is not the mindset that will find a solution."

A green future is about sharing the wealth and saving the planet. Is this an impossible mandate? We need to stave off biodiversity extinction and reduce carbon emissions, while rebuilding the world economy and supporting the needs of developing nations. Is this possible?

It is. To understand the solutions, we need to look closer at the root of the problem so we can change it. The Bretton Woods global financial institutions, which were created after WWII, mandated and supported rapid expansion of international markets. They succeeded beyond anybody's expectations. International trade expanded during this period three times faster than the world economy as a whole: this is what globalization is all about. Industrialization is resource intensive. It was fueled in this period by cheap resources exported from developing nations, threatening their forests, minerals, and biodiversity.

Resources were and continue to be exported at very low prices. As a result, poverty grew in resource-exporting regions and provided "competitive advantage" in the form of cheap labor and cheap resources that exacerbated and amplified resource over-consumption in the industrial North. Resources were over-extracted in poor nations desperate for export revenues, and were over-consumed in industrial nations. Globalization after WWII increased together with an increasing global divide between the rich and the poor nations, the North and the South. This is how the global financial system that was created by the Bretton Woods Institutions in 1945 is tied up with the financial crisis of the day, and how it is also tied up with the global environmental crisis we currently face. And this is how the global financial institutions caused an enormous global divide between the North and the South.

Energy is at the center because its use goes hand-in-hand with economic progress, and most of the energy used in the world today is fossil (87%). GDP growth is closely tied with carbon emissions today. Industrial nations consume about 70% of the world's energy. The North-South divide is therefore inexorably connected to the carbon emissions that are undermining the stability of the global climate. The North-South divide has been a stumbling block in every United Nations negotiation on climate issues, for example in the 2009 Copenhagen Convention of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) (COP15) and then in 2010 in Cancun Mexico COP16. The same issue surfaced in the Paris COP21 in December 2015. The problem is: who should use the world's resources: the rich or the poor? Or, otherwise put, who should abate carbon emissions?

It can be said that we are reliving last century's Cold War conflict, but this time as a conflict between China and the U.S.A. Each party could destroy the world as they are the largest emitters and alone can change the world's climate. Each wants the other to reduce carbon emissions (to "disarm") first. But this time the conflict is between the rich nations represented by the US and the poor nations represented by China. The solution requires that we overcome the North-South Divide, and the use and trade of the world's resources between the rich and the poor nations. One could say that global justice and the environment are two sides of the same

coin. Poverty is caused by cheap resources in a world where developing nations are the main sellers of natural resources into the international market, resources which are over-consumed by the rich nations and lead to environmental havoc. Perverse economic dynamics are destroying the stability of the atmosphere, undermining climate patterns and causing the sixth largest extinction in the history of the planet. How long will it take until this situation reaches its logical limits and victimizes our own species? How to avoid extinction?

The Gordian knot that we must sever is the link between natural resources, fossil energy, and economic progress. Only clean energy can achieve this. But this requires changing a \$45-55 trillion power plant infrastructure, the power plants that produce electrical power around the world because 87% of world's energy is driven by fossil fuels and power plants produce about 45% of the global carbon emissions.

MR: How do we make a transition to renewable energy?

Energy is the mother of all markets. Everything is made with energy: our food, our homes and our cars, the toothpaste and the roads we use, the clothes we wear, the heating of our homes and offices, our medicines: everything. Changing the cost of energy, making dirty energy more expensive and undesirable and making clean energy more profitable and desirable, changes everything. It makes the transition to clean energy possible. We have the technologies, we just have to get the prices right. Is it possible to thus change the price of energy?

Yes, it is. In fact it has already been done, although it requires more input at present to continue this process, as is discussed below.

