IEEE POWER ENGINEERING SOCIETY
ENERGY DEVELOPMENT AND POWER GENERATION COMMITTEE

International Practices Subcommittee

PANEL SESSION: Developments in Implementing Technology to Limit Greenhouse Gases

IEEE 2002 WM, New York (Monday), January 28, 2002, 2:00 p.m.

Chairman: T. J. Hammons, Chair, International Practices for Energy Development and Power Generation, University of Glasgow, Glasgow, UK.
Co-Chairman: Jim McConnach, Castle Hill Engineering Services, Canada

The Panel Session discussed the latest progress and technology developments to limit greenhouse gas emissions. Reviewed was the status of scientific debate on global warming and climate change, progress in technology on limiting climate change, the California Climate Registry, Ontario Power Generation's Green Response Program, and an IEEE Standard for CO2 Credits. There was also a presentation on whether or not there is an energy crisis, and a discussion on economic growth and greenhouse gas reduction.

Principal contributors included:

- S. Fred Singer, SEPP, USA, who discussed 'Status of the Scientific Debate on Global Warming and Climate Change: Is the Climate Warming;
- Chris Marnay, Berkeley Lab, USA, who commented on the 'California Climate Registry';
- Scott Rouse, Ontario Power Generation, Canada, who examined 'The OPG Green Response Program';
- Jim McConnach, CHES, Canada, who outlined 'An IEEE Standard: Quantification of CO2 Emission Credits;
- Peter Meisen, Global Energy Network Institute, USA who made a presentation entitled 'There is no Energy Crisis';
- Richard Hosier, UNDP, New York, USA, who discussed UNDP-GEF Capacity-Building for Renewable Energy Markets and Clean Energy Technologies, and
- Wayne S. Richardson, Climate Change Technology Early Action Measures, Natural Resources Canada, who discussed economic growth and greenhouse gas reduction.

Each Panelist spoke for approximately 20 minutes. Each presentation was discussed immediately following the respective presentation. There was a further opportunity for discussion of the presentations following the final presentation.

The Panel Session was organized by T. J. Hammons, Chair of International Practices for Energy Development and Power Generation (University of Glasgow, UK) and Jim McConnach (Castle Hill Engineering Services, Canada). The Panel Session was moderated by T. J. Hammons (University of Glasgow).

The first presentation was on the status of the scientific debate on global warming and climate change: is the climate warming; and was presented by S. Fred Singer, Science and Environmental Policy Project, Arlington, VA, USA.

1. THE KYOTO PROTOCOL IS NOT BACKED BY SCIENCE

S.Fred Singer, University of Virginia and The Science and Environmental Policy Project, Arlington, VA 22202, USA

Summary:

The balance of evidence suggests that the climate is not warming. A U.S. National Research Council report [1] has highlighted but not explained the disparity between different data sets: While a variety of surface thermometers report a substantial warming trend, microwave sensing units (MSU) on weather satellites, and also radiosondes carried in weather balloons, show little if any warming of the atmosphere in the last twenty years. As is well understood, however, climate models predict the opposite, namely a stronger warming trend for the atmosphere than for the surface.

The recent measurements of surface warming trends may not be credible. We note that while there is general agreement that the global climate warmed before 1940, and then cooled slightly until about 1975, well-controlled surface temperature data for the United States and Europe do not show any appreciable post-1940 warming, after correction for local urban warming ("heat islands"). Furthermore, proxy data from tree rings, ice cores, etc. show no post-1940 warming trends; many even show a cooling trend after 1940. The observations of Arctic sea-ice shrinking, deep-ocean warming, glacier-length changes and sea-level rise can all be explained as delayed consequences of earlier climate warming; they are all in good accord with the hypothesis that the Earth's climate has not warmed appreciably in the past 60 years.

This conclusion seems to contradict the commonly held wisdom that a substantial warming is currently taking place. The UN's Intergovernmental Panel on Climate Change even asserts that this warming is human-caused [2]. The IPCC predicts further temperature increases during this century as the level of atmospheric greenhouse gases rises. But any such prediction must be based on climate models, and these have not been validated by actual data.

`Thus, action to "combat" global warming is hard to justify when the preponderance of data show no warming that can be assigned to human causes, when economists conclude that higher CO2 levels and a warmer climate would be beneficial not harmful [3], and when proposed schemes to control greenhouse-gas emissions are largely ineffective [4]. Considering the high cost of such controls and their political nature, the Kyoto Protocol, as President George Bush has stated, is "fatally flawed" and should be abandoned.

[1] National Research Council. "Reconciling Observations of Global Temperature Change." National Academy Press. Washington, DC. Jan. 2000.
[2] UN-IPCC. "Climate Change 2001: The Scientific Basis." Cambridge University Press, Cambridge, 2001.
[3] S. Fred Singer. "Hot Talk, Cold Science: Global Warming's Unfinished Debate." The Independent Institute, Oakland, CA. (second edition, 1999). p.25.
[4] Ibid. p.68.

S. Fred Singer, an atmospheric physicist, is professor emeritus of environmental sciences at the University of Virginia, and the president of the Arlington (VA)-based Science & Environmental Policy Project, a non-profit policy institute. [SEPP is an association of working scientists concerned with providing a sound scientific base for environmental policies.] He has held several academic and governmental positions, including as the first director of the US Weather Satellite Service (now part of NOAA), deputy assistant administrator for policy of the Environmental Protection Agency, and most recently, chief scientist of the U.S. Department of Transportation. He devised instruments used to measure atmospheric parameters from satellites and was first to point to and calculate the human-based production of atmospheric methane, an important greenhouse gas and source of stratospheric water vapor. He is author and editor of a number of books, including *Global Effects of Environmental Pollution* (Reidel Publishing Company 1970), *Global Climate Change* (Paragon House 1989), and *Hot Talk, Cold Science: Global Warming's Unfinished Debate* (Independent Institute 1997 and 1999). The author of the monograph "*The World Price of Oil*" and coauthor of "*Free Market Energy*," he has served as an advisor to the Secretary of the Treasury and the Secretary of Energy.

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The greatest environmental challenge of the new century is global warming. . ..
--President William Jefferson Clinton, State of the Union Address to Congress, January 27, 2000

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1.1 Why the Kyoto Protocol should not be implemented

This essay discusses several reasons why the Kyoto Protocol should not be implemented. The first argument is a legal one, based on Article 2 of the FCCC (Rio Climate Treaty). A more substantive argument is based on climate science, which does not support the actions envisioned in the Protocol. A third argument is perhaps the most convincing to the general public: Enacting the Kyoto Protocol would be economically harmful, raise fuel prices, destroy jobs, create poverty, and lower the standard of living. A fourth argument is that the Kyoto Protocol is quite ineffective; it would not produce the desired results; in addition, it is unworkable, too complicated and contentious. Its real basis appears to be ideological, rather than a concern with climate. Here we concentrate on climate science. The other topics are discussed more fully in "*Climate Policy: From Rio to Kyoto --- and Beyond*" Public Policy Essay No. 102. Hoover Institution, Stanford University. June 2000.

1.2 The Rio Climate Treaty as Basis for Kyoto Protocol

International climate policy is embodied in the Kyoto Protocol, concluded in December 1997. Signed by most nations but not yet legally binding (May 2002), it derives from the U.N. Framework Convention on Climate Change (FCCC), the Global Climate Treaty concluded in Rio de Janeiro in 1992.[1] The Protocol calls for an average reduction of 5.2 percent (relative to 1990 levels) in the emissions of man-made greenhouse gases to be accomplished within the time period 2008 to 2012. It applies only to thirty-nine industrialized (so-called Annex-I) nations but not to developing nations like China and India. The United States would be required to reduce its greenhouse-gas (GHG) emissions by 7 percent from its 1990 level; in the case of carbon dioxide (CO2), this would amount, by 2010, to an actual reduction in the use of fossil fuels of between 30 to 40 percent from the current estimate for 2010.

The Kyoto Protocol is being advertised as an international agreement to reduce the "threat" of greenhouse warming to the global climate. As its framers and supporters phrase it, global warming is the "greatest challenge to human existence on this planet"; this apparently ignores the challenges from nuclear war, attacks with biological and chemical weapons by terrorists or rogue nations, and the perennial problems of poverty and social unrest. It also ignores the very real threat of a geologically imminent ice age. The late political scientist Aaron Wildavsky more correctly characterized global warming as the "mother of all environmental scares." In reality, the Kyoto Protocol is a radical, ecology-based initiative for launching economic and social policies that threaten personal freedom, economic growth, and national sovereignty; it would also result in a major transfer of wealth from the industrialized nations.

1.2.1 Dubious Legal Basis for Kyoto

Whereas the Kyoto Protocol calls for specific quantitative reductions in GHG emissions, the FCCC ("Rio Climate Treaty of 1992") itself sets out the ultimate objective. It is not widely appreciated that the purpose of the Climate Treaty is *not* a reduction in GHG emissions or even in their atmospheric concentration. Rather, Article 2 states only "the ultimate objective is to achieve *stabilization* of greenhouse gas concentrations in the atmosphere at a level that would prevent *dangerous* anthropogenic interference *with the climate system*" (emphases added). (There is no further definition here of the desired or "dangerous" level or any mention of human health or ecological values. We do know, however, that plants would stop operating if CO2 levels were somewhat lower than during the last ice age.)

We may presume that the drafters of the FCCC were chiefly concerned with the stability of the climate system, fearing that a higher level of GHG might endanger this stability or increase the variability of global climate. This is a difficult scientific question, which was never addressed in the IPCC report. The evidence we have, however, going back to the recent Ice Age, suggests that the climate was more variable--or less stable--during *colder* periods than during the warmer period of the present Holocene (of the past ten thousand years).[3] On shorter time scales, it also seems that warmer periods exhibit a more stable climate.

In preparing for the Kyoto negotiations, its chairman specifically requested the IPCC to provide scientific guidance on Article 2, but this request was never fulfilled.[4] The goal of the Climate Treaty remains undefined to this day; we simply don't know whether a higher or a lower concentration of GHG will represent a "danger to the climate system." It is known, however, that the Earth has experienced much higher levels of carbon dioxide in the past, apparently without any ill effects to the climate. We must therefore conclude that, strictly speaking, the FCCC furnishes no legal basis whatsoever for restricting the emission of greenhouse gases.

1.3 Weak Scientific Basis

To place the Kyoto Protocol in context, to understand its implications, and to appreciate its many problems--if it is ever adopted--one must first stipulate a large number of items about the science of climate change and about the economic impact of global warming. These are more fully discussed in my book *Hot Talk, Cold Science: Global Warming's Unfinished Debate* (*HTCS*)[5]. Below are some of the highlights:

1.3.1 Data are fundamental: The subject of climate change must rest on observations of the climate in all of its aspects; with temperature as the most important and easily measured parameter. On the one hand, we are inundated with data, many of which do not add appreciably to the discussion; on the other hand, we lack crucial information about the past that may never be recovered. For example, individual temperature measurements using thermometers date back for only about three hundred years; the record for the Northern Hemisphere (NH) dates from about 1860; and it is only since 1979 that weather satellites have been able to obtain truly global data, including also from the hitherto poorly observed 70 percent of the surface covered by oceans. The satellites show that the global atmosphere has not warmed significantly. This finding is confirmed by independent observations from radiosondes on weather balloons.

1.3.2 Climate has varied in the past: To gain perspective on the subject of climate change, one needs to look at the past. Proxy data from tree rings, corals, ocean sediments, ice cores, and other evidence can tell us about paleotemperatures. Although the data are not exactly global and not always of the best quality, certain conclusions can be reached. The Earth's climate has never been steady; it has either warmed or cooled--without any human intervention whatsoever. The measured variations have often been large and rapid -- larger and more rapid than those predicted by climate models for the year 2100. In the last 3,000 years (i.e., during recorded human history), temperatures in the North Atlantic have changed by as much as 3°C within a few decades (*HTCS*, p. 6). During the most recent Ice Age, the variability has been even greater. Is the climate more stable during warmer periods? We cannot be sure, but the evidence points in this direction. Current controversy revolves around whether the twentieth century was the warmest in the past thousand years. Although the analysis of some proxy data supports this notion, it is clearly contradicted by others that show evidence for the warm period around 1100AD, often termed the "Medieval Climate Optimum," followed by the "Little Ice Age" that lasted off and on until about 1860.

1.3.3 What has caused the climate to vary? All sorts of theories have been propounded, and many have been backed up by data. It is clear, however, that different causes can be acting simultaneously, with their importance depending primarily on the timescale involved. The frequent ice ages of the last few million years appear to be caused by changes in the absorbed incident solar radiation, in turn affected by orbit changes of the Earth described by the so-called astronomical theory. Longer-term climate changes seem to be linked to continental drift and other tectonic events, such as mountain building. Shorter variations, on the timescale of decades, appear to be caused by atmosphere-ocean interactions and changes in ocean circulation. Alternatively, they could be due to external causes, such as variations in solar irradiance (solar "constant") or in solar activity (ultraviolet radiation and/or solar corpuscular radiation). There are suggestive correlations of the 11-year sunspot cycle with cloudiness and with temperature, but as yet no convincing physical mechanism that links them (*HTCS*, p. 7). But recent evidence from proxy data shows clear solar control of climate changes; the Sun may even control atmosphere-ocean oscillations.

