Tools and Objectives for a Sustainable Energy Economy[1]

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Overview: The Challenge of a Problem we are Unable to Articulate

Energy is in the news everyday, discussed and described in many ways, and yet we remarkably struggle for even a basic currency in which we can reflect the energy system we wish to build. This simple fact drives many of the seeming paradoxes of our interest in clean, sustainable energy, and our inability to launch a new scientific and industrial revolution to build this new energy economy. We have seen decades of papers extolling the opportunities and needs for a new energy system. However, the sad fact is that we as a global society have wasted many good years – decades actually -- during which we could have launched an economy based on job creation and investments in human capacity and creativity. Instead we have ignored the clearly changing signals that nature has been sending us about the status and stresses we are placing our rivers, oceans, skies, mountains and of the health of every ecosystem.

There are many metrics we might cite that consistently tell us that we are approaching, or that we are at, or that we are beyond, the carrying capacity of the planet in terms of flows of pollutants, and our need for resources[2]. That is not to say we do not have options; we do, and we need to both listen to the planet, and ourselves, and put our ideas into practice.

I am a physicist by training who wandered into the world of energy science and policy quite by accident. I did so because the most interesting people I met were consistently rebelling against disciplinary boundaries and I wanted to see what I could contribute in that exciting and challenging environment. It was and remains to me clear where to apply such tools; energy. The reason is simple: energy is the largest (legal) piece of the global economy, by a factor of two over the global food industry. Several of my advisors said that an easy way to pick problems to tackle is to start with issues that matter most, and this one does.

How big is the problem? Not only is energy the dominant part of our economy, but its impact on the planetary system can be seen in a few historical trends which are summarized in Figure 1.

The Intergovernmental Panel on Climate Change – which shared the 2007 Nobel Peace Prize – has been issuing reports on the state of climate science since 1990. Several thousand

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[2] Rokström, J. *et al* (2009). A safe operating space for humanity, *Nature*, **461,** 472 – 475.

climate and energy experts participate in the IPCC assessment and reporting process during any one assessment report (AR). I have been involved in several since my first 'special report' on technology transfer in 1999[3].

Figure 1 shows the consensus data on three broad climate indicators. It also shows the timing of each of the first four assessment reports.

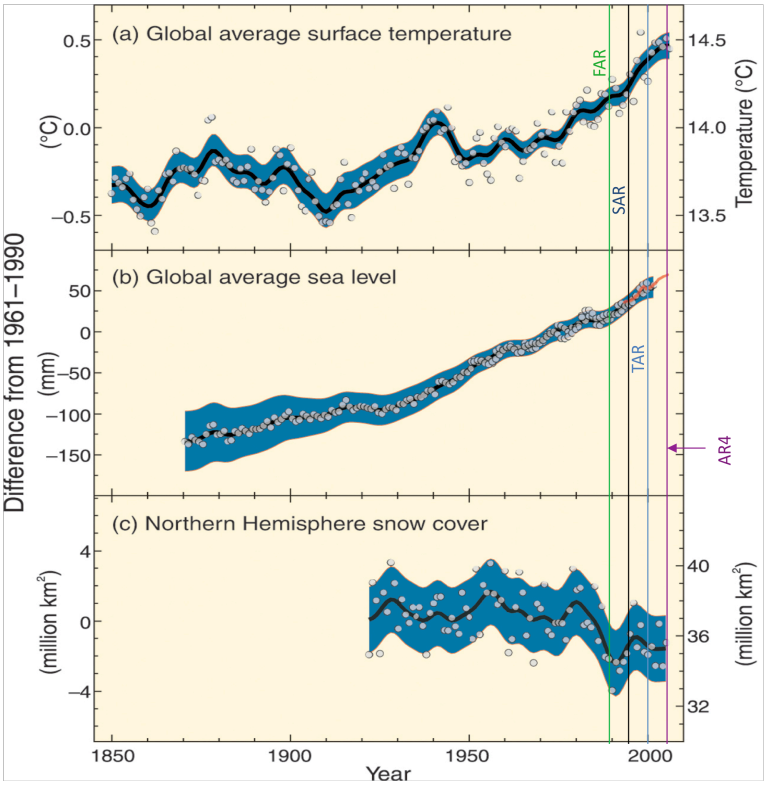
In 1990 the first assessment report concluded that it would take another decade at least to see clear signs of climate change in the natural record. In Figure 1 the First Assessment Report, *FAR* is indicated by the green vertical line in 1990. The key language – hotly debated and worked over most carefully – is shown to the right of the figure. This is as far as the first report could go.

