The Role of Legislative Processes and Electric Utilities in Effecting Global Environmental Goals

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(ABSTRACT)

Electricity generation in the world is growing at a rapid rate. Growing at an equally proportional rate are the amounts of electric power plant-induced greenhouse gas and acid rain causing emissions which are being spewed into the air. Developed countries are to blame for most of the anthropogenic global warming gases which have already accumulated in the atmosphere. Developing countries, however, which are facing periods of large population and industrial growth, are predicted to produce the majority of electricity-generated-emissions in the foreseeable future, between 2000 and 2010. More and more power generation capacity will be necessary in these countries to facilitate the industrialization necessary to improve the standard of living of their citizens. While these countries are now planning for the infrastructure to accompany this growth, little attention is being given to the global environment and to the technologies which have become available to control power plant emissions. This is due largely to the high capital costs of abatement technologies and unconventional power generation options, and to the lack of

policy in these developing countries requiring that new generating capacity be GHG-neutral as much as possible. Most developed countries have been able to set some guidelines for achievable levels of local and global emissions through such policies. Achievable limits, however, are bounded by many constraints, including the culture of a region, its political orientation, and its socio-economic status.

The author contends that given the proper political climate and flexibility, any country can attain some level of environmental-friendliness in its power generating capacity mix. In support of this claim, the author addresses some of the many variables included in controlling global emissions due to electric power generation through legislative processes. Policies in certain countries which have achieved some level of success with emissions control are studied. The unique nature of attempting to implement similar programs in developing countries is also discussed. Finally, the role electric utilities can play in achieving global environmental goals is examined. Software tools are included to assist utility planners, policymakers, and financial institutions with environmental analysis of power generation projects.

Dedicated to the loving memory of

my paternal grandmother, Frances Rhymer,

my uncle, Eugene Mack,

and

my high school classmate and family friend, Dexter Maduro,

who passed away during my pursuit of this degree.

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List of Abbreviations

ADB - Asian Development Bank

BACT- Best Available Control Technology

BTU -British thermal unit

CAAA - Clean Air Act Amendment

CCAP - Climate Change Action Plan

CCP - Climate Challenge Program

CFC - Chlorofluorocarbons

$CFCl_3$ - F-11 refrigerant

CF_2Cl_2 - F-12 refrigerant

CFL - compact fluorescent lamp

CH_4 - methane

CO - carbon monoxide

CO_2 - carbon dioxide

DOE - US Department of Energy

DSM - demand side management

EPA - Environmental Protection Agency

EPAct - US Energy Policy Act of 1992

FCCC - Framework Convention on Climate Change

FGD - flue gas desulfurization

FIP - Federal Implementation Plan

GEF - Global Environment Facility

GHG - greenhouse gas

GWP - global warming potential

IRP - integrated resource planning

IUEP - International Utility Efficiency Partnership

JI - Joint Implementation

kWh - kilowatt-hour (10E3)

LAERT- Lowest Achievable Emissions Control Technology

MT -- metric ton

MONTREAL PROTOCOL - 1987 Montreal Protocol on Substances that Deplete the Ozone Layer

N_2O - nitrous oxide

NAAQS - National Ambient Air Quality Standards

NMP - non-Montreal Protocol

NO_x - nitrogen oxides

NSPS - New Source Performance Standards

O_3 - ozone

OECD - Organization for Economic and Co-operative Development

ppB - parts per billion

ppM - parts per million

PUHCA - Public Utilities Holding Company Act of 1935

PURPA - Public Utilities Regulatory Policy Act of 1978

PV - photovoltaic

RACT - Reasonably Available Control Technology

R&D - research and development

SO_2 - sulfur dioxide

SIP - State Implementation Plan

STIG - steam injected gasifier plant

T&D - transmission and distribution

TWh -- terawatt-hour (10E12)

USIJI - United States Initiative on Joint Implementation

UV - ultraviolet

WB - World Bank

1.0 Introduction

The depletion of the stratospheric ozone layer surrounding the earth, and the global warming phenomenon that may result from the atmosphere's breakdown are posing a grave threat to the earth's climate. Scientists have predicted that by the year 2075, the temperature of the earth's surface will have risen by as much as 3° C (plus or minus 1.5°) unless precautions are taken to limit the amounts of anthropogenic global warming or greenhouse gases emitted into the atmosphere [1].

Greenhouse gas (GHG) is the term given to a molecule which resides in the atmosphere and absorbs certain wavelengths of infrared (thermal) radiation [1]. These wavelengths are naturally absorbed by the carbon dioxide (CO_2) and water vapor that help to make up the atmosphere. As this heat is absorbed, some is reradiated to earth, helping to maintain the temperature of the surface. When GHGs are released into the atmosphere, they absorb and reradiate an unnaturally large amount of infrared radiation. As a result, the natural flow of infrared radiation to and from the earth is disturbed. More heat is trapped below the atmosphere than would occur naturally, producing a greenhouse effect. GHGs include CO_2, nitrous oxide (N_2O), methane (CH_4), and carbon monoxide (CO). Table 1 lists previous and projected atmospheric concentrations of selected GHGs. Note that from 1880 - 2030, CO_2 concentrations in the atmosphere almost double. Most of this projected increase will occur in the 40 years between 1989 and 2030.

Table 1: Statistics of Selected Greenhouse and Ozone Depleting Gases [1]

GAS	Sources	Emissions(million tons/year)	Atmospheric Lifetime (years)
CO_2	Fossil fuels, Deforestation	5500	100
Methane	Rice fields, cattle, landfills, hydroelectric plants	300-400	10
Nitrogen Oxides	Fertilizers, deforestation	15	170
CFCs	Aerosol sprays, refrigerants	1	70-100

GAS	1880 Concentrations	1989 Concentrations	Projected 2030 Concentrations
CO_2	290 ppM	350 ppM	400-550 ppM
Methane	900 ppB	1700 ppB	2200-2500 ppB
Nitrogen Oxides	285 ppB	310 ppB	340 ppB
CFCs	0	3 chlorine atoms	4-6 chlorine atoms

ppM - parts per million

ppB - parts per billion

Also of concern to the environment in the past several years has been the release of regional pollutants from power plants, particularly those that are known to contribute to acid rain. Sulfur and nitrous oxides are the main contributors to acid rain, which has been shown to be detrimental to many aspects of the local environment which it affects [2]. Man-made buildings and monuments have suffered defacement and erosion because of the acid content in precipitation. Lakes have "died" when their plant and animals could no longer sustain the low pH levels introduced to their ecosystems.

Recent research has shown that when present in the atmosphere, SO_2 reflects incoming solar radiation back to space [41]. This results in a cooling effect, which opposes the greenhouse effect [41]. However, emitting more SO_2 into the atmosphere is not an acceptable solution to the global warming problem for several reasons [42]. First, SO_2 has only a few days to a few weeks lifetime in the atmosphere as compared to the 100 year lifetime of CO_2. Second, whereas GHGs produce a continual warming effect, SO_2 only cools in the presence of sunlight. Finally, the short lifetime of SO_2 in the atmosphere results in uneven concentrations over certain areas. As it cools in these areas, the global warming effects in other areas (flooding, droughts, sea level rise) will still be felt. Therefore, increased SO_2 concentrations in the atmosphere would not be an effective deterrent against climate change. Additionally, such an increase would also increase societal costs due to the following: acid rain damage, visibility limitations resulting from more haze, restricted plant growth resulting from blocked sunlight due to increased cloud formation, and less rain due to the restriction of its release from clouds. Studies are underway to determine the exact cooling potential of SO_2 and other sulfates.

Since the initial discovery of the hole in the ozone layer over Antarctica in 1985, several countries have taken steps to limit the effect that their industrial practices have on the environment [43]. The ozone hole is the term used to describe the seasonal losses in the stratospheric ozone layer (between 15 and 45 km above the earth) above Antarctica. The ozone hole recurs annually in the southern hemisphere's winter months. Ozone absorbs ultraviolet (UV) light in the stratosphere. This absorption regulates the heat that penetrates the atmosphere, helping to sustain the earth's climate and its ecological cycles. It also prevents excess UV radiation from reaching the earth. Without this screen, there would be much higher rates of skin cancer and cataracts, and damage to the human immune system would occur.

Chlorofluorocarbons (CFCs) are mostly responsible for the ozone hole [5]. Their release into the atmosphere is strictly anthropogenic, due to their use as refrigerants and in aerosol spray cans. CFCs cause the ozone hole by decomposing ozone molecules, O_3, in the atmosphere. When exposed to ultraviolet radiation at 200 nanometers, which can be found at an altitude of 40 kilometers, organic compounds containing chlorine decompose to form chlorine atoms. Chlorine and CFCs, including $CFCl_3$ (F-11 refrigerant) and CF_2Cl_2 (F-12 refrigerant), act as catalysts in this reaction. That is, they accelerate the rate of decomposition of O_3 molecules without being used up. This process is shown below for $CFCl_3$.

Catalytic Decomposition	$CFCl_3 \rightarrow CFCl_2 + Cl$
	$Cl + O_3 \rightarrow ClO + O_2$
	$ClO + O \rightarrow Cl + O_2$
Overall Reaction	$O_3 + O \rightarrow 2O_2$ [5]

The overall reaction would occur naturally at a very slow rate due to direct collision between O and O_3 [1,5]. During catalytic decomposition, one $CFCl_3$ molecule releases one Cl atom which in turn, bonds with one of the oxygens from an O_3 molecule and breaks it down. The ClO created then goes on to bond with a stray oxygen molecule, forming

$Cl + O_2$. This newly formed Cl atom can now bond with another O_3 molecule and repeat the process for the lifetime of the atom. Thus, the presence of Cl in the ozone layer speeds up and multiplies the breakdown of ozone. One CFC molecule can remain in the atmosphere for as long as a century (see

Table 1).

On the ground, ozone is a major component of photochemical smog, created when nitrogen dioxide is exposed to light at ~ 392 nanometer wavelength [5, 40]. Ozone molecules then react with organic compounds in the air whose products can cause eye irritation. By itself, ozone on the ground decreases visibility by scattering and absorbing light, it breaks down organic materials such as rubber and paint, it decreases production of certain types of vegetation and it can cause respiratory problems in humans at certain concentrations.

In order to combat high global emissions levels, many developed countries have imposed legislative restrictions on the amounts of harmful pollutants their industries are allowed to produce. The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol), discussed throughout this thesis, requires the complete phase out of CFCs in the signing countries.

Banning the use of CFCs is an important step in sustaining the ozone layer, but may not be enough to prevent global warming. GHG emissions must also be limited to reduce anthropogenic effects on natural gaseous cycles, which will help to preserve the climatic balance. Electric power plants and other industries are now being targeted for emissions restricting legislation since their emissions are quantifiable and their origins are easier to trace than emissions from non-stationary sources, such as transport vehicles.

While certain countries have taken measures to restrict their emissions, others have not. The reasons for this are twofold. The first reason for inaction is the lack of technological alternatives. Fossil fuel generation accounts for more than 60% of the electricity generation worldwide [3]. In many countries, fossil fuels are plentiful, accessible, and provide cheap electricity. While some products of fossil fuel combustion can be contained or reduced through emission abatement technologies, other products pose a more difficult challenge. For example, a cost effective solution to eradicate CO_2 emissions created by burning fossil-fuels in power plants is yet to be found.

The second reason some countries have opted not to restrict emissions is that economic and social development rank higher on their list of priorities than the global environment. This school of thought is found mainly in developing countries, whose governments prefer to spend money on problems that directly affect their society and their standard of living than on improving power generation techniques. This is easily understood, since the governments in these countries are attempting to raise the population's quality of life to the very same level that citizens in developed countries have been enjoying for years.

For countries which are willing to take the proper steps, a balance can be found between socio-economic development and preservation of the environment, a process called sustainable development. Some type of legislative process must be incorporated into the emissions control problem in these countries, so that programs are properly designed and enforced. When the cost to the environment is considered with the entire life cycle cost of unconventional power generation techniques and emission control technologies, it can be shown that the cost of emissions control is not as obtrusive as it would be otherwise. Through technology exchanges and financial assistance from developed countries and international organizations, developing countries may yet be able to achieve that well-sought balance.

2.0 The Need for Global Emissions Controls for Power Plants

2.1 World-wide Power Plant Emissions

World-wide electric power generating capacity is on the increase. As the standard of living in nations around the world rises, as population growth occurs, and as new technology surfaces, more electricity will be needed to sustain such development. In 1991, world electricity generation was 12,080 terawatt-hours (TWh). This showed an average annual growth rate of 3.6 % between the years of 1981-1991. It is projected that in 1995, 2000, and 2005, the world will require 13,503, 16,020, and 19,134 TWh of electricity, respectively [3].

Over the years, several international organizations have begun to observe such growth trends out of concern for the global environment [4]. One of these organizations, the Organization for Economic Co-operation and Development (OECD), was established in part to promote international sustainable development practices. The OECD consists of the member countries of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

OECD countries generated most of the world's electricity in 1991 (Figure 1). Based on predictions, this trend will continue until at least the year 2000, as shown in Figure 2 and Figure 3. However, as developing countries become more developed and their demand for electricity increases, it is projected that by 2005 non-OECD countries will generate the majority of the electricity in the world (Figure 4) [3].