1.3.4 What about the association of climate change with atmospheric greenhouse gases? On the timescale of hundreds of millions of years, carbon dioxide has sharply declined; its concentration was as much as twenty times the present value at the beginning of the Cambrian Period, 600 million years ago. Yet the climate has not varied all that much, and glaciations have occurred throughout geologic time even when CO2 concentrations were high.

1.3.5 CO2 lags temperature change: On a timescale of decades and centuries, there seems to be an association between temperature and CO2 concentration, as judged by measurements of Greenland and Antarctic ice cores. (The association is even better for the greenhouse gas methane.) Yet the causal connection is not at all clear. Only recently has it been possible to obtain sufficient resolution to demonstrate that the increase in CO2 *lags* about six hundred years behind the rapid warming that signals deglaciation (the end of an ice age and the beginning of an interglacial warm period). (*HTCS,* p.73)

1.3.6 There is general agreement that the increase in atmospheric greenhouse gases, such as CO2, methane, nitrous oxide, and so on, over the last hundred years or so is due to human activities. Attention has focused mainly on CO2 from fossil fuel burning, the most important anthropogenic GHG. Less than half of the released CO2 remains in the atmosphere; this fraction seems to be diminishing. The rest is absorbed by the ocean and by the biosphere, thereby speeding up the growth of agricultural crops and forests. Informed opinion holds that half of the released CO2 is absorbed into the shallow oceans within thirty years, that the mean residence time is about seventy-five years, and that a "tail" may last more than a century (*HTCS*, p. 73). The residence time of methane is much shorter, only about twelve years. For reasons as yet unexplained, the rate of increase of atmospheric CO2 has slowed considerably in the last decades, and methane may have stopped increasing altogether. This makes it extremely difficult to predict future concentrations of CO2 and methane, the latter depending primarily on the rate of population growth (originating mainly through cattle raising and rice growing). With respect to CO2, estimates of emissions vary greatly, depending on energy scenarios. These are determined not only by population growth and economic growth but also by the availability of fossil fuels -- in turn a strong function of technology and of price. Much to the surprise of many experts, the price of oil has generally decreased, even as readily available low-cost resources are being depleted. There is considerable disagreement about the probable date when atmospheric GHG concentration might reach double the pre-industrial level. Estimates vary from the year 2050 all the way to never.

1.3.7 **Temperature Data:** There is general agreement that the global climate warmed between about 1860 and 1940, following several centuries of the "Little Ice Age," which in turn was preceded by the "Medieval Climate Optimum" around A.D. 1100 (see figure 1). There is less agreement about the causes of this recent warming, but the human component is thought to be quite small (*HTCS*). This conclusion seems to be borne out by the fact that the climate cooled between 1940 and 1975, just as industrial activity grew rapidly after World War II. It has been difficult to reconcile this cooling with the observed increases in greenhouse gases. To account for the discrepancy, the 1996 IPCC report has focused attention on the previously ignored *cooling* effects of sulfate aerosols (from coal burning and other industrial activities), which would reflect a portion of incident sunlight. But this explanation to support the "discernible human influence" conclusion is no longer considered valid. Leading modelers all agree that the aerosol forcing is more uncertain than any other feature of the climate models.[6]

The temperature observations since 1979 are in dispute. On the one hand, surface observations with conventional thermometers show a rise of about 0.1-0.2°C per decade, which is only half that predicted by most GCMs (General Circulation Models). On the other hand, satellite data, as well as independent data from balloon-borne radiosondes, show no perceptible warming trend between 1979 and 2001 in the lower troposphere, and could even indicate a slight cooling (if one ignores the unusual warming of 1998 by El Nino).[7] Direct temperature measurements on Greenland ice cores show a cooling trend between 1940 and 1995 (*HTCS*, p. 74). It is likely therefore that the surface data (from poorly distributed land stations and sparse ocean measurements) are contaminated by the local warming effects of "urban heat islands" (*HTCS*, p. 13).

Although it is certainly true that temperatures at the surface affect human activities, the GCMs are best validated by observations in the troposphere. It should be noted also that GCMs predict a warming trend that *increases* with altitude, rising to about 0.5°C per decade -- in clear disagreement with all observations, whether from the surface, balloons, or satellites (as documented in a U.S. National Research Council report of January 2000).[8]

1.3.8 **Climate Models:** The large discrepancy between model results and observations of temperature trends (whether from the atmosphere or surface) demands an explanation. The twenty or so models developed around the world by expert groups differ among themselves by large factors (*HTCS*, p. 49). Their "climate sensitivities" (defined as the temperature increase for a doubling of GHG forcing) vary from as low as 1°C to as high as 5°C; the IPCC gives a conventional range of 1.5°C to 4.5°C. An inter-comparison of models has established that a major uncertainty relates to how clouds are treated. Since the models are still quite coarse (400 km), lacking the required spatial resolution, they must parameterize clouds and even cloud systems in some fashion. In many models, clouds add to the warming, but in others clouds produce a cooling effect (*HTCS*, p. 5). The situation is even more confused with respect to water vapor (WV), the most important greenhouse gas in the atmosphere, contributing more than 90 percent of the radiative forcing. In current climate models, water vapor is taken to produce a positive feedback, thereby amplifying the warming effects of a CO2 increase. Everyone agrees that a warming produced by an increase in CO2, or by any other cause, will lead to more evaporation and therefore to a higher level of atmospheric WV; however, it is the WV concentration in the upper troposphere--not in the boundary layer--that determines whether the feedback is positive or negative (*HTCS*, p. 52). On that score, opinions differ widely and probably will continue to do so until the necessary data are at hand.9 Yet until GCM climate sensitivity is validated by observations, one cannot accept the GCM predictions of large future temperature increases.

1.3.9 Impacts of Climate Change: If the climate were to change according to model predictions, one would expect to see fewer severe storms, in view of the reduced temperature gradient between the tropics and high latitudes. Model calculations do not indicate an increase of hurricanes, El Niño events, or other kinds of climate oscillations (*HTCS*, p. 75). The empirical evidence displayed in the IPCC report shows a decline in hurricanes over the last fifty years in both frequency and intensity; a future warming is not expected to affect frequency or intensity appreciably. Observations on El Niño events are not conclusive as yet.

With respect to sea-level rise, it has been assumed, conventionally, that a warming will increase the rate of rise because of the thermal expansion of ocean water and the melting of mountain glaciers. Certainly, when viewed on a millennial scale, sea level has been rising steadily, by about 120 meters (360 feet) since the peak of the last ice age, about eighteen thousand years ago. It will continue to rise at about 18 cm (7 inches) per century for another six thousand years or so, as the West Antarctic ice sheet slowly melts away; there is nothing humans can do to affect this. But when examined on a decadal scale, which is more appropriate to human intervention, this ongoing sea-level rise is found to slow during periods of temperature increases, for example, during the temperature rise from 1900 to 1940. Evidently, increased evaporation, linked to warming, followed by precipitation, results in increased accumulation of ice in the Polar Regions, thereby *lowering* sea level. This conclusion seems to be backed by direct observation of ice accumulation, as well as by some modeling studies (*HTCS*, p. 18). A future modest warming should therefore slow down, not accelerate, the ongoing rise of sea level.

1.3.10 Economic Impact of a Possible Climate Warming: Economists have recently reexamined the 1996 IPCC (Working Group III) review of economic impacts. (Some of these studies had shown large losses for agriculture but not for sea-level rise, whereas others showed the opposite.) This reexamination shows a substantial gain for agriculture and forest growth but little effect on other economic activities in the United States; it finally concludes that a warming, from whatever cause, would produce economic benefits rather than economic losses (*HTCS* p. 26).[10] Our new findings on sea-level rise (above) would reinforce this conclusion, which has not yet been widely publicized or discussed.

1.4 Conclusions

By almost any assessment, human-induced climate change over the next hundred years is likely to be much less important than other agents of global change, such as population growth, economic growth, and development of new technology. If, as has been argued here, climate change is a minor problem compared to other societal problems, then adaptation becomes the preferred option; one can then devote any resources thus saved to more urgent societal problems. It is difficult to justify major expenditures, governmental or private, for mitigation or for the control of GHG emissions that ignore other unmet human needs: improved health care, adequate nutrition, sanitary drinking water, education, and personal and public safety.

Can we predict the outcome of this struggle about the adoption of the Kyoto Protocol? If the basis were just science or economics, then Kyoto won't make it. But in a democracy, the battle will be political, which makes the outcome a little difficult to fathom, particularly since the media appear to have already chosen to accept and promote global warming fears.

The science is fairly straightforward. Even if one were to trust the model predictions of future temperature rise, Kyoto is not the way to go: too expensive and quite ineffective. If it is decided that the Climate Treaty (FCCC) calls for limits to CO2 in the atmosphere, sequestration may be the better alternative for mitigation--at least as an adjunct to the emission controls of the Kyoto Protocol. (Current research suggests that fertilizing the oceans with iron, a micronutrient, may become a cost-effective method.) But the main message from science is that we have already seen high temperatures in the historic climate record; and further, we can be fairly sure that a little warming will restrain sea-level rise--not accelerate it--and that severe storms and even hurricanes will not increase. Economics also paints a benign picture of global warming. If the latest analyses are borne out, then more warming is what we need--to increase GNP and prosperity.

Recommendation: In the absence of scientific support or any evidence that a warmer climate would on balance be harmful, and in view of the ineffectiveness and exorbitant cost of the Kyoto Protocol, it is recommended that the United States exercise Article 2 of the FCCC and withdraw from the 1992 Rio Climate Treaty. Such an action would have a sobering effect on politicians globally and allow them to focus on real world problems: avoidance of general warfare and alleviation of poverty in the developing countries.[11]

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1.5 Notes

[1] The text of the 1992 Global Climate Treaty, formally known as the Framework Convention on Climate Change (FCCC), and of the 1997 Kyoto Protocol (listing Annex-I countries and status of ratification) is available at www.unfccc.de.

[2] IPCC WG-I, J. T. Houghton et al., eds., *Climate Change 1995: The Science of Climate Change* (Cambridge, U.K.: Cambridge University Press, 1996). See SPM, p. 5.

[3] I have raised the issue in a forum article in the Transactions of the American Geophysical Union ("Unknowns about Climate Variability Render Treaty Targets Premature," *Eos* 78 [1997]: 584; *Eos* 79 [1998]: 188). The variability of the past climate is documented in references listed there. A 2002 report by a National Academy panel confirms that the warmer Holocene has a more stable climate than the recent ice age.

[4] R. Estrada, chairman, Kyoto conference, lecture at Stanford University, Center for Environmental Science and Policy, February 11, 1999. Only recently has the IPCC decided to undertake the task of defining "dangerous interference."

[5] Most of the issues entering into the scientific debate are discussed in S. Fred Singer, *Hot Talk, Cold Science: Global Warming's Unfinished Debate* (*HTCS*) (Oakland, Calif.: Independent Institute, 1997). A second edition of *HTCS* (1999) updates the scientific discussion and includes a summary of the economic impact of a hypothetical global warming.

Additional scientific points

(i) There is a striking contrast between theory and measurements. The models expect the most dramatic temperature rise at high latitudes, but scientists searching for such evidence in the Polar Regions are coming up empty-handed (J. D. Kahl et al., "Absence of Evidence for Greenhouse Warming over the Arctic Ocean in the Past 40 Years," *Nature* 361 [1993]: 335-37). Temperature records taken at the South Pole between 1957 and 1987 also show no warming (J. Sansom, "Antarctic Surface Temperature Time Series," *Journal of Climate* 2 [1989]: 1164).

(ii) A recent paper by D. Dahl-Jensen et al. ("Past Temperatures Directly from the Greenland Ice Sheet," *Science* 282 [1999]: 268-79) displays a temperature record from a Greenland ice-core borehole that clearly shows an absence of warming in the last fifty years (*HTCS* p. 74).

(iii) Another important paper is by H. Conway et al. ("Past and Future Grounding-Line Retreat of the West Antarctic Ice Sheet," *Science* 286 [1999]: 280-83); it demonstrates the continuing melting of the West Antarctic ice sheet, which is responsible for much of the sea-level rise that has been ongoing since the end of the last Ice Age, about 15,000 years ago. *HTCS* (figure 11 and the accompanying discussion on pp. 18-19) suggests that a putative global warming will slow down rather than speed up the ongoing sea-level rise as more evaporation and precipitation lead to more rapid ice accumulation on the Antarctic continent.

