350/650/1050 – Implications of Global Warming for Demand-Side Management

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ABSTRACT

This paper looks at how Demand Side Management (DSM) will have to shift as the greenhouse gas content of the atmosphere increases. We first look at climate change from a technical perspective. Then, we look at barriers that make individual and societal response to climate change difficult. We then outline an approach that begins from current DSM and shifts to total social mobilization.

Introduction

Hansen (2009:xi;140-171) identifies 350 ppm as the upper boundary for CO_2 concentration in the atmosphere to avoid disasters.[1] McKibben (2010:15) notes that we are already at 390 ppm and several accounts (Zurawski 2008; Kolbert 2006; Lord 2011) document physical, plant and animal changes already observed. Due to the lag time for carbon to cycle from the atmosphere, CO_2 will likely reach 650 ppm, even if active social mobilization begins.

Interlinked but separate, the tipping point for methane release from tundra and undersea ice has likely occurred. This will greatly accelerate climate change and may result in abrupt climate transition.[2]

Technical Perspective

Climate science models rely on current and historic data of atmospheric carbon in the form of carbon dioxide, methane and chlorofluorocarbons. Carbon dioxide has long been the proxy for the determination of future anthropogenic climate changes and has been tracked continuously at the Mauna Loa Atmospheric Research Observatory since the late 1950's (Figure 1). Current climate models vary in projections of predicted surface-air temperature increases. Recently updated climate models from MIT indicate that the earth's surface temperature will increase by a median value of 5° Celsius by 2095 with projections as high as 7° Celsius. (Sokolov, et al: 2009). However, this model assumes a reduction in anthropogenic methane emissions from previous models by 300%, and disregards the large-scale increases of methane contributions from natural sources that recent field research has revealed. Even with this incorrect assumption, the model has determined that the global effects of climate change will be catastrophic.

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[1] We use CO_2 initially as a proxy for the set of greenhouse gases. According to the 350 Website, for most of human history, until about 200 years ago the ppm for CO_2 was 275 (http://www.350.org/en/about/science). Methane is discussed separately due to its sudden emergence as a problem equivalent to carbon in the short (20 year) range.

[2] While 350 ppm was re-attainable though a quick phase out of coal plants by 2030 in a wider portfolio of efforts (Hansen 2009:184), the new releases of methane now add to the problem. Ontario will have closed all 19 of its coal plants by the end of 2014 (Ontario Hydro, *OPA News Online*, April 2011), but much of the world is building coal plants.

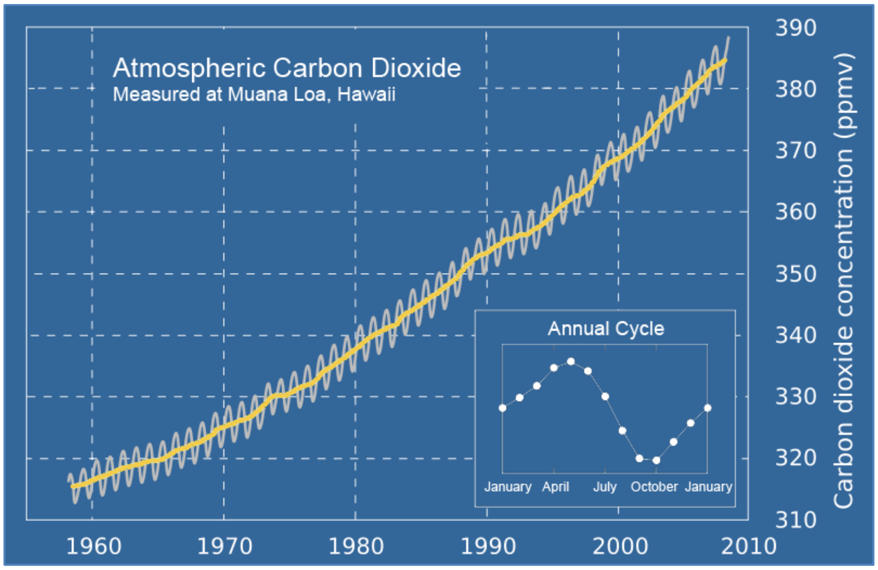

Figure 1: The Keeling Curve.[3]

