

Avoiding Extinction: The Way Out Of Climate Change



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For the first time ever, humans are dominating 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. What will come next?

We see that the changes we are precipitating in the atmosphere are fundamental and can lead to 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.

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

(<http://newsroom.unfccc.int/unfccc-newsroom/human-mobility-and-the-paris-agreement/>). 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 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.

The world is 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. 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. What is the solution?

Below I propose a realistic plan that involves market solutions in industrial and developing nations which will simultaneously resolve the problems of economic development and climate change and the global climate negotiations. But climate change is 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?

The issue now is how to avoid extinction.

Bacterial Altruism

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 (see Hyun Youk and Alexander van Oudenaarden, "Altruistic Defence," *Nature*, Vol 467|2 September 2010). 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.

Let us start from some basic principles. Survival is about protecting life, not just about inducing death. Life is difficult to define, but we all agree that it is a phenomenon characterized by reproduction. Only those systems that incorporate reproduction are said to be alive. Life forms are able to reproduce. To be alive means to be part of a time series of reproductive activities. Reproduction characterizes life. Destruction does not. Asteroids destroy very effectively, and so do volcanoes. But they are not alive, because they do not reproduce. We humans are alive because we do.

Reproduction requires in essence altruism rather than dominance and aggression.

How so? This is simple. We must donate our energy and even our bodily resources and substance to be able to reproduce.

Yet, 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.

The great British author and social commentator Jonathan Swift once suggested, as a “humble proposal,” that the problem of hunger in Ireland can be resolved by humans eating their own children (Jonathan Swift, *A Modest Proposal*, 1729). This is not as outlandish a proposal as it may sound at first. In any case it helps to illustrate the point I want to make. If the essence of life was the survival of the fittest, then humans would eat their children who are powerless at birth — nothing is less fit than newborn infants. Their bodies could certainly provide protein and nutrition to fit adults.

The question that we must answer is: Why don’t we follow Swift’s “humble proposal?” Why not eat our own children?

Some societies may have done exactly that, but those societies are not here to tell their tale because if we ate our children, humans would not be around. Our species would not have survived.

No species that ate its children would survive; it may not even get started as a species. Survival depends crucially on reproduction and this means protecting the

weak, the weakest of all, the small children. This is quite different from the blanket policy of survival of the fittest, with regards to the adult members of the species. Indeed, one may say that survival is more than anything about altruism and cooperation, and about the protection of the weakest. It is not about "dog eat dog"; it is not about dominance and survival of the fittest. It is about the nurturing and protection of new generations; it is about voluntary donations, about the protection and nurturing of the weakest, sometimes at the expense of our own survival. Humans are doing the opposite right now by endangering the survival of our children for economic gain today, a modified version of Swift's modest proposal.

Women and Survival

Women understand 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.

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 (Graciela Chichilnisky, "The Gender Gap," *Review of Development Economics*, 12 (4): 828-844, 2008). 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.

A U.S. Congress Committee on Violence Against Women is currently evaluating the situation and defining policy. Until we change the current male-dominated culture of abuse and its barbaric treatment of women for example, until we revolt against the acceptance of electronic games involving the systematic torture and killing of women as entertainment that the U.S. Supreme Court found acceptable for children in its recent 2011 decision and until we develop altruism as an efficient survival skill, our society will not be well prepared to avoid extinction.

Avoiding Extinction: Summary of What is to Come

The future of humankind may be played out in the rest of the 21st century. Here is a summary of the situation and what to do about it which is developed further below.

First, let us take stock of the world today: in a nutshell we see energy limits confronting enormous future global needs for energy today and in the future. The problem of overuse of natural resources, more generally, continues to be a clash of civilizations: it is an impasse between the global North and the global South. The North refers to the rich nations that inhabit mostly the Northern hemisphere of planet Earth, the South refers to the poor. The former represent about 20% of the world population, and the latter about 80%. We examine the market's role in getting us here and in finding a solution, and define three building blocks that are needed for a solution going forward. We discuss the next generation of green markets; how to bridge the global wealth gap and to transform capitalism as needed for this purpose, and whether this is possible. In particular, we examine the role of the United Nations and its Carbon Market in the global transformation process by itself and in conjunction with other global markets for environmental resources for water and biodiversity, which are still to emerge. We examine the critical role of women, how the global financial crisis fits into all this, how it elucidates our future, and the lessons we have learned.