[6] James E. Hansen et al., "Climate Forcing in the Industrial Era" *Proceedings of the National Academy of Sciences* 95 (1998): 12753-58. The paper throws doubt on the ability of models to make predictions: "The forcing that drive long-term climate change are not known with an accuracy sufficient to define future climate change." Some supporting facts are the following:

(iv) Climate models have not yet incorporated the presumed large but poorly understood *indirect* cooling effects of sulfate aerosols (by increasing cloudiness) or the quite different optical effects of carbon soot from industrial and biomass burning and of mineral dust arising from disturbances of the land.

(v) None of the climate models incorporate the effects of a variable sun. It has always been assumed that solar variability is simply too small, but this view is now changing. Even if the radiative forcing from changes in solar irradiance is less than that from GHG, the larger variability of the sun in the ultraviolet may play a much greater role. Evidence is now forthcoming that UV-caused variations of the ozone layer or changes in solar corpuscular emissions ("solar wind") could (indirectly) influence atmospheric circulation or cloudiness--which in turn can cause significant climate changes. (*HTCS*, p. 15)

(vi) Climate models generally do not incorporate the large surface albedo changes that have come about through land-clearing for agriculture and, more recently, through reforestation in some parts of the world. Nor do the models take account of the likely climate effects of rapidly growing air traffic. (*HTCS*, p. 54)

(vii) An earlier story by Richard Kerr exposed other shortcomings of climate models: "Climate Modeling's Fudge Factor Comes under Fire," *Science* 263 (1994): 1528. He refers in particular to the need for "flux adjustments," an arbitrary correction of the energy flux between atmosphere and ocean to prevent a drift of the atmospheric temperature. One researcher stated bluntly: "The oceanographic models that are coupled to the atmospheric ones are so primitive that I have no confidence in any integration carried out for a year or two" (reported in S. Shackley et al., *Adjusting to Policy Expectations on Climate Change Modeling: An Interdisciplinary Study of Flux Adjustments in Coupled Ocean-Atmosphere General Circulation Models*. Report No. 48 [Cambridge, Mass.: MIT Joint Program on the Science and Policy of Global Change, 1999]).

(viii) Richard Kerr also interviewed a number of IPCC scientists and published their opinions in "Greenhouse Forecasting Still Cloudy," *Science* 276 (1997): 1042. See also p. 16 of *HTCS*.

7 Christy, J.R., R.W. Spencer, and W.D. Braswell, 2000: "MSU Tropospheric temperatures: Data set construction and radiosonde comparisons." *J. Atmos. Oceanic Technol*. 17,1153-1170. See also figure 9 and discussion in *HTCS* (p. 19).

8. National Research Council, *Reconciling Observations of Global Temperature Change* (Washington, D.C.: National Academy Press, January 13, 2000). The report confirms the validity of the satellite data that show no appreciable warming of the bulk of the atmosphere and of the surface data that show a strong warming of the surface in the past twenty years. The report does not resolve the disparity.

9 The book *HCST* also discusses cloud feedback and water vapor feedback uncertainties and quotes (on p. 52) from three IPCC reports that demonstrate how modelers are increasingly becoming aware of model shortcomings.

10 R. Mendelsohn and J. E. Neumann (in *The Impact of Climate Change on the United States Economy* [Cambridge, U.K.: Cambridge University Press, 1999]) led a team of twenty-three economic experts who analyzed the impact of the putative warming accompanying a doubling of CO2. Contrary to the IPCC conclusion, they found overall benefits rather than damages, with the important reversals for agricultural crops and timber resources (see pp. 18-19 of *HTCS*). Of particular relevance to economic impacts is the book by Thomas Gale Moore, *Climate of Fear: Why We Shouldn't Worry about Global Warming* (Washington, D.C.: Cato Institute, 1998).

11 S. Fred Singer. "*Climate Policy: From Rio to Kyoto --- and Beyond*" Public Policy Essay No. 102. Hoover Institution, Stanford University. June 2000.

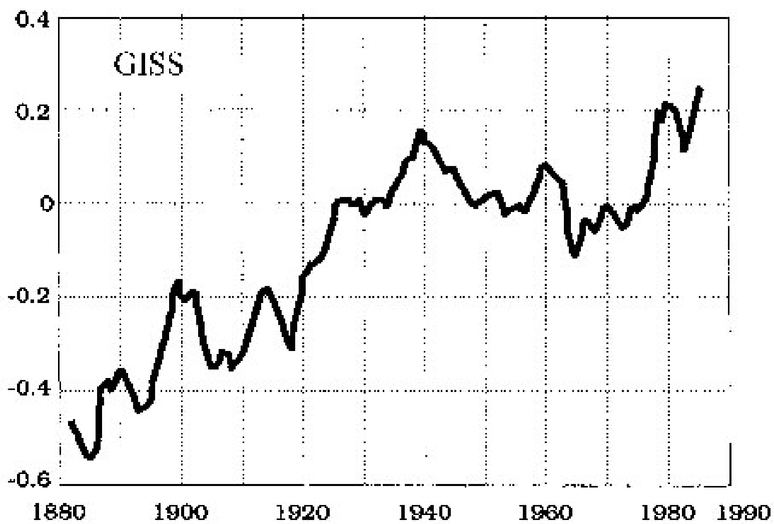

Figure 1. Changes in the global surface air temperature since 1880 (referred to the average temperature for 1951 to 1980).

Note the rapid rise up to about 1940, likely the recovery from the "Little Ice Age" that followed the "Medieval Climate Optimum." Temperatures fell till about 1975, when there was a sudden jump, tied to changes in ocean circulation and other worldwide changes. The climate record since 1979 has been in controversy, with surface observations indicating a warming while satellite and balloon-borne radiosondes showed no appreciable warming of the bulk of the atmosphere. This disparity has not yet been satisfactorily explained. See the National Research Council, *Reconciling Observations of Global Temperature Change* (Washington, D.C.: National Academy Press, 2000).

2. THE CALIFORNIA CLIMATE ACTION REGISTRY: DEVELOPMENT OF METHODOLOGIES FOR CALCULATING GREENHOUSE GAS EMISSIONS FROM ELECTRICITY GENERATION

Chris Marnay, Diane Fisher, Scott Murtishaw, Amol Phadke, Lynn Price, and Jayant Sathaye, Lawrence Berkeley National Laboratory,

2.1 Introduction

The California Climate Action Registry, which was initially established in 2000 and will begin operation in Fall 2002, is a voluntary registry for recording annual greenhouse gas (GHG) emissions (California Climate Action Registry, 2002). The purpose of the Registry is to assist California businesses and organizations in their efforts to inventory emissions and document reductions. The Registry will establish a baseline and to document early actions to increase energy efficiency and decrease GHG emissions. The State of California has committed to use its "best efforts" to ensure that entities that establish GHG emissions baselines and register their emissions will receive "appropriate consideration under any future international, federal, or state regulatory scheme relating to greenhouse gas emissions" (California Senate, 2001). Reporting of GHG emissions involves documentation of both "direct" emissions from sources that are under the entity's control and "indirect" emissions controlled by others. Electricity generated by an off-site power source is considered to be an indirect GHG emission and is required to be included in the entity's report (Arthur D. Little, Inc., 2002).

Registry participants include businesses, non-profit organizations, municipalities, state agencies, and other entities. Participants are required to register the GHG emissions of all operations in California, and are encouraged to report nationwide. For the first three years of participation, the Registry will only require the reporting of carbon dioxide (CO_2) emissions[1] although participants are encouraged to report the remaining five Kyoto Protocol greenhouse gases (CH_4, N_2O, HFCs, PFCs, and SF_6). After three years, reporting of all six Kyoto GHG emissions is required (California Climate Action Registry, 2002).

The Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) was asked to provide technical assistance to the California Energy Commission (CEC) in establishing methods for calculating average and marginal emission factors, both historic and current, as well as statewide and for sub-regions. This summary describes the results of that study which illustrated the use of three possible approaches but was not intended to be a rigorous estimation of actual emission factors (Marnay et al., 2002).

2.2 Developing Electricity Emissions Factors for California

A number of existing GHG inventories, registries, and protocols provide annual average electricity emission factors for California (CEC 1998, US EPA 1999, US DOE/US EPA 2000,

[1] While emissions are referred to as CO_2, quantities of emissions are reported in mass of equivalent carbon, where 1 kg C = 0.27 kg CO_2. We focus on CO_2 emissions since emissions of the other GHGs from utilities are comparatively negligible (U.S. EPA 2001a).

Torrie Smith Associates 2001, US EPA 2001b, US DOE/EIA 2001).[2] The reported average annual emissions factors vary significantly, from 0.037 kgC/kWh to 0.125 kgC/kWh, due not only to different reporting years but also to whether imports, exports, utility-owned out-of-state generation and non-utility generation are included. These electricity emission factors are the only factors currently available to quantify CO_2 emissions associated with electricity generation for entities within California.

The large variation in published electricity emissions factors indicates a further need to develop and compare methods that account for emissions from all sources providing power to California. Berkeley Lab developed three methods that yield not only annual statewide emissions factors but also factors for specific utility service areas (shown in Figure 1), marginal emissions factors, and seasonal emissions factors.

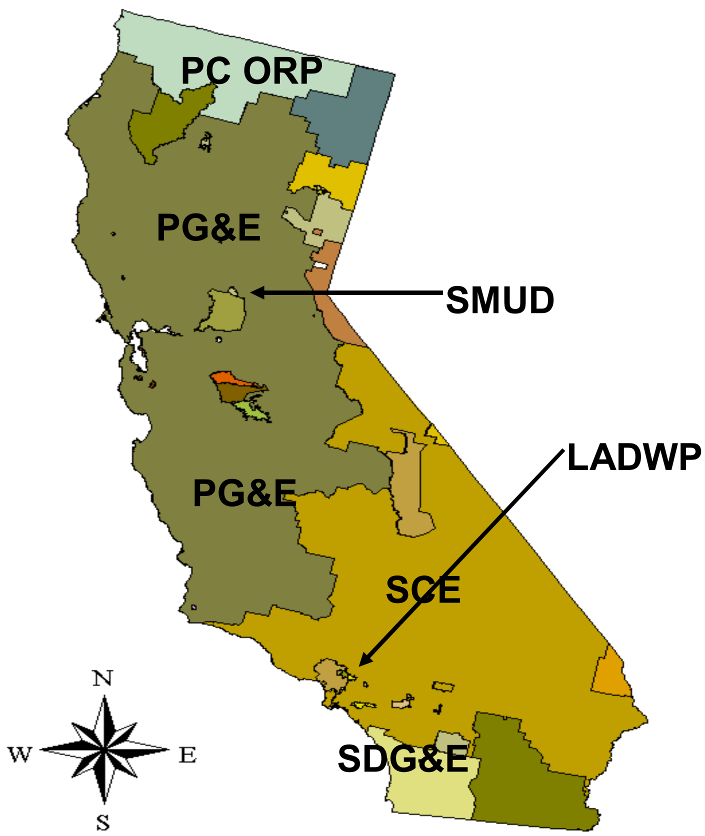

Figure 1. Major California Utility Service Areas

The overall objective of this work was to develop methodologies for estimating *average emission factors* (AEFs) and *marginal emission factors* (MEFs) that can provide an estimate of the combined net CO_2 emissions from all generating facilities that provide electricity to California consumers. The methods developed cover the historic period from 1990 to the present, with 1990 and 1999 used as test years. The factors derived take into account the location and season of consumption, direct contracts for power which may have certain atypical characteristics (e.g., specific purchases of "green" electricity from renewable resources), resource mixes of electricity providers, import and export of

[2] None of the published sources provide marginal electricity emission factors, factors for utility service districts, or monthly emission factors.

electricity from utility-owned generation sources and other sources, and electricity from cogeneration.

It is assumed that the factors developed in this way will diverge considerably from simple statewide AEF estimates based on standardized inventory estimates that use conventions inconsistent with the goals of this work. A notable example concerns the treatment of imports and exports, which despite being a significant element in California's electricity supply picture, are excluded from inventory estimates of emissions that are based on geographical boundaries of the state.

The California electricity sector has undergone significant changes since 1990, and this creates some major challenges for establishing a consistent method of estimating emission factors from 1990 on. California is a particularly challenging state for calculating emission factors for several reasons: the fuel mix is among the most diverse in the nation; a large share of California's electricity is supplied by independent power producers, much of which is from combined heat and power[3] (CHP); several California utilities own shares of generating facilities in other states; California imports much of its electricity in addition to the power it receives from these California owned out-of-state resources; and direct retail access was in effect from 1998 to 2001. Finally, specific data on non-utility generators are not available prior to 1998.