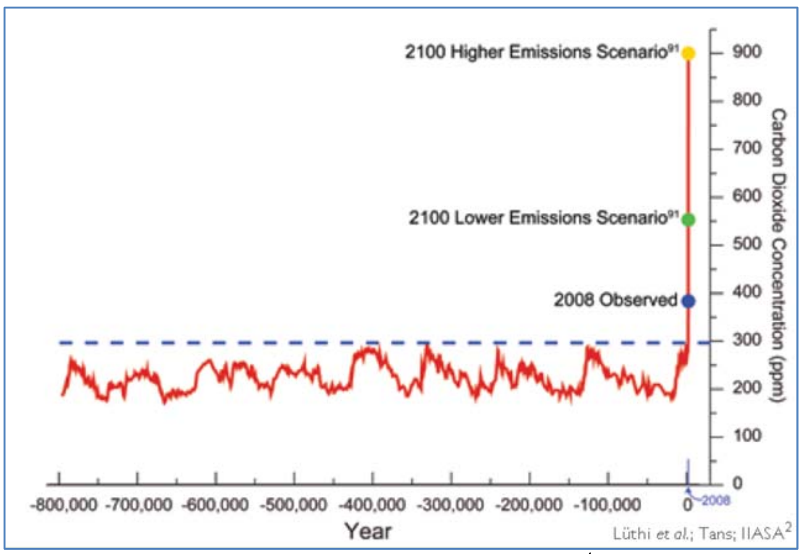

Figure 2: Long-Term Historic Atmospheric Carbon Dioxide.[4]

Long-term historic trends of atmospheric carbon dioxide levels (Figure 2) are determined by the analysis of air pockets trapped in Antarctic ice core samples taken from the Russian Vostok Antarctic Research Station (Petit, et al: 1999) and the European Project for Ice Coring in Antarctica (EPICA) Dome "C" locations in Eastern Antarctica(Luthi, et al: 2008). Long-term rainfall effects studies that used older models with a relatively gentle projected temperature increase of 3° Celsius over the next century have produced dire predictions of global drought and mass migrations from affected areas. A 2006 study (Burke, et al: 2006) indicated that regions of the globe that will experience extreme drought

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[3] Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Dr. Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/), graph used by permission.

[4] Data set from the Paleo Climate NOAA site: http://www.ncdc.noaa.gov/paleo/metadata/noaa-icecore-6091.html,, graph used by permission.

conditions, as measured by the Palmer Drought Severity Index (PDSI), will increase from the current value of 1% of the Earth's surface to 30% by the year 2100 (Figure 3). Effectively, these areas will become deserts and will be unable to support sustained human activity. Recent projections show that the number of people affected by perennial water shortages in the developing world will increase from 150 million in 2000 to 1.1 billion people by the year 2050 (McDonald, et al: 2011).[5]

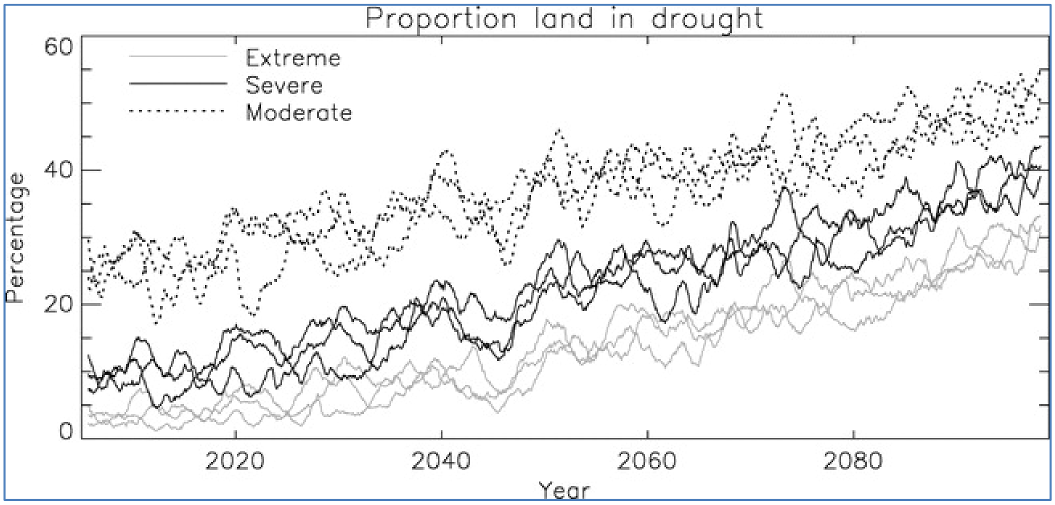

Figure 3: Long Term Modeling of Global Drought Patterns through the Year 2100.[6]

The U.S. will experience areas of significantly decreased rainfall. This process will mirror the global trend of increased desertification forcing large-scale human population migrations. While temperatures will climb but still remain bearable, the decreasing ability to produce food and drinking water in regions that are severely impacted by droughts will necessitate large movements of populations from cities in the south and southwest into northern areas of the US. Projections are that the process of desertification will spread throughout the Southwest region by 2100 and that this process has already begun with the recent 10-year drought happening at this time (Karl, Melillo and Peterson: 2009.