Avoiding extinction is the ultimate goal of Sustainable Development.

Financial and Global Environmental Crisis

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. How so?

It is possible to illustrate this with simple examples available through the media that is read by the average person. The urgency of the situation has become clear. On Tuesday June 21, 2011, The Times newspaper in London wrote "Marine life is facing mass extinction" and it explained: "The effects of overfishing, pollution and climate change are far worse than we thought. The assessment of the International Program on the State of the Oceans (IPSO) suggests that a "deadly trio" of factors " climate change, pollution, and overfishing " are acting together in ways that exacerbate individual impacts, and that "the health of the oceans is deteriorating far more rapidly than expected. Scientists predict that marine life could be on the brink of mass extinction." All three causes of extinction just mentioned " 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. What about planting trees? Can't they do the job? On the same day, June 21, 2011 The Times stated: "Planting trees does little to reduce global warming" and explained how a recent Canadian report (The Times, p.17) has found that "even if we were to plant trees in all the planet's arable land — an impossible scenario with the global population expected to rise to 9 billion this century — it would reduce less than 10 percent of the warming predicted for this century from continued burning of fossil fuels." Observe 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 (Graciela Chichilnisky, "The Economic Value of the Earth's Resources. In E. Gutter (ed), Scientists on Biodiversity. American Museum of Natural History. New York, 1998). 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 "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.

This view is shared by the recently created international group G20, the first leading group of nations that includes developing countries. The group met for the first time in Pittsburgh, U.S.A., on September 24-25, 2009. The G20 Leader's Statement (September, 2009) states:

As we commit to implement a new, sustainable growth model, we should encourage work on measurement methods so as to better take into account the social and environmental dimensions of economic development. Modernizing the international financial institutions and global development architecture is essential to our efforts to promote global financial stability, foster sustainable development, and lift the lives of the poorest. Increasing clean and renewable energy supplies, improving energy efficiency, and promoting conservation are critical steps to protect our environment, promote sustainable growth and address the threat of climate change. Accelerated adoption of economically sound clean and renewable energy technology and energy efficiency measures diversifies our energy supplies and strengthens our energy security. We commit to:

- Stimulate investment in clean energy, renewables, and energy efficiency and provide financial and technical support for such projects in developing countries*
- Take steps to facilitate the diffusion or transfer of clean energy technology including by conducting joint research and building capacity. The reduction or elimination of barriers to trade and investment in this area are being discussed and should be pursued on a voluntary basis and in appropriate fora.*

The G20 statement continues:

Each of our countries will need, through its own national policies, to strengthen the ability of our workers to adapt to changing market demands and to benefit from innovation and investments in new technologies, clean energy, environment, health, and infrastructure. It is no longer sufficient to train workers to meet their specific current needs; we should ensure access to training programs that support lifelong skills development and focus on future market needs. Developed countries should support developing countries to build and strengthen their capacities in this area. These steps will help to assure that the gains from new inventions and lifting existing impediments to growth are broadly shared.

And it goes on to say that

We share the overarching goal to promote a broader prosperity for our people through balanced growth within and across nations; through coherent economic, social, and environmental strategies; and through robust financial systems and effective international collaboration, and that

We have a responsibility to secure our future through sustainable consumption, production and use of resources that conserve our environment and address the challenge of climate change.