There is no practical way to identify where or how all the electricity used by a certain customer was generated, but by reviewing public sources of data the total emission burden of a customer's electricity supplier can be found and an AEF calculated. These are useful for assigning a net emission burden to a facility. In addition, MEFs for estimating the effect of changing levels of usage can be calculated. MEFs are needed because emission rates at the margin diverge from the average.[4]

2.3 Description of Three Methods for Calculating California Electricity Emissions Factors

Berkeley Lab developed three methods for calculating California electricity emissions factors. The first is an accounting method that draws primarily from public data sources (PDS). The second uses the Elfin model to simulate plant operations and estimate emissions for 1990. The third, used for the 1999 test year, is a spreadsheet that

[3] Total fuel consumption is reported by combined heat and power units on the U.S. Energy Information Administration survey forms, and several methodologies exist for determining how fuel consumption should be split between the heat and electric outputs. The approach used in this study assigned a fixed conversion efficiency of fuel input to useful thermal output and allocated the remaining fuel to electricity production.

[4] Note that this is not a *life cycle analysis*. These emission factors estimate only the emissions that take place within the boundaries of generating stations. Emissions incurred by the construction of electricity generation facilities and delivery infrastructure; by the extraction, processing, and delivery of fuels to the power plant; or by utilities' support services (e.g. office buildings and maintenance operations) are not included. Even so, transmission and distribution losses should be included for purposes of the Registry. It is recommended that Registry participants assume an average loss of 8% and divide the emission factors reported in this paper by 0.92 (A.D. Little, 2002; Marnay et al., 2002).

applies a simplified load duration curve (LDC). Table 1 compares these approaches and summarizes what is included in each approach.

Table 1. Comparison of Three Methods for Estimating Emission Factors

Method	Year	Average Emission Factors	Marginal Emission Factors	Includes Imports	Includes Exports	Includes CA-Owned Out-Of-State Generation	Excludes Specific Purchases[a]
Public Data Sources	1999	Yes	No	Yes[b]	No	Yes	Yes
Elfin Model	1990	Yes	Yes	Yes	No	Yes	N/A
Load Duration Curve	1999	Yes	Yes	Yes[b]	No	Yes	Yes/No[c]

[a] "Specific Purchases" refers to purchases of electricity by retailers for use in green power products. Generation and associated emissions for these products should be separated from the resources providing power for the general pool of grid electricity to avoid double counting.
[b] Imports are net imports. Thus, exports are not treated explicitly but are subtracted from import totals.
[c] The LDC approach could include specific purchases; however, they have not been included here due to time limitations.

2.3.1 Public Data Sources Methodology

The first approach for deriving AEFs is an accounting method that draws primarily from U.S. Energy Information Administration (EIA) reporting forms, with some supplemental information from the CEC and the Federal Energy Regulatory Commission (FERC). This method was used to estimate emissions and derive AEFs for the 1999 test year.[5] Historical data on power plant generation and fuel consumption were used to determine plant-specific emissions. These were then aggregated into emission totals for each power control area (PCA)[6] as well as for the entire state.

Emissions from CHP units were assigned using a method of deducting fuel input for heat based on a standard conversion efficiency of fuel to useful thermal output. Electricity was assumed to serve the load of the PCA where it was generated, and data on PCA generation and loads were used to estimate electricity imports.[7] The shares of generation from out-of-state plants partially owned by California utilities were also assumed to serve these utilities' loads before other imports would be purchased.

Out-of-state emissions associated with imported electricity were calculated by multiplying the quantity of imported electricity by the AEF of the region from which the electricity was assumed to originate. *Specific purchases* of electricity for green power products and the associated emissions were subtracted from the totals of the PCA in which the electricity was generated.

[5] The absence of data on non-utility generation and monthly utility loads precluded the use of the PDS approach to calculate emission factors for 1990.
[6] A power control area is defined as a grid region for which one utility controls the dispatch of electricity. Some smaller utilities are embedded in the power control areas of larger utilities.
[7] By late 1999, California's CAISO utilities had divested most of their thermal power plants to independent power producers; therefore, the relatively fixed relationship between customer load and the plant available to serve it no longer holds. For lack of precise sales data, a traditional fixed relationship is assumed in this report.

2.3.2 Elfin Model Methodology

The Elfin model was used to simulate plant operations and estimate emissions for 1990. Since the Registry allows for participants to enter data and set baselines back to 1990, it was important to test whether it is possible to derive electricity emissions factors for the early 1990s. This model was a widely used forecasting tool for California utility power systems during the 1980s and early 1990s, roughly until publication of the last biennial CEC Electricity Report for 1996. Fortunately, old data sets that were compiled and publicly scrutinized during this period are still available in the public domain and can be used to replicate historic conditions. Data sets for six electricity utility service territories were provided by CEC and all were run for 1990. Elfin has its own built-in plant and contract data for modeling emissions from cogeneration and imports. This model provides a great deal of versatility for determining emission factors. In addition to providing annual AEFs and MEFs for the state and each PCA, it can also estimate emission factors on a monthly basis as well as for other sub-periods, such as for on- and off-peak hours (CEC, 1990; CEC, 1993).

2.3.3 Load Duration Curve Methodology

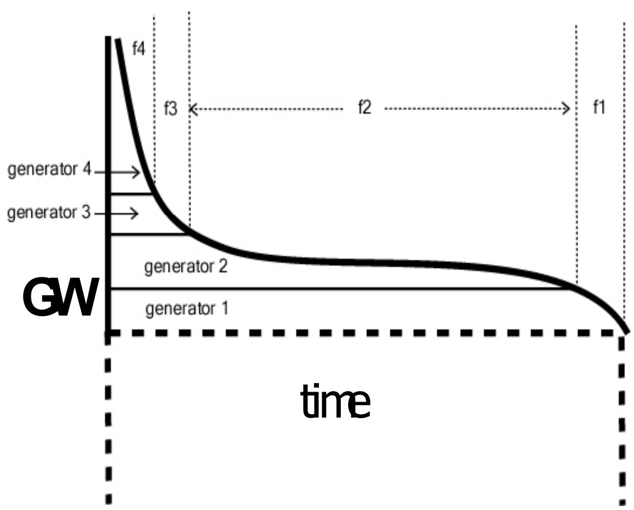

Figure 2. Schematic of LDC Method

The third methodology, used for the 1999 test year, is a spreadsheet that applies a simplified load duration curve (LDC), as many simulation models do (such as Elfin). Figure 2 shows a schematic of this method. An algorithm is used to fill the load duration curve, and determine which generators will appear on the margin. A weighted average is taken of all the marginal generators, where the weight of each plant is its time on the margin (f_1 etc, in Figure 2).

The approach uses publicly available data from the National Energy Modeling System (NEMS) input files. The LDC model provides estimates of AEFs and MEFs by an approximation of the complex plant operation algorithms of more sophisticated models. In the LDC method, plants were placed in order of probable dispatch as follows: 1) nuclear plants, 2) non-thermal imports 3) renewables such as wind, geothermal, and biomass, 4) co-generation facilities, and 5) hydro. All remaining resources (thermal, non-cogeneration facilities) were then taken in order of their historic capacity factors, highest to lowest. For the LDC model, plants were assigned to utilities as follows. Those plants which are owned directly by each utility were assigned to that utility. All other plants which were located in the PCA of any of the three ISO utilities were considered to be part of an ISO market in which all three ISO utilities would participate. Each ISO utility was assigned a share of each "ISO market" plant. The share assigned was proportional to that utility's share of the total ISO system load. Some results for the combined load of the California Independent System Operator (CAISO) are also presented. This is equivalent to treating the three CAISO utilities – Pacific Gas & Electric (PG&E), Southern California Electric (SCE), and San Diego Gas & Electric (SDG&E) as one PCA. Specific purchases have not been separated from the generation totals, but the model can be adapted to do so. Cogeneration did not require additional assumptions as the NEMS data files contain plant-specific heat rates for calculating fuel consumption for electricity generation from CHP plants.

2.4 Results: California Electricity CO2 Emissions Factors

2.4.1 Average Emissions Factors for California Electricity Production

The three approaches yield consistent annual AEFs for the four utilities (see Table 2), with the exception of SCE's AEF from the LDC method being somewhat higher than by the other two methods. The level of CO_2 associated with electricity usage varies considerably among the utilities, although it comes as no surprise that these values are lower for PG&E than for the southern California utilities. PG&E has a large share of carbon-free generation, such as hydro, nuclear, and predominantly hydro imports from the Pacific Northwest.

Table 2. Comparison of Annual Average Emissions Factors from Three Electricity Emission Factors Calculation Methods (kgC/kWh)

	1990 AEFs Using Elfin	**1999 AEFs Using LDC**	**1999 AEFs Using PDS**
LADWP	0.195	0.207	0.192
SCE	0.132	0.163	0.132
SDG&E	0.132	0.131	0.140
PG&E[a]	0.070	0.068	0.064
CAISO		0.101	
California[b]	0.110	0.105	0.108

[a] LDC and PDS results for PG&E include Sacramento Municipal Utility District (SMUD).
[b] Includes irrigation districts and municipal utilities

2.4.2 Marginal Emissions Factors for California Electricity Production

Table 3 shows that the LDC and Elfin methodologies produced divergent MEFs for SCE and SDG&E, and similar results for LADWP and PG&E. With the exception of LADWP, utility MEFs are significantly higher than the corresponding AEFs. The difference in Elfin's 1990 and LDC-derived 1999 MEFs for SCE is especially striking. The high 1999 MEF using the LDC method occurs because a large share of the gas-fired generation for this utility is from cogeneration, which is assumed not to respond to changes in the load. Thus, the load-following resources consist largely of imports from the Southwest. Since the MEFs of the PCAs other than LADWP range from 27% to over 120% greater than the corresponding AEFs, using AEFs to estimate CO_2 savings from reducing electricity usage would significantly underestimate actual savings.

Table 3. Comparison of Annual Marginal Emissions Factors from Three Electricity Emission Factors Calculation Methods[a] (kgC/kWh)

	1990 MEFs Using Elfin	1999 MEFs Using LDC	1999 MEFs Using PDS
LADWP	0.191	0.199	N/A
SCE	0.165	0.221	N/A
SDG&E	0.201	0.167	N/A
PG&E[b]	0.153	0.155	N/A
CAISO		0.193	

[a] MEFs were not calculated using the PDS methodology

[b] LDC results for PG&E include Sacramento Municipal Utility District (SMUD).

2.4.3 Seasonal Variation in Average Emissions Factors

The large share of seasonally varying hydro generation in California combined with typically hot late summer weather implies that AEFs may be higher when increased output from thermal generating sources must compensate for diminished hydro output. Conversely, as more thermal generation is used, the share of natural gas is likely to increase relative to coal, pushing down the AEF of thermal generation. Table 4 shows the AEFs calculated for May and October, months that usually have relatively high and low hydro generation, respectively. PG&E, the most hydro-dependent utility, has by far the largest variation between the two months. This occurs both because more gas-fired generation is used by this utility, and more electricity is imported from the Northwest. The decrease in hydro generation also causes the AEF of the imported power to increase, as more coal-fired electricity is used to replace the reduction in hydropower. PG&E, being the largest utility, is a large enough share of the statewide total load that the seasonal change in its resource mix significantly affects the statewide AEF. The variation in the other utilities is much less pronounced, being less influenced by differences in hydro output. This suggests that accounting for seasonal changes in resource mix, particularly for entities located in the PG&E service area, is important to accurately estimate emissions throughout the year.

Table 4. 1999 Seasonal Changes in Average Emissions Factors

	May	October	Percent

Utility	CA Generation LDC[a]	CA Generation PDS[a]	Total w/ Imports PDS	CA Generation LDC[a]	CA Generation PDS[a]	Total w/ Imports PDS	Difference Oct/May PDS Total
PG&E	0.051	0.043	0.046	0.080	0.079	0.083	79%
SCE	0.072	0.083	0.122	0.106	0.105	0.132	8%
SDG&E	0.085	0.096	0.150	0.106	0.089	0.134	-11%
LADWP	0.205	0.194	0.192	0.208	0.184	0.184	-5%
CA[a]	0.082	0.074[b]	0.098	0.113	0.103[b]	0.117[b]	19%

[a] Includes the shares of out-of-state plants owned by CA utilities.
[b] Includes only the PCAs listed in the table.

2.5 Conclusions

Using three different methods to estimate annual AEFs, MEFs, and seasonal AEFs by utility, Berkeley Lab found that using a simple annual statewide AEF could significantly under- or over-estimate an entity's emissions responsibility due to the large variation in generating resources among the utility service areas. Also, differentiating between marginal and average emissions is essential to accurately estimate the CO_2 savings from reducing electricity use. Seasonal differences in AEFs due to fluctuations in hydro generation should be accounted for at the statewide level, and particularly for the PG&E area. Overall, this study demonstrates that there are significant differences in CO_2 emissions factors from electricity generation, depending upon whether the factor represents average emissions, marginal emissions, utility service districts, and various seasons. Programs that estimate total annual CO2 emissions from electricity generation as well as programs that estimate CO_2 emissions reductions related to mitigation efforts should carefully choose the emissions factors that are used for calculating emissions from electricity. The Registry will ultimately decide whether to use one statewide AEF, AEFs for sub-areas of California, and whether to offer the option of using MEFs for use by Registry participants when calculating their electricity-related CO2 emissions.