Carbon dioxide in the Earth's atmosphere does not remain indefinitely. Natural forces work to remove carbon dioxide gas from the atmosphere on a regular basis. The global warming potential lifetime of a specific "pulse" of injected carbon dioxide in the Earth's atmosphere is measured to be approximately 100 years.[7] However, the Earth's ability to remove carbon dioxide is greatly affected by air and sea surface temperatures. It has recently been determined that the projection of a 5° Celsius increase of surface air temperatures will lead to a decline in the natural removal rates of carbon dioxide by 301 Giga-tons per year (Frank, et al: 2010). This correlates to a total weight of 82 Giga-tons of carbon. In comparison, the total annual weight of carbon, in the form of carbon dioxide, removed through the process of land-based photosynthesis is only 60 Giga-tons per year. (Barsanti & Gualtieri: 2006).

Current U.S. national security estimates agree that 2030 is "the approximate timing for ice-free summer months in the Arctic Ocean"[8]

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[6] Used by permission of the American Meteorological Society.

[7] Carbon Dioxide Information Analysis Center, http://cdiac.ornl.gov/pns/current_ghg.html

[8] National Security Implications of Climate Change for U.S. Naval Forces, National Research Council of the National Academies, Committee on National Security Implications of Climate Change for U.S. Naval Forces. National Academies Press, Washington D.C. December, 2008

Figure 4: Lake Mead Water Approaching Critical Shortage Levels.[9]

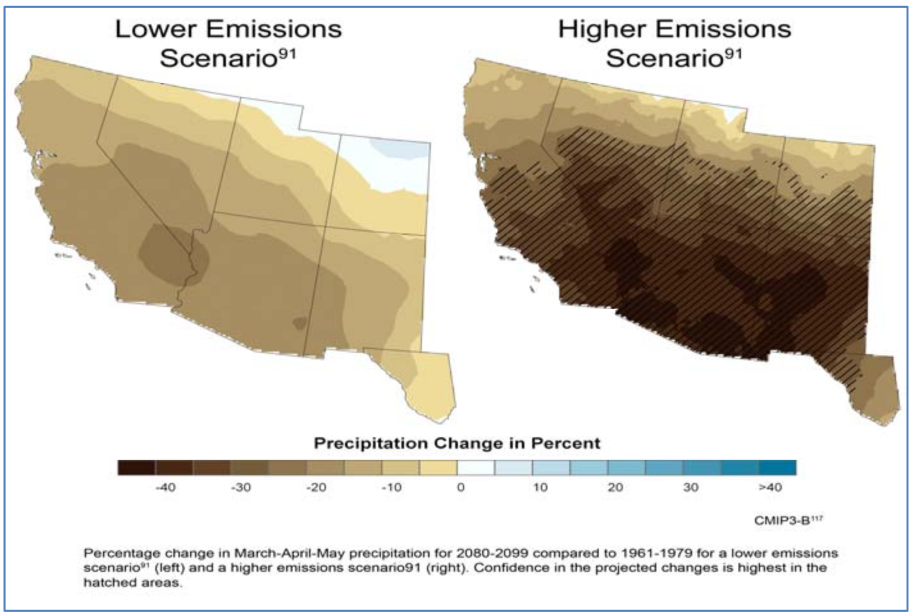

Figure 5: Projections of Decreases in Spring Rainfall Totals in the Southwestern United States.[10]

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[9] Lake Mead graphic courtesy of P. Lutus, http://arachnoid.com.

[10] This image was developed using an open sourced model (CMIP3) and is not copyrighted. The model is at http://cmip-pcmdi.llnl.gov/cmip3_overview.html?submenuheader=1 , and has open use permission.

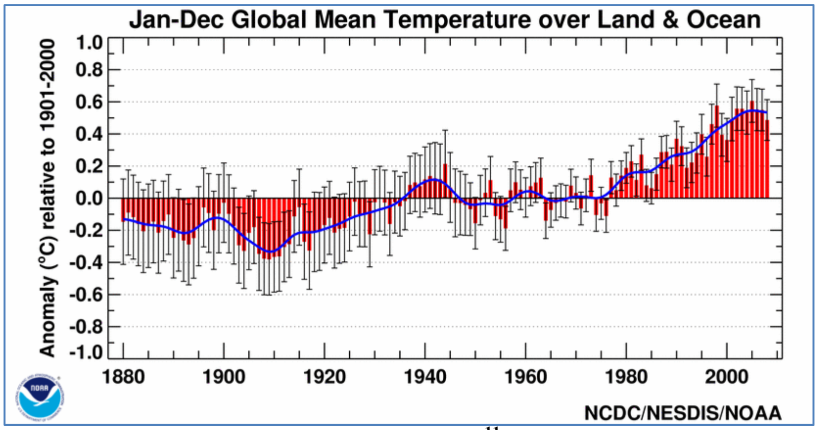

Figure 6: Global Surface Temperatures Increasing.[11]