Here is the background and a summary of the current situation. In 1997, the Carbon Market of the United Nations Kyoto Protocol was signed by 160 nations. In it, and after a long period of lobbying and designing the carbon market, I was able to write the structure of the carbon market became international law in 2005, when the protocol was ratified by nations representing 55% of the world's emissions. The KP and its carbon market were adopted as law by 195 nations. The U.S. is excluded. The carbon market helped change the value of all goods and services in the world economy because it changes the cost of energy the world over: it makes clean energy more profitable and desirable and dirty energy unprofitable. This changes the prices of all products and services in the world, since everything is made with energy, and drives the economy to use cleaner rather than dirty energy sources. It is more profitable and less costly to use clean energy that reduces emissions of carbon now; this is precisely the role of the carbon market in the United Nations Kyoto Protocol in Kyoto, December 1997.

The carbon market started trading carbon credits at the EU Emissions Trading System (EU ETS) in 2005 since it became international law. The World Bank reported on its progress in its report "Status and Trends of the Carbon Market" which was published annually since 2005. The carbon market requires support for the carbon emission limits to continue working. Sadly enough, the Paris Agreement supported no carbon emission limits — none at all — which is what is needed to avert catastrophic climate change. The World Bank documents that by 2010–2011 the EU ETS was trading about \$175Bn billion/year, and succeeded in decreasing the equivalent of over 20% of EU's emissions of carbon. Through the carbon market, those nations who over-emit compensate those who under-emit, and throughout the entire process the world's emissions remains always under a fixed total emissions limit. These limits are for Annex I nations, and they are documented nation by nation in the Appendix to the Kyoto Protocol. Annex 1 nations are essentially OECD nations. A "carbon price" emerges from trading "carbon credits" or rights to emit, which represent the monetary value of the damage caused by each ton of CO₂. The carbon market therefore introduces a "carbon price" that corrects the negative impact that the emissions of CO₂ have on climate, which has been called "the biggest externality in the history of humankind" according to Nicholas Stern.

The carbon market cuts the Gordian knot and makes change possible. It does so because it makes clean energy more profitable and dirty energy less profitable, and therefore encourages economic growth without environmental destruction: it fosters green development. The carbon market itself costs nothing to run, and requires no subsidies except for minimal logistics costs. In net terms, the world economy is exactly in the same position before and after the carbon market: there are no additional costs from running the carbon market, nor are there from its extremely important global services. The over-emitter nations are worse off, since they have to pay. But every payment they make goes to an under-emitter, so some nations pay and some receive. In net terms the world economy is exactly in the same position before and after the carbon market is introduced. There are no costs to the world economy from introducing a carbon market, nor are there from the limits on carbon emissions and environmental improvement that it produces. It is all gain.

As of 2010, the carbon market had been ratified by 195 nations, and this included all the industrial nations

except the U.S. It is an international law since 2005. Its nation-by-nation carbon limits expired originally in 2012 and were extended to 2015 and in a second period to 2020. But the KP itself — its overall structure and the structure of the carbon market do not expire: they are and continue to be an international law. All we have to do to keep the carbon market's benefits is to define new emissions limits nation by nation for the OECD nations, something that we should be doing in any case as they are major emitters and without limiting their emissions there is no solution to the global climate issue.

MR: What's the situation like with the carbon market in the U.S., which is the only advanced nation- that has not yet verified the Kyoto Protocol?

GC: There are cross currents in U.S., since it is a politically divided nation. But the U.S. has already a carbon market for 10 Northeastern U.S. States, called Regional Greenhouse Gas Initiative (RGGI), which is operating, but timidly: the limits on emissions are small and so are the prices for carbon credits therefore. The economic incentives of KP's carbon market are enormous. China, for example, created a reported one million new jobs and became the world's main exporter of clean technology, wind and solar equipment, since 2005 after signing on and ratifying the KP in 2005 and benefiting from about \$75Bn from its carbon market's Clean Development Mechanism (CDM). China has introduced its own national carbon markets: however useful they may be, national or regional markets do not have the same status nor positive effect in controlling climate change as the global carbon market does, because they are not based on global emissions reductions. Reducing global emissions of CO₂ is required in order to avert catastrophic climate change.

