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Greenhouse gas trading credits and geothermal heat pump systems

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ABSTRACT

International agreements to limit greenhouse gas (GHG) emissions allow for trading of reduction credits to achieve an overall lowest cost to realize emissions targets. **The** Kyoto Agreement calls for different percentage reductions from a 1990 baseline for individual countries. In the United States, the State of New Jersey is developing a pilot project to generate GHG emission reduction credits. This will initially be a voluntary program in which entities will follow a protocol to document real reductions of GHG emissions and apply those credits to meet later regulations. This program will help achieve targeted reductions by allowing facilities to anticipate and take early action. Geothermal Heat Pump (GHP) systems usually result in either reduction or avoidance of some GHG emissions. However, many installations are on a small scale. This paper addresses how GHP systems can be included in a GHG trading credit program and the importance of the development of appropriate protocols for inclusion of small-scale projects.

KEYWORDS

Geothermal beat pump, carbon emissions, greenhouse gases, climate change, emission reduction trading credits

Introduction

By taking advantage of the **earth as** a source or sink for thermal **energy,** GHP systems reduce and/or avoid the release of CO_2 from electrical generating plants or conventional **fuel** burning heating systems. Their value in controlling climate change can be recognized by granting early action emissions credits which can be traded or held by the generator for **use** against eventual GHG emissions restrictions.

"Early action" refers to reductions accomplished before 2008, the time established in the Kyoto protocols for dropping GHG emissions. Unless current trends in the United States are altered, a 28% cut in carbon dioxide emissions will be needed in 2008 to reduce the level of emissions to the targeted level of 7% below the 1990 value (NORDHAUS et al. 1998) The dislocations accompanying such a massive change would stretch the limits of political and social acceptability. The purpose of an emissions reduction crediting program is to encourage prompt improvements in energy efficiency.

An emissions crediting program needs to be designed to reward and encourage good citizenship as well as fiscal prudence. Individuals as well as policy makers may be motivated by the desire to do something positive for the environment. Voluntary behavior changes have occurred in other spheres. For example, over the past fifteen years Americans have put considerable effort into separating recyclable wastes from their trash, because they believe this makes a difference. In the late 1970s, sales of ozone threatening aerosol products declined before their use was actually regulated.

The heat pump industry and government regulators have a common interest in convincing the public of its ability to have an impact on the problem of global warming. Heat pump technology, which can be applied at the household level, can provide a positive avenue for environmental good citizenship. Incorporation of this issue into a crediting program is discussed below.

Determining greenhouse gas savings associated with GHP installations - general considerations

One serious barrier to assertion of GHG reduction claims on the part of GHP installers is that, when energy savings are known, they are often expressed as electrical savings. Converting this data to determine GHG emissions avoided is not straightforward. Electricity is generated in many ways, with the most significant variable in the United States being the presence or absence of nuclear generation. The generation profile of the local utility may be available, but the utility will frequently purchase power from other utilities. Statewide average emission factors are generated for use in specific programs, such as the federal Climate Wise conservation program (UNITED STATES DEPARTMENT OF ENERGY 1997). It is important that they be updated regularly. Furthermore, a user will not be able to determine how much out-of-state power was received. Regional power pools such as the PJM (Pennsylvania-JerseyMaryland) interconnection may provide data on their generating mix.

It seems likely that future regulations will specify the use of a broad-based average value like that fiom a regional power pool. The complications described here will likely worsen because the American utility industry is undergoing a process of de-regulation; that is, conversion from a government regulated monopoly to a competitive marketplace. The American GHP industry needs to strongly support the development of clear, accurate and legally acceptable emissions factors linking electrical savings to GHG reductions.

Documentation of GHG reductions becomes even more complex when energy savings are expressed in terms of cost. Utility rates reflect peaking problems and other variables. It is possible to save money without saving energy or reducing GHG emissions.

Another way to express GHG savings is to compare them to some other source of pollution, preferably one which is familiar. It is useful to be able to say that an installation saves the same amount of carbon dioxide as taking a certain number of automobiles off the road. The public and non-technical decision makers can grasp this **type** of analogy.