Sudden Climate Change (Methane)

The previous section indicated long-term (100 year) effects of the carbon content of the atmosphere. New information indicates a rapid speed-up of climate change due to methane. Methane now has a very high potential for causing a short range (20 year) climate change feedback. The possibility is for an abrupt (decadal) severe climate change. On a mass-to-mass direct comparison with carbon dioxide, methane has up to a 105-fold greater warming potential for a 20-year time horizon. It also has a 33-fold greater warming potential for a 100-year time horizon when compared to carbon dioxide (Howarth et al). Current estimates indicate that the increase of global atmospheric methane since pre-industrial times is a significant contributor to the currently observed anthropogenic climate change (Dlugokencky, et al: 1998):

> "The global atmospheric methane burden has more than doubled since pre-industrial times and this increase is responsible for about 20% of the estimated change in direct radiative forcing due to anthropogenic greenhouse-gas emissions."

Figure 7: Methane is a Significant Contributor to Direct Radiative Forcing.[12]

As arctic sea ice levels retreat, very recent observational data from deep-ocean buoys has determined that deep-arctic ocean temperatures are rapidly rising. A draft study of waters off the coast of northwest Greenland has found temperature rises at a depth of 350 meters as great as 0.63°C per decade and attributes this to a "changing ice regime" (Münchow, et al: 2011). Significant amounts of methane are currently sequestered within sediments located underneath the relatively shallow Eastern Siberian Arctic Shelf. As sea temperatures rise in this location, the methane clathrates[13] contained within the sub-sea sediments are rapidly melting and releasing large quantities of stored methane. If only 1% of this area's sub-sea methane is released into the atmosphere it will increase the earth's current

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[11] This image is subject to the National Oceanographic and Atmospheric Administration open access to data policy, https://docs.google.com/viewer?url=http%3A%2F%2Fwww.ncdc.noaa.gov%2Foa%2Fabout%2Fopen-access-climate-data-policy.pdf.

[12] Radiative Forcing or RF is defined by the Intergovernmental Panel on Climate Change (IPCC) as the, "change in net irradiance at the tropopause after allowing for stratospheric temperatures to readjust to radiative equilibrium, but with surface and tropospheric temperatures and state held fixed at the unperturbed values." An alternative definition would be the net energy exchange rate at the surface of the earth's troposphere, measured in Watts per square Meter. A positive value indicates warming and a negative value indicates cooling.

[13] A clathrate is a kind of cage in which a lattice of one type of molecule captures and holds another kind of molecule. In plain language the methane is breaking free of these cages due to rising temperature in the seas.

methane burden by 300 to 400 percent.[14] Since the doubling of the atmospheric methane burden between 1750 and now currently contributes 20% to the observed effects of anthropogenic climate change, this release would result in an increase in the radiative forcing effects of anthropogenic greenhouse gasses in the earth's atmosphere by 100% to 140% in a very short amount of time. In 2008 The U.S. Department of Energy recognized this release as a credible threat to national security and established the Investigation of the Magnitudes and Probabilities of Abrupt Climate Transitions (IMPACTS) Project, a collaboration of six national energy labs working to determine the potential for abrupt climate changes to occur.

> "Plausible scenarios could lead to methane becoming more important than CO2 as a greenhouse gas on a time-scale of decades, with the associated warming leading to further hydrate dissociation, as well as terrestrial permafrost melting, that will release additional methane and be self-sustaining."
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> -- Investigation of the Magnitudes and Probabilities of Abrupt Climate Transitions (IMPACTS) Project

Figure 8: Methane May Be More Important Than Carbon.

Barriers to Thought and Action (The Opposition)

Next, we look at barriers that make response to climate change difficult. These include valuing inappropriate conventions of economics and finance over physical reality, the weakening of the middle and professional classes, and the promotion of anti-science doubt.

First, with the exception of ecological economics, economics and finance (whether capitalist or Marxist) are very weak in treatment of physical limits. In their conventional ways of looking at the world, the costs to all of us from corporate production processes are obfuscated. Current economics can only be corrected by situating it within physics. With this shift, the interlinked problems of overpopulation, pollution, global warming, and increasing energy resource scarcity become the dominant features of economic reality.[15] The conventional focus on profits and returns, financial discounting of the future and on the "the market" as a solution is outdated and misdirected. Without this correction, economics offers inaccurate models of production without resource depletion, without pollution and without the warming (except as unimportant residuals). It typically indicates that a solution to problems is to "grow our way out"![16] Conventional financial perspectives are based on mechanical models that discount the future![17]

Second, we have the weakening of the middle and professional classes since 1970. The attentive public on important issues in a democracy is made up of persons who have the time, security and resources to follow issues beyond their immediate needs. Currently, as one DSM Manager has put it, we are trying to do DSM in a consumer ridden, stratified culture. In this culture, radically increasing