Successive reports –the Second Assessment Report *(SAR)* shown as a black vertical line in Figure 1, five years later, in 1995 – advanced the clarity with a consensus statement that, "the balance of evidence suggests discernible human influence". This was clearer than the *FAR*, but still far from sealed.

The Third (blue vertical) and Fourth (red vertical in Figure 1) Assessment Reports clarified things considerably, assigning an analytic confidence (66% in the *TAR*) to the likelihood that the environmental change in the Figure is due to human activities (energy generation, agriculture, and forest disruption.

By the Fourth Assessment Report the IPCC concluded that most of the warming is very likely (90% confidence) is due to human activity. At this point the climate community branched out more strongly into social issues and arrived at the conclusion that the consequences of global warming *will most strongly and most quickly affect the world's poor.* What this also – sadly – means is that because in general society ignores the poor, that we will then ignore climate change longer than we should.

[3] Intergovernmental Panel on Climate Change Working Groups II and III (2000) *Methodological and Technological Issues in Technology Transfer* (Cambridge University Press: New York, Cambridge UK and New York, NY).



1st IPCC Assessment (1990): unequivocal detection of human impact not likely for a decade

2nd (1995): balance of evidence suggests discernible human influence

3rd (2001): most of the warming in the last 50 years is likely (>66%) due to human activities

4th (2007): most of the warming very likely (> 90%) due human activity

AND NOTE IN THE 4TH AR:

4th (2007): warming will most strongly and quickly impact the global poor

Figure 1: Changes in three key environmental indicators, 1850 – 2010, and vertical lines indicating the dates of the first through the fourth *Intergovernmental Panel on Climate Change* (IPCC) assessment reports. At right are key findings, stated in the official negotiated text, of each of these successive Assessment Reports.

This record of environmental change is already very significant, and has only just begun. What is needed in response is an ambitious set of individuals and networks of people and institutions committed to changing this *status quo* of our energy economy. There are basic scientific breakthroughs needed, for example in energy storage and solar cells. There are business opportunities in smart-grid energy services and in electric vehicles, and there are tremendous political wins for the elected officials who truly champion the clean energy economy.

Our collective challenge, then, is to find ways to work to change these trends. Collectively we need to put more of our good ideas into practice: as an academic community and as a entrepreneurial private sector, and as a civil society, and as a community of public servants, we need to do better – not next year or next month, but right now. First, we need a sustained and vibrant research base to understand our energy options and their resulting climate impacts[4].

[4] Nemet, G. F. and D. M. Kammen (2007). U.S. energy research and development: Declining investment, increasing need, and the feasibility of expansion, *Energy Policy*, **35(1):** 746 - 755.

We also need something that may sound very simple, in fact mundane[5], for people in fields outside of energy such as agriculture and education where 'extension services' are common. Farmers rely on information networks to plan their activities. Universities, community colleges and night schools all focus on making continuing education an available extension service. We need a mechanism to bring these innovations from the laboratory to the market. In agriculture every country essentially has a network of agricultural extension services. Perhaps because much of the 'modern' energy system has been managed by large, centralized utilities energy has not such extension network. It is time to build one.

One of the most important tools that we need to develop is an economy-wide "appreciation" of the costs and benefits of our energy choices. That, in fact, is why I felt it was so critical for me to work at the World Bank. First, the World Bank is significantly increasing its commitment and investment in energy efficiency and in clean and sustainable energy.