Documentation of energy savings at a large GHP installation - case study

An example of detailed documentation of energy savings is provided by consideration of the Stockton College geothermal project (retrofit portion only), which with a capacity of 4900 kW_c, contains the world's largest single closed-loop well field. This project was treated as a research opportunity and monitoring was carefully planned in advance.

Data was collected during the last five months of operation of the old heating/cooling system (three months of heating season, two of cooling). Electrical use was recorded in 16 zones (about 60% of the total). Eight climate and usage related parameters were also monitored. Four of them turned out to be significant in more than one zone (daily scheduled use and occupancy, *dry* bulb outdoor temperature, and weekend vs. weekday). **The** statistical package **SAS** was used to determine significance of parameters.

Results of the pre-project monitoring were used to predict, for each of the 16 zones, the energy that would have been used **after** the new project became operational. This was compared to actual usage. These savings pertain only to the rooftop heatinglcooling units. It is necessary to subtract the energy used to pump water through the system. Gas usage savings also had to be calculated. For this, three years of monthly data was used. Regression indicated that the only significant variable was outside temperature.

Energy savings at Stockton were found to be about 1.7 MWh per year of electricity, and $1.3x10^5$ Therms per year of natural gas. Expressed in savings per kWc installed GHP cooling capacity, this is 340 kWh of electricity per kW_c and 26 T of gas per kW_c. **A** very rough attempt to calculate avoided CO_2 emissions was conducted using an emission factor. It indicates annual savings of not less than 200 kg per kW_c of installed heat pump capacity (including gas savings). This was further estimated to be the equivalent of taking 370 American automobiles out of service (SWEIKERT 1995). The engineering estimates during the design stage were ***25%*** higher than those found from monitoring.

Despite the unusual level of detail in its studies, Stockton College must still temper its claims regarding energy savings with considerable caution. Major reasons for this are the simultaneous installation of a new, computerized energy management system and significant changes in College enrollment and scheduling.

Research to improve understanding of energy savings at GHP installations

In practice, a homeowner or small businessperson will not be able to accurately determine the carbon dioxide savings associated with a heat pump installation. Research is therefore needed to determine the average electrical savings per unit of cooling capacity installed, which will vary according to climate. It is also expected that this will also vary widely by **type** of installation. A school, for example, may operate nine months a year, eight hours a day, while a health care facility would impose a far steadier load, operating day and night throughout the year.

A recent, detailed Canadian modeling study concluded that in multi-unit residential buildings and primary schools the use of GHPs reduces carbon dioxide emissions 15-77% compared to conventional construction. The range reflects the variation in climate and electrical generating mix across Canada (CANETA RESEARCH INCORPORATED 1999).

A computer modeling project is being undertaken by the Stockton Geothermal Project to determine the load profiles (energy **use** per month) typical of GHP installations in New Jersey such as office buildings, schools and health care facilities. This is being done using the Axcess computer model for building energy studies, running data for existing *or* planned buildings with two or more energy supply configurations. The goal is to he able to say that, for example, an office building in southern New Jersey saves about **200** kg of carbon dioxide per year per kWc of installed heat pump capacity. Regulators need to consider GHG reductions based on this **type** of engineering calculation, rather than requiring monitoring or detailed modeling at every facility.

The results of Axcess computer modeling for seven GHF' applications are given in table 1 expressed as quantity of carbon dioxide avoided per unit of installed cooling capacity. The calculation of GHG avoidance for schools is particularly important because in the United States decisions about school construction are made at the lowest level of government, the municipality. Elected school board members, reflecting community values, want to know about the environmental consequences of their decisions, hut they are not technically trained and information must be provided in an understandable form.

When characteristic load profiles and energy savings projections are available, it will behoove the GHF' industry to be sure their clients, however small, apply for and receive the emissions reduction credits to which they are entitled. Even a credit which (if traded or sold) will never be worth more than a few dollars may be valued by a homeowner who conscientiously installed an energy efficient heat pump. The value of "bragging rights" should not be overlooked as a motivator.