2.6 Acknowledgements

This work was supported by the California Energy Commission (CEC) and the California Institute for Energy Efficiency (CIEE) using support from the CEC through the U.S. Department of Energy under Contract No. DE-AC03-76SF0098. This work does not necessarily represent the views of the CEC, its employees or the State of California. Publication of these research results does not imply CIEE endorsement of or agreement with these findings, nor that of any of its sponsors.

2.7 References

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3. ONTARIO POWER GENERATION'S GREEN RESPONSE PROGRAM

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Abstract

Competition in the electricity market is driving the need for generation companies to lower cost, increase output and at the same time meet strict environmental obligations. Change is probably the only constant in the new market. To help respond to the new challenges - Ontario Power Generation is working with others to develop cost effective solutions to help maintain it's leadership position in areas such as energy efficiency, emission trading, green energy, etc. For example, the emission credits from energy savings are providing greater flexibility in the operation of our fossil fleet that is worth millions of dollars because of the volatile energy prices.

One of Ontario Power Generation's successful programs was the internal energy savings program that saved over 2 billion-kWh/yr. worth over $90 million/yr. The program evolved from a corporate wide commitment to energy improvement. The principles were simple - to focus on improving energy efficiency on our side of the meter. In 1997, the benefits of the program were expanded to calculate the emission savings that resulted from fossil generation. The result was lower cost, increased production and an added bonus of improved environmental performance. Emission credits from energy savings are now registered and provide greater operating flexibility through the use of these emission credits. Emission credits from internal energy efficiency are conservatively estimated at several million dollars. The environmental credits are calculated from the reduced fossil production resulting from the energy efficiency savings. Ontario Power Generation 'retires' 10% from each transaction to ensure a net environmental benefit. See the attached site for a more completed explanation: http://www.wbcsd.org/casestud/ontario/index.htm

The 1994-2001 energy efficiency program targeted a 5% improvement in the energy used or lost in generating, transmitting or distributing energy - about 700 GWh. The target is increased to 3% annually from 2001 to 2006 and tied into the annual incentive plans. The success of the program won Canada's Industry Tier One Energy Efficiency award. As well as the US EPA award in 2002; details from respective award are available from: http://oee.nrcan.gc.ca/awards/1999.cfm
EPA's Climate Protection Award, US EPA, 2002: http://www.epa.gov
http://www.cee1.org/resrc/news/02-04mtn/ontario_power.html

The eight-year energy efficiency program demonstrates how energy efficiency can help transform assets, increase productivity and reduce waste. From the experience gained and the need to continue to evolve and improve - a best practice guide was developed to help articulate and focus efforts towards continuous improvement that will lead to best practice.

Scott Rouse joined Ontario Hydro in 1982. He is now manager of the Energy Efficiency Department, Ontario Power Generation. The group helped the nuclear, fossil and hydroelectric business units save over 2 billion kWh /yr and now worth over $85 Million per year. Energy savings are converted to 2.4 million tonnes of emission savings - CO_2, NO_x and SO_x. These emission benefits provide greater operation flexibility to the fossil fleet as well as increased revenue. Some of the earlier projects were used to create emission credits. He is a recipient of Canada's energy efficiency industrial tier one award. He has been in both the transmission and generation business units for the past 20 years. Rouse has authored papers for IEEE, CIGRE, and EPRI. He is a professional engineer in Ontario.

4. IEEE STANDARD FOR QUANTIFYING CO2 EMISSION CREDITS

Jim McConnach, Secretary and Acting Chair IEEE Working Group on Implementing Technology to Limit Climate Change, Ontario, Canada.

Commodity traders have a saying “you grade it and we’ll trade it.” The IEEE-Standards Association (IEEE-SA) has recognized the need to grade and quantify greenhouse gas emission reduction credits from initiatives and projects implemented throughout the electricity industry, end users and associated processes. The electricity industry is a major contributor (about one third) to global CO2 emissions. Therefore it makes good sense for the industry to develop and implement technology options to achieve cost effective reductions. It also makes sense for the industry to develop the standard rules for quantifying emission reduction credits from such initiatives. If the industry does not, others will, and the industry may not like the result.

Emissions Trading

The potential options to reduce emissions available to participants in different countries and companies vary greatly in magnitude and cost.

An effective tool or mechanism to achieve cost effective global reduction targets is the concept of emissions trading or transfers among participants. A simple and clear description of how an international emissions trading scheme for greenhouse gases would work is given in Reference [1]. Essentially this involves treating emission allowances and emission reduction credit units like any other commodity in the marketplace. Arrangements would then be made for them to be traded on international exchanges. The marketplace would set the value of emission credit units. These would be bought and sold by countries and companies to facilitate meeting reduction targets at lowest cost.

For this to work there must be an internationally accepted standard or a “common currency” for the measurement, quantification and certification of emission credit units. Imagine the confusion today in the market trading of electricity, if we did not have “common currency” standards for measuring and quantifying units of electrical energy.

The worldwide growth in interest in emissions trading and emissions exchanges is proceeding at a steady pace, as a few hours spent surfing the inter-net will prove. Reference [2] gives a good summary of the status of national, regional and international emissions trading initiatives as of December 2000. There have been a number of developments since then. In particular the British and Danish programs have started up. The Kyoto Protocol includes three mechanisms for the exchange and trading of emission credits. See Reference [3], articles 6, 12 and 17.

An internationally accepted standard for quantifying emission credits will be a catalyst to accelerate the development and acceptance of regional and international trading programs.

4.1 The IEEE Standards Product 1595

In August 2001, the IEEE Standards Board approved project 1595 to develop a “Standard for the Quantification of Emission Credits for Electrical Industry Processes”. The project is sponsored by the IEEE Energy Development & Power Generation Committee and will be developed by the International Practices Working Group on Implementing Technology to Limit Climate Change. The author is chair and secretary of this working group. The approved scope and purpose of project 1595 are given below.

Scope

The Standard is intended to cover the measurement and quantification of CO2 (or equivalent) reductions for emission credits in the electricity supply and demand industry, as brought about by technology applications, innovations and improvements. It will cover "cradle to grave" project life cycles in all aspects of the industry. This includes fuel chain and processing, energy conversion systems (generation); emission control systems (pre and post combustion); delivery systems (transmission and distribution); and end uses (demand side management and conservation).

Purpose

The purpose of the Standard is to establish an internationally accepted basis for measuring, evaluating and quantifying the eligible, real, measurable, verifiable, and unique reduction in CO2 emissions attributable to a specific technology project for use in emissions trading systems. The Standard will help provide an answer to the generic question: “How can one country or jurisdiction to an emissions trade be assured and satisfied that it is getting real and true value for a purchased emission credit from another country or jurisdiction?”

Benefits

The list of benefits of having standards as cited by the IEEE Standards Association is:

1. Facilitate trade and commerce
2. Create and expand markets
3. Increase competitiveness in industry
4. Foster quality in design and implementation
5. Safeguard against hazards

The emission credits standard will certainly have benefits in areas 1 to 4 and while area 5 is primarily aimed at public safety and the public interest, the standard will reduce other types of risks such as financial and commercial.

Schedule

The project approval is open until the end of 2005. However a preliminary schedule has been developed which targets the spring of 2002 for a first draft “strawman” document for review by the climate change Working Group. The fall of 2003 is the target for a final draft of the Standard to go for balloting. This is ambitious for an international standard of this complexity and magnitude, but fits well with the timing of developments in regional and international emission trading programs.

Status

As of the end of February 2002, an initial Task Force of 14 members has been formed to develop the strawman standard document. The members are from Canada, USA, UK, Europe, Australia and South America and represent major segments of the industry. A draft outline and key messages has been developed and reviewed. Work packages have been identified based on the outline and work has begun on the strawman document.

Participation

All IEEE standards development projects are open to everyone for participation and to keep informed. Openness is one of the five imperative principles of the standards process. The Task Force membership is expected to grow as the project develops.

Anyone interested in joining the Task Force to research and develop material and/or review drafts, please contact Jim McConnach at jsmcconnach@iee.org. Please note you do not have to be an IEEE member to join and you can enter and leave the process at any time. Much of the work can be done over the Internet via e-mail. However there will be a need for occasional meetings to debate and resolve key issues. Task Force members are expected to fund their own time and expenses.

4.2 Issues

There are a number of key issues, which will need full and open debate for resolution in developing such a complex and politically charged international standard. A few of these are listed below:

- Universality: This issue concerns not only the scope of the project, but aspects such as vested interests in existing domestic trading programs
- Methodology: This is likely to consume much debate, both in terms of the approach to assessments and the issue of measured versus estimated quantities. The ISO Life Cycle Assessment (LCA) approach is ideal but complex and simpler approaches will also be looked at.
- Grading: As in the case of other commodity standards, should there be a distinctive grading system of emission credits according to source, quality, technology and time frame.
- Standardization and Certification: These are generally separate activities, but certification of credits will be an inherent part of quality assurance.

The above complex issues will need to be thoroughly debated to obtain international consensus.

Other considerations in developing the standard are:

- Recognizing existing work: There is a need to avoid re-inventing the wheel as much work exists on aspects such conversion factors for CO2 equivalents of other greenhouse gases and examples of credit assessments and verification already done.
- Coordination with other standards bodies: Other standard bodies such as ISO, IEC and national bodies will be consulted to look for opportunities for coordination and synergy.

4.3 Conclusions

To facilitate international trading of greenhouse gases, there is a need for a universally accepted standard for the quantification and certification of CO2 emission credit units. This will enable them to be traded just like any other commodity and will encourage and accelerate the growth of regional and international emission trading programs.

The IEEE Standards Association have approved project 1595 for the development of such a Standard. This is a complex and ambitious task and much help will be needed from the industry and others to bring it to a timely and successful completion.

4.4 References

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[3] "Kyoto Protocol to the United Nations Framework Convention on Climate Change" A copy may be downloaded from the UNFCC web site.

Key Web sites for Further Study

UN Framework Convention on Climate Change www.unfccc.de

Intergovernmental Panel on Climate Change	www.ipcc.ch
International Emissions Trading Association	www.ieta.org
(IETA has links to National Trading Schemes and International Agency Sites)	
Intergovernmental Panel on Climate Change	www.ipcc.ch
The Science & Environmental Policy Project	www.sepp.org
PEW Center, USA	www.pewclimate.org

Jim McConnach is Principal Consultant, Castle Hill Engineering Services. After a 36-year career in the electricity supply industry in the private and public sectors, he is now an independent consultant offering training and special services to the industry. He obtained a first class honors degree in Electrical Engineering from St Andrews University, Scotland in 1964. From 1964 to 1972 he was involved in the design, development and selling of specialized power transmission equipment for a major UK manufacturer. This led to five years in international consulting in the design and planning of utility and industrial supply systems in developing countries. In 1977, McConnach joined Ontario Hydro in Toronto, Canada where his work included strategies, plans, regulatory approvals and management of special projects for T&D; fossil, nuclear and hydroelectric generation; energy efficiency; and system operations. He retired from Ontario Hydro in 2000. He is a registered Professional Engineer in Ontario, a Fellow of the IEE, UK, and a Senior Member of the IEEE. He is chair and secretary of the IEEE Working Group on Implementing Technology to Limit Climate Change.

5. THERE IS NO ENERGY CRISIS

Peter Meisen, President, Global Energy Network Institute, San Diego, CA 92101, USA

The United Nations Intergovernmental Panel on Climate Change (IPCC) has twice stated that human activity is now causing a noticeable impact on the world's climate -- primarily through the combustion of fossil fuels in the power and transportation sectors. These 2000 IPCC experts are countered by a smaller group of industry experts who disagree with the conclusions. With the measured increase in CO2 ppm over the past century, it seems that a low-regrets strategy makes good sense.

The business-as-usual future scenarios presented by the International Energy Agency assure increasing levels of greenhouse gas emissions from the utility sector. These projections recognize that energy demand has closely tracked population growth and global GNP. On the other hand, the Shell long-range planners and IIASA/UNDP have offered a radically different scenario that shows renewable energy, especially solar, becoming a major market share by 2050. For this to occur, there would necessarily be a shift in resource investment.

Several critical factors would make this possible. First, the cost of renewable energy resources must become competitive with the conventional fuels. Second, utilities and their operators must find means to provide system reliability as intermittent resources expand into the daily load mix. Lastly, the public acceptance and government commitment to address climate change will determine the rate of growth. Recent surveys indicated that a majority of people would pay more for more renewable energy, but the actual numbers of people who changed energy providers remained just a few percentage points.

Studies of the renewable resource potential indicate an enormous capacity of wind, solar, geothermal, tidal, biomass and hydropower. Several renewable technologies have matured in the past decade, and growth rates of solar and wind are now at 17% and 24% respectively. The leading companies in these two areas today are Shell, BP, Enron and Siemens -- indicating recognition by the energy providers of a growing market opportunity.