Second, and of vital importance, banks are focused on the bottom line, pure and simple, and that is a virtue – a virtue of *clarity*. Our society, however, is so far only *casually* and *vaguely* interested in sustainability. Beyond specific technical and policy innovations there have been some important insights: such as the realization that distributed networks of energy suppliers and consumers (some of whom may be one and the same) could not only complement large, traditional energy systems – but that in some ways they may be superior. I liken this to a transition from thinking. The old way was to view the energy gird as a one-way flow of energy *to* consumers. *Instead*, it could be more of an eBay: where anyone can buy and/or sell power, with the job of the utility – and the network regulator – to provide fair and transparent rules for these transactions.

These (potentially critically important) innovations aside, our interest in sustainability (accessing the resources we need without degrading the opportunities of future generations) remains very casual. This is not because individuals are not worried about the world that their children will inhabit. Poll after poll shows that when asked this question in isolation, people respond that they are very concerned about the future. Nor are we afraid to make hard decisions for what we want – people and even governments (much to the surprise of some skeptics) do this all the time. People in government generally work very hard for the public good, and civil society and non-governmental groups put exceptional effort into innovating and into giving voice to the watchdog role that every community large or small critically needs. It is true that immediate gratification versus long-term quality of life (and thus we must also address the complicated issue of discounting and of undervaluing the world in which we and then our children will live[6]) remains a problem for most people to keep squarely in mind. This issue, however, relates to the clarity that honest banks – and in particular the value of having a clear and well understood *currency* – can bring to our planning for the future.

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[5] Kammen, D. M. and Dove, M. R. (1997). The virtues of Mundane Science, *Environment.* **39 (6)**, 10 - 15, 38 - 41

[6] Schelling, T. C. (1997). The cost of combating global warming: Facing the tradeoffs. *Foreign Affairs*, **76**, 8 – 14.

As a society we are only vaguely interested in sustainability in part because we collectively do not speak a language that permits us to value the world in which we live, except when we cut it down, spoil our waters with human and industrial effluent, or poison the skies with the waste of our energy generation. In contemplating this situation my friend and colleague George Lakoff has made a remarkable and chilling observation that it is vital I relate to you.

It is clear to the environmental science community that nature is being degraded[7], in fact destroyed by the current course of human action and neglect. Yes, it is true that the so called industrialized nations emitted the majority of the greenhouse gas emissions if we go back to the beginning of the industrial revolution. So, by one measure they should 'pay'. And yet, the so-called developing nations will emit the bulk of the greenhouse gases over the coming decades, so they should 'pay it forward', if you will. What is more important than all that, however, is that we will all live in the world of the future. So while we can argue about that all day, the solution must be a collective one.

We have established that anthropogenic climate change is the act of degrading our collective home, the planet. Yet the environment is a *complex system* that responds in ways that are not always predictable. Professor Lakoff's observation is that we actually lack a means to express – and thus fully understand this situation. In other words, no language has a simple verb form that captures the effect of a system acting on the individual[8]. Certainly, there are ways to express this idea – notably if we become anthropomorphic and refer to the planetary system as an entity: *Mother Nature*, for example. However, if we move beyond this view of the planet as a single, coordinated, entity to the complex system that it is, we are not equipped to understand the process of this collective causality in terms of how it relates to us as individuals.

So, we are in a difficult place. First, we lack a *language* and, second, we lack something else vital to understand the planet. We lack a *currency* by which to *value* the planet, in which to value a clean energy economy, and in which to value our future.

Placing a price on greenhouse gas emissions to the atmosphere will not solve global climate change and environmental destruction by itself, but it gives us a language in which to express our values. Given that humans are social creatures that communicate constantly about every aspect of our individual and collective existence, to be without a means to communicate about our future is not only shortsighted, it is simply unacceptable.

Now, those who study economics and are interested in valuing the planet will correct me here and say, "actually, things are worse than you say." They, in fact, would be right.

The true story is *not* that we don't value the environment in a positive way, but quite the contrary, that we reward actions that damage the environment, and hence ourselves.

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[7] Intergovernmental Panel on Climate Change (AR4). *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2007 (available online at http://www.ipcc.ch).

[8] Lakoff, G. (1987) *Women, Fire, and Dangerous Things: What Categories Reveal about the Mind* (Chicago: University of Chicago Press).