The G20 knows the problems that nations face today. What they do not know are the solutions. On April 30th 2016, *The Economist* ran a story on a new measure of economic welfare introduced by James Tobin, a famous economist from Yale. A 2009 report commissioned by the French President Nicolas Sarkozy, chaired by my Columbia colleague Joseph Stiglitz, a prominent economist, called for changes in our measurement of economic progress and growth and for an end to "GDP fetishism" in favor of a "dashboard" of measures that capture human value. These reports offered appropriate criticisms, recognizing the problem at hand. "The report is in part a response to environmentalist concerns that GDP treats the plunder of the planet as something that adds to income" writes *The Economist* (April 30th 2016, p 22), adding, *The report was much talked about: it was not much acted*". Once again, the problem is identified, but solutions are lacking. We turn next to the solutions.

Human Future: Green Capitalism

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 World since WWII

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 (Graciela Chichilnisky, "North-South Trade and the Global Environment. *American Economic Review*, 84 (4), 1994, pp. 851-874). 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? (Graciela Chichilnisky and George Heal, "Who Should Abate Carbon Emissions: An International Perspective. *Economic*

Letters, Spring 1994, pp. 443-449).

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. (Graciela Chichilnisky, "Forward Trading Between the U.S. and China, Time Magazine, October 5, 2009). 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 (see IEA), because 87% of world's energy is driven by fossil fuels and power plants produce about 45% of the global carbon emissions.

How to make a swift transition to renewable energy?

Who Needs a Carbon Market?

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 (see Graciela Chichilnisky and Kristen A. Sheeran, *Saving Kyoto*, New Holland Publishers, 2009). The Kyoto Protocol (KP) 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 (Nicholas Stern, Review: The Economics of Climate Change, Cambridge University Press, 2006).

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.

What is the current status of the carbon market in the U.S., which is the single industrial nation that has not yet ratified the KP? 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 stationary 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 2014¹⁵. 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. A former Republican candidate for president, Mitt Romney who was formerly a Governor of Massachusetts, endorsed the creation of a "cap and trade" system or a carbon

market. A similar sequence of events took place when the SO₂ market was created at the Chicago Board of Trade (CBOT) 20 years ago: first it was quite controversial, but SO₂ emission limits were eventually passed for U.S. power plants and then traded efficiently in an SO₂ market at the CBOT, which is now widely considered to have been very successful in eradicating acid rain in U.S.A.

Are the new EPA carbon limits the beginning of the U.S. 10 carbon market as were the SO₂ limits 20 years ago? History is being written right now.

Green Markets are the Answer □ They will Transform Capitalism in the 21st Century

What is a green market and why does it matter? 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 (The World Bank, State and Trends of the Carbon Market (Annual Report 2006–2014)).

The North–South conflict, namely, who should abate first, puts all this at risk. To move forward in the global climate negotiations we must overcome the China–U.S. impasse, which is in an intense form of the same conflict that prevails between rich nations and poor nations as a whole, the conflict between the rich North and the poor South (see Graciela Chichilnisky, *Beyond the Global Divide: From Basic Needs to the Knowledge Revolution*, 2009).

Is it possible to overcome the North–South divide? Yes, it is. But the interests of the industrial and developing nations are so opposed that once again, we need a two-sided coin. This is the same dual role that the carbon market played in the UNFCCC 1997 global negotiations, allowing it to save the negotiations from which the Kyoto Protocol was born. The carbon market was acceptable to the rich nations because it provided market efficiency that the U.S. and the OECD wanted; at the same time the carbon market placed mandatory emission limits solely on Annex 1 (OECD) nations’ emissions, which is what poor nations wanted. This was what I saw then: how, by introducing the carbon market into the wording of the Protocol, it was possible to save the negotiations. This is how the Protocol was voted by 160 nations in December 1997. Equity and efficiency are the two sides of

the same coin. Together they win. We need both.