Figure 5 illustrates 1991 power plant related emissions world-wide. Although according to the above trends non-OECD countries will not actually produce more electricity than OECD countries until 2005, it is thought that beginning as early as 1995, SO_2 emissions in these countries will rise above those in OECD countries. By 2000, CO_2, sulfur dioxide (SO_2), and NO_x (includes nitrogen dioxide and nitric oxide) emissions from electricity production in non-OECD countries could overtake like emissions in OECD countries, as illustrated in Figure 6 [3]. This would occur because OECD countries are taking steps now to limit the adverse effects their power generation techniques have on the environment. If allowed to grow unbounded, emissions by non-OECD countries will counteract the benefits to the global environment that emissions limits in other countries will have made. Damage to the region's environment will also result.

2.2 Effect of Power Plant Emissions on the Environment

When discussing the effects power plants have on the environment, a distinction between the local and global environment must be made. For the purposes of this thesis, the local environment is defined as the region which is affected by the geographically-

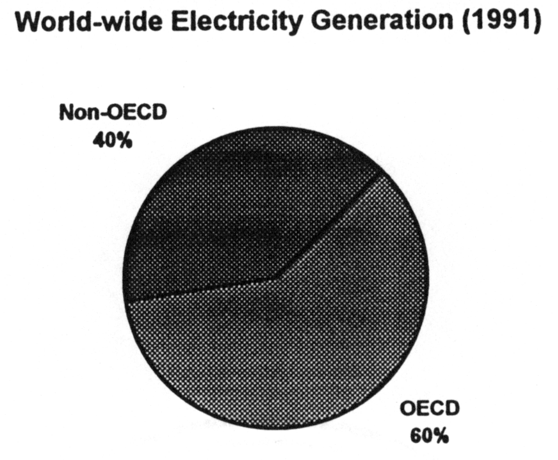

Figure 1: World-wide Electricity Generation in 1991 [3,4]

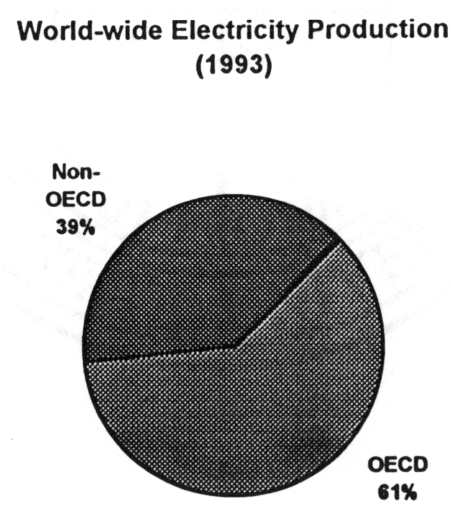

Figure 2: World-wide Electricity Generation in 1993 [44]

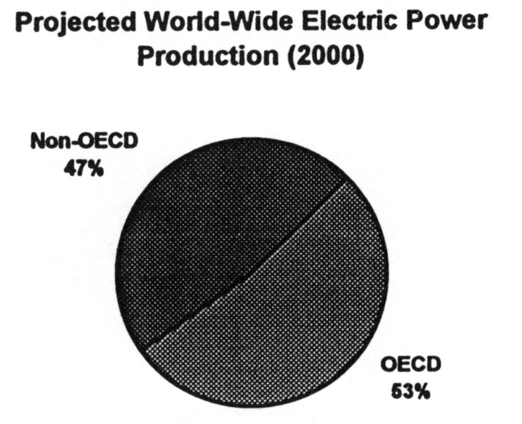

Figure 3: Projected World-wide Electricity Generation in 2000 [3]

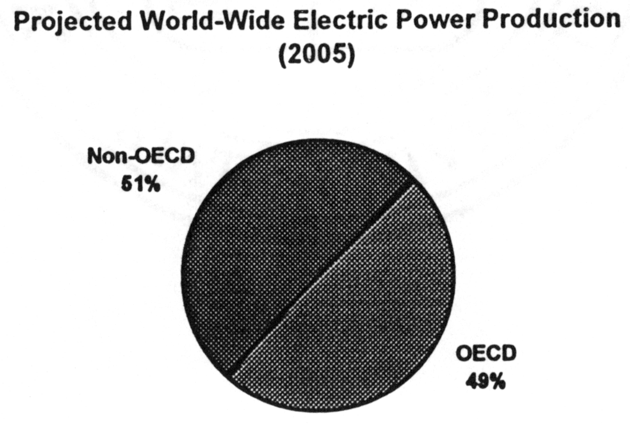

Figure 4: Projected World-wide Electricity Generation for 2005 [3]

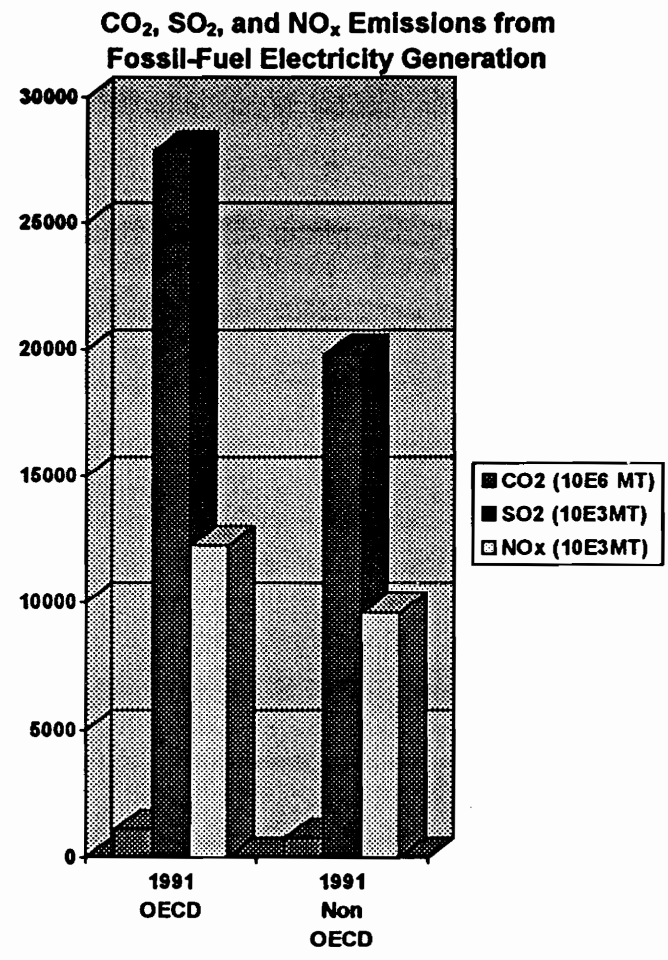

Figure 5: CO_2, SO_2, and NO_x Emissions from Fossil-fuel Generated Electricity for 1991 [3,4]

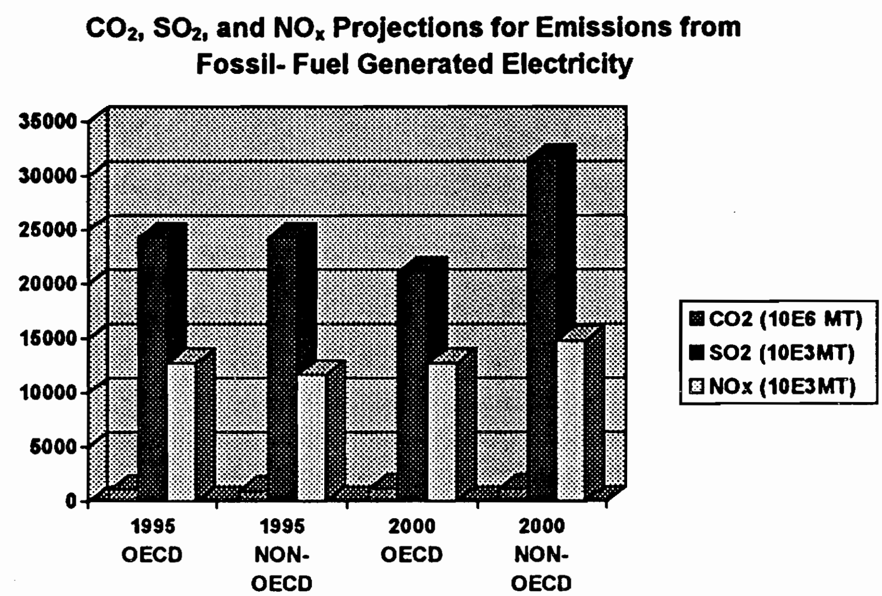

Figure 6: Projected CO_2, SO_2, and NO_x Emissions from Fossil-fuel Generated Electricity for 1995 and 2000 [3]

restricted effects of a single power source. Such effects include acid precipitation, fog, ice, flooding, and electromagnetic interference, among others. SO_2 and NO_x are power plant emissions which affect the local environment via the formation of acid precipitation [2]. Aside from particulate emissions, waste heat from thermal power plants stimulates local fog and ice formation.

The global environment is, simply, the entire earth. The term global power plant emissions refers to all byproducts of electricity generation which will ultimately become dispersed throughout the entire world. This distribution occurs within the atmosphere and is easiest understood using the analogy of a chemical solution or a homogeneous mixture [5]. Picture the atmosphere as a glass of water at room temperature and emissions particles as the individual crystals in a pinch of sugar being added to the water. Although the sugar is only added to the water at the top of the glass, eventually it will dissolve and become distributed throughout the entire glass, so that its point of introduction into the glass is indistinguishable. Greenhouse gases emitted by power plants, specifically CO_2 and N_2O, are distributed throughout the atmosphere in a similar manner, although they may change form in the process by bonding with oxygen. Therefore, regardless of the location of the source, the entire world will be affected by CO_2 and N_2O emissions from individual power plants.

2.3 Emissions and Political Boundaries

Global environmental goals for power plant emissions can only be met through local commitment to emissions control. We cannot confine global, or even local emissions to political boundaries. Therefore, emissions control practices in one country, or lack thereof, can affect not just that country, but its political neighbors and the entire world as well.

One example of the effect acid rain has had on neighboring countries is the Japanese experience. Just 15% of Japan's electricity is generated by coal [6], whereas that number is 36% world-wide [3]. In addition, strict environmental standards require the Japanese power industry to restrict acid rain emissions from the coal that they do burn. Yet such efforts to decrease the acid content of rain over Japan has proven unsuccessful. Studies have shown that Japan's close neighbors, China and South Korea, are collectively responsible for 65% of Japan's acid rain [6].

A country's choice of power generation technology dictates the extent to which changes to the local and global environment will occur as a result of its practices. For instance, a conventional coal-fired, steam turbine power plant with no emission abatement technologies installed, will emit CO_2, SO_2, and NO_x. This plant will affect both the global and local environment. On the other hand, the operation of a windfarm will affect its immediate surroundings by producing electromagnetic interference, audible noise, and undesirable visual effects, yet it will have no effect on the global environment.

Virtually all power generation technologies will have some type of environmental trade-off. Thus, the key for a sustained global environment is for each country to balance these trade-offs in an attempt to find feasible, cost-effective methods of producing bulk electricity.

2.4 A Global Emission Control Commitment

With the guidance of international organizations such as the United Nations and the OECD, several member countries have made a commitment to control their GHG emissions [7]. The United Nations Framework Convention on Climate Change (FCCC) [7] is a legally binding agreement between participating countries to take some form of action to control their nationally produced global emissions. Under the agreement, Annex I countries[1] shall establish policies and take the necessary measures required to return CO_2 and other GHGs not controlled by the Montreal Protocol to their 1990 levels. The agreement, which went into effect in March 1994, requires the signing countries to report semi-annually on their progress and projected progress towards these ends. The FCCC does not specify emission control strategies that these countries must conform to. Instead, it leaves room for specific courses of actions to be decided upon by the individual countries in accordance with their achievable limits of emissions control.

Achievable limits of emissions control for a country are determined by several factors, including its socio-economic position, its population, its physical area, and its

[1] Annex I countries include the European Union, countries transitioning to market economies (mostly former Soviet Union republics), and all OECD countries except Mexico.

geography, among many others, all of which differ from country to country [7, 45]. The intent of the FCCC was to generate a commitment from each country toward some self-determined goal, based upon these variables. Given this flexibility, countries have adopted a variety of different goals. The European Union, a conglomeration of the European contingent of the OECD, has a regional goal to reduce CO_2 emissions to 1990 levels by 2000. Higher CO_2 emissions in some of its member countries will be offset by lower CO_2 emissions in other member countries.[2] Most countries have opted to stabilize, reduce, or limit growth of CO_2 emissions to 1990 or earlier levels by 2000. Some countries, such as Austria, Denmark, and Germany have adopted base years earlier than 1990, thus have listed 2005 as their commitment year. Countries chose either to reduce CO_2 only or all GHGs, whether to reduce emissions in all sectors or the energy sector only, and whether to reduce net (including sinks) or gross emissions. Table 2 lists FCCC commitments in selected countries. Table 3 shows estimated progress in several countries towards achieving FCCC goals as reported during the first conference held under the FCCC in March, 1995. Only five of the 15 countries which reported project that they will achieve 1990 levels.

[2] This is a form of bubble policy. Under the CAAA of 1990, utilities can apply this technique to several units in their system.