Rewarding practices that generate waste is in fact, *placing a negative value on the planet and saying financially that sustainability is a bad thing.* This is not to say that we are *intentionally* damaging our 'nest', but that through our inactions, we are in fact sending the economic and political signal that individual profit is more important that our collective well-being and that of the natural ecosystem. We can, for example, choose to invest in local job creation by supporting people and companies that provide energy services without spoiling nature. We know the job creation benefits are real in terms of the *higher* numbers of jobs created in clean energy areas relative to polluting sectors[9]. This is not because 'clean energy' is inherently superior, it is simply because when ramping up a new field, greater investments in infrastructure and hence in jobs is needed. This means that when our energy dollars are put to productive use, and not simply used to increase out debt to the environment, we gain an added benefit. When adding up these environmental advantages of 'going green' it is often hard to see why this transition is so hard, and yet it clearly has been. In this regard, I am reminded of a perplexing cartoon (Figure 2), particularly because we know, as we can see in Figure 1, that climate change is not a 'big hoax'.

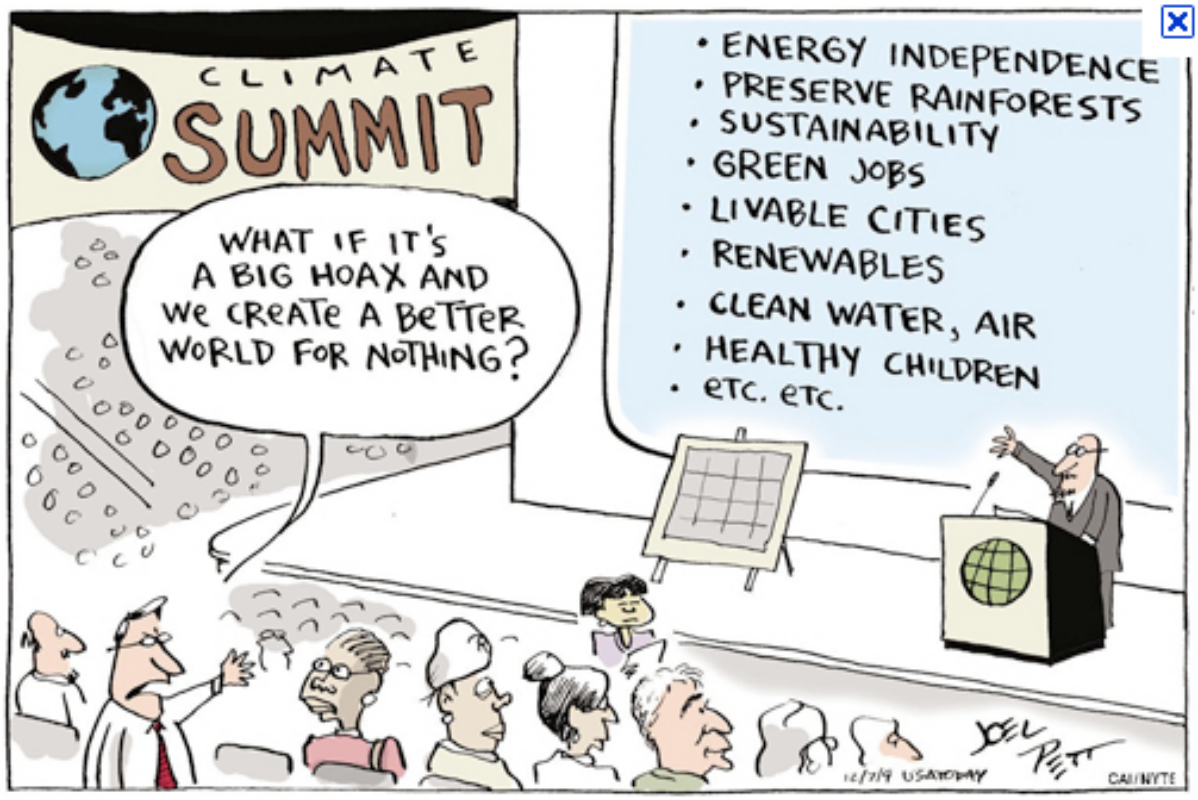

Figure 2: What value is there in saving the planet?