Many in the U.S. want part of the UN carbon market advantages. President Obama said he wished to ratify the KP, and by now 22 States are planning to create a Carbon Market of their own, including California, which already has a carbon market in operation. Hundreds of cities and towns support the carbon market in the U.S. In the Fall 2007, the U.S. Supreme Court agreed that Federal government and the Environmental Protection Agency (EPA) could enforce carbon emissions limits without requiring Congressional approval. Every effort to deem this regulation illegal by Republican representatives has failed so far. It is generally accepted that global businesses (for example, the automobile industry) would benefit from KP's guidelines, and could suffer economic losses without the benefit of KP's economic incentives at home. This is because the automobile industry is global, and cars that do not sell in other OECD nations create huge losses. Since all OECD nations are buying carbon-efficient cars, because they ratified the KP, the U.S. car industry could be commercially isolated. In part for these reasons, in 2010 the EPA imposed automobile emission limits of 36.7 m per gallon, an efficiency requirement that has been increased further by the Obama administration in 2011 and since then. The automobile industry voluntarily supported a rise to 54 MPH in 2011. Furthermore, in December 2011, EPA announced that it would impose limits on stationery sources like power plants, which is the beginning of a U.S. carbon market, and the breakthrough Clean Power Act (COA) imposed 30% reductions on power plants, a law created by President Obama and the EPA in 2014-15. Several states are contesting this law and in 2016, in an unprecedented move, the US Supreme Court froze its implementation pending the states' decisions. The issue is still hotly contested by the Republican Party, which typically freezes decision making since the U.S. is in a presidential election year.

MR: You place faith in Green Markets. How will they impact on capitalism in the 21st Century?

GC: A shining example of a green market was just discussed: it is the Kyoto Protocol Carbon Market, which became international law in 2005. By 2011 the EU ETS was trading \$175Bn annually and had transferred about \$130Bn in total to developing nations for clean technology private projects that promote sustainable development. Most importantly it succeeded in its mission as it decreased over 20% of the EU emissions since becoming a law in 2005. This happened while all other nations outside the Kyoto Protocol, such as the U.S., increased their emissions. Another successful example of a green market is the SO₂ Market in CBOT that was created about 20 years ago, as mentioned above. This market is quite different from the carbon market because SO₂ concentration is not a "global commons," because it varies city by city while CO₂ is the same uniformly all over the planet. This changes fundamentally the structure and functioning of the market. There are more green markets in the works. Today the UN is exploring markets mechanisms for biodiversity and for watersheds. As in the case of the KP carbon market, these are markets that would trade rights to use the global commons — the world's atmosphere, its bodies of water, its biodiversity — and therefore have a deep built-in link between efficiency and equity. In the carbon market of the KP, by design, the poor nations are preferentially treated, having in practical terms more access and more user rights to the global commons (in

that case the planet's atmosphere). This is not the case with SO₂ which is a simple "cap and trade" approach as SO₂ is not a public good, as was mentioned above.

Efficiency with equity is what green markets are all about. They are really two sides of the coin: One is equity and the other is efficiency. Both matter. The carbon market provides efficiency with equity. How? Through its CDM the KP provides a link between rich and poor nations, indeed the only such link within the Kyoto Protocol, since poor nations do not have emissions limits under the Kyoto Protocol and therefore cannot trade in the carbon market. Nevertheless developing nations have strong incentives for emission reductions through the Clean Development Mechanism (CDM) of the carbon market — how does this work?

The CDM works as follows. Private clean technology projects in the soil of a developing nation — for example in China, Brazil or India — that are proven to decrease the emissions of carbon from this nation below a "UN agreed baseline," are awarded "carbon credits" for the amount of carbon that is reduced. These "carbon credits" are themselves tradable for cash in the carbon market, in recognition for the amount of carbon avoided in those projects. The carbon credits are a monetary compensation for clean technologies, and therefore shift prices in favor of clean technologies as the carbon market does. By law, the CDM carbon credits can be traded for cash within the carbon market. This is the role of the carbon market in the CDM. This is how the CDM has provided about \$130Bn in funding to developing nations since 2005.