The G20 and the rest of the world seem to recognize the need for sustainable development, both in terms of financial practices and the environment. In a nutshell Sustainable Development means giving the future a fair treatment in our policies. The concept of Basic Needs created in the Bariloche Model in 1974 (see Graciela Chichilnisky, 'Economic Development and Efficiency Criteria in the Satisfaction of Basic Needs.' *Applied Mathematical Modeling*, 1 (6), 1977, pp. 290-297; Chichilnisky, "Development Patterns and the International Order." *Journal of International Affairs*, 1 (2), 1977, pp. 274-304; and A. Herrera et al., *Catastrophe or New Society: A Latin American World Model*. International Development Research Centre, Ottawa Canada, 1976) is its backbone since sustainable development is defined as the right of the present to satisfy needs without depriving the future from satisfying its own needs. A formal theory of Sustainable Development was created in 1993 (Graciela Chichilnisky, 'What is Sustainable Development?' Paper presented at the 1993 workshop of the Stanford Institute for Theoretical Economics, 1993).

We now turn to the principles and the practice of a new economic system that can achieve what is needed in the context of the global environment, avoiding extinction.

Blueprint for Sustainable Development

In its creation, the G-20 stated as its top priority to achieve Sustainable Development for the world economy. This requires

- (1) Economic growth in developing and rich nations to satisfy the Basic Needs of the present and the future*
- (2) Smooth and accelerating transition to renewable energy and a harmonious use of the earth's resources*
- (3) Clean and abundant energy available worldwide;*

Nobody knows the economic systems that will prevail in a long-term future. However, In the immediate future, sustainable development can be achieved by

Green Capitalism: below we discuss what this means and how it works.

Organizing Principles for Green Capitalism

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 (the basis for Green capitalism was explained in Time Magazine (Chichilnisky, 2009 (op. cit.)). 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 (see The Economist issue on "The Prosperity Puzzle", April 30 2016, p. 10, and "The Modern Economy", p. 7).

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.

Below are the building blocks for Green Capitalism and practical examples of how these organizing principles can be put in practice right now. They illustrate how new carbon negative technology can help achieve the climate negotiations goals, averting climate change.

Building Blocks for Green Capitalism

Here are three building blocks for Green Capitalism:

- (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 resolving key goals of global policy, such as:

(4) Create a \$200Bn/year Green Power Fund from existing funding sources, including the CDM, to ensure a smooth and accelerated transition to clean energy, achieve the goals of the UN Paris Agreement and of the UN Green Climate Fund.

In terms of global policy, the three building blocks offer practical ways to assist the ambitious goals of the COP21 Paris Agreement, which cannot be achieved within the Agreement terms itself.

Indeed, according to the 2014 5th Assessment Report of the IPCC (IPCC, 5th Assessment Report, Bonn 2014, p. 191) carbon negative technologies, also known as “carbon removals,” are now needed in our century in most scenarios and in massive scale in order to avert catastrophic climate change. Here is a practical example of how the three building blocks can help achieve the goals of the UNFCCC, using carbon negative technologies while fostering growth in developing nations and overcoming poverty, all of which requires more energy:

1. Carbon negative power plants for developing nations

New generation technologies can capture CO₂ from air at low cost (<http://www.globalthermostat.com>). These technologies build carbon negative power plants that clean the atmosphere of CO₂ while producing electricity (Graciela Chichilnisky and Peter Eisenberger, “Carbon Negative Power Plants.” Cryogas International, 2011). Global Thermostat LLC is an award winning firm that can be used as an example. The firm 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 (e.g. Chichilnisky and Eisenberger, 2011). 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 transform the world economy. In recognition of this fact Global Thermostat received three prominent awards recently, including "World's Top Ten Most Innovative Company" in energy (Fast Company Magazine 2016) and in April 22 2016, "World's Top 50 Innovator in Renewable Energy," and IAIR (International Alternative Investment Review) "2015 CEO of the Year" at the NY Yale Club, June 2015.