[14] University of Alaska Fairbanks (2010, March 5). Methane releases from Arctic shelf may be much larger and faster than anticipated.
[15] Georgescu-Rogen (1971, 1999: 1-3) notes that economics was modeled on the mechanical systems of classical physics while subsequent discovery of the laws of thermodynamics occurred outside these mechanical models. Thermodynamics can be understood "…as a physics of economic value" (Georgescu-Rogen 1971, 1999:3).
[16] This is exactly the wrong response for a "fruit flies in the bottle" type of situation.
[17] But with resource depletion and global warming the problems call for exactly the opposite valuation.

income inequalities are a huge barrier to market driven programs. For example, some home audit programs now try to take income into account so that well-to-do families are provided with different measure recommendations than low income families, a process that is not rational from a physical perspective. The gradual defunding of the middle, upper middle, and portions of the upper classes in the United States began in about 1970 with the continuing transfer of wealth and income to the extreme upper 2% of US households. This trend weakens the ability of market-based DSM. It also weakens government action by undermining the tax base necessary to provide a strong collective response to DSM and global warming.[18] The warming, interacting with the intentional "creative destruction" endemic to a corporate market economy and focus on growth of the worldwide profit system pushes these tensions further. As weather becomes "unnatural," as inflation grows, as food production becomes more difficult, as the job structures start modestly to recover and then fail again*, it will become harder to do effective DSM*. This is especially true as portions of the social safety net are retracted for the poor and middle class, as pay is cut for professional workers; and as government employees are dismissed from essential positions. For example, we are having some very good solar promotion with good take up at the local level but the scale of participation is limited by the draining of economic capability with sustained 22%-25% unemployment.[19] By contrast, *what we need for either market-based or collectively financed DSM is a vibrant middle, upper middle and upper class* that can provide a basis for a pro-science government policy as it affects both resource depletion and global warming.

Third, there is intentional creation of doubt. From the 1920's some critical industries have worked directly to create doubt on science issues through various strategies: directly, through think tanks, and through capture of federal regulatory agencies (Ross & Amter 2010). From the 1950's, a relatively few individuals and industry funded think tanks have created doubt about tobacco and cancer, second-hand smoke, the hole in the ozone layer, the need to control DDT, the need to control acid rain, and (now) the need to mobilize to control global warming (Oreskes & Conway 2010). The current major political effort to weaken the Environmental Protection Administration (EPA)[20] is supported by the work of corporately funded "free market" think tanks. Science recognizes resource depletion, pollution, and global warming at the *center* of material reality. Some corporations directly affected (and others on simple economic model or viewpoint grounds) would prefer that the limits implied by reality did not exist because they interfere with their "liberty" and "…certain kinds of liberty are not sustainable—like the liberty to pollute" (Oreskes & Conway:239). Once scientific thinking asserts priority over conventions of economics, finance, and production it is a threat to the basis of a capitalist form of organizing the economic system.

A doubt creation example is a recent article by John Tierney in the March 7, 2011 *New York Times*, "When Energy Efficiency Sullies the Environment." The article begins, "For the sake of a cleaner planet, should Americans wear dirtier clothes?"[21] Tierney highlights the economist's "rebound effect" or "Jevons Paradox," named after an 1850's economist who observed that increased efficiency of steam engines led to increasing use of steam engines and to more coal consumption.[22] Modern

[18] For example, like the peoples' movement which was instrumental in persuading our political leaders to withdraw the military from Viet Nam.
[19] For real unemployment, take the government number (U3), double it, and add three percent. See John William's Shadow Government Statistics (http://www.shadowstats.com/alternate_data/unemployment-charts).
[20] As this paper is completed, the President and Congress are withdrawing EPA funding. The climate program has been saved but remains under continuous political assault.
[21] This is a made-up and misleading issue. For the rebuttal on the dirty laundry for energy efficiency trade-off see the the response by Consumer Reports, "Come on New York Times – washers can be green and efficient," March 8, 2011. There are top-loaders that clean clothes well plus a large assortment of front loaders that are highly energy efficient and clean clothes well.
[22] The Jevons Paradox/Rebound effect from the 1850s when steam engines were just beginning to rise along their market transformation "S-curve" is not news; nor is take-back in energy efficiency. Evaluators measure direct take-back and have