Table 1: Carbon di ide emissions avoided per unit of installed cooling capacity

Project type	Size (m^2)	GHP capacity (kW_c)	avoided emissions (kg/kW_c) per year
Commercial office building - 1	517	88	156 - 255
Commercial office building - 2	15630	1755	86 - 111
College housing - 10 month use	2286	105	75 - 91
College housing - 12 month use	2286	105	167 - 198
College classroom building - 1	1791	263	63 - 87
College classroom building - 2	7509	1053	51 - 73
Elderly care facility	5390	632	120 - 144

Open market emissions trading of volatile organic chemicals (VOC) and oxides of nitrogen (NOx) in New Jersey

In the United States, several states including New Jersey are in the process of developing GHG emissions crediting programs. Because of the large size of the federal bureaucracy, environmental programs are often initiated by one or more states before federal action. The most striking example of this was California's automobile emissions standards, which not only came first but also were more stringent than those eventually adopted nationwide. New Jersey had a program for cleaning up abandoned contaminated sites before the federal Superfund program (Comprehensive Environmental Response, Cleanup and Liability Act) was started.

The process now underway in New Jersey to create a GHG emissions trading program has included participation by industrial and citizen groups in an Advisory Board which meets regularly to review and refine concepts to be included in the trading program. When drafted, the regulations will be published for more formal public review before adoption. It is crucial for the GHP industry to involve itself at every stage **of** regulatory development.

New Jersey policy makers expect to model their program on that state's Open Market Emissions Trading (OMET) program, which has been in effect since August of 1996. Under certain circumstances, a factory operator who wants to increase emissions of an air pollutant must purchase credits earned by an operator who accomplished and documented a corresponding decrease (NJAC 1996).

The OMET program applies only to nitrogen oxides and volatile organic chemicals, the precursors of photochemical smog. *An* emissions reduction of **45** kg is defined as one DER, or discrete emission reduction. A DER may be generated in a variety **of** ways - by lowering emissions below a baseline emission rate, by controlling fugitive emissions, by reformatting motor vehicle fuel or by implementation of conservation measures. Measuring emissions against a baseline requires five years of data, two of which are designated by the generator as "most representative **of** normal source operation". A reduction may not be claimed if there is a related increase in emissions from another source. During a brief period after promulgation of this regulation, generators were permitted to file for reductions generated back to 1992.

DERs are claimed by submission of certification to a Registry created by the New Jersey Department of Environmental Protection and maintained by a professional data management service, the Mosakin Corporation located in Mattawan, New Jersey. Before a DER may be traded, it must be "verified" by a licensed Professional Engineer or Certified Public Accountant. The lack of inspection or review by the Department **of** Environmental Protection is an obvious weak point of this program. A comprehensive audit scheduled for 1999 should answer questions about the validity of emissions reduction claims. To date thirty two companies have claimed or purchased DERs, as well as two brokerage firms (OMET Internet Web site 1999).

The major motivation for development of this emissions trading program was to permit the industries which release the compounds in question to achieve reductions as economically as possible (WILLINGER 1999). Nonetheless, to ensure continuing environmental improvement, at the time of use all DERs are discounted by 10%. At present, use or consumption of DERs is very stringently regulated, resulting in a build-up of "banked" emissions reductions. Nitrogen oxide credits are being banked about ten times faster than they are being used, and those for VOCs are accumulating even faster. The Department of Environmental Protection plans to increase the market for credits by creating other uses for them, for example use in lieu of fine payment when deadlines (for stack testing, for instance) are not met. Prices paid for transferred DERs must be reported. In 1998, the average price per DER of nitrogen oxides was **$54** during the ozone season (May through September) and **$40** the rest of the year. The average price for VOCs was $132 during the ozone season and $147 the remainder of the year (OMET Internet Web site 1999).