MR: In your forthcoming book you talk of organizing principles for Green Capitalism. What are they?

GC: Green capitalism is a new economic system that values the natural resources on which human survival depends. It fosters a harmonious relationship with our planet, its resources and the many species it harbors. It is a new type of market economics that addresses both equity and efficiency. Using carbon negative technology™ it helps reduce carbon in the atmosphere while fostering economic development in rich and developing nations, for example in the U.S., EU, China and India. How does this work?

In a nutshell Green Capitalism requires the creation of global limits or property rights nation by nation for the use of the atmosphere, the bodies of water and the planet's biodiversity, and the creation of new markets to trade these rights from which new economic values and a new concept of economic progress emerges updating GDP as is now generally agreed is needed.

Green Capitalism is needed now to help avert climate change and achieve the goals of the 2015 UN Paris Agreement, which are very ambitious and universally supported but have no way to be realized within the Agreement itself. The Carbon Market and its CDM play critical roles in the foundation of Green Capitalism, creating values to redefine GDP. These are needed to remain within the world's "CO₂ budget" and avoid catastrophic climate change.

As I see it, the building blocks for Green Capitalism are then as follows;

- (1) Global limits nation by nation in the use of the planet's atmosphere, its water bodies and biodiversity - these are global public goods.
- (2) New global markets to trade these limits, based on equity and efficiency. These markets are relatives of the Carbon Market and the SO₂ market. The new market create new measures of economic values and update the concept of GDP.
- (3) Efficient use of Carbon Negative Technologies to avert catastrophic climate change by providing a smooth transition to clean energy and ensuring economic prosperity in rich and poor nations.

These building blocks have immediate practical implications in reversing climate change and can assist the ambitious aims of Paris COP21 become a reality.

MR: What is the greatest advantage of the new generation technologies that can capture CO₂ from the air?

GC: These technologies build carbon negative power plants, such as Global Thermostat, that clean the atmosphere of CO₂ while producing electricity. Global Thermostat is a firm that is commercializing a technology that takes CO₂ out of air and uses mostly low cost residual heat rather than electricity to drive the capture process, making the entire process of capturing CO₂ from the atmosphere very inexpensive. There is enough residual heat in a coal power plant that it can be used to capture twice as much CO₂ as the plant emits, thus transforming the power plant into a "carbon sink." For example, a 400 MW coal plant that emits 1 million tons of CO₂ per year can become a carbon sink absorbing a net amount of 1 million tons of CO₂ instead. Carbon capture from air can be done anywhere and at any time, and so inexpensively that the CO₂ can be sold for industrial or commercial uses such as plastics, food and beverages, greenhouses, bio-fertilizers, building materials and even enhanced oil recovery, all examples of large global markets and profitable opportunities.

Carbon capture is powered mostly by low (85°C) residual heat that is inexpensive, and any source will do. In particular, renewable (solar) technology can power the process of carbon capture. This can help advance solar technology and make it more cost-efficient. This means more energy, more jobs, and it also means economic growth in developing nations, all of this while cleaning the CO₂ in the atmosphere. Carbon negative technologies can literally transform the world economy.

MR: One final question. You distinguish between long-run and short-run strategies in the effort to reverse climate change. Would carbon negative technologies be part of a short-run strategy?

GC: Long-run strategies are quite different from strategies for the short-run. Often long-run strategies do not work in the short run and different policies and economic incentives are needed.

In the long run the best climate change policy is to replace fossil fuel sources of energy that by themselves cause 45% of the global emissions, and to plant trees to restore if possible the natural sources and sinks of CO₂. But the fossil fuel power plant infrastructure is about 87% of the power plant infrastructure and about \$45-55 trillion globally. This infrastructure cannot be replaced quickly, certainly not in the short time period in which we need to take action to avert catastrophic climate change. The issue is that CO₂ once emitted remains hundreds of years in the atmosphere and we have emitted so much that unless we actually remove the CO₂ that is already there, we cannot remain long within the carbon budget, which is the concentration of CO₂ beyond which we fear catastrophic climate change. In the short run, therefore, we face significant time pressure. The IPCC indicates in its 2014 5th Assessment Report that we must actually remove the carbon that is already in the atmosphere and do so in massive quantities, this century (p. 191 of 5th Assessment Report). This is what I called a carbon negative approach, which works for the short run. Renewable energy is the long run solution.