Putting our new language and energy and climate into action

Let us hope that we are able to build and use this language of energy and environmental clarity. In this respect, the story begins to get brighter and brighter. Once we recognize that

[9] Wei, M., Patadia, S. and Kammen, D. M. (2010) "Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the U. S.?" *Energy Policy*, **38**, 919 - 931.

our language and financial metrics are (or were) lacking, action becomes not only clearer, but in my view, easier than many people think.

How can this be?

First is the observation that not only is sustaining the planet good for us in the long-term, but there are many other positive returns on wasting less and in polluting less.

One of the most important lessons of the rapidly-expanding mix of energy efficiency, solar, wind, biofuels, and other low-carbon technologies is that the costs of deployment are lower than many forecasts, and at the same time, the benefits are larger than expected.

This seeming 'win-win' claim deserves examination, and continued verification, of course. Over the past decade, the solar and wind energy markets have been growing at rates over 30% per year, and in the last several years growth rates of over 50% per year have taken place in the solar energy sector. This explosive and sustained growth has meant that costs have fallen steadily, and that an increasingly diverse set of innovative technologies and companies have been formed. Government policies in an increasing number of cities, states, and nations are finding creative and cost-effective ways to build these markets still further. At the same time that a diverse set of low-carbon technologies are finding their way to the market, energy efficiency technologies (e.g. 'smart' windows, energy efficient lighting and heating/ventilation systems, weatherization products, and efficient appliances) and practices are all in increasingly widespread deployment. Many of these energy efficiency innovations demonstrate negative costs over time, meaning that when the full range of benefits (including improved quality of energy services, improved health, and worker productivity) are tabulated, some energy efficiency investments are vehicles for net creation of social benefits over time.

Carbon abatement curves have become famous since the Swedish power company Vattenfall collaborated with the McKinsey & Company to develop a set of estimates on the costs to deploy and operate a range of energy efficiency, land use, and energy generation technologies. (They are actually just knock-off of marginal pricing curves used in the electricity industry for decades, but context and timing is everything!) These costs of conserved carbon curves depict the costs (or savings, in the case of a number of 'negative cost' options such as building efficiency) as well as the magnitude (in giga-tonnes) of abatement potential at a projected future time. In Figure 3 such an abatement curve for the entire world for 2030 is presented. The basic message: saving money often saves carbon emissions, if you are strategic about where to invest.