Extension of OMET-NJ to carbon dioxide

As the adaptation of the open market emissions trading approach to GHGs has been attempted, certain difficulties have emerged. When considering modifications to an existing operation, at what level **of** operation should energy savings be measured? If installation of a *GHP* saves a certain amount of energy in one part of a facility, should a GHG reduction be claimed? Or must the whole product line show a net decrease? The entire factory? Or all the facilities owned by that corporation in the state of New Jersey? Limiting credit claims to large entities such as an entire manufacturing plant has anti-growth implications which are not inherent in the state and national effort to control GHG emissions. The real improvement seen through one specific and inherently desirable change might be masked by an increase in economic output. Another complication arises from weather-related energy savings, which should not be rewarded with GHG credits. A technique to adjust baselines according to weather has not yet been defined.

The unit of measurement for carbon dioxide reduction (corresponding to the DER described above) has not yet been defmed. The ton is often used in the United States. In view of the small size of household GHPs (10-18 kW_c), it would be desirable to adopt a unit which does not make the improvement associated with a domestic installation sound vanishingly small.

A monetary value cannot be assigned for avoided carbon dioxide emissions, because no market for emissions "credits" currently exists. It is possible to offer some suggestion as to value by considering how utility company subsidies (in the form of payments after completion of a GHP installation) have effected installation of GHPs in the United States. These subsidies (which have ranged fiom about \$30/kW_c to \$270/kW_c) decidedly stimulated the American rate of GHP installation. As indicated above, GHP projects in the US typically avoid 75-200 kg/kW_c. Therefore the utility "paid" a little over one dollar, on average, for each kilogram of carbon dioxide avoided. It may then be assumed that a value of \$1/kg would be sufficient to motivate businesses to reduce CO_2 emissions in order to claim credits. That is, the market will be influenced if emissions credits are worth \$1/kg or more.

This may be put in perspective by comparing it with another, flashier energy saving technology, the zero-emission automobile. A true zero-emission auto in the United States would save about 1900 liters of petrol per year, which corresponds to an avoidance of about 2500 kg of carbon dioxide per year. Using the value derived above, the car would generate \$2500 in credits per year. The shorter life expectancy of the car (versus a GHP) must be taken into account, so a GHP carbon dioxide credit would have a longer term impact on reducing emissions than a comparable automobile generated credit. From this we can realize that GHP systems are a current technology that has potential for carbon emission reduction that is more valuable than a true zero-emission automobile which costs \$2500 more than its traditional counterpart.

Emissions credits and new installations

The OMET program does not offer a model for crediting emissions avoided by innovative systems installed at new facilities. It is important to structure incentives to encourage new construction of the highest possible efficiency. At the worst, improper regulatory structure could encourage the intentional building of maximally polluting but legal installations by operators wanting to be sure they will be able to make some relatively easy improvements in the year 2008 when GHG caps are eventually imposed. One approach would be to extend the definition of facility or entity to include all operations under one ownership. When an older, more polluting operation is shut down and replaced by something more efficient, the owner could claim the difference as an emission reduction.

Another option is to evaluate an innovative energy efficient installation by comparing it to a theoretical "conventional" system that could also legally be constructed. Mathematical modeling would reveal the energy savings accrued. Credits might be granted on a declining basis, with full credit for the first year of operation and reduction by a given percentage each subsequent year. Credit would be completely phased out after a few years. It would he hoped that the innovative system, by that time, would have become standard in the industry in question.

Some interested parties argue that no emissions reduction credit should be granted for any type of new construction, because reduction is the aim of an emissions credit policy. The implications of this approach need to be explored. Industrial infrastructure is always being retired and replaced, and economic growth remains an accepted goal. Incentives need to be created so these activities are accomplished as cleanly as possible. This should be one part of an early actions emission crediting program.

Conclusion: the role of the GHP industry in policy development

The voluntary emissions credit banking and trading programs which will dominate the period before the imposition of mandatory caps (2008) are being developed now, and the geothermal heat pump industry needs to play an active role in these deliberations. Geothermal heat pump installations are often relatively small, but their potential contribution towards the control of greenhouse gases is large, and should be recognized by state and national policy.

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