Table 2: FCCC Commitments in Selected Countries [11]

Country	Gases Included	Sectors Included	Action	Base Year	Commit Year	Net or Gross Emissions	Conditions/ Comments
Australia	NMP GHGs	All	Stabilization 20% reduction	1988 1988	2000 2005	Not specified	Plans conditional on similar action by other countries
Canada	NMP GHGs	All	Stabilization	1990	2000	Net	Stabilize GWP of combined gases
Denmark	CO_2	All	20% reduction	1988	2005	Not specified	Transportation sector: stabilize by 2005, 25% reduction by 2030
France	CO_2	Energy	Per capita stabilization	------	2000	Net	Stabilize emissions at below 2 metric tons C per capita per year
Germany	CO_2	Energy	25-30% reduction	1987	2005	Gross	Reduce GWP of total GHGs by 50% of 1987 levels by 2005
Japan	CO_2	All	Per capita stabilization	1990	2000	Gross	Stabilize total CO_2 emissions beyond 2000 at 1990 levels
New Zealand	CO_2	All	Per capita stabilization	1990	2000	Net	Reduce CO_2 by 20% of 1990 levels by 2000
Switzerland	CO_2	Energy	Stabilization Reduction	1990 1990	2000 post 2000	Gross	--------------
United Kingdom	CO_2, major GHGs	All	Stabilization	1990	2000	Gross	Gas-by-gas approach, specific targets are set for different gases
United States	All GHGs	All	Stabilization	1990	2000	Net	Stabilize GWP of combined gases

NMP - Substances not controlled under the Montreal Protocol GWP - global warming potential

Table 3: CO_2 Emissions Projected for the Year 2000 in National Reports [45]

Country	*CO_2 Emissions (E6 tons)*	*% Change from 1990 Levels**
Australia	336	16.3
Austria	66	9.8
Canada	510	10.6
Czechoslovakia	136	-17.2
Denmark	54	-7.9
Germany	890**	-13.7
Holland	168	-3.7
Japan	1200	2.3
New Zealand	30	15.7
Norway	40	11.6
Spain	277	24.1
Sweden	64	4.1
Switzerland	44	-3.5
United Kingdom	587	0
United States	5,163	3.0

* "0" -- 1990 levels will be exactly met in 2000
"+" -- 2000 levels will be that percent above 1990 levels
"-" -- 2000 levels will be that percent below 1990 levels
** Figures are projected for 2005

Within these countries, the most effective means to ensure widespread action on global environmental reform is through legislative initiatives. Individual industry commitment to conform is not enough to ensure compliance with international agreements. Because there are so many polluting sectors in a country, from transportation to commercial to industry, no one sector can be held solely responsible for the region's pollution problem. It is unlikely that any individual or sector would voluntarily incur the costs of the technology enhancements which would be necessary to combat their own emissions, especially if there is no guarantee that others would do the same. In addition, mass cooperation is required in order for the cumulative effects of emission controls to be felt. Therefore, emissions limits must be set and some means of monitoring emissions must be established as a method of maintaining accountability for emissions. If the proper processes are in place in a given country, the legislative approach can be taken to define and monitor progress towards its global environmental goals.

3.0 Review of Climate Change Policies in Selected Countries

The use of policymaking to promote alternative uses to fossil fuels for power generation began in the early 1970's in several countries. Ironically, this was not done out of concern for the environment, but rather out of concern for supply. The 1973 oil crisis stirred concern in many countries that were dependent upon oil imports for electric power generation. Subsequently, many countries began to explore alternatives to fossil fuel generation in order to decrease their dependency on such imports and unreplenishable supplies. In the 1990's, while countries are not as concerned that the influx of oil may cease or that fuel reserves will be depleted, policy has shifted towards finding alternative methods to conventional power generation because of the environmental effects of burning fossil fuels.

This chapter examines the effects of policy on the power sector in three countries: Denmark, France, and the United States. The achievable limits of emission control for each of these countries, set during the FCCC, are discussed. The extent to which these goals are actually met is dependent upon the effectiveness of the policies these countries have established.

3.1 Denmark

Before the 1973 oil crisis, Denmark was a major oil importer. After the country was greatly affected by the crisis, it aggressively promoted other power generation options through implementing policies to pursue alternate means of generation. Dependence upon imported oil was reduced by energy conservation programs, development of indigenous oil, natural gas and renewables, and by switching from oil to coal as the primary fuel for electric power generation [7,8].

The Danish government became dedicated to environmental reform in the 1990's. Post-1973, although the country's dependence on oil imports was reduced, the proportion of CO_2 produced by power plants to electricity generation increased due to the switch from oil to coal as the primary fuel for electricity generation. Energi 2000, Denmark's new energy policy, was voted upon and enacted in 1990. Energi 2000 includes provisions for further development of wind power and more research into solar and biomass energies in an effort to reduce global emissions. According to McGowan [8], in 1991 about 3% of Denmark's total electricity generating capacity, or 273 MW, was produced by windmills. By the year 2000, that number is expected to be 10% [9]. The country is even attempting to produce wind power offshore to decrease the local environmental effects of wind generation, which include visual effects as well as the effects of audible and electromagnetic noise [9]. In the near future, the country expects to add 450 MW of biomass fueled capacity [8]. When combined with replanting, the combustion of biomass has no net effect on the global environment [10].

The Danish program has had high success with its renewable program due to its implementation of high energy taxes on fossil fuels. High taxes on electricity have slowed growth in power demand, further reducing local and global power plant emissions. In addition to the strides Denmark has already made, when signing the FCCC agreement in 1992, it estimated that through the year 2005, it can reduce gross energy consumption by almost 15%, CO_2 emissions by almost 30%, SO_2 emissions by about 60%, and NO_x emissions by 50%. These percentages are relative to the respective 1988 levels [7].

Denmark expects to meet the goals outlined in the FCCC through legislation tailored to: 1) improve end-use energy efficiency and conservation, 2) enhance efficiency in energy supply, 3) increase use of environmentally benign energy sources, and 4) promote research and development. The Danish Parliament also included a CO_2 tax in its plan as partial incentive to decrease such emissions [7].

McGowan [8] suggests that the barrier of politics is the most important to surmount in the case of renewables. The Danish energy policy program is an example of how politics, legislation in particular, can incite progress towards environmental reform by making provisions for the use of renewables.

3.2 France

Like Denmark, France was able to significantly reduce its power plant emissions beginning in the early 1980's. France accomplished this by implementing an energy policy which heavily promoted nuclear power and energy efficiency [7]. As a result, by 1991, the country's CO_2 emissions due to energy transformation (including power plants, heat plants, and refineries) were almost half what they were in 1980, despite growth in population and higher electricity generation every year.

Although France has already significantly reduced its CO_2 emissions over 1980 levels, the country has dedicated itself to decreasing such emissions to below 0.54 tons of carbon equivalent (two tons of CO_2) per capita per year by 2000 (France's energy related CO_2 emissions per capita were 1.85 tons of carbon equivalent in 1991). The country intends to achieve these goals by imposing thermal efficiency regulations on buildings, promoting wood-burning furnaces for space heating in buildings, expanding its public transportation, establishing GHG reduction programs for GHG intensive industries, labeling energy consumption of products in new housing, and possibly imposing a tax on the carbon content of fossil fuels [11].

France's commitment to the goals outlined above is contingent upon the establishment of similar goals in other industrialized countries [7]. Since GHGs affect the global environment, France would like to ensure that all countries that are economically able to control their global power plant emissions contribute their fair share. The country recognizes that a global emission control commitment is necessary in order to achieve significant results.

3.3 The United States

In 1991, the United States was by far the largest emitter of power plant-generated CO_2 in the world (599 million metric tons of carbon equivalent). Per capita, this number was 3.37 tons of carbon, also the largest in the world [3]. In keeping with international goals for GHG stabilization and reduction, the US had initially agreed to stabilize net GHG emissions at 1990 levels by 2000[3] [11]. It has now been determined that this target will be missed, but efforts to stabilize are continuing (see Table 3). Two policy instruments have begun to work towards achieving these results.

In 1992, the US signed into law the Energy Policy Act (EPAct), which was designed to meet the country's energy objectives sustainably. In October of 1993, the Climate Change Action Plan (CCAP) was enacted to work with the EPAct in achieving the specific goals outlined in the FCCC [12].

The US energy policy objectives include suppressing growth in electricity demand, protecting the environment, and reducing oil imports. These objectives will be met by the implementation of several strategies including improved energy efficiency, promotion and development of renewable energy sources and new technologies, increasing natural gas markets, and reducing GHG emissions [12]. Figure 7 illustrates how the emission control strategies are related to the policy objectives in the context of electric power generation.

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[3] Net emissions include GHGs absorbed by natural sinks, for example, CO_2 absorption by trees.

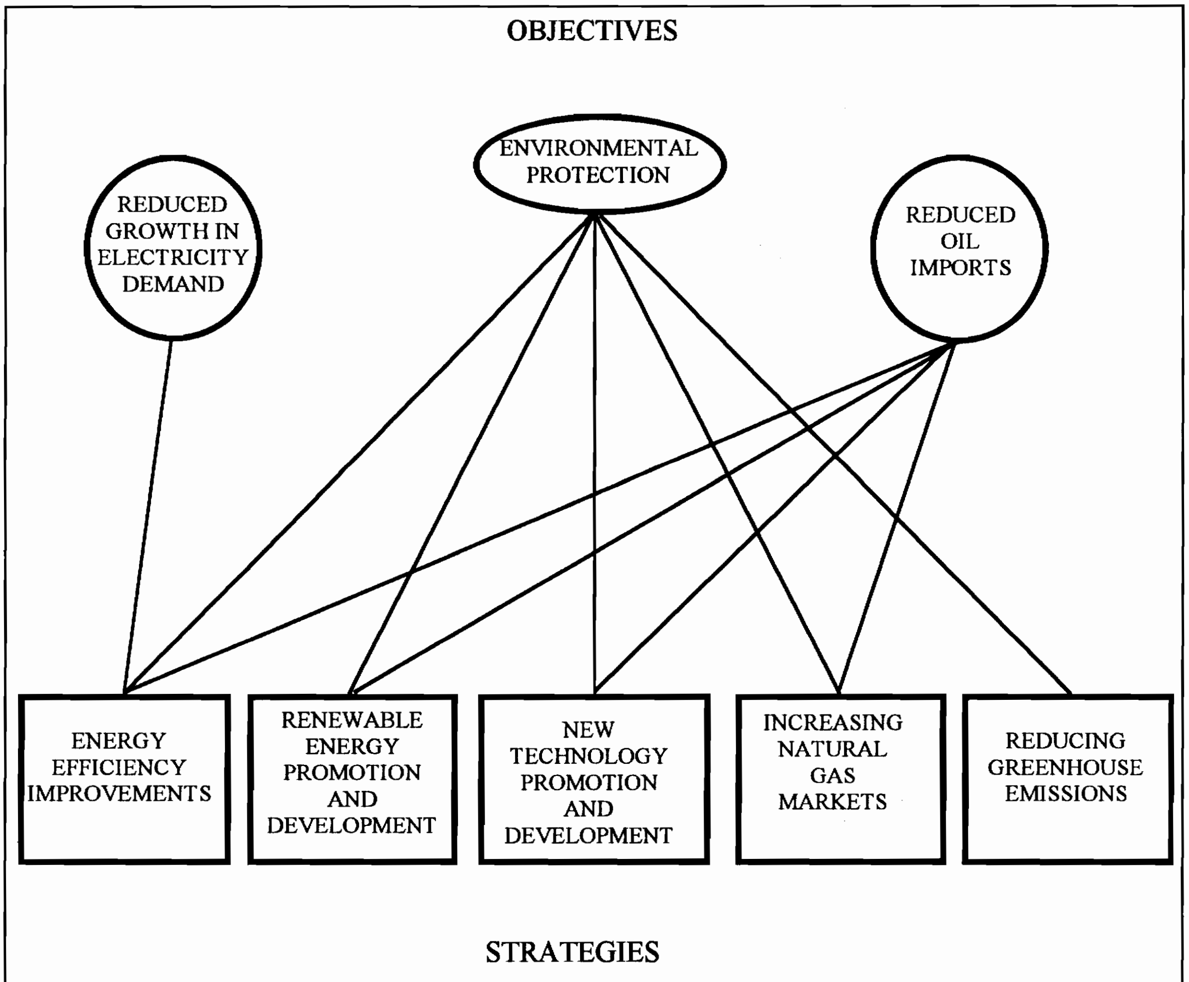

Figure 7: US Energy Policy Objectives and Related Emissions Control Strategies [12]

3.3.1 Reduced Growth in Electricity Demand

Under the provisions included in the EPAct, reduced growth in electricity demand will be accomplished mostly by energy efficiency improvements. The EPAct has set a goal to increase overall US energy efficiency by 30% over 1988 levels by 2010 [12]. Several programs which have been established or expanded through the CCAP to encourage use of energy efficient equipment are presently being implemented by the Department of Energy (DOE) and the Environmental Protection Agency (EPA). One example of such programs is the Golden Carrot program through which the two agencies will work with utilities and manufacturers to commercialize more energy efficient products [12].