Renewable energy is too slow for a short run resolution since replacing a \$45-55 trillion power plant infrastructure with renewable plants could take decades. We need action sooner than that. For the short run we need carbon negative technologies that capture more carbon than what is emitted. Trees do that and they must be conserved to help preserve biodiversity. Biochar does that. But trees and other natural sinks are too slow for what we need today. Therefore, negative carbon is needed now as part of a blueprint for transformation. It must be part of the blueprint for Sustainable Development and its short term manifestation that I call Green Capitalism, while in the long run renewable sources of energy suffice, including Wind, Biofuels, Nuclear, Geothermal, and Hydroelectric energy. These are in limited supply and cannot replace fossil fuels. Global energy today is roughly divided as follows: 87% is fossil, namely natural gas, coal, oil; 10% is nuclear, geothermal, and hydroelectric, and less than 1% is solar power — photovoltaic and solar thermal. Nuclear fuel is scarce and nuclear technology is generally considered dangerous as tragically experienced by the Fukushima Daichi nuclear disaster in Japan, and it seems unrealistic to seek a solution in the nuclear direction. Only solar energy can be a long term solution: Less than 1% of the solar energy we receive on earth can be transformed into 10 times the fossil fuel energy used in the world today.

Yet we need a short-term strategy that accelerates long run renewable energy, or we will defeat long-term goals. In the short term as the IPCC validates, we need carbon negative technology, carbon removals. The short run is the next 20 or 30 years. There is no time in this period of time to transform the entire fossil infrastructure — it costs \$45-55 trillion (IEA) to replace and it is slow to build. We need to directly reduce carbon in the atmosphere now. We cannot use traditional methods to remove CO₂ from smokestacks (called often Carbon Capture and Sequestration, CSS) because they are not carbon negative as is required. CSS works but does not suffice because it only captures what power plants currently emit. Any level of emissions adds to the stable and high concentration we have today and CO₂ remains in the atmosphere for years. We need to remove the CO₂ that is already in the atmosphere, namely air capture of CO₂ also called carbon removals. The solution is to combine air capture of CO₂ with storage of CO₂ into stable materials such as biochar, cement, polymers, and carbon fibers that replace a number of other construction materials such as metals. The most recent BMW automobile model uses only carbon fibers rather than metals. It is also possible to combine CO₂ to produce renewable gasoline, namely gasoline produced from air and water. CO₂ can be separated from air and hydrogen separated from water, and their combination is a well-known industrial process to produce gasoline. Is this therefore too expensive? There are new technologies using algae that make synthetic fuel commercially feasible at competitive rates.

Other policies would involve combining air capture with solar thermal electricity using the residual solar thermal heat to drive the carbon capture process. This can make a solar plant more productive and efficient so it can out-compete coal as a source of energy.

In summary, the blueprint offered here is a private/public approach, based on new industrial technology and financial markets, self-funded and using profitable greenmarkets, with securities that utilize carbon credits as the “underlying” asset, based on the KP CDM, as well as new markets for biodiversity and water providing abundant clean energy to stave off impending and actual energy crisis in developing nations, fostering mutually beneficial cooperation for industrial and developing nations. The blueprint proposed provides the two sides of the coin, equity and efficiency, and can assign a critical role for women as stewards for human survival and sustainable development.

My vision is a carbon negative economy that represents green capitalism in resolving the Global Climate negotiations and the North–South Divide. Carbon negative power plants and capture of CO₂ from air and ensure a clean atmosphere together innovation and more jobs and exports: the more you produce and create jobs the cleaner becomes the atmosphere.

In practice, Green Capitalism means economic growth that is harmonious with the Earth resources.

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