The World Energy Council describes a "window of opportunity" between now and 2020. Because of the life times of power plants, refineries and other energy investments, there is not sufficient turnover of such facilities to change course quickly. But the seeds of the post-2020 world will be sown by then. Thus, the choices we make now will determine whether climate change is solved by better technologies or remains a scientific uncertainly.

Peter Meisen is a graduate (1976) of the University of California at San Diego with an Applied Mechanics and Engineering Sciences Degree. In 1986 he founded GENI, a non-profit research educational institute to explore global solutions for sustainable development. The institute focuses on the strategy of linking high-voltage electrical networks between countries and continents, with an emphasis on tapping local and remote renewable energy resources. In 1983, Meisen co-founded SHARE (Self Help and Resource Exchange), currently the largest private, self-help food distribution program in the United States.

6. UNDP-GEF CAPACITY-BUILDING FOR RENEWABLE ENERGY MARKETS AND CLEAN ENERGY TECHNOLOGIES

Richard Hosier, Principal Technical Adviser on Climate Change, UNDP-GEF, New York

Summary: The United Nations Development Program (UNDP) supports the building of capacity for renewable and clean energy markets in developing countries. Through its Energy and Atmosphere Program, the UNDP provides policy advice and advocacy in the field of sustainable energy. Through its role as an implementing agency of the Global Environment Facility (GEF), UNDP supports projects that are intended to strengthen capacity and open markets to renewable and clean energy technology. This paper focuses on three such areas of technology focus: off-grid renewable electrification using photovoltaic panels; on-grid renewable power generation using biomass; and fuel-cell buses.

6.1 Introduction

As the largest multilateral grant-making institution in the world, the United Nations Development Program (UNDP) has offices in over 130 developing countries and countries with economies in transition. UNDP has a long history of supporting work in conventional energy exploration and development dating back to its founding over 40 years ago. Recently, UNDP has been incorporated as an implementing agency of the Global Environment Facility and has re-focused its energy work to focus on principles of sustainable energy. As such, its work increasingly focuses on providing both policy and project support for sustainable energy, including renewable energy and clean, modern energy technologies.

This paper briefly summarizes UNDP's work in the promotion of sustainable energy. After discussing briefly its policy advocacy and support work, it turns to the projects support provided by GEF through UNDP to expand the markets in developing countries for renewable energy and modern clean energy sources. In particular, the discussion briefly cites the programmatic work undertaken in 3 promising technological clusters: off-grid electrification using PV's; on-grid power generation using biomass; and sustainable transport making use of fuel-cell buses.

6.2 UNDP's Policy Support for Sustainable Energy

From 1965 to 1990, UNDP supported energy projects that were valued at $460m (in current dollars). Much of this support went to exploring and developing conventional energy resources; providing technical assistance to energy and electricity sectors; and promoting geothermal energy. Since 1995, UNDP's focus has shifted. With the publication of the UN Initiative on Sustainable Energy (UNDP, 1996), UNDP's focus has shifted to the achievement of access to and sustainability of energy services. In particular, UNDP began actively supporting policies to improve end-use efficiency; increase the utilization of renewable energy; and introduce modern clean energy technologies. Working with the World Energy Council, UNDP also took the lead in the development of the World Energy Assessment of 2000 (UNDP, UN-DESA, and WEC, 2000).

Under UNDP's Energy and Atmosphere Program, the agency provides support to all program countries in a number of concrete activities, based upon country needs and requests. The first area for support is that of capacity building and training for energy planners—helping to familiarize a new generation of professionals with the principles and practices of sustainable energy. The second area is in the field of energy sector policy regulation. In particular, UNDP is interested in working with countries to promote a "third way" in electricity sector reform. UNDP's approach acknowledges that there are many market imperfections in the electricity sector—not just that of monopoly power. Therefore, we promote power sector solutions that do not leave the solution entirely to the private sector but rather that make arrangements for compensating for other power-sector market imperfections. To do this, UNDP promotes cross-sectoral and cross-national dialogue and the sharing of "best practices" between countries. Finally, UNDP's sustainable energy program promotes technological innovation and the adoption of new, clean sources of energy. "Technological leapfrogging"--designed to give developing countries early experience with and exposure to cutting edge energy technologies-- is an important feature. One of the technologies that UNDP has focused upon and drawn attention to in recent years is the modernized use of biomass for heat and power. UNDP's Bioenergy Primer (Kartha and Larson, 2000) is an example of a guidebook developed to share "best practice" experience using this under-exploited renewable resource.

6.3 UNDP-GEF's Work to Support Renewable and Clean Energy

From its initiation in 1991, the Global Environment Facility (GEF) was established to support projects that are beneficial to the global environment in three focal areas: climate change; biodiversity; and international waters. In the climate change focal area, the GEF have devoted roughly $1.3b to projects helping countries achieve the goals of the United Nations Framework Convention on Climate Change. These funds have leveraged in perhaps an additional $10b of investment around the world through the GEF's three implementing agencies: UNDP, the World Bank, and the United Nations Environment Program (UNEP).

As the concentration of greenhouse gases (GHG's) in the atmosphere is responsible for accelerated climate change or global warming, GEF support in the climate change area is designed to reduce present and future GHG emissions (or concentrations). GEF's Operational Programs (GEF, 1997) focused initially on programs designed to improve the efficiency of energy use; to promote the adoption of renewable energy; and to invest in low-greenhouse emitting energy technologies. Since this inital focus, one additional program has been added, focusing on supporting projects in the areas of sustainable transport.

The focus within all of these programs is to acknowledge that the climate change problem requires a long-term solution. GEF money, therefore, is better spent ensuring market-based development and dissemination for these clean, low GHG emitting energy technologies than in pursuing short-term GHG emission reductions. The goal in any GEF climate change project is to identify activities that on paper, at least, are "win-win" in character—good for the global environment and good for the economy. The challenge is then to identify why these activities or investments are not being implemented of their own accord. The job of the agency, such as UNDP, is then to implement these activities designed to permanently remove the barriers to these investments taking place. In cases of new technology, where the cost of the technology itself is the barrier, the GEF may provide "incremental cost" support to promote the technology's deployment; stimulate its production; and reduce its long-term costs.

The following sections briefly summarize UNDP-GEF's experience to date in three technology areas. The first is the use of photovoltaics for off-grid electrification. The second is in the area of biomass-power use for on-grid applications. The third addresses fuel-cell buses demonstrations in key developing countries.

6.3.1 Off-Grid Renewable Electrification: Photovoltaics

With nearly 2 billion people around the world without access to modern energy services, the provision of electricity to people without prior access to it can have an enormous impact on quality of life. Photovoltaic panels can provide small amounts of electricity to rural households and enterprises where there is no connection to the electric grid. With 45 to 50 W panel systems, most households can obtain electric lighting, electricity for a radio or small television set; and possibly even sufficient power to run a small refrigerator. However, for this to be a sustainable solution in meeting the needs of all those without electric power, markets and businesses for PV systems will have to grow, flourish and multiply. The nature of the challenge is far greater than what any number of feasible, traditional government-sponsored programs can achieve—hence, the need for market-based stimulation and a focus on active replication.

Through UNDP, GEF has supported roughly $30m of PV projects in at least 8 countries. The total value of these projects—including funds from users, financiers and other sources—exceeds $70m. The preparatory analysis undertaken to prepare for these projects shows that there are informational, technological and human capacity barriers to the widespread dissemination of PV technologies. The approach adopted in these projects involves correcting the policy environment; providing training, establishing national technical standards for PV systems and components, and stimulating successful investment and business models.

A recent GEF-sponsored review of PV project experiences (Martinot, Ramankutty, and Rittner, 2000) to date has shown that the most important question in this sector concerns the business model or delivery mode by which the systems will be disseminated. PV systems can be delivered to rural users via direct sales; lease-hire arrangements; and concession or utility-type fee for service institutional arrangements. Each approach has proven to be valid under certain circumstances and each one poses different opportunities and challenges. The review of PV projects also shows that national standards are easy to establish using international guidelines and experiences, and they serve a very useful role in ensuring the quality of systems in the market. Financing the high up-front costs is essential for widespread adoption and long-term market growth beyond the small fraction of the population able to afford cash sales. Finally, the policy playing field should be levelized, to the maximum extent possible. Not only are fossil-fuel subsidies detrimental to the market-based dissemination of PV systems, but import duties and taxes imposed on PV systems and components frequently serve to make them less affordable, rather than more so. Successful cases are beginning to emerge from GEF experiences around the world, but large challenges clearly remain in bringing clean, modern energy to the world's "unpowered" masses.

6.3.2 On-Grid Renewable Electricity Generation: Biomass

Biomass includes all forms of biological matter, and is one of the most plentiful forms of renewable energy found around the world. If utilized in a sustainable manner, wherein biomass harvesting and utilization occurs at a slower rate than it regenerates, biomass energy is entirely renewable and poses zero net GHG emissions. As such, expanding its use and improving the efficiency of its use are important goals in the global war on climate change. Biomass can be used to generate steam and electric power in both grid-based electricity and steam networks as well as in remote-stand alone applications. To date, most GEF-sponsored work has focused on expanded biomass use for power generation.

UNDP-GEF has sponsored about 12 biomass projects in 10 countries, accounting for over $40m of GEF resources. The total value of these projects—including resources from all sources—comes to nearly $100m. A range of technologies and applications have served as foci, from biomass gasification and biomethanation to high pressure boilers for district heating or co-generation. The barriers to the expanded use of biomass energy identified include poor policies; limited experience managing the supply and off-take agreements; weak institutional arrangements; and financial sector limitations.

Experience to date (Hosier and Sharma, 2000) has shown that a number of biomass conversion technologies are available "off-the-shelf" for use in developing country applications. The challenge is in identifying or "engineering" the conditions that will lead to successful commercial operations and future replication. That is not to say that all biomass plants are created equal—in fact, depending upon whether the approach adopted is one of cost minimization, GHG reduction, or profit maximization, the same initial conditions can result in very different projects, technologies, and systems. Another important finding is that expanded biomass use does not always result in environmental improvement either on the fuel-supply side (viz., deforestation) or emission side. If not properly managed, biomass emissions can exacerbate existing particulate pollution problems, for example. Another finding is that the power or steam off-take contracts are essential to the project as a commercial operation—they are as important as the fuel-supply contracts. Projects will neither obtain financing nor succeed without first locking up these commercially important contracts related to the project's validity as a business. Despite biomass' attractiveness as a power option, concessionary tariffs may be necessary to stimulate the initial expansion of biomass power in a deregulating power sector—in both developed and developing countries alike.

6.3.3 Clean Energy Technologies: Fuel-Cell Bus Demonstration Program

GEF has committed itself to provide support to help bring down the long-term costs of a limited number of advanced, clean energy technologies that can have little or no GHG emissions. The rationale is that by helping pay "incremental costs" to increase the demand for these technologies, there will be an increase in their production and a decline in their costs. A small number of technologies are eligible for this type of funding (solar-thermal electric; fuel-cell buses; biomass gasification through a gas turbine engine). But as these are among the technologies identified by the Intergovernmental Panel on Climate Change has identified as being critical to their low-emission future scenarios to resolve the global warming challenge, it is hoped that timely and focused investments can have a strategically large, long-term payback.

UNDP-GEF began supporting work on fuel-cell buses with China and Brazil as far back as 1995 (Larson, Hosier, and Page, 2002). Fuel-cell buses use hydrogen to generate electricity to drive the buses and have no tailpipe emissions other than distilled water. At present, UNDP-GEF have gained approval for a set of 5 fuel-cell bus projects in Brazil, Mexico, China, Egypt, and India. This program, designed to put 46 fuel-cell buses on the road in the countries hosting the largest bus markets in the world, is focused on getting developing country markets with major air congestion problems early experience with this new and innovative technology. It is hoped that the first buses will begin to operate in 2004 in Sao Paolo and Mexico City. Buses in the other cities are hoped to begin operating shortly thereafter. Because the GHG emissions from the transport sector are the most rapidly growing sector in most developing countries, providing a technological solution can be extremely important in reducing both GHG emissions and local pollution.

Table 1. Fuel-Cell Bus Program

Country	City	Number of Buses	Expected Total GEF Contribution (all phases)
Brazil	Sao Paolo	8	$12,274,000
Mexico	Mexico City	10	$12,013,800
Egypt	Cairo	8	$11,914,000
China	Beijing Shanghai	6 6	$11,582,000
India	New Delhi	8	$11,850,000
Total		46	$59,633,800

Note: The Mexico, Egypt, China, and India projects are broken into two phases. The GEF contribution column includes the total funding for both phases.