In addition, the EPAct requires state utility commissions to consider adopting incentives for their utilities to implement integrated resource planning (IRP) before adding new capacity [12]. IRP is a planning approach which weighs all factors involved in serving load requirements and meeting customer demands. On the supply side this includes options for generating, transmitting, and distributing power. Demand-side management (DSM) is incorporated on the demand side to control customer load at different times during the day [14]. On today's agenda, the challenge of IRP is to find the least cost, least emission path to fulfilling these goals.

3.3.2 Environmental Protection

All strategies outlined in the EPAct will serve to protect the environment. Improvements in energy efficiency will reduce electricity demand, thereby saving capacity.

Lower capacity requirements translate into less fossil fuels being burnt to generate power. The emissions that would otherwise have resulted from burning fossil fuels will be avoided due to these capacity savings.

Increased renewable energy promotion and development will lead to more installed electricity-generating capacity from these environmentally benign sources. The EPAct has established tax incentives for renewable energy sources in an effort to increase their production by 75% over 1988 levels by 2010 [12].

Natural gas fired plants emit significantly less CO_2 than coal or oil plants. In addition, new technologies are being developed to reduce emissions from fossil-fired plants, such as clean coal technologies and methods of scrubbing or sequestering CO_2 emissions. Reduction in GHG emissions from power plants, accomplished via the above measures and others, will serve to reduce the effect of US power plants on the global environment.

3.3.3 Reduced Oil Imports

Reduction in oil imports would require a reduction of US consumption of oil. To successfully accomplish this, the country would have to find alternate methods of supplying its energy needs that are presently met by oil. One strategy to accomplish this is by reducing the need for oil supply through energy efficiency. This can be achieved by reducing demand via energy efficient appliances and equipment. Energy efficiency improvements can also be achieved on the supply side. One such example is the combined cycle plant. In such a plant, a combustion turbine cycle is combined with a steam turbine cycle to attain greater plant operation efficiency. The exhaust heat from the gas combustion turbine is fed into a heat recovery steam generator which produces steam. The steam is then used to turn the steam turbine and generate electricity [13].

Dependency on oil for electricity generation can further be reduced through low- or no-GHG emission sources such as natural gas fired plants and renewable energy sources. New technology which provides supply side and demand side energy efficiency improvements, resulting in capacity savings, will also reduce the country's need to import oil.

4.0 Effective Emissions Control Through Legislative Processes

As the reviews in chapter 3 showed, the establishment of policies can be an effective tool in controlling a country's global emissions. This chapter will highlight the necessary conditions for legislative processes to be effective in reducing power plant emissions.

4.1 General Steps to Forming Legislation[4]

Legislatures, or lawmaking bodies, are institutions in which elected representatives of a nation congregate to discuss the establishment or ratification of laws and policies [14]. Most legislatures in large democracies throughout the world are bicameral, consisting of two houses, such as the House of Representatives and the Senate of the United States. The following are steps which legislatures typically follow when establishing laws.

I. Request for specific legislation in the form of a bill

II. Lobbying

III. Committee assignment and recommendation

IV. Floor Action

V. Consideration in second house (bicameral legislatures)

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[4] Unless otherwise noted, section 4.1 is drawn exclusively from reference 15.

VI. Final Passage

4.1.1 Request for Legislation

A request for specific legislation usually comes from individuals or groups who have a special interest in having a law passed. This request is made in the form of a bill, a carefully drafted document which discusses specific details of the prospective law. The bill is submitted to one house (the sponsoring or originating house) along with documents or other supporting evidence which exemplify the need for the law.

4.1.2 Lobbying

Lobbying is the process whereby non-legislators help pass a bill by explaining its merits to legislators and the public. Lobbying is a critical step in the legislative process since it provides visibility to the bill. When the public is aware of a bill and shows support for it, legislators are more likely to give the bill careful consideration. Often, public advertising campaigns are begun to solicit the support of the public. Without an external push by visible sponsors, an individual bill could very easily get laid over to another session or killed altogether due to the sheer volume of bills which must be considered with each legislative session.

4.1.3 Committee Assignment

The houses in a legislature are broken down into committees to divide responsibility. Bills are assigned to a committee in the originating house for initial consideration before being introduced to the floor of the house where the general body is present. Committees research bills and make recommendations to the general body. Of benefit to a bill would be a committee assignment in which the skills of the committee members match the skills required to give due consideration to the bill.

A subcommittee may be established to take testimony, develop compromises, and redraft a bill so that it is more complete when resubmitted to the full committee and the floor. Once the subcommittee resubmits a bill to the committee, the committee can return the bill to the subcommittee for additional testimony, polishing, amending, or so that conflicts with existing laws can be worked around; it can pigeonhole the bill; or it can recommend it to the floor.

4.1.4 Floor Action

If a committee recommends a bill to the floor of the house, it is confirmed by the floor and becomes an official action of the house. At this point, the bill has surmounted a major obstacle of the legislative process since it can now receive the consideration of all the elected officials of the sponsoring house, and hopefully, both houses (the committee has the power to keep any proposal away from the floor). The floor then votes on the bill and passes or defeats it by majority rule.

4.1.5 Bicameral Legislatures

In a bicameral legislature, once a bill has passed in one house, it must also pass in the other house. The second house may accept the bill as it is written or it may amend it, then pass it. If amended, the originating house must vote on the amended bill. If the bill passes, it is sent to the executive for approval. If the amended bill does not pass in the originating house, a conference committee is formed to resolve the conflicts. The conference committee consists of members from each house, including bill authors and the original committee members. Once the task of the conference committee is completed, the bill is resubmitted to the originating floor and the procedure is reiterated.

4.1.6 Final Passage

The result of a bill which is introduced to the floor will be passage or defeat by majority rule. If defeated, the bill can be reconsidered once for a short period and voted upon again. During this period, lobbyists and bill sponsors try to obtain votes in their favor from other legislators. If passed, the bill is signed into a law which must be implemented. Legislatures generally have the power to delegate these responsibilities to appropriate government agencies.

4.2 Molding Legislation to Meet Treaty Obligations -- The US Process

Under international law, a treaty is defined as any legally binding agreement between nations [16]. There are two methods by which the United States can enter into treaty as it is defined by international law, by executive agreement, requiring only the signature of the president, and through advising with the Senate, who must then give two thirds consent before the treaty can be ratified [16]. A treaty is not presented before both houses of Congress unless it requires implementing legislation, in which case, the treaty does not become US law until such legislation is passed [16].

This facet of US government raises interesting questions as to Congress' obligation to implement legislation to fulfill a treaty that is already a matter of international law [16]. The slow nature of the US legislative process does not allow time for pending treaties to be implemented or even considered as domestic law prior to ratification. Although the president can seek Senate advise and consent, the large size of the Senate, the different interests of all involved, and the time required for Senate members to approve any agreements placed before them prohibits him from doing so. Therefore, legislators are faced with having to implement legislation for treaties they had no say in and may not agree with.

The possible resulting lack of congressional support for treaties may doom them before they are even assigned to committee. Although Congress may feel obligated to implement *some* laws to save America's face, they may be reluctant to pass the laws the President requests, or to give the programs adequate funding [16]. Also, Congress could take its time in drafting and passing legislation. Such half-hearted program implementation may undermine both the benefit of the treaty internationally and the success of the US in meeting its treaty commitments.

Even if legislators are in support of a treaty placed before them, again, the nature of the US system may make it difficult for legislation that fulfills all aspects of the treaty in an unbiased manner to be passed. Special interest groups with conflicting interests may lobby to prevent particular legislation from being passed. Legislators could be swayed to resist clauses that may have an economic effect on certain industries. Resulting legislation may be more lenient than effective controls require, and, thus, less effective as policy instruments.

Legislation may contain provisions which grant authority to federal agencies to monitor activities and sanction behaviors that do not comply with the laws [17]. If an industry does not succeed in preventing offending legislation from being passed, it may employ tactics to convince the regulating agency to be more lenient in sanctioning truant behavior. Even after a law is passed, these agencies are required to consider industry arguments as to why they cannot comply with regulations. Industries can bog these agencies down with so many such arguments that the resources these agencies have available to consider these positions become depleted. Agencies may then feel compelled to reach a compromise with the industries so that progress can be made in fulfilling the law. These compromises, by design, will not fulfill the law to the extent it was designed for, which stifles progress towards fulfilling international agreements.

4.3 Successes and Failures of the CAAA of 1990 and the EPAct of 1992 in Meeting International Treaty Obligations

Portions of the EPAct and the Clean Air Act Amendment (CAAA) of 1990 will act to fulfill agreements in the FCCC and the Montreal Protocol, respectively. The CAAA of 1990 imposes tighter restrictions on airborne emissions over the 1977 version of the act [18]. Provisions were made for smog, air toxins, motor vehicle emissions, stratospheric ozone depletion, and acid rain [19].[5] This section examines why the provisions contained in the CAAA of 1990 and the EPAct may or may not succeed in fulfilling these goals.

Under the CAAA of 1977, states were required to design state implementation plans (SIPs) by which regions in the state could meet the National Ambient Air Quality Standards (NAAQS) which were laid out in the act [18]. These plans were ineffective in producing desired results since state legislators were faced with divided interests. Concerned with continued economic growth through thriving industries in their state, yet required to implement air quality measures, state legislatures enacted plans that were not stringent enough to require real pollution controls. Industry often found it easier and cheaper to pay fines than to attempt to comply with the standards.

When SIPs enacted as a result of the CAAA of 1977 failed to comply with NAAQS by the 1987 deadline, lawsuits filed by environmental groups forced the EPA to impose federal implementation plans (FIPs) to achieve attainment [17]. However, when the CAAA of 1990 became law, the EPA deemed FIPs unnecessary and called for new SIPs. Mechanisms were put in place in an attempt to ensure that SIPs would fulfill their goals and actually encourage compliance. Implementation of SIPs that were more lenient than the FIPs would undermine the progress that had been made via the FIPs and would cause emissions control in these states to retrogress.

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[5] Title IV, the acid rain title of the CAAA, will be discussed in more detail in section 5.4.

The CAAA of 1990 may have three redeeming qualities in this respect over its previous version: provisions for allowance trading (see section 5.4), stricter requirements on the EPA, and a variety of attainment requirements for states [18]. SO_2 allowance trading and corresponding fines for emitting above allowance limitations provide incentives for electric utilities to reduce their emissions or purchase allowances for their emissions [18]. Current provisions state that if a utility emits above its allowances, it is fined $2000 for each excess ton of SO_2. The current market price for allowances is ten times less, therefore significant incentive exists for utilities to purchase them if other options are too costly or impractical to implement presently. Utilities can then allocate allowances in the short term as needed while designing longer range compliance plans which would include emission control techniques [18].

When SIPs have proved inadequate in the past, the EPA has been reluctant to require adjustments in the plans or to impose required sanctions for noncompliance [17]. Reasons for this include the costly and lengthy SIP revision process, vulnerability to interest groups, and fear of becoming unpopular to the public. Latin [17] states that "negative feedback from public and private pressures may induce EPA to shape its policies in ways that lessen criticism rather than promote legislative goals."

In drafting the CAAA of 1990, Congress addressed these issues by mandating the EPA to collect for noncompliance [17]. In many instances the CAAA of 1990 also imposes sanctions against the states themselves vice individual polluters (this does not apply to point source emitters of SO_2) in hopes that SIPs will be more realistic and effective [17], requiring less sanctions and providing less opportunity for the EPA to fall into the same traps as before.

The CAAA of 1990 contains three additional checks to ensure that states encourage and achieve compliance. SIPs are required to be consistent with federal standards, whose effectiveness must be demonstrated by modeling, and states are required to comply with reductions specified in the legislation [17]. Also, if Best Available Control Technologies (BACT) (see section 5.3) are required for existing sources and if strict limits are imposed on new sources, state's annual reduction limits may be relaxed [17].

Unanticipated were the indirect actions states would take in response to these stricter requirements. Currently, several states are either suing the EPA or are attempting to pass legislation that would restrict emissions trading. Virginia filed suit because rigid EPA requirements are hindering their attempts at compliance to automobile tailpipe emissions testing [20]. The EPA requires a centralized testing location, yet Virginia residents' resistance to the plan would preclude its success [20]. New York filed suit claiming that emissions trading would allow certain utilities to emit more emissions whose consequences would be felt in New York [18]. It called for the EPA to prohibit emissions trading when such situations could result [18]. Other states have chosen to protect their interests in acid rain by introducing legislation to restrict allowance trading within their states, to require utilities to publicly announce proposed trades, or to obtain state approval prior to trades [18].

Section 3.3 has already outlined various ways in which the EPAct will be an effective policy instrument. The act also contained provisions for the restructuring of the US electric utility industry, an action which may have mixed results in terms of its global environmental gains.

The two major factors that will make restructuring of the electric utility industry possible are the amendment of the Public Utilities Holding Company Act (PUHCA) of 1935 and new transmission access laws. Amendment of PUHCA builds upon some of the ownership restrictions on power generation that were lifted under the Public Utility Regulatory Policies Act of 1978, making it possible for independent power producers, power producers associated with electric utilities, and other electricity suppliers to compete to supply electricity under an exempt wholesale generator status [12]. That is, they are exempt from PUHCA regulations, which in short, restrict the merging of utilities and their operation across state borders [12]. Projects that fall under the amended version of this act must generate electricity exclusively for wholesale [12].