economists Jenkins, Nordhaus and Shellenberger[23] are quoted as suggesting that increasing energy efficiency in a steel plant in China is likely to increase production.[24] Tsao et al (2010) are cited as showing people spend about the same percentage of income on light today (LEDs, etc.) as they did in 1700 (candles, etc.).[25] Further, Saunders, a co-author with Tsao is quoted as saying that LEDs and other advances in energy efficiency do not reduce energy use: "We find the opposite is true."[26] The National Research Council is cited as authority for a finding of additional highway deaths each year due to cars being less safe because they are more efficient.[27] Tierney concludes, quoting Sam Kazman of the Competitive Enterprise Institute ("a free-market-oriented nonprofit research group"): "Efficiency mandates … results…have ranged from costly fiascos, such as once-dependable top-loading washers that no longer wash, to higher fatalities in cars downsized by fuel-efficiency rules. If the technologies were so good, they wouldn't need to be imposed on us by law." What this article is really about is not science but the liberty to choose in a so-called "free market" to avoid the collective social responsibility embodied in energy efficiency programs and regulation to improve product efficiency and reduce greenhouse gas emissions. It is about a mechanical model.

Organizational Response

The DSM community is responding with strong improvements in building codes, the movement to near zero energy buildings, the new social rationing technologies inherent in the smart grid and smart meters and, for example, the European Committee for an Energy Efficient Economy's development of the cost optimality project selection criterion. Many other projects are underway including "deep" DSM research by joint utilities in Massachusetts and by a coalition put together by Affordable Comfort, Inc.

Part of this response involves the question of agency. By "agency" we mean the organizational structure through which DSM will be accomplished. We will contrast two extremes, current organization and total social mobilization. We expect DSM to slowly transition from the first to the second. The first case is what we have now. The second is based on the precedent of the WWII Office of Price Stabilization (Galbraith 1952). Currently, DSM is administered by the states and provinces of North America as independent jurisdictions and regulated by Utility Boards or Public Utility Commissions. However, certain programs such as Energy Star and Low-Income Weatherization are federal programs though administered through the jurisdictions. Complementing this formal structure, much of what makes DSM work are the regional administrative and coordinating groups (NEEP, NEEA,

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found it to be typically non-existent or small. However, indirect rebound is not measured. The Jevons Paradox includes both direct rebound (or take-back) and indirect rebound (if a solar array on a residential rooftop causes the electric bill to drop by one-third, the money saved will be spent on other goods and services causing increased energy use in those areas). We recommend that both effects be carefully quantified. See: Nadel, Steve, (2011) and Polimeni, et al. (2008).

[23] These economists are associated with the Breakthrough Institute, which promotes an anti-climate action agenda.

[24] This is a sub-case routinely included DSM accounting. But the real question is "Would steel production increase in China in any case?" Efficiency improvements mean that new production is less energy intensive than it would be without the improvements and the improvements represent a net energy savings *at the new production level*. In many cases efficiency improvements do not lead to increased production.

[25] Tsao, J Y, H D Saunders, J R Creighton, M E Coltrin and J A Simmons, "Solid-state lighting: an energy-economics perspective," *Journal of Physics D: Applied Physics*, Vol. 43, No. 35, September 2010, Pp. 1-17. Note that spending a percentage of income on light does not relate to efficiency, it is a different question.

[26] This is primarily due to the indirect rebound effect throughout the less developed economies of the world. See Evan Mills' rebuttal to these misinterpretations of Tsao, et al.; also see a letter to the Economist by the authors challenging anti-efficiency interpretations of their work as based on a misunderstanding of comparisons (Mills, 2010).

[27] Traffic deaths are associated with small (efficient) cars but that is a problem of failure of highway regulation that mixes small efficient cars with huge cars, busses, and double and triple trailer trucks. Also, it is a problem of the deregulation of safety rules enforcing the number hours truck drivers must take as resting time.

MEEA, SEEA), professional groups (Association of Energy Engineers, American Energy Services Professionals), working groups on buildings and renewable energy at the national laboratories and the American Council for an Energy Efficient Economy. Most of the DSM achievements are accomplished by private sector program delivery agents and results are primarily assessed by a network of private sector evaluation, measurement and verification firms and individual consultants. This kind of porous and multi-centered structure is excellent for innovation for a climate change framework. And, as shown by the many recent innovations in DSM cost tests, is innovating in the general direction of movement towards creating the capabilities to introduce deep DSM suited to our climate change problems.

Moving Towards an Adequate Cost Test

There are three frameworks for structuring Demand-Side Management efforts. These are resource acquisition[28], market transformation, and climate change. Formal Demand-Side Management (DSM) began as a component of utility Integrated Resource Planning with the resource acquisition framework." The market transformation framework further incorporates market shifts that permit the cost per unit of a transformed product to drop to virtually zero in the long-term. The high cost units of the first or middle years, when melded with the zero cost units of the late years show an average cost competitive with the marginal plant or the market price of the alternative generation mix. The climate change framework requires another transformative change of this kind.