While the projects are still in their beginning stages, the analysis undertaken to date has shown that any improvements in the system-wide GHG emissions are a function of the source of hydrogen used to fuel the buses. If the hydrogen comes from renewable sources, the improvement is significant; if it comes from fossil-fuels, it is not. In all cases, it is clear that merely changing the propulsion system of the buses will neither solve all environmental problems nor all mobility problems. Rather, the improved buses must be incorporated into a system-wide effort to dampen auto traffic, reduce other transport-sector pollution, and improve the mobility of the urban population. While solving the urban transport equation in these countries is not an easy task, it is one where the risks are large, but the potential rewards—in both economic and environmental terms--are enormous.

6.4 Preliminary Conclusions

Any conclusions drawn from this discussion can only be preliminary. But based upon experience so far, it is very important to remember that placing renewable energy investments into successful business models or “delivery modes” is a key to widespread replication. In many of these instances, the renewable energy technology is no longer a challenge—rather, the challenge has shifted to ensuring the commercial viability and replicability of the technology. For technologies that may not yet be commercially viable, the cost still poses a challenge—tracking these costs as they decline will be important to know when the right conditions for "take-off” are encountered.

Developing countries do face capacity constraints in the area of renewable energy. Training is important, as the development of human resource potential to manage and develop these technologies is an essential first step. In addition, the institutional and policy environment often requires greater clarification and strengthening to set in place the conditions for commercial replication. Finally, the investment environment and the local financial institutions that should serve as the key investors need to be examined and improved, so that these actors will see renewable energy as a new and promising line of business.

UNDP’s work in developing countries has shown that the de-regulation or rather re-regulation process need not exclude support for renewables and energy efficiency. The challenge in advising countries on their re-regulation will be to find ways to support clean, renewable energy on the newly “levelized” playing field.

UNDP's goal in this field is to promote sustainable energy development in developing countries. This means focusing on power sector reform in ways that allow for social and environmental preferences to be expressed. UNDP is advising developing-country governments on recent thinking and "best practices" in this field. Using GEF resources, UNDP is also supporting work to remove barriers to the expanded use of renewable energy and newly developed clean energy. The challenge is enormous but—in collaboration with Governments, donors, the private sector, and civil society—we are helping make a sustainable energy path viable and attractive.

6.5 References

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Dr. Hosier has published over 50 scientific publications on energy, natural resources and climate change.

7. A CLIMATE OF OPPORTUNITY: TECHNOLOGY EARLY ACTION MEASURES – INNOVATION, ECONOMIC GROWTH AND GREENHOUSE GAS REDUCTION

Wayne S. Richardson, P. Eng., Director, TEAM Operations Office, Government of Canada

Through careful analysis and very creative thinking, Canada has devised a climate change strategy that will yield business opportunities and put Canada among the world leaders on this issue. Canadian companies are poised to supply global markets for GHG-reducing solutions as we shift into an era with a new approach to energy production and use. The Government of Canada recognized that the mandate and design of a new initiative to assist companies in achieving these objectives needed to be as innovative as the projects it would fund and, with that in mind, created Technology Early Action Measures – or "TEAM". This initiative is a component of Canada's Climate Change Action Fund (CCAF) and involves partnering with industry, provinces and municipalities in Canada and internationally.

TEAM is co-chaired by three federal government departments – Natural Resources, Environment and Industry – with project delivery through existing federal technology programs. There are three categories of projects within TEAM – Industry, Community, and International. Figure 1 illustrates the broad base of the TEAM initiative.

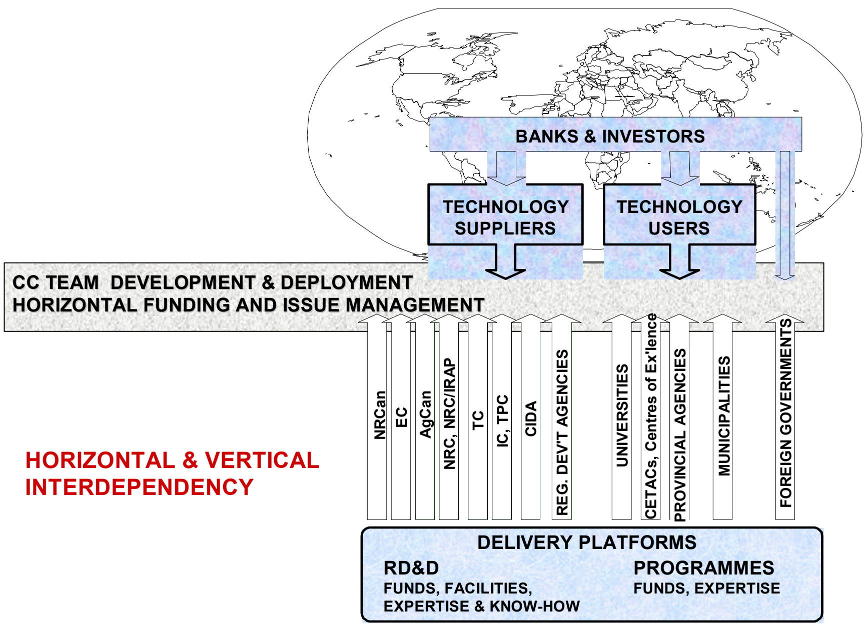


Figure 1: Why TEAM Works

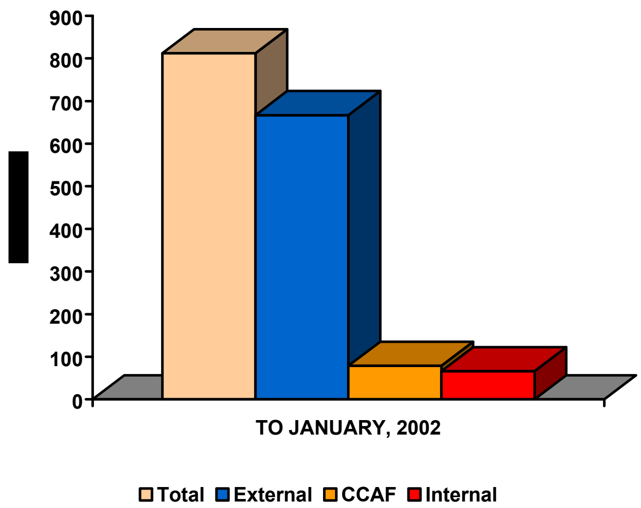


Figure 2: The TEAM Bottom Line

The mission of TEAM is to fund technology deployment and late stage development in support of early action to reduce GHG emissions, both nationally and internationally, while sustaining economic and social development. $60M over three years starting in 1998 was allocated from the CCAF, and this has been extended with $35M for an additional three years starting in fiscal 2001/2002. TEAM's original investment target was a 50/50 private sector to federal ratio with federal delivery agents covering at least 25% of the federal share.

TEAM's bottom line clearly shows tremendous success in leverage (at a rate of about 10:1) both internally through the horizontal mechanism and delivery agents, and externally with investment from the private sector and other government partners domestically and internationally.

As shown in Figure 2, the $79M TEAM resource has attracted $66M from federal partners plus $667M, primarily from the Canadian private sector but also including investments from municipal and provincial governments across Canada, as well as from foreign governments and the foreign private sector.

The 86 TEAM projects cover a broad range of sectors with a potential reduction over a ten year replication period of well over 60 megatones of CO_2 equivalent annually. These sectors include:

- Transportation--electric vehicles, intelligent control systems
- Alternative fuels--hydrogen, fuel cells, natural gas, biomass conversion
- Conventional energy production/generation--oil and gas, oil sands--electricity
- Agriculture--manure, crop residues
- Construction--cement
- Renewable energy--wind, solar, small hydro
- Food processing
- Pulp and paper
- Tool and die
- Community energy systems--residential and commercial buildings, district heating/cooling, cogeneration, energy from waste, fuel cells.

There are currently about 68 domestic and 18 international TEAM projects. TEAM's international coverage is shown in Figure 3.

Country	Project(s)
China	• Solar Photovoltaics; automated turbine controls; solar jujube, biofuel briquette drying
Romania	• Natural Gas vehicles
Pakistan	• Natural Gas auto rickshaws
Brazil	• Energy management/ efficiency
Panama	• Solar coffee drying
India	• Solar tea, coir peat, cardamon drying
Nepal	• Small hydro
Chile	• Seedling inoculation
Argentina	• Energy from waste cell
Vietnam	• Solar rice drying
Poland	• Low head hydro
United States	• PEM fuel cell • Solid oxide fuel cell
Egypt	• Landfill bioreactor, Natural Gas motorcycles
Cuba	• Hydrocarbon refrigerant

Figure 3: TEAM International Coverage

This unique set of international projects provides the opportunity to support Canada's international policy objectives to assist developing countries, as well as to develop GHG reduction technologies that can also be used at home. TEAM projects have also demonstrated the benefits of linking the business strategies and technology capabilities of Canadian companies with global business opportunities, while at the same time affording the opportunity to the government to link these opportunities with Canada's international policy objectives.

Several of the TEAM international projects have also demonstrated that the best opportunity for new technology benefits in international development requires the sharing of research, development and demonstration (RD & D) risk among business and government partners from both the developed and the developing countries. If both sides are to benefit from new technology demonstration and commercial application, then investment from both parties is essential. Traditional foreign aid and reliance on the "donor" mentality does not build a permanent capacity and base for implementing and profiting from new technologies.

A rewarding aspect of TEAM projects has been the myriad of associated environmental and health benefits resulting from the projects and their replication in the marketplace. These projects provide some key tools for a sustainable transformation in the way we live, travel, utilize natural resources and manufacture products. The "co-benefits" from GHG reduction are as important as the GHG reduction itself in achieving sustainability. Figure 4 lists some of the current and anticipated environmental and health co-benefits accruing in various sectors from efforts to reduce GHGs.

Sector	Environmental and Health Co-Benefits
Urban transportation	Smog, particulates, VOCs, toxics
Power generation	Reduced carbon based emissions
Residential	Improved indoor air quality, reduced urban emissions
Solid waste	Reduced landfill requirements, energy from waste, clean residual products
Industrial eco/energy efficiency	Reduced air and water emissions, reduced solid waste
Distributed power, cogen & reverse billing	Reduced emissions, reduced CFCs
Lumber, pulp & paper	Elimination of beehive burners
Agriculture	Reduced chemical use, air emissions, water pollution, waste generation
Oil & gas/oil sands production	Emission reductions, less land for development, huge reduction in tailings pond requirement
Concrete	Reduction of air emissions, waste product reuse
Small hydro	Reduced emissions, reforestation, fish habitat/entrainment
Water treatment	Reduction of sludges, reduced energy consumption
Food processing	Reduced energy requirements, health benefits
Aluminum production	Reduced waste, energy use, improved worker exposures

Figure 4: Current and Anticipated Environmental and Health Co-Benefits from TEAM Projects

TEAM has been very successful in shifting the commercialization yardsticks of GHG mitigation technologies from ten years or more out in the future to three years out and now. With our partners, our investments are making a wide variety of environmentally sound technologies available as policy options for government, with accompanying environmental and health co-benefits. Figure 5 provides a breakdown of a number of TEAM technologies and companies, showing project dollar values and their identified co-benefits.

Technology	Companies	Total $	TEAM $	Co-benefits
Ethanol from Agricultural Waste/Crops	Iogen, Petro Canada	$25M	$5M	Reduced transportation fuel emissions
Municipal Solid Waste Digestion	Eastern Power SUBBOR	$19M	$2.7M	Reduction of landfill, reduced emissions from power generation
Residential Advanced Integrated Mechanical Systems (eKOCOMFORT™)	Heating, Refrigeration and Air Conditioning Institute et al	$14m	$2.9	Improved indoor air quality, reduced urban air pollution
Solid Oxide Fuel Cells	Global Thermoelectric	$550K	$163K	Reduced emissions from power generation
	Siemens-Westinghouse & Kinectrics et al	$17M +$1.6M	$1.1M +$378K	

Micro-Turbine Cogeneration	Mariah Energy Systems	\$670K	\$113K	Reduced air emissions from power and heat generation

Figure 5: TEAM Projects and Co-Benefits

Selected TEAM Projects

To provide a clearer picture of the breadth of the TEAM initiative and the innovative technologies being developed with TEAM support, a number of these projects are briefly profiled below.

Stuart Energy

The Stuart Energy Systems fleet H_2 refueler technology and the small H_2 fuel appliance for the "individual" user aim to reduce the cost of hydrogen production and distribution and increase its convenience – the main keys to success in setting up a viable infrastructure for hydrogen-fuelled vehicles. Both projects will pave the way to a more widespread, global adoption of these clean modes of transport, to the benefit of the environment – and to innovation and economic growth in Canada.

The success of these projects has already resulted in an exciting joint venture with Hong Kong investors. This will serve to introduce hydrogen-based power backup to replace diesel generators in many large Hong Kong buildings over the next decade. Examples of the Stuart Energy fleet and individual H_2 fuel appliances are shown in Figure 6.