The new transmission access law included in the act mandates for electric utilities to wheel power from other generators over their lines at a negotiated cost. These provisions will create a market for electricity, since they allow customers and other utilities to shop for the cheapest source of electricity [12].

The amendment of PUHCA can potentially assist in environmentally friendly generation of electricity through its creation of a competitive market for power producers. Independent power producers can choose from a variety of small scale options for generating electricity. These include the use of renewables and fuels which are less harmful to the environment than coal, such as gas and oil, for electricity generation.

With its creation of a market for electricity, the new transmission access law will unfortunately do little to clean up the environment, or promote renewables and DSM. DSM is quite useful in reducing demand, which in turn produces capacity savings. With new transmission access laws, instead of spending money and manpower on DSM or building new plants, a utility can simply get its extra capacity from the lowest priced source. The incentive of DSM, its capacity savings, is therefore not as attractive.

The same argument can be used to show how a decrease in the use of renewables for electricity generation will result. Utilities needing new capacity and yet wanting to avoid the price of controlling emissions from a fossil-fired plant might benefit from the use of renewables. However, by purchasing wheeled power, physical capacity additions are unnecessary, power is available instantaneously, and there is no clean-up involved on the purchasing utility's end.

Wheeled power, when chosen over renewables and IRP, must come from somewhere. Most likely, the sources will be fossil-fired power plants. The emissions due to this generation would otherwise have been saved. Thus, the new transmission access laws will result in higher capacity from fossil-fired plants, reduced DSM programs and use of renewables, and reduced incentive to implement the latter two.

4.4 Design of Successful National Legislation for Global Emissions Control

Section 4.2 and 4.3 demonstrated the need for precautions to ensure that domestic legislation is successful in producing results consistent with treaty obligations. This section discusses some elements essential to the successful design of such legislation: universal commitment by all players involved, the removal of the opportunity for deceptive tactics through clear and concise definition of goals and expectations within the legislation, flexibility in state implementation plans, flexibility in allowable compliance methods and technologies, and revision of laws as necessary to adjust for additional scientific discoveries.

4.4.1 Universal Commitment

Legislators, industry, and scientists may not be fully committed to global emissions controls due to lack of scientific evidence that our activities on earth are contributing to global warming. Irrefutable evidence exists that CFCs deplete the stratospheric ozone layer. Since CFCs do not occur naturally on earth, it is safe to conclude that their effects on the ozone layer are all manmade. This knowledge not only inspired ratification of the Montreal Protocol, but may have made CFC-controlling legislation easier to implement due to increased support by environmentalist, the concerned public, conscientious legislators, scientists, industries, interest groups, and lobbyists [21]. Despite this knowledge, the CAAA of 1990 was enacted three long years after the Montreal Protocol became international law and nine years after negotiations for the protocol began in 1981 [21].

While it is a fact that global warming is occurring, the role that anthropogenic CO_2 has in global warming is uncertain [21]. Policymakers, industry, scientists, and environmental groups must come to some consensus regarding emissions control [22]. This will be challenging given the differing interests of those involved in the legislative process and the aforementioned lack of evidence. Nevertheless, a consensus should be reached based on available knowledge, fear of the unknown, and an understanding that all players have a personal interest in preserving the planet. Environmentally responsible legislation and resulting industrial practices should incorporate control measures that sustain to the best of our technological abilities.

4.4.2 Precise Definition of Compliance Requirements

Where possible, legislation should define clear and concise baseline goals that industries nationwide are required to comply with. This will reduce the role of states and federal agencies in formulating compliance plans, leaving these decisions to policymakers who can openly debate issues, who have varying interests, and who, as a whole, are less likely to succumb to pressures from industry. This strategy would remove the influence of self-serving interest groups on states and individual states on regulating agencies that could result in industrial practices that are contrary to or inconsistent with policy intentions. The function of the regulating agency, and to some extent the state, should be to monitor activities and impose sanctions for noncompliance.

If states desire to achieve even tighter emissions controls than federal standards require, they can individually formulate plans as long as they do not conflict with national compliance legislation or lead to doubt as to which compliance plan to follow. Plans that are in accordance with national legislation, but otherwise affect progress at the national level should also be rejected. For example, states with special interests could require electric utilities to adopt strategies that would discourage use of better technological alternatives. States that have abundant high sulfur coal supplies have an interest in continued use and sale of coal from their state because it represents a significant portion of the state's economy. Their economies would undoubtedly suffer if their coal market were reduced.

At least four high sulfur coal-producing states have proposed measures to protect their market for coal: Ohio, Kentucky, Pennsylvania, and West Virginia [18]. Ohio and Kentucky grant a tax credit to facilities that choose control technologies that would allow them to continue to burn coal (flue gas desulfurization, fluidized bed, pulverized coal, or others). Pennsylvania forbids utility purchases of power from cogenerators that burn nondomestic coal. Finally, West Virginia requires its utilities to purchase power from domestic fuel-burning sources when purchasing capacity.

Although these four measures promote the use of coal, they do not cross the boundary of acceptable practices according to the CAAA of 1990. Yet there is a fundamental difference between how the former two cases and the latter two cases may affect power plant emission controls intended by federal legislation. Ohio and Kentucky have made no attempt to dictate practices that their utilities choose within the limits of the CAAA of 1990. They have applied incentives to promote the practices that the states feel are in their best interest, but ultimately the choice of control strategies lies with the individual utilities.

However, Pennsylvania and West Virginia's laws expressly prohibit activities that are allowed under the CAAA of 1990 and that could result in lower emissions than the state preferences would. Some utilities, such as Gulf Power Company in Florida, formed compliance plans which included the use of low sulfur, low ash Venezuelan coal rather than incurring the cost of building scrubbers to continue burning high sulfur coal [23]. Pennsylvania's indiscriminate restrictions on purchase of power from foreign coal sources gives no regard to the sulfur content in the coal. When denied purchase of power from plants burning low sulfur foreign coal, a utility's alternative source of power may be produced from scrubbed higher sulfur coal. Scrubbing sacrifices plant efficiency, which then requires the production of more power, and produces waste that must be disposed of. The same arguments apply to West Virginia, with the additional arguments that gas and oil, domestic or not, produce less emissions than any type of coal. Restrictions such as these impose upon the flexibility purposely given to utilities in the act, designed to facilitate compliance.

Any global environmental legislation should protect the free choices of electric utilities to comply within the limits of that legislation so that they do not fall victim to the state's special interests and consequently slow global progress. If a state's economy will be significantly affected by reduced use of coal, the legislation should provide for special funding or programs to help the state research and establish new markets.

4.4.3 Flexibility in State Implementation Plans

If states are required to provide SIPs for compliance with global emissions legislation, these plans must be thoroughly reviewed by the overseeing agency (i.e., the EPA) to ensure that these plans will achieve their promised goals. Legislation should provide for continual funding and adequate resources so that this review can be achieved timely and accurately. Such provisions will decrease the incidence of pressure on the agency from outside sources. Additionally, the oversight agency must be flexible in allowing states to implement their plans as long as they can show that their emissions limits are achievable, that their plans are designed to work within federal guidelines, and that their plans do not counteract federal provisions.

4.4.4 Flexibility in Compliance Methods

Industry may use lack of alternatives as an excuse to not comply with legislation. Industry vehemently rejected regulation of CFCs in the 1970s and 1980s, prior to the development of alternative coolants [21]. In 1986, DuPont announced that they could have alternatives available by 1991. This discovery led to immediate industry support of a global reduction of CFCs. This development of an alternative was necessary before industry cooperation in the decision to limit CFCs could result.

Presently, there are no affordable methods of eliminating CO_2 once it is produced. However, technologies do exist whereby electric capacity can be provided with reduced CO_2 creation. One such alternative is the use of steam injected gasifier plants (STIG). Coal is gasified underground to trap the CO_2 and is then combusted in the plant to produce electricity [24]. Exhaust gases from the gas turbine are fed to a boiler along with water to produce steam [24]. The steam is then recycled through the combustion chamber [24]. Variations of STIG plants can provide greater 52% efficiency, versus the 35% efficiency provided by conventional thermal plants [24]. Capacity savings via DSM or efficiency improvements suppress the creation of CO_2. Use of these or other such control methods should be expressly required by global emission control legislation, but the legislation should be flexible enough to allow utilities to choose their own compliance plans. Adequate time should be allotted for the utilities to develop and implement these plans.

Meanwhile, government R&D programs must be established for continued development of scientific alternatives. Existence of alternatives will help encourage industrial practices, therefore funding must be earmarked for these programs. In addition, there must be a vehicle to easily transfer advanced research or prototypes to industry for fine tuning and manufacture of marketable merchandise.

4.4.5 Revision of Laws

Legislation should be flexible enough to allow additional provisions or amendments to require use of emerging technologies in new plants as control technologies become available and economical. On the international level, the Montreal Protocol left room for revision due to economics and scientific evidence [25]. Such provisions led to a 1992 amendment of the protocol which completely banned the use of CFCs in developed countries after 1 January 1996. This was in response to new scientific evidence on the rate of ozone depletion [26]. Domestic law would benefit from parallel amendments as new evidence develops on the global warming issue and as new control technologies surface. Application of financial incentives can remove economically induced hesitations by industry in implementing these technologies.

5.0 Policy Options for Reducing Global Emissions from Power Plants

Policymakers can employ a variety of options to reduce or offset CO_2 emissions due to electricity generation. These include: financial incentives, performance standards, pollution control technology standards, market-based regulation, research and development, education, and legislative reform. Policy involvement can be as low key as funding a program to provide an incentive for participation, or it may be complex enough to require assignment to a regulatory agency to monitor progress and impose sanctions. This chapter is not intended to be an exhaustive list of policy options, but merely a guide to strategies which have been implemented throughout the world in a variety of scenarios, and which are viable legislative strategies for national control of global power plant emissions. Of course, any number of these strategies can be used in concert to provide a more comprehensive emissions control program.

5.1 Financial Incentives

The implementation of financial incentives in policymaking can take the form of taxes, loans, and subsidies designed to encourage or discourage certain activities [27]. In the context of reducing CO_2 emissions from power plants, taxes can be applied to the use of undesirable fuels, including those with high carbon content [27]. By applying taxes to fuels that yield high CO_2 emissions, power producers are encouraged to use lower CO_2 emitting fuels to generate power.

In countries where electric utilities are regulated monopolies, such as the United States, such tactics may not directly encourage a shift in fuel use. In these structures, utilities recover their expenditures through their rate base so there is no incentive for utilities to reduce their costs up front. However, as higher electricity costs are passed on to the customers, customers may react by reducing electricity use and finding alternatives to electricity use which will result in lower electricity sales (a similar situation occurred during the 1973 oil crisis). If utility planners consider historical reactions to increased fuel prices, taxes may be directly beneficial to reducing CO_2 emissions.

Going one step further, if such legislative strategies are implemented, in order for them to succeed it would be absolutely critical for utility planners to recognize the possible economic and environmental repercussions of continued use of excessively taxed fuels. This is because the purpose of these taxes would not be to reduce sales, but rather to influence fuel choices for electricity generation. An unpleasant side effect to power planning that did not take this into account would be lower electricity sales despite fixed capital and operating costs. This situation would result in financial disaster for the utility, unless it could find additional markets for its power. If utilities are successful in this venture, they will continue to use carbon-based fuels and the tax program will have failed to achieve its objective of lowering power plant emissions.

As taxing can be used to discourage use of certain fuels, subsidies, tax incentives, and low interest loans may encourage the use of favored technologies [27]. Careful application of these three techniques to favored technologies can encourage their growth in industry, especially among smaller, non-utility power producers. While many critics frown on the use of financial incentives to encourage use of low impact technologies such as renewables, such actions can be justified on the basis that they help to internalize the social and environmental costs of continued use of carbon-based fuels back into these fuels.

5.2 Performance Standards

Performance standards have been used world-wide to reduce fuel and electricity consumption. Such standards can include mileage requirements for automobiles, energy efficiency requirements for household appliances and industrial equipment, and power saving features on commercial electronic products. Performance standards can reduce CO_2 emissions from power plants in two ways: by reducing losses and by reducing demand. Policies that require power plant generators and T&D equipment such as transformers and lines to operate at certain efficiencies can help to reduce the losses attributed to transmitting electricity, providing generation savings.

Energy efficient appliances and power saving features, such as low power automatic stand-by modes for computers, monitors, printers, and photocopy machines will help to reduce the demand for electricity. Countries like Denmark, Japan, and New

Zealand have established energy efficiency standards for various sectors [12]. Such requirements apply to household appliances, space coolers and heaters, industrial equipment, computers, and insulation, lighting and windows in commercial buildings [12].

Policy-induced energy efficiency programs are often targeted toward manufacturers and the commercial sector in the form of incentives to produce and utilize more efficient products [12]. In the US, the Green Lights program encourages the commercial sector to implement more efficient lighting in offices, stores, and buildings. In test cases, the retrofit of selected office lighting systems with different combinations of compact fluorescent lamps (CFLs), T-8 lamps with electronic ballasts, halogen lamps, and occupancy sensors saved companies hundreds of thousands of dollars annually, reduced their load by between 25% to more than 80%, and avoided four hundred thousand to 1.8 million kilograms of CO_2 annually [28].[6] Continued research and development has resulted in improvements in power factor and harmonic distortion in CFLs over early 1990's models, which makes their use more "invisible".