The climate change framework has not been fully worked out, but there are many people developing 'work-arounds' that provide indications of this framework coming together (Hall et al 2009; Neme & Kushler, 2010; Dakin, Aiona & Hedman 2011). Wisconsin lowered the discount rate of its Total Resource Cost Test (TRC) to a low social discount rate, several states call their primary cost test the TRC but have introduced small changes that make the test more like a societal test (including some non-energy benefits and/or an environmental adder), some states move the application of the TRC to the program or portfolio level. California is working on a comprehensive Integrated Demand Side Management (IDSM) test that will include valuation of energy embodied in water and several other factors.

We outline a much simpler approach as a trial climate change framework for testing climate change DSM programs. This framework is rooted in the second law of thermodynamics (heat energy) in its application on a human scale and takes into account this law of physics as the primary economic law for the framework. The theory of the climate framework for DSM draws on the environmental and climate sciences.[29]

In the climate approach, in contrast to earlier DSM cost-testing, policy goals for energy efficiency must be set to accomplish goals by specific dates. This necessarily means that the future is not discounted – it is either counted as equal to the present or, preferably, counted as more important than the present.[30] At the same time, the appropriate primary cost test shifts to a combination of the Administrator's Cost Test and the BTU/dollar test. In addition, it will be necessary to include within the

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[28] For an overview, see Gellings, Clark & John H. Chamberlin, *Demand-Side Management Planning*. Lilburn, Georgia: The Fairmont Press, 1993.

[29] In conventional Resource Acquisition and Market Transformation DSM programs, amenity is preserved or enhanced. In the Climate Change paradigm the focus is on doing with less, doing without, localization, mutual cooperation, and community survival Murphy (2008), Odum & Odum (2001), Greer (2008). For an introduction to climate change, see Volk (2008) and Hensen (2008).

[30] This is, in part, simply a different philosophical perspective in which we wish the future to be better than the present or the past. It is also a perspective based on realistic expectations that energy prices will rise and available resources diminish due to peak oil, peak gas, peak uranium, peak coal and disruptions to food supply, production, and jobs due to climate change. In other words, we may be much more able just now to work with these changes that we will be in the future.

program authorization procedure a review by a small team of engineers and DSM policy people. In itself, the Program Administrator's Cost Test frees the field for climate change programs by explicitly treating cost sharing as leverage. The BTU/Dollar test does not discount energy so it makes it possible to fund an incentive for a Passivehaus designed to last 150 years and to compare possible projects using their actual energy streams (1 year for one, 17 for another, and 150 for another). Note that by not discounting the future, the value of conserved energy does not go to zero at approximately 17 years as an artifact of the cost-testing method. Until the DSM climate framework becomes established it is conservative and prudent to include an expert team review as part of the process of project authorization. This is to prevent "green folly" projects.

To extend the climate perspective further, we need to use the BTU/Dollar test simply as a tool for optimizing packages of energy efficiency improvements. Beyond this test, we need to be able to specify homes, business, industrial, and institutional building characteristics that will last 150 years under the specific local and regional climate conditions of the new world that we face. If this means walls three feet thick, then walls have to be three feet thick *regardless of cost*. *Physics rather than economics or finance has to dictate the new built environment*. This is a very different perspective than the perspective that gave rise to the current cost tests and the new tests that are being evolved.

To push perspective beyond this point, energy efficiency is only one part of the solution to climate change. It is essential, but only a component. We envision that a command and control economic system will be necessary to deploy both energy efficiency and direct conservation (enforced rationing and voluntary and involuntary modifications of lifestyles to "do without"). What we face is a sustained emergency longer than any other that humans have ever consciously faced and it is likely that even if we win only a small fraction of the current world population will make it through.

Total Social Mobilization

In the face of catastrophic global climate change, energy efficiency must take on, as President Carter said long ago, "the moral equivalent of war." It will have to be deployed as a set of coordinated global warming DSM strategies and programs.[31] Far from free market economics and as feared by free market anti-science interests, DSM will have to be deployed on a command and control basis. Total social mobilization means central federal control of global warming effort, including DSM strategies and programs operated through the jurisdictions. By analogy, the theory and practice of this model is best worked out by Galbraith (1952) in the operations of the World War II Office of Price Control (OPC). During WWII it was necessary for all combatant nations to operate their economies outside of the market system. In the US, the OPC allocated resources by command and control to the war industries to meet the enormous material needs of the fighting forces. Galbraith shows that for such a system (which breaks most of the rules and expectations of market economics) to work, both prices and wages throughout the economy had to also be controlled. And, for control of production allocations to work, a successful rationing of food, medical, and all consumer goods was necessary. This system worked well throughout World War II and was dismantled after victory.