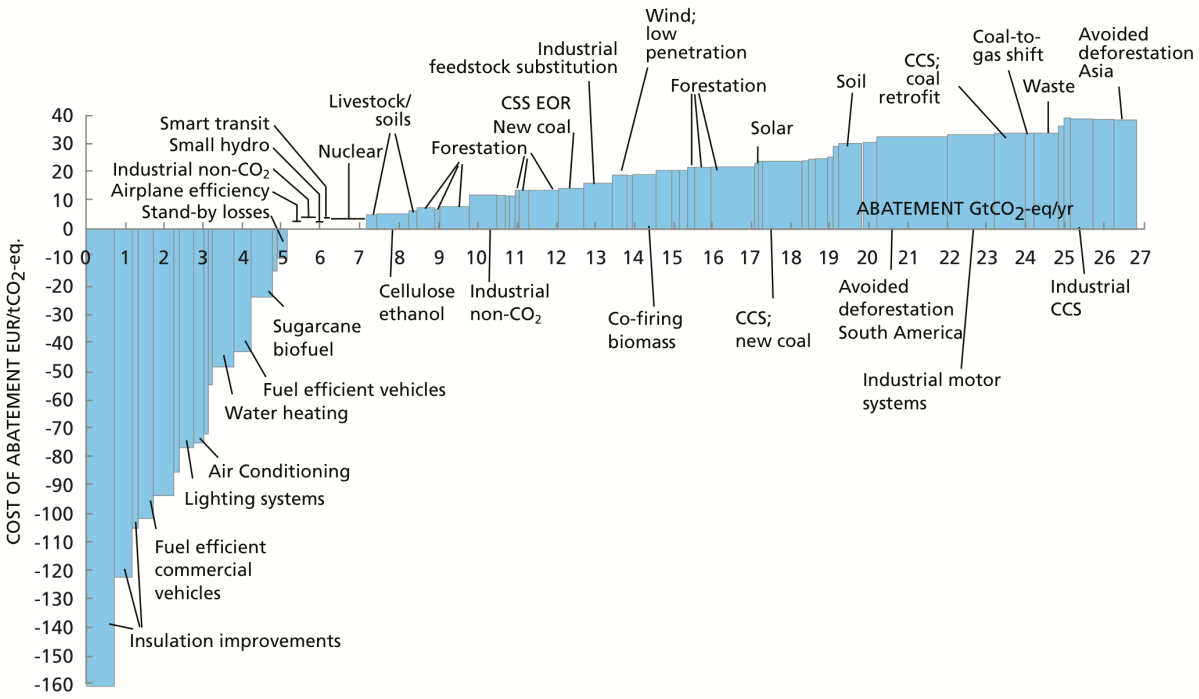

Figure 3: A 'carbon abatement curve' showing financial cost (+) or savings (-) for a range of efforts, projects, and programs with the unit financial impact per ton of carbon dioxide *not* emitted to the atmosphere. Examples exist for a range of countries, including Brazil, China, Mexico, the United States, and the United Kingdom, with the list expanding every day.

A World Bank-supported low-carbon development study shows that Mexico can reduce carbon emissions by 42% more than its target of 1,137 metric tons by 2030—477 million tons, to be precise—by decisive action on multiple fronts. It can achieve this by moving in key areas such as improving bus systems, road and rail freight logistics, fuel economy standards, and vehicle inspection at the border, among others.

This is exciting news. It shows that significant—even dramatic—carbon reductions can be achieved by adjusting use of existing technologies. Such adjustments can reduce costs too. These conclusions emerged from calculations based on a marginal abatement cost curve, or MAC, an analytical tool developed in 2008 by McKinsey & Company, and used by a team of experts studying Mexico's climate challenges headed by the World Bank.

The study in which this methodology was used, *Low-Carbon Development for Mexico*, by Johnson, Alatorre, Romo and Liu[10], is one of a series of such studies financed by the Energy Sector Management Assistance Program (ESMAP) that also includes Brazil and Nigeria (forthcoming).

[10] Johnson, T., Alatorre, C., Romo, Z, and Liu, F. (2009) *México: Estudio Sobre las disminicución de emisiones de carbono* (The World Bank: Washington, DC).

This same MAC tool has now been applied, with promising results, to two tiny communities of 1,100 people on Nicaragua's Atlantic coast. Results of a study published November 26 in ***Science*** Magazine demonstrate that low-carbon rural energy services can be delivered at cost savings in cases where communities utilize diesel-powered, isolated, electricity grids.

The study, on which I was working with Christian Casillas before I joined the World Bank will (we hope) spur efforts elsewhere to build similar community-level carbon abatement and energy service tools. This could mean that communities often ignored or lumped together as "those billions without modern energy" can create their own locally appropriate development goals, and groups working with them can develop energy solutions at a price lower than the one they're paying now.

In 2009, the rural Nicaraguan communities of Orinoco and Marshall Point, which share a diesel micro-grid, partnered with the national government and an NGO to implement energy efficiency measures including metering, which prompted residents to reduce wasteful use of electricity. Compact fluorescent light bulbs were also introduced, as well as more efficient outdoor lighting, and replacement of part of the diesel power with biogas from dung.

After the government installed meters, energy use dropped by 28%, and people's electric bills dropped proportionately. The NGO, blueEnergy, based in San Francisco, which offered the compact fluorescent light bulbs (CFL), was able thereby to cut household energy use by another 17%.

The net result was reduced burning of diesel, even allowing for the fact that the community's reduced energy needs allowed the local energy supplier to run its generators two extra hours each day, providing longer service to customers. In the month after the conservation campaign, energy costs per household had dropped by 37 percent.