5.3 Pollution Control Technology Standards

Pollution control technology standards can be used to regulate emissions from industrial and power plants. They dictate the type of equipment (in terms of their emission control potential) that these plants must install to reduce the environmental effect of their

[6] The energy savings resulting from the retrofit of specific lighting systems depends upon the energy consumption of the previous lighting system. For example, replacing incandescent bulbs with CFLs will result in greater load reduction than replacing the same number of T-12 lamps using magnetic ballasts with CFLs.

emissions. Policy can stipulate both the type of technology and the industries or types of plants which are required to comply to these regulations. The Clean Air Act established guidelines for required control technologies by defining four standards, best available control technology (BACT), reasonably available control technology (RACT), lowest achievable emission rate technology (LAERT), and new source performance standards (NSPS) [29]. The standard that applies to an individual unit depends upon the type of industry, whether the unit is planned or existing and whether the unit is located in an attainment area [29]. An attainment area is an area which has achieved ambient air quality standards for specific pollutants as defined in the Clean Air Act and its subsequent amendments [29].

RACT standards apply to existing sources in nonattainment areas. These older plants are recognized as having special economic and technological constraints and are therefore subject to the least rigorous control requirements [29]. RACTs are those that achieve the lowest emissions limits possible given these constraints. NSPS' consist of the best proven technological emission reductions options. As new technologies become available, the EPA continually reevaluates the technologies which will apply to new sources. BACT standards are at least as stringent as NSPS and apply to new and modified sources in areas that have achieved attainment and are subsequently expected to prevent significant deterioration of that air quality. BACT standards take into consideration emissions reduction potential, and energy, environmental, and economic impacts. LAERT standards apply to new and modified sources in nonattainment areas. They are at least as strict as NSPS and are defined by the most stringent emissions limit contained in any SIP for that type of source or achieved in practice by that type of source. Continual evaluation and application of emissions control technologies as they become available and economical assures that major pollutant sources will always incorporate the most feasible and advanced control measures in their designs.

5.4 Market-based Regulation

The SO_2 allowance provisions in Title IV of the CAAA of 1990 initiated market-based regulation of industrial and power plant emissions. This approach was designed to control emissions by requiring permits, or allowances, to pollute. Each allowance translates into one ton of SO_2 emissions. The goal of the program is to cap annual SO_2 emissions from fossil fired utilities in the US to 8.9 million tons beginning 1 January 2000 [18].

Phase I plants, older, coal burning plants which were specifically named in Title IV, were given allowances by the EPA equal to their average 1985-1987 fuel consumption multiplied by 2.5 pounds per million British thermal unit (BTU) [30]. These plants could also earn additional allowances by saving fossil fired capacity, either by promoting DSM activities or by generating electricity from cleaner sources. By 1 January 1995, Phase I plants were required to limit their SO_2 emissions to the allowances they possessed. Plants that built scrubbers could extend their obligation to 1 January 1997.

Phase II plants were all plants not specifically named as Phase I plants. These plants were given opportunities to purchase allowances at auctions in which a set number of allowances were made available to the public for bidding. These plants could either trade allowances, use them, or bank them for later use. SO_2 allowances were also granted to certain Phase II plants based on their capacity, their capacity factor (average power output from a plant divided by its rated power output), their age, and their 1985 emissions rates [30]. In general, by 1 January 2000, Phase II plants must achieve a 1.2 pounds per million BTU average SO_2 emissions rate [30]. Any plants polluting over their allowances after 1 January 2000 will be fined $2000 for each extra ton of SO_2 emitted.

By requiring allowances to pollute, a monetary value is placed on polluting and a market is created. By restricting the amount of available allowances, a ceiling is placed on that particular emission. Imposition of a fine for polluting over these allowances will serve to discourage such actions (see 5.1) and will force plants to search for alternative capacity options to reduce emissions.

Critics of market-based regulation cite it as a scheme to simply shift emissions around rather than prevent them. However, once an allowance is surrendered to the monitoring agency (the EPA in the case of the CAAA), it can either be reintroduced to the market or it can be removed from circulation. This evaluation will be made based upon the benefits and disadvantages of recirculating the allowance and how close the country is to meeting its SO_2 limits for the year [18]. Also, this strategy gives power plants an opportunity to manage their emissions and make necessary long term provisions, whether they be retrofitting plants with emission control technologies, repowering or shifting fuels, or decommissioning plants and planning for new capacity additions. As plants' emissions taper off, the EPA can withdraw allowances from the market accordingly, increasing the cost of allowances, and making it less economical for plants to rely on their use than to pollute less [18].

5.5 Research and Development

Much research is needed before we can successfully apply legislative strategies to CO_2 control from power plants, as the discussion in Section 4.4 pointed out. CO_2 control technologies are costly and still under development, and their impacts are unclear. Japanese scientists are currently experimenting with the injection of liquid CO_2 in the deep ocean. At a depth of 3,000 meters or more, experimental results show that liquid CO_2 is heavier than sea water [31]. Also, under certain conditions, it will react with water to form a crystal compound [31]. These results lead scientists to believe that CO_2 can possibly be deposited in the deep ocean for disposal [31]. The impacts of sequestering CO_2 in this manner may include changes in the pH value of sea water, ecological issues, and unknown long term effects [31]. Many complex issues are involved in any such project and must be thoroughly researched. Government funding which can be granted through legislative action is essential to stimulate additional research in this area.

5.6 Public Education

The establishment of public education programs can encourage citizens to do their share to reduce energy consumption. Public Service Announcements that teach energy conservation practices are simple, inexpensive tools that can be very effective. An example of a more structured program is the consumer labeling program in New Zealand. The required labeling informs the public of energy consumption and operating costs of appliances such as refrigerators, washing machines, dryers, dishwashers, stoves and water heaters [12]. An initial value tax added to new purchases of less efficient products is a more aggressive method of getting the public involved in power plant emissions issues [27].

5.7 Legislative Reform

At times, preexisting laws may conflict with the intended goals of future laws. When forming legislation, it is important that preceding laws be examined carefully and amended or superseded by the new legislation in order to resolve any conflicts. Removal of laws which discourage particular activities that the new legislation would like to encourage is especially important. The EPAct took two major steps toward these type of revisions. First, the reform of PUHCA made possible the creation of a market for electricity (see section 4.3).

Secondly, cost recovery for projects undertaken by electric utilities in the US is subject to approval by state utility commissions. Prior to the EPAct, utilities often hesitated to participate in DSM programs because there was no assurance that their costs would be recovered, including those due to reduced sales. This served as a disincentive for utilities to implement such programs. Following EPAct requirements that state commissions consider allowing IRP-related costs, more than thirty states began to assure returns for DSM investments that encompass any costs due to loss of sales [12]. Future global climate change legislation should address more incentives for utility participation in DSM programs to counteract the disincentives attached to DSM through the transmission access laws.

6.0 Power Plant Emissions Control in Developing Countries

6.1 Establishment, Funding and Support of Sustainable Programs

In order for global climate change programs to be effective, it is necessary for developed countries to work closely with less developed countries to assist them with technology and necessary analytic capabilities. The success of climate change programs in developed countries appears to be linked to consensus among the executive branch, the legislative branch, the scientific community, interest groups and the public. Consensus among these parties can be reached and sustained in a system of government where parliamentary procedures are involved in lawmaking.

Even though developed countries have such structures in place, treaty obligations are still subject to implementation via legislative action. Many developing countries lack the governing structure required to give due consideration to the scientific and engineering community and the public when faced with formulating policies to comply with international treaties. As a part of the lawmaking process, agencies would have to be established to monitor and sanction industrial activities, an undertaking that is costly logistically, financially, and skill-wise.

Compliance programs, as well, are costly to implement and new equipment may require special training to install, operate, and maintain. Implementing global change programs over existing practices may seem extraneous to countries who view socio-economic progress as a far more pressing problem than global climate change. These countries may feel that sustainable development practices will inhibit their economic growth since they may not be equipped to provide necessary personnel, funding and training to support these programs while continuing to fund social programs.

International organizations and developed countries should make provisions for assisting developing countries who would like to participate in climate change programs, yet may not have the funding or the legislative structure to support national programs. These countries should be actively encouraged to participate in global climate change programs geared towards implementing sustainable development practices, regardless of how much assistance, logistically or financially, they require.

As developed countries became industrialized, they polluted without bound because no one knew the dangers of pollution. Today, not only do we know the dangers of pollution, but we also have the technology to control, reduce, or even prevent most types of local and global emissions. Therefore, there is no excuse for any country to not have the knowledge of or access to such control measures and technologies. As a show of good faith and as recompense for the part they played early on in global warming and ozone depletion, much of whose effects may be felt disproportionately in developing countries [21], developed countries should provide services to fund and teach sustainable practices to those less able to do so.

6.2 Achievable Emissions Limits

As discussed in Chapter 3, many developed countries have a long history of implementing environmental reform programs. Although these countries recognize the urgency of the global warming problem, many countries find it difficult to comply with the demands of international agreements like the FCCC. Within one country, regions may have differing levels of achievable emissions limits. Earlier discussions cite political, economic, social, technological, and cultural factors which affect these limits. As developed countries are now discovering, it takes some trial and error before these limits can be determined and to decide which methods are the most effective at achieving them. It is easy to understand then, that developing countries may need extra time to determine these limits, formulate mitigation plans, and actually achieve their targets.

In light of these observations, developing countries should be given more leeway in complying with international global climate change programs. Because the nature of the global warming problem requires immediate action, the level of leniency on developing countries should be carefully determined based on their achievable limits, keeping in mind the financial assistance and technological alternatives that will be made available to them by developed countries and international organizations.

By way of example, as shown in Table 4, the Montreal Protocol specifies a later deadline for CFC phase-out in developing countries than in developed countries [32]. It also allows production and use of hydrofluorocarbon substitutes in developing countries,

Table 4: Selected Montreal Protocol Requirements [32]

	Developed Countries	Developing Countries
Chlorofluorocarbons	Complete production phase-out by 1 January 1996	Begin phase-out on 1 January 1999 Complete phase-out by 1 January 2010
Halons	Production banned on 1 January 1994	Begin phase-out on 1 January 1999 Complete phase-out by 1 January 2010
Hydrofluorocarbons	Production freeze on 1 January 1996 Use cut by 35% by 1 January 2004 Use cut 65% by 1 January 2010 Use cut 99.5 % cut by 1 January 2020 Complete phase-out by 1 January 2030	No controls

which is unacceptable in developed countries [32]. This design grants much needed flexibility for compliance in developing countries. As alternatives to the use of these chemicals become accessible to these nations, the protocol can be adjusted accordingly. An international global climate change program which allows for similar flexibility in electric power production options could muster more widespread acceptance in developing countries, acceptance which is critical for continued progress.

6.3 Assistance from Developed Countries and International Banks

There are several existing international institutions through which developing countries can obtain assistance for sustainable development. Three types of such institutions are discussed: international banks and funds, financial programs designed to facilitate compliance with international agreements, and development programs established in conjunction with developed countries. These or similar programs can be utilized to promote sustainable electricity generation in developing countries and reduce or offset their global power plant emissions.

The World Bank (WB) and the Asian Development Bank (ADB) are international financing institutions that fund development projects in developing countries [33]. A primary mission of the WB is to promote sustainable development. In support of this mission, reforestation, pollution control, agricultural extension, strengthening of institutions for management of development programs, and encouragement of public participation in decisionmaking are among the types of projects that the WB funds. The

WB has recently revised its guidelines to give funding priority to projects that use clean fuels and combustion technologies, contain alternate plans that include environmental assessments, and provide for airborne emissions reductions and environmentally sound waste disposal.

The ADB concentrates its development efforts in the Asian and Pacific region. Its activities include providing technical assistance and assisting in policymaking for development exercises in developing countries [34]. The WB, the ADB, and similar institutions can utilize their position as lending institutions to influence sustainable practices by screening the projects they choose to fund for environmental integrity.

The Multilateral Fund and the Global Environment Facility (GEF) are institutions through which developed countries contribute financially to development programs in developing countries to facilitate compliance with international agreements. The Multilateral Fund is a financial program which was established under the Montreal Protocol to help developing countries adapt to life without CFCs [26]. The establishment of this fund was crucial to ensure the participation of some developing countries such as India and China in the protocol [26].

The GEF is a similar program run by World Bank and the United Nations designed to provide grants for projects that protect the global environment [35]. It presently acts as the interim financing institution for the FCCC [36]. Projects addressing climate change, stratospheric ozone depletion, and deforestation are among the activities that are eligible for funding through the GEF [37]. Several renewable energy projects have be financed through this fund, such as the combustion of gasified wood and sugar cane bagasse in gas turbines for electricity generation in Brazil [35]. When developed countries agree to fund sustainable projects during negotiations for international agreements, developing countries are more likely to participate in the agreements.

Finally, developed countries can assist developing countries in reducing their global emissions through mutually beneficial technology exchange programs. Joint Implementation (JI) is a cooperation between countries in forming development projects for the purpose of reducing GHG emissions [11]. The FCCC states that JI programs may be undertaken to achieve framework objectives. Many countries are divided on JI, as they have differing opinions as to whether and in what capacity JI projects should apply to current FCCC commitments [11]. Some developed countries may use JI projects as a substitute for instead of a supplement to national climate change programs. Table 5 lists the standing of signing countries of the FCCC on JI. Future negotiations on the FCCC will determine the role JI will play in meeting its objectives.