Conclusion: Ramping Climate Change DSM along with the increase in CO_2

Can Climate Change DSM be ramped to correspond in both organization and projects as need increases? Climate projections in this section are taken from the readings provided in the References

[31] To imagine DSM on the equivalent of a war footing remember that economic history has shown three primary modes of production – tradition, command and control systems, and varieties of market systems. Of course, each economic system has contained elements of the others as residuals.

section of this paper, in particular Hanson (2009), McKibben (2010), and Zurawski (2008). The projections are only approximate and they are gathered eclectically from texts that not in exact agreement. This part of the paper opens a vision of the future.

Through 2020

Ocean levels rise, CO_2 level rises to about 430 ppm, tundra and undersea ice continue to rapidly outgas methane. Movements of small numbers of climate refugees has already begun and will become large. In some lucky areas, planned relocation will be made with the support of national governments or the UN. In others, people will just start moving. Storms will become more severe. Crop yields will slowly decline and farmers will experience more frequent "freak weather."

DSM continues much as it is now. With many independent centers in different political jurisdictions, working groups and associations there is a high potential for innovation. In particular, the old DSM Total Resource Cost Test (TRC) will be continually challenged, both in the ways suggested in this paper and in much more complex technical approaches as in the California Integrated DSM models. The "deep" energy projects of the joint Massachusetts utilities and Affordable Comfort will produce usable results. There is a potential across jurisdictions to develop variants of a DSM Climate Change framework and to try out a few climate change DSM programs on a trial basis. Good initial candidates for climate demonstration projects and trial programs are universal transformation to LED street lighting (in cold areas remember to select a brand that warms the electronics), fire, police, and medical facilities, schools and military facilities. Climate change housing is also a good focus (include climate change ready permanent emergency housing for the expected masses of climate change immigrants). In Europe, the ECEEE will proceed with the continuing development of strong improvements in building codes, the movement to near zero energy buildings, and with development of the cost optimality project. In both the North America and Europe new social rationing technologies represented in the smart grid and smart meters will be operated for rationing and social control.

Through 2050

Physical forces will have moved the warming forward perhaps very rapidly based on methane releases or more slowly based on carbon releases to the atmosphere. The changes required for dealing with the extent of global warming will cause the loss of corporate and individual liberty to misuse, pollute, and destroy the world. But loss of liberty will be not be noticeably worse than in WWII when major nations were in a contest for their continued existence. For the most part, people will try to make things work. Water levels and greenhouse gas levels will continue to rise. Summer Arctic sea ice will be non-existent. The oceans will be much more acidic causing die offs of ocean life and including stocks of food fish. We will still be below a runaway greenhouse effect. Farming will have become challenging in many areas. Both plants and animal life will have been trying for some years to migrate, resulting in extensive die offs but some successes. Invasive species entering new areas will cause major changes in natural food networks and insects and diseases will likely become pestiferous in most places.

The former great farming areas of the US and Canada will be drying out yet subject to frequent intense storms, including tornados and also be subject to rapid evaporation. Farming from Oregon through British Columbia and from Maine through the Maritime Provinces will remain viable. Land will become available in Northern Canada, but not topsoil. Greenland and a part of Antarctica will start to be available for precarious settlement. There is clean topsoil from ancient jungles in the part of Antarctica that becomes available for settlement. Some governments will collapse, but other will remain intact, very small elites continue to have access to the good life, and in lucky areas nearly all institutions will continue to function though at reduced levels. The entire world society will be under strain and *human population will drop substantially*. Still, the changes are tolerable in the whole. In the carbon future, New Hampshire is now becoming South Carolina, but South Carolina is a good place. In the methane future, things have speeded up and we are far beyond that point.

Nations will necessarily shift to command and control to support the armed defense of territory and resources and to insure allocation of prices and wages as well as production and consumer goods. There may be resource wars which will further drain social resources and weaken governments.

DSM in this period will have moved to a climate change framework. Coal-friendly cost tests like the TRC Test will be quaint history. Energy policy will have to include new construction of nuclear plants on a production basis to attempt to make up for the close out of coal. DSM energy efficiency and renewable energy will be combined and projects will be set according to energy targets in specific locations and specific years. It is likely that the officers of AESP and ACEEE will be pulled into government and given military ranks as happened to essential civilian professionals during World War I. DSM will convert to a command and control basis for the long duration of sustained emergency.

Through 2075 or 2111.

The CO_2 models suggest that it is unlikely that we will be able to prevent a runaway greenhouse effect in the long range (100 years). Looking beyond carbon as a proxy for all greenhouse gasses to specifically consider methane, these problems may speed to a twenty to thirty-five year range rather than a one-hundred year rage. With the tipping point for release of methane clathrates now passed and fracking releasing perhaps twenty times more methane than ordinary gas wells and proceeding at full speed, methane moves from a minor to a major concern. This could speed up the climate effects on the order of a decade or a few decades.

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