Source: Stuart Energy

Figure 6: Stuart Energy Fuel Appliances

EcoSmart Concrete

From 1995 to 2010, production of cement is expected to increase by about 40 percent, throwing an additional 600 million tonnes of CO_2 per year into the atmosphere – approximately equal to the total CO_2 emitted by all of Canada today[8]. With one tonne of carbon dioxide produced for every tonne of cement made, cement manufacture accounts for about eight percent of global emissions of GHGs.

Cement production itself represents more than 90 percent of the energy used to make concrete. Replacing cement in concrete structures with materials with lower environmental impacts could reduce these emissions, and dramatically lower GHG production. Worldwide CO_2 emissions from cement manufacturing are shown in Figure 7.

[8] Source: EcoSmart Partners

Working with EcoSmart Partners, concrete made with up to 50 percent fly ash has been successfully used in trials in several projects in Vancouver. Figure 8 is a photograph of a new rapid transit station under construction using EcoSmart concrete. Besides its environmental benefits, the new material reduces reconstruction and ongoing maintenance because it is more durable than conventional concrete, and eliminates industrial waste that would otherwise be disposed of in landfill. Moreover, it is much less expensive than the cement it replaces.

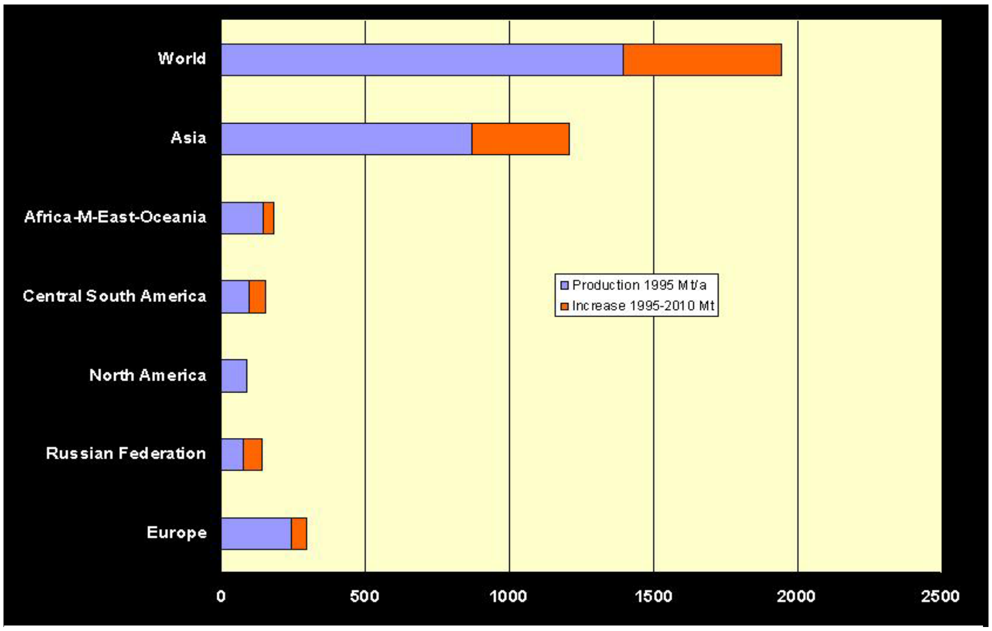


Figure 7: CO_2 Emissions from Cement Manufacturing and the EcoSmart Alternative

Source: EcoSmart Partners

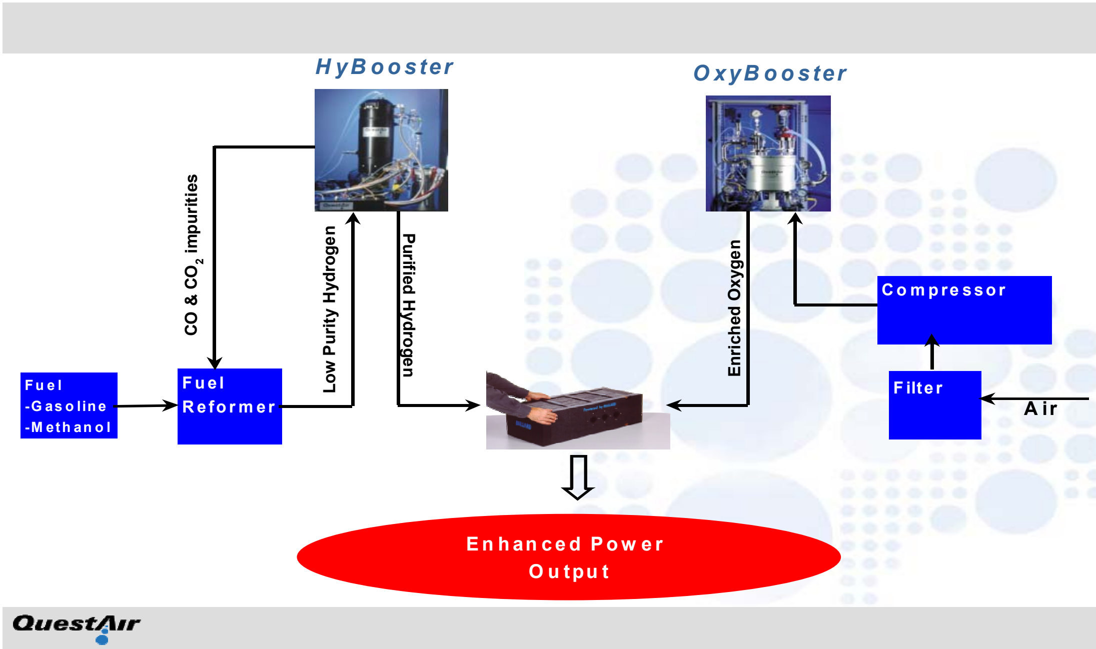
Source: EcoSmart Partners

Figure 8: Rapid Transit Station under Construction using EcoSmart Concrete

QuestAir

QuestAir has developed a more efficient and competitive fuel cell engine package that is being used in the cells produced by the leading company in the field, Ballard Power Systems. The government investment has also helped the company to design an oxygen and hydrogen purification system that will increase the operating efficiency of high-temperature fuel cell systems.

Another success has been the design and demonstration of a compact pilot plant that dramatically reduces the production costs of large volumes of oxygen. This will be valuable where the removal of nitrogen from feed air increases thermal efficiency and eliminates the generation of nitrogen oxides. Figure 9 provides an illustration of the QuestAir process.



Source: QuestAir

Figure 9: H_2 and O_2 for Fuel Cells

Dynetek

The Dynetek project with TEAM covers designing, building and testing a lightweight system that allows hydrogen to be kept at a pressure of 5,000 psi. This is 66 percent higher than existing systems and translates directly into a similar improvement to the driving range for hydrogen-fuelled vehicles. Figure 10 shows a Dynetek hydrogen tank in a Nissan fuel cell vehicle that is being demonstrated in California.

Source: Dynetek

Figure 10: Dynetek H_2 Storage at 5,000 psi

ATS Automation Tooling Systems

Automation Tooling Systems is building innovative, semi-automated assembly lines to make solar photovoltaic panels in Changshu, a city near Shanghai in China, along with test sites in China and in Canada. The factory began operation in early 2002, after which the Canada-China joint venture expects to install the panels in homes and build solar power stations in communities in China. Figure 11 shows an ATS rooftop solar PV system in Beijing, China. This project also involved the development of an automated unit for manufacture of large solar panels in Canada.

Source: ATS Automation Tooling Systems

Figure 11: ATS 10 KW Solar Photovoltaic System

System of Measurement and Reporting to TEAM – SMART

TEAM projects are required to measure and report performance and associated impacts of their technology or project. Measurement and reporting of technology and/or project performance is an important consideration for both market acceptance of new technology and the provision of a sound basis for calculation and/or verification of GHG reduction. SMART (System of Measurement And Reporting to TEAM) was developed through extensive consultation with key experts and reference to crucial documents in Canada and internationally to provide guidance to proponents and delivery agents. SMART provides the Government of Canada with a clear methodology to use as an illustration to the international community of one approach to assessing the GHG-mitigating impact of projects and technologies.

The principles underlying SMART require that the assessment:

- Is cost efficient (i.e., costs less than $30K Cdn or $20K US)
- Follows best practices
- Is practical and produces useful results
- Uses a consistent approach
- Is transparent and accurate.

There are four parties involved in every SMART review. These include:

- The proponent – provides project technical data and input to the scoping report. Proponents are permitted to self-report.
- Government delivery agent – provides contracting assistance and administrative coordination.
- Third-party GHG auditor – completes SMART.
- TEAM Operations Office – provides overall coordination, SMART guidance, checks and approvals, and receives the final report.

Companies in completing their SMART report use four templates. These include:

- Project Description and Signoff
- Project Data
- Benchmark Data
- Project Gain (Delta) and Impact.

Figure 12 provides an overview of each of the template category requirements.

Project Description and Signoff Template	**Project Data Template**	**Benchmark Data Template**	**Project Gain (Delta) and Impact Template**
Description	Production	Production	Production
Summary	Transportation	Transportation	Transportation
Signoff	Installation	Installation	Installation
	Operation	Operation	Operation
	Maintenance	Maintenance	Maintenance
	Utilization	Utilization	Utilization
	Decommissioning	Decommissioning	Decommissioning
	Human Resources	Human Resources	Human Resources
	Health & Safety	Health & Safety	Health & Safety
	Environmental	Environmental	Environmental
	GHG Intensity	GHG Intensity	GHG Gain & Impact

Figure 12: Overview of SMART Templates

Each GHG or climate SMART report clearly indicates the technical performance of the TEAM-supported technology and assures customers, investors and the public that these solutions are real and that they are working now. The SMART report indicates the total GHG reductions of the project, the GHG intensity gain, and the annualized GHG intensity gain. This is calculated using the following two equations:

Project GHG Intensity – Benchmark GHG Intensity = "Gain" of GHG Intensity

"Gain" in GHG Intensity x Project Magnitude = GHG Reductions Impact

There are many benefits accruing to the proponent from the SMART review, including:

- Credibility and leadership
- Learning and experience
- Competitive advantage
- Marketing and technology sales
- Recognized basis for GHG reduction crediting
- Enhanced government and public relations.

Figure 13 provides a breakdown of the companies currently involved with the pilot and start-up phase of the TEAM SMART Process.

Companies Currently Undergoing the SMART Process	**Companies about to Commence the SMART Process**
Mikro-tek Seedling Inoculation	Montreal Electric Vehicles
MAP™ Energy Efficient Oil Extraction Process	
Levelton HVFA RCC	
EcoSmart™ HVFA	
Cleenit Greenit Composting Process	
CAFI LFG to LNG & Industrial-Grade CO_2	
BIOX Bio-diesel	

Figure 13: Companies in the SMART Pipeline

<u>Conclusions</u>

There are a number of clear conclusions that can be drawn based on the experience with the TEAM initiative.

- TEAM has demonstrated the benefits of linking the business strategies and technology capabilities of Canadian companies with global business opportunities linked to climate change, as well as with Canada's international policy objectives to assist developing countries.
- TEAM has demonstrated that the best opportunity for new technology benefits in international development requires the sharing of RD & D risk among business and government partners from both the developed and the developing countries.
- TEAM has demonstrated the significant benefits of technology partnering with industry, provinces and municipalities in Canada and internationally.
- TEAM has demonstrated the critical relationship between successful technology demonstration and commercialization and long-term, patient RD & D that enables the short-term "reaping of the harvest".
- TEAM has demonstrated technology as a foundation for policy and the critical role of government investment in building technology capacity to address present and emerging policy issues such as climate change.
- TEAM has demonstrated that GHG reduction and economic benefits can be achieved together, along with environmental and social co-benefits.
- TEAM is pioneering with other partners in Canada and internationally to develop relatively inexpensive yet rigorous methodologies for assessing and validating new GHG reduction technologies – the TEAM SMART process.

By connecting a project-delivery distribution network across the country and by harnessing the great ideas, expertise, enthusiasm and investment of Canadian companies, TEAM has quickly developed a reputation for being agile, responsive and productive. TEAM has become a new model for service delivery by minimizing staff and maximizing the involvement of the private sector. Its current project portfolio of over $800 million includes six times more investment from the private sector and other partners than from the federal government. This level of investment demonstrates clearly that Canadian firms are taking bold steps into a future of reduced GHG emissions and that TEAM is an effective vehicle to help them get there.

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During 1997, he was Special Advisor to the Director General, Environmental Technology Advancement Directorate in Environment Canada where he provided leadership on technology funding, privatization and commercialization issues. Mr. Richardson spent 1996 as President, North American Environmental Services Inc., a consortium of Canadian companies focused on developing business in the US DOE and US DOD site remediation market. Prior to 1996, he spent 16 years in a variety of policy, regulatory and technology areas with Environment Canada. His time with the federal government followed several years in Toronto as Senior Environmental Scientist with the Ontario Environment Ministry's Great Lakes Unit, and as an engineer/planner with the Toronto Harbor Commissioners.

E N D

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