Meanwhile, several countries have begun pilot projects to determine the feasibility of GHG reduction through JI [38]. The US has became a leader in this arena through the establishment of the United States Initiative on Joint Implementation (USIJI) under the CCAP. USIJI was established to invite the involvement of private-sector organizations in the development of technologies to reduce or sequester GHG emissions. Fifteen USIJI projects in six countries have been approved since February 1995. Most of these projects, which are outlined in Table 6 and Table 7, involve reforestation to

Table 5: Stated Positions of OECD Countries On Joint Implementation [11]

	Joint implementation should apply to current commitments under the FCCC	*Intends to meet its own targets without joint implementation*	*Joint implementation should not apply to current commitments under the FCCC*
Joint implementation projects between Annex I and other parties may be possible at a later stage under certain conditions	Austria Finland Iceland	Belgium	Denmark European Union Switzerland
Joint implementation projects between Annex I and other parties may be possible at a later stage under certain conditions	Australia Italy United States	Japan Norway	Germany Netherlands New Zealand United Kingdom
Joint implementation projects between Annex I and other parties may be possible at a later stage under certain conditions	France		Spain

Table 6: First Round USIJI Projects Approved 3 February 1995 [38]

Project	Location	Sponsors			
		United States	Type	Host Country	Type
Rio Bravo Conservation and Forest Management	Belize	Wisconsin Electric Power Company The National Conservancy	U N	Programme for Belize	P
Plantas Eolicas S.A. Wind Facility	Costa Rica	Merrill International Ltd. Charter Oak, Inc. Northeast Utilities KENETECH Corp.	P U U P	Plantas Eolicas S.A.	P
ECOLAND: Esquinas National Park	Costa Rica	Tenaska, Inc. Trexler and Associates, Inc. National Fish and Wildlife Foundation	I P N	COMBOS Ministry of Natural Resources, Energy and Mines Counsel of the Osa Conservation Area	N G N
Project CARFIX: Stabilize Existing and Expand Forest Cover	Costa Rica	Fundecor	P	Ministry of Natural Resources	G
Fuel Switching for District Heating System0	Czech Republic	Center for Clean Air Policy Wisconsin Electric Power Company NIPSCO Industries, Inc. Unicom Enterprises	N U U U	City of Decin	G
Enersol Rural Solar Electrification	Honduras	Enersol Associates, Inc.	N		
RUSAFOR Saratov Afforestation Project	Russia	Oregon State University Civil Engineering International Forestry Institute EPA Climate Change Division	E N G		

Key for type of Sponsor:

E - Educational
N - Nonprofit Organization
G - Government, noneducational
P - Private Company
I - Independent Power Producer
U- Utility or affiliate

Table 7: Second Round USIJI Project Approved 19 December 1995 [38]

Project	Location	Sponsors			
		United States	Type	Host Country	Type
Bio-Gen Biomass Power Generation Project	Honduras	Nations Energy Corp. Add On Energy 1 International Utility Efficiency Partnership	U U U	Biomasa Generacion	P
Dona Julia Hydroelectric Project	Costa Rica	New World Power Corp.	I	Ministry of Natural Resources, Energy, and Mines Compania Hidrolectrica Donia Julia	G P
Aeroenergia Wind Facility	Costa Rica	Power System, Inc. Energy Works (International)	P P	Aeroenergia S.A.	P
Rusagas Fugitive Gas Capture	Russia	Oregon State University Sealweld Corp. Sustainable Development Technology Corp. EPA Climate Policy and Programs Division	E P P G	GAZPROM Center for Energy Efficiency (Joint Russian/American Organization)	P N
Biodiversifix: Forest Restoration Project	Costa Rica	The Guanacaste Conservation Area	E		
El Hoya-Monte Galan Geothermal Project	Nicaragua	Trans-Pacific Geothermal Corp.	P	C and R Inc.	P
Klinki Forestry Project	Costa Rica	The Newton Treviso Corp. Yale School of Forestry and Environmental Studies The Forest Products Lab of the USDA	P E G	Cantonal Agricultural Center of Turrialba The Tropical Agriculture Research and Higher Education Center	N E
Tierras morenas Windfarm Project	Costa Rica	New World Power Corp.	I	Ministry of Natural Resources, Energy, and Mines	G

Key for type of Sponsor: E - Educational; N - Nonprofit Organization; G - Government, noneducational; P - Private Company; I - Independent Power Producer; U- Utility or affiliate sequester CO_2. Funding organizations range from private-investors to investor-owned utilities and environmental groups. In general, the governments of targeted countries are receptive to USIJI projects, since they provide jobs, funding for development, and technology transfer. It is hoped that in addition to improving net GHG emissions, these projects will also benefit the local environment and economy.

7.0 The Role of Electric Utilities

What role, if any, should utilities play in controlling their global emissions? Some could argue that a utility's only role is to fulfill their legal obligations. Laws designed on a broad scope, however, must be flexible enough to account for factors that will affect individual compliance strategy decisions. Compliance strategies that are suited for one utility may be unrealistic for another. It is impossible for any legislation to anticipate and account for all such nuances that may exist. Knowing the particulars of their individual circumstances, however, there may be actions utilities can take beyond what is lawfully expected of them. These actions can assist them in complying with current legislation while simultaneously serving the broader purpose of preserving the global environment, as well as their own local environment. Utility companies should feel compelled to act within their power to consider some of these tactics.

7.1 Multidimensional Capacity Planning Options

Legislative initiatives targeted at industrial reform are often designed so that industry has a variety of options through which to comply. When the CAAA of 1990 was enacted, utility companies all over the US were forced to make tough choices about how they could conform to these strict regulations. Planning approaches would now have to encompass the local environmental costs of generating electricity.

Although the CAAA made great strides in holding utilities financially responsible for their local emissions, it made no provisions for the global environment. We should expect though, that sometime in the near future similar laws will be passed for the control of global emissions from power plants. Therefore, while planning compliance strategies for current laws, utilities should look ahead into what may be expected of them in the future and seek out options that may accomplish these goals concurrently. Such planning is referred to here as multidimensional planning.

When considering multidimensional options, environmental consequences beyond those that are guarded against legally must be considered. For example, when planning capacity options, a utility may decide to purchase power between twelve midnight and three AM on weeknights. The new transmission access laws afford this utility with an infinite number of options for where to get this power. The utility can decide not to purchase power from utilities whose generation mix consists of over a certain percentage of coal generation. This would serve to reduce the environmental effects of all capacity attributed to the utility, not just the power which it generates itself.

DSM is a multidimensional strategy that is widely used to provide capacity savings and savings to both the local and global environment. It achieves this by reducing the need for generation and by slowing the need for construction of new plants and transmission lines. Technological options can also be applied using a multidimensional approach. Some technologies, such as flue gas desulfurizers, sacrifice plant efficiency and generate waste. After examining the limitations of emissions control technologies, a utility may choose to build a STIG turbine system, which produce less NO_x emissions than conventional gas turbines and operate at higher efficiencies [24]. These systems have less impact on the local and global environment than conventional methods of generation electricity from coal, oil, or natural gas. By incorporating multidimensional approaches into planning, electric utilities can decrease the effects of electricity generation and distribution on the environment. The next section describes a practice through which these utilities can go one step further.

7.2 Ecological Industrial Practices

Utilities should practice industrial ecology wherever possible, not only to reduce their effects globally, but locally as well. Industrial ecology is the term given to the manufacture of products in a manner which reduces their impacts on the environment throughout their entire life cycle [39]. This includes recycling of byproducts wherever possible. Electric utilities can incorporate these practices in a variety of fashions. For instance, a coal plant with a flue gas desulfurizer (FGD) produces up to 90% less SO_2 than a conventional plant with no scrubber. Although SO_2 removal is achieved, the use of an FGD unit may not be considered multidimensional in scope due to the waste that it produces. The waste is in the form of sludge or solid waste whose composition is determined by the particular scrubbing process. These by-products can consist of calcium sulfite/sulfate, gypsum, sulfur, sulfuric acid, magnesia, sodium sulfite, ammonium sulfate, and salt [40]. Many of these products can be recycled for use in manufacturing. For instance, gypsum can be sold for use in construction and sulfur and sulfuric acid can be sold for use in industrial processes. Recycling of these products saves on waste in landfills and saves the energy it would have otherwise taken to process these materials for use in industry. The use of industrial ecology practices in power plants is a multidimensional approach to planning.

7.3 Involvement with Legislature

A utility company should keep abreast of current legislative initiatives that may affect it. This serves three purposes. Most practically, it gives the utility a head-start towards planning for compliance. Secondly, it gives the utility an opportunity to voice its concerns over issues placed before legislative committees. The utility can be a major resource to legislative committees in determining feasible plans for legislation and final compliance strategies. Of course, suggestions made by utilities are subject to committee scrutiny due to a utility's inherent special interests. However, without utility input as to reasonable expectations, laws regulating their activities may be too unreasonable to bring about compliance and would therefore be ineffective in achieving their goals.

Finally, by staying informed of current legislation, utilities may discover legislative strategies that can assist them financially in achieving compliance goals. For instance, there may be in place some financial incentives that offer subsidies or tax benefits for construction of new photovoltaic (PV) plants. Since initial capital costs of PV plants are high, these incentives would reduce the financial burden on the utilities. In addition, such plants operate cleanly, require no fuel, can be centrally located, and need little maintenance.[7] Financial incentives combined with the environmental benefits and convenience of such a venture would almost demand consideration by utilities who are aware of these added benefits.

7.4 Participation in Voluntary Emissions Reductions Programs

In signing the Climate Change Action Plan (CCAP) in 1993, President Clinton initiated the Climate Challenge Program (CCP), a voluntary partnership between the electric utility industry and the DOE [46]. CCP was designed to reduce individual utility GHG emissions, assisting in achieving national GHG emission reductions to 1990 levels by 2000, as agreed to in the FCCC. The DOE estimates that voluntary commitments by electric utilities to date (as of October 1995) will reduce US GHG emissions by 47 million metric tons of carbon equivalent in 2000.[8] Thus far, only 50% of the nation's utilities have made commitments under the CCP. Such reductions could be drastically improved if similar commitments are made on the part of the remaining utilities.

In 1991, fossil-fuel generation of electricity in the US caused 2197 million metric tons of CO_2 to be released into the atmosphere [3]. This number was over half

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[7] There are local and global environmental costs associated with the fabrication of PV modules, including extraction of the silica used to form the cells and emissions due to fuel use during manufacture and transport. All of these costs must be considered to form a proper basis for comparison of the costs of PV generation versus other power generation techniques.

[8] The global warming potential (GWP) of GHGs are often measured in terms of their carbon equivalent, or their effect on the global environment as compared to the effect of an equivalent amount of carbon emissions. Table 8 lists the GWP of selected gases.

Table 8: Global Warming Potential (GWP) of Selected Gases [46]

	Greenhouse effect by molecule relative to CO_2	*Concentration change/year (parts per billion volume)*	*Percent contribution to greenhouse effect*
CO_2	1	1500	55
CH_4	21	10	15
N_2O	160	1	6
CFC	12000	.03	24

of that value for total OECD countries (4048 million metric tons) and almost one third of world CO_2 emissions from burning fossil-fuels for electricity generation that year (6881 million metric tons). Coal plants contributed 1912 million metric tons (54.6%) to the US total.

The replacement of 10% of the coal-fired generation in the US in 1991 with oil or gas generation would have resulted in 99 or 192 million metric tons less CO_2 emissions, respectively, reductions of 4.5 and 8.7%. If requirements under Phase I of the CAAA had been in place in 1991 while maintaining a 54.6% coal generation mix, 105 million metric tons of CO_2 from coal fired plants would have been avoided (4.9%). (Calculations based on 1989 EPRI figures for emission characteristics of US power plants [47]).

1991 capital costs for several generating units are given in Table 9. A full economic analysis and comparison of generation costs would include life-cycle costing and consideration of the social costs due to the environmental impacts of each source. Reilly [48] lists estimated costs from various studies for CO_2 abatement that range from $0 to $450 per ton of carbon abated.

Several initiatives, such as the International Utility Efficiency Partnership (IUEP), have been formed by utilities participating in the CCP to jointly accomplish CO_2 reduction or offset goals [46]. Initiatives include investing in the development of renewable technologies, promotion of electric vehicles, forest management for carbon sequestration, identification of project opportunities, and sponsorship of workshops on project development in developing countries [46]. Utilities that are tentative about making

Table 9: Estimated Overnight Construction Costs for New Generating Units, Midwest Region [49]*

Type of Generating Capacity	Cost (1991 $ per kilowatt)
Oil-Fired Steam	937
Gas-Fired Steam	824
Coal-Fired Steam with Flue Gas Desulfurization	
• Bituminous (Low-Sulfur)	1,434
• Bituminous (Medium-Sulfur)	1,464
• Bituminous (High-Sulfur)	1,512
• Sub-bituminous (Low-Sulfur)	1,479
• Sub-bituminous (Medium-Sulfur)	1,526
• Lignite(Low Sulfur)	1,502
• Lignite (Medium-Sulfur)	1,434
Combined Cycle	590
Combustion Turbine -- Gas	342
Combustion Turbine -- Oil	342
Conventional Hydroelectric	1,067
Pumped Storage Hydroelectric	1,209
Nuclear	1,548

* Overnight Costs -- Interest rates are not included

Figures for this region are representative of national average individual commitments to reduce their CO_2 emissions to a set level may benefit through participation in one or more of these partnerships. The success of this program will be key to the US achieving its FCCC goals.