2. The Role of the KP carbon market

The role of the Kyoto Protocol Carbon Market and its Clean Development Mechanism (CDM) is critical as it can provide needed funding and financial incentives for investment to build carbon negative power plants that were described above in developing nations. To provide access to all nations to the carbon market, the KP carbon limits must be generalized to all nations, since no Carbon Market can operate without carbon emission limits. The CDM can be used to provide "offsets," namely contracts that promise to buy the electricity that is provided by carbon negative power plants for a number of years. Using these offsets as validation of future revenue, unlocks banking resources for the investment required to build carbon negative power plants. The plants themselves are profitable, since their costs are low and their electricity is sold. The scheme covers fixed costs and greatly amplifies private profits from clean technologies. The private green capital markets recognize this enormous business potential, having achieved now a record scope of about \$260 Bn/year in today's markets.

3. The green power fund and global capital markets

To accelerate and enhance the impact of the UN Carbon Market and its CDM, we have to create a \$200 billion a year Private/Public Fund called the Green Power Fund that was proposed. The funding can be used to build carbon negative power plants in developing nations, particularly in Latin America and Africa, therefore enhancing their economic development while cleaning the planet's atmosphere. The Green Power Fund was named and proposed by the author in writing to the U.S. Department of State in Copenhagen COP15 December 2009, and was also published by the author at the time in the Financial Times in 2009. It was accepted by the US State Department, and two days later was publicly offered by U.S. Secretary of State Hillary Clinton as the United States' contribution in the

global negotiations in COP15. Part of the proposal, now called the Green Climate Fund (one word was changed), became international law and received substantial financial support. Most of the financial promises to The Green Power Fund unfortunately have not yet been delivered. The Green Climate Fund lacks the funding which the KP and its carbon market could provide if the link was made between the two. But the US has not ratified the Kyoto Protocol and therefore has severed this natural and desirable source of funding. This connection can still be worked out while reinstating nation-by-nation carbon limits after 2020, and thereby the US carbon market based on those limits. The complete scheme as was proposed by the author in COP15 2009 is a private-public Green Power Fund with funding raised from global capital markets to invest in investment grade firms that build carbon negative power plants in developing nations, and with access to CDM funding to provide off-takes to buy the ensuing electricity.

The background and financial feasibility of the Green Power Fund can be seen as follows. Existing technologies (www.globalthermostat.com) can efficiently and profitably transform coal power plants and solar thermal sources of energy into carbon sinks that reduce atmospheric carbon concentration while producing electricity. The more electricity is produced, the more residual heat is released, which drives the new generation carbon capture technologies.

The Green Power Fund provides the project finance that is needed to build carbon negative power plants in developing nations and elsewhere. This can accelerate the renovation of the \$45-55 trillion power plant industry infrastructure worldwide (IEA) which is 87% fossil today, to transform it into a powerful "carbon sink" that cleans the atmosphere of CO₂. Financially what is required is about \$200 billion/year for 15 years. By 2011 the UN Carbon Market was already trading \$175 billion/year, which almost suffices to cover these costs.

The funding will go to investment-grade power plant builders and new ones (including General Electric, SSE, Siemens, Linde, as well as new and smaller firms) to build carbon negative power plants in developing nations. \$200Bn is what the carbon market can trade per year (or more), thus providing the funding required (see The World Bank's "Status and Trends of the Carbon Market" 2010 and 2011). Therefore the financial target proposed here seems eminently achievable.

Green Capitalism and Traffic Lights for Human Survival

The three building blocks just described include new types of markets that are

needed to transform capitalism into Green Capitalism. This transforms the economic values and prices of the new economy providing market incentives that make green economic projects more profitable than their alternatives and fostering conservation of biodiversity, clean water, and a safe atmosphere. Some of these new markets already exist and are described above. Green markets change GDP by valuing the Global Commons (the atmosphere, biodiversity, clean water), which in turn changes the measure of economic progress that is defined as the sum of all goods services produced by an economy at market prices. In a nutshell, as pointed out by *The Economist* ("The Trouble with GDP", April 30, 2016) the well-known economists James Tobin and Bill Nordhaus gave examples of environmental concerns stating that at present "GDP treats the plunder of the planet as something that adds to income, rather than a cost" (p. 22). For example, cutting down all trees in the US national parks and making toilet paper from their wood, increases US GDP and counts as economic progress. This is because GDP uses market prices in its computations. Toilet paper has a market price, since there is a market for toilet paper, while there is no market for standing trees in national parks.