That the MAC curve can be used to analyze energy use in the community and pinpoint areas where investments would save the most energy and the most money for homeowners is something of a breakthrough. Until now, the model has been used mostly on a global or country-wide scale to target areas for carbon abatement. But now it has gone local. That means some of the world's poorest communities can reduce their energy costs by local action which, multiplied worldwide, could produce global change in reduced carbon emissions.

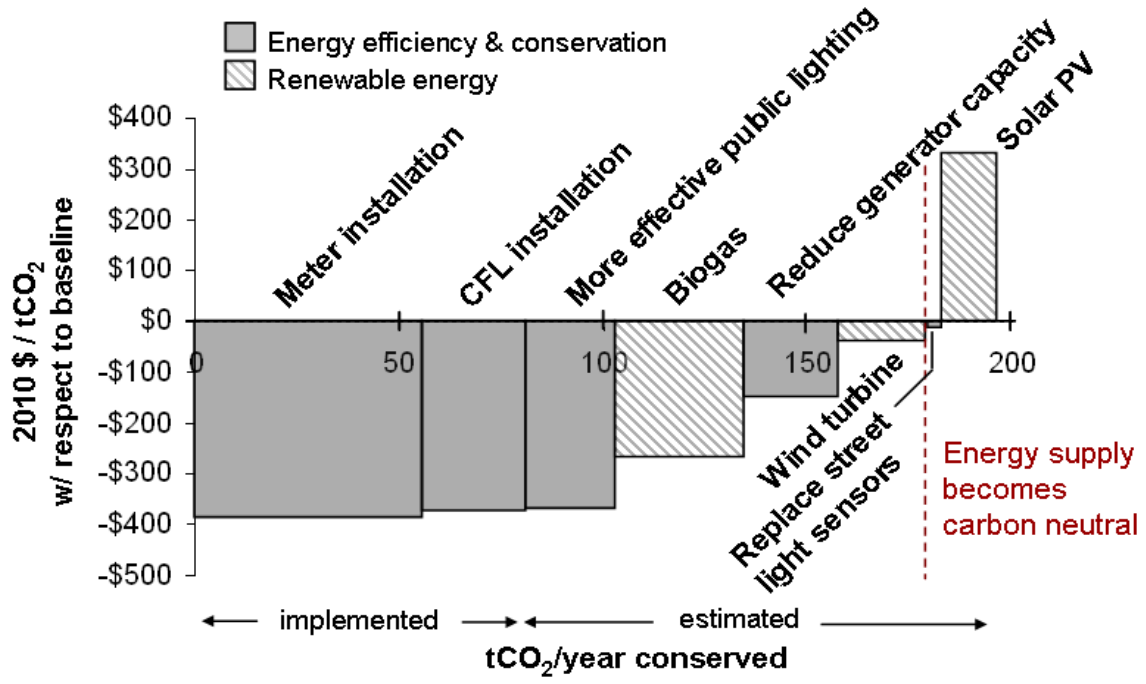

Figure 4: Marginal abatement curve for greenhouse gas emissions for a rural community on the Atlantic coast of Nicaragua. Source: Casillas and Kammen (2010)[11].

These curves illustrate the range of low-carbon options that exist, and that if we can continue to build a menu of options that have been tested, vetted, and implemented, a new paradigm of clean energy development has a very solid economic footing in a wide range of national, city, and community environments.

Finally, let me conclude with a brief note on building the business model for clean energy.

This is a piece of the story that gets left behind in many discussions: creating a new energy economy cannot be a battle between environmentalists saying we must 'go green' and the business community saying we 'cannot go green' today, or not that rapidly. In fact there is a great deal of emerging data – such as these marginal abatement curves -- that if one manages the process of innovation and implementation well, we can find ways to both growth the economy and make it dramatically greener. The German experience in wind and solar, and sound urban and agricultural planning is a great example of doing both well. In fact, Germany is finding that export earnings, job creation, and a stable economy in a time of oil and gas shocks can be found in this emerging green economy as well.

[11] Casillas, C. and Kammen, D. M. (2010) "The energy-poverty-climate nexus," *Science*, **330**, 1182 – 1182.