How green markets change the measure of economic progress and redefine GDP

The creation of new markets that trade the use of the global commons, such as rights to emit CO₂, drinkable water and biodiversity, changes the measure of economic progress. The Carbon Market for example changes the GDP of a nation, which is a number defined as the sum of all goods and services produced at market prices. Indeed, if two nations that we can call Solar Nation and Coal Nation, produce exactly the same goods and services both produced at the same cost, the first using solar energy and the second coal, then the GDP of Solar Nation will be significantly higher than the GDP of Coal Nation on any given year. This is because if Coal Nation emits too much CO₂ and has to pay Solar Nation that emits none. The difference makes Solar Nation's GDP higher and Coal Nation's GDP smaller. In reality, the purchase and sale of carbon credits now enters the computation of GDP, giving a positive edge to Solar Nation and a negative one to Coal Nation. This is exactly what we wish to achieve, providing information about the negative effects on GDP that should measure the damages that Coal Nation is causing to the environment, the nation, and indeed the entire world.

In addition, Green Markets that trade global public goods link equity with

efficiency as was explained, and this is different from standard markets for private goods in which equity and efficiency are unrelated.

Examples of global green markets are:

The UN Carbon Market, which has been international law since 2005.

The SO₂ Market in U.S., which started trading at the CBOT (Chicago Board of Trade) in 1991.

Markets for Water and Markets for Biodiversity: these are in embryonic stages and still to emerge. They have been proposed by the author and are under UN consideration.

These markets provide the missing signal of scarcity that is normally provided by market prices when a good or service becomes very scarce. Such signals are tantamount to Traffic Lights for Human Survival.

Here are sign posts to implement the above strategies going forward. Within the UNFCCC Global Climate Negotiations, the annual COP meetings, the next of which is COP22 in Marrakesh December 2016, we have been able to insert the Carbon Market in December 1997 COP3 in Kyoto; in Copenhagen 2009 COP15 we inserted wording allowing carbon negative technologies to be compensated as part of the CDM, namely, that the CDM may fund negative carbon technologies, and in CO221 we were able to insert four articles about carbon removals or carbon negative technologies.

Economic Incentives for the Short and the Long Run: Why Negative Carbon?

Long-run strategies can be 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 (Graciela Chichilnisky and Peter Eisenberger, "Carbon Negative Power Plants," Cryogas International 2011). 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 already saw that planting trees is not feasible either, for similar reasons. 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 as seen above trees and other natural sinks are too slow for what we need today.

Negative Carbon as part of the world's economic transformation

Negative Carbon is needed now as part of a blueprint for transformation, as already explained. 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. As we saw 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 outcompete 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. In the examples provided above, 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.

A Vision for Sustainable Development

Avoiding extinction is about the survival of the human species. Survival is not about violent competition and struggle. Survival is about life not death. Carbon Negative Solutions are the future of energy, and green markets lead the way to Green Capitalism, resolving the global climate negotiations and the Global Divide, providing clean energy and economic growth for the North and the South that is harmonious with the Earth's resources, creating and nurturing life. Building a sustainable future.

About the author:

Graciela Chichilnisky is Professor of Economics and of Statistics at Columbia University, Visiting Professor of Economics at Stanford University, and co-founder and CEO of Global Thermostat. Professor Chichilnisky has worked extensively on the Kyoto Protocol, creating and designing the carbon market that became international law in 2005 and wrote the wording for the carbon market into the Kyoto Protocol at the COP in Kyoto in December 1997. She is the creator of the formal theory of Sustainable Development and acted as Lead US author of the Intergovernmental Panel on Climate Change, which received the Nobel Prize in 2007. Her pioneering work uses innovative market mechanisms to create Green Capitalism.

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