7.5 Public Awareness Programs

Electric utilities can administer public awareness programs geared at teaching society about energy conservation and efficiency. Through these programs, utilities can enlighten electricity consumers to strategies they can implement on their own to lower their electricity bills. A public awareness program may be effective on customers who hesitate to actively participate in structured DSM programs.

Some consumers find DSM programs such as water heater controls or time-of-use rates to be too restrictive or inconvenient to take advantage of. These consumers may be more inclined to practice simple conservation strategies within their households. Simple tips that accompany monthly electricity bills can offer suggestions on how consumers can lower their bills. Examples of simple tips may be to lower thermostats by a few degrees in the winter and to raise them a few degrees in the summer, to hang insulating draperies, to install water heater blankets, and to turn off outdoor lights when going to bed. The utility can also suggest home improvement schemes that will reduce electricity consumption, such as upgrading to energy saving appliances, sealing drafty doorways and windows or replacing windows with thermally efficient ones. As these program succeed in reducing customer bills, they will also assist in reducing a utility's residential load.

The above programs demonstrate options that electric utilities can pursue to reduce their effect on the global environment. Ultimately, it is the responsibility of the utility to incorporate feasible and sound environmental practices in its planning approaches which go above and beyond legislative requirements.

8.0 Planning Tools

Electric utility planners in the United States and abroad can use this thesis as an aid to determine the actions they will take to assist in the mitigation of global power plant emissions. Several planning approaches which utilities can implement towards fulfilling these ends have been identified. Since utilities in developing countries are less able than developed countries to fund and maintain technology-constrained emissions control options, methods in which developed countries can assist in their efforts were discussed.

To facilitate the efforts of those who will use this thesis as a resource, three software tools are provided. The first tool was designed for electric utility planners, independent power producers, and parties interested in participating in USIJI projects. The second tool is a guide for utilities in developing countries who are interested in obtaining international financial and technical assistance for power generation projects through World Bank. The third tool is a simple interactive program to estimate emissions generated in a coal-fired plant.

The first tool, JOInt Programs for Net Global Emissions Reductions (JOINE), is a Microsoft EXCEL spreadsheet application that serves as an informational database for utility companies. It requires the use of MS EXCEL Version 5.0 or later. JOINE gives information on USIJI and the Climate Challenge Program. It discusses requirements for USIJI proposals and how to keep abreast of USIJI activities via the World Wide Web. It also informs users on details of the CCP, the types of projects participants in the CCP are experimenting with, and where utilities can obtain more information on becoming involved.

The second tool is designated DEveloping Country Resource for Emissions Reduction StrategiEs (DECRESE). This is a Microsoft EXCEL spreadsheet application that serves as an informational database for utilities and other parties in developing countries that are interested in reducing global emissions. It requires the use of MS EXCEL Version 5.0 or later. DECRESE lists steps to go through to obtain funding for development projects, World Bank energy policies, how to obtain information to become involved in USIJI, and low emission power generation options.

Finally, EMISSION is an interactive executable file generated using Visual C++. It requires the use of Microsoft Windows 3.1 or later. Emissions created due to the fuel bound content of carbon, sulfur and nitrogen of coal are calculated. The user has the option of providing removal percentages of amelioration technologies to compare the savings to the environment such technologies can provide. The user must provide percentage content of each of the elements in the fuel (typical values are suggested) and removal efficiencies of technologies. Fuel usage per unit time in tons is also required. This can be provided by the user or it can be calculated from the program from user inputs of electricity generation per unit time, heat rate of the plant and heat content of fuel.

9.0 Conclusions

In order to achieve lower global power plant emissions, the entire world must commit to reforming their electricity generation and consumption practices. National governments must form effective policy instruments to achieve CO_2 reduction goals. Cooperation on the part of legislators, scientists, the utility industry, special interest groups, and society is essential to the formulation of policy with compliance strategies which are environmentally responsible, yet are economically and technically feasible. The majority of legislation should be performed on the national level to protect against local special interests jeopardizing the national cause. During periods of uncertain results of our actions, policy and utility planning approaches must support the use of the most environmentally benign options which are feasible, the degree of which should be determined foremost on the national level. Sanctions must be applied and enforced, and must be strict enough to incite compliance.

On the international level, developed countries must assist developing countries financially, logistically, and technologically in achieving global emissions reductions. Sustainable development will be challenging for these countries in many respects. Strategically-placed expertise of developed countries in areas that desire assistance can facilitate this process.

Much research is still required in the field of amelioration of CO_2 emissions from power plants. Meanwhile, electric utilities must practice multidimensional planning in the form of energy efficiency improvements, generation and purchase of power from more benign sources, and operation within regulatory structures to offset emissions and transfer technology in other areas of the world.

This thesis can be used to assist electric utilities, policymakers, and international financing institutions in their efforts to determine achievable limits of power plant emissions control and to build appropriate policies based on these limits. Electric utility planners can use this thesis to become aware of their role in controlling global emissions, to learn about planning options which are available to them, and to determine the environmental impacts of their present and planned power generation practices. Policymakers at the national level and with international financial institutions can use information contained here as a tool to help quantify emissions due to various power generation options for consideration when setting policy restrictions on emissions.

This thesis has shown that significant reductions in power plant CO_2 emissions can be achieved despite lack of specific CO_2 amelioration technologies. Multidimensional approaches will continue to be a factor in reduction of the effects of power plant emissions on the global environment even after technological alternatives are found.

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Appendix -- Output and Source Code from Software Tools

Source Code for EMISSION

```
/*                    SOURCE CODE of the PROGRAM EMISSION                      */

/*                                                                             */
/* This is a program to calculate CO2, SO2, and NO2 emissions due              */
/* to combustion of coal.  Emissions savings based on user-defined             */
/* emission removal efficiencies are also calculated.  Only emissions          */
/* due to coal-bound substances are reflected.  Additional compounds           */
/* formed by combustion in air (specifically, compounds of N2) are             */
/* not factored in. Written by Concha Maria Callwood February 1996             */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <conio.h>
#include <math.h>
#define MAX 10
#define MAXSIZE 128
#define ERR1 "You must enter a numeric value.  Reenter."
char *ERR2 = "You must enter a value between 0 and 100.  Reenter.";
char *ERR3 = "You must enter a positive number.  Reenter.";
void main (int argc, char *argv[])
{
      int count, index, notdone, finished;
      char ch;
      float temp, generation, heatrate, heatcontent;

      float carbon[MAX], sulfur[MAX], nitrogen[MAX];
      float CO2[MAX], SO2[MAX], NO2[MAX];
      float fuel[MAX];
      double produce[MAX][3], savings[MAX][3];

      float getupperlimit(char *errmsg, float value);
      float getlowerlimit(char *errmsg2, float num);

      fflush(stdin);

      count = 0;
      index = 0;
```

```
notdone = 1;

printf("Welcome to the Coal-fired Power Plant ");
printf("Emissions Calculation Program.\n");

while (notdone && count < MAX)
{
      printf("\nEnter percent carbon, sulfur, and nitrogen ");
      printf("content in the fuel.\n");
      printf("Valid values are between 0 and 100.\n");

      printf("Percent carbon content?  ");
      printf("Typical values are 70-90 percent.\n");
      carbon[count]=getupperlimit(ERR2, temp);

      printf("\nPercent sulfur content?  ");
      printf("Typical values are 0.5-5 percent.\n");
      sulfur[count]=getupperlimit(ERR2, temp);

      printf("\nPercent nitrogen content?  ");
      printf("Typical values are 1-2 percent.\n");
      nitrogen[count]=getupperlimit(ERR2, temp);

      printf("\nEnter tons of fuel used by plant in desired ");
      printf("timeframe or enter 0 to calculate\nfuel usage ");
      printf("based on plant generation, heat rate of fuel ");
      printf("and heat content of\nfuel.\n");
      fuel[count]=getlowerlimit(ERR3, temp);

      if (fuel[count]==0.0)
      {
            printf("\nEnter generation in GWhs for ");
            printf("desired timeframe.\n");
            generation=getlowerlimit(ERR3, temp);

            printf("\nEnter heat rate of fuel in MBTU/GWh ");
            printf("for desired timeframe.\n");
            heatrate=getlowerlimit(ERR3, temp);

            printf("\nEnter heat content of fuel in ");
            printf("MBTU/ton for desired timeframe.\n");
            heatcontent=getlowerlimit(ERR3, temp);

            fuel[count]=(generation*heatrate)/heatcontent;
       }/* if */

      produce[count][0]=((fuel[count]*3.67*carbon[count])/100.0);
      produce[count][1]=(fuel[count]*2.0*sulfur[count])/100.0;
      produce[count][2]=(fuel[count]*3.29*nitrogen[count])/100.0;
```

```
printf("Enter percent efficiency of C02 removal techno");
printf("logy.\nValid values are between 0 and 100 ");
printf("percent.\n");
CO2[count]=getupperlimit(ERR2, temp);

printf("Enter percent efficiency of S02 removal technolo");
printf("gy.\nValid values are between 0 and 100 ");
printf("percent.\n");
SO2[count]=getupperlimit(ERR2, temp);

printf("Enter percent efficiency of N02 removal technolo");
printf("gy.\nValid values are between 0 and 100 ");
printf("percent.\n");
NO2[count]=getupperlimit(ERR2, temp);

savings[count][0]=((CO2[count]/100.0))*produce[count][0];
savings[count][1]=((SO2[count]/100.0))*produce[count][1];
savings[count][2]=((NO2[count]/100.0))*produce[count][2];

if (count < (MAX-1))
{
      finished = 0;
      printf("\nWould you like to run the program again?");
      printf("  Enter Y or N.\n");
      while (finished != 1)
      {
            ch=getchar();
            if (ch == 'n' || ch == 'N')
                  {
                        finished=1;
                        notdone=0;
                  }
            else if (ch=='\n'||ch==' '||ch=='\t')
                  continue;
            else if (ch=='y' || ch=='Y')
                  finished=1;
            else
                  printf("You must enter Y or N.\n");
      }/* while */
 }/* if */
 else
 {
       notdone=0;
       printf("You've run the maximum number of times");
       printf(" for this session\n.  Please restart and");
       printf(" try again.\n");
 }
 ++count;
```

```
	}/* while */

	printf("\n");
	printf("\nFUEL          CARBON       CO2         CO2        CO2");
	printf("\nUSAGE         CONTENT      PRODUCED    REMOVAL    SAVED");

	printf("\n(tons)       (percent)     (tons)     EFFICIENCY  (tons)");
	printf("\n                                      (percent)\n\n");

	for (index=0;index<count;index++)
	{
		printf("%6.3g\t%6.3g\t\t",fuel[index],carbon[index]);
		printf("%6.3g  %6.3g\t",produce[index][0],CO2[index]);
		printf("%6.3g\n",savings[index][0]);
	}/* for */

	printf("\n");
	printf("\nFUEL          SULFUR       SO2         SO2        SO2");
	printf("\nUSAGE         CONTENT      PRODUCED    REMOVAL    SAVED");

	printf("\n(tons)       (percent)     (tons)     EFFICIENCY  (tons)");
	printf("\n                                      (percent)\n\n");


	for (index=0;index<count;index++)
	{
		printf("%6.3g\t%6.3g\t\t",fuel[index],sulfur[index]);
		printf("%6.3g  %6.3g\t",produce[index][1],SO2[index]);
		printf("%6.3g\n",savings[index][1]);
	}/* for */

	printf("\n");
	printf("\nFUEL          NITROGEN     NOx         NOx        NOx");
	printf("\nUSAGE         CONTENT      PRODUCED    REMOVAL    SAVED");

	printf("\n(tons)       (percent)     (tons)     EFFICIENCY  (tons)");
	printf("\n                                      (percent)\n\n");

	for (index=0;index<count;index++)
	{
		printf("%6.3g\t%6.3g\t\t",fuel[index],nitrogen[index]);
		printf("%6.3g  %6.3g\t",produce[index][2],NO2[index]);
		printf("%6.3g\n",savings[index][2]);
	}/* for */
	printf("\nBye!\n");
}/* main */

float getupperlimit(char *errmsg, float value)
{
```

```
        int valid;
        char invalid[MAXSIZE];
        valid=0;
        while (valid!=1)
        {
                while (scanf("%f",&value)!=1)
                {
                        puts(ERR1);
                        scanf("%s",invalid);
                }
                if ((value < 0)||(value > 100))
                        printf("%s\n",errmsg);
                else
                        valid=1;
        }
        return value;
}/* getupperlimit */

float getlowerlimit(char *errmsg2, float num)
{
        int valid;
        char invalid[MAXSIZE];
        valid=0;
        while (valid!=1)
        {
                while (scanf("%f",&num)!=1)
                {
                        puts(ERR1);
                        scanf("%s",invalid);
                }
                if (num < 0)
                        printf("%s\n",errmsg2);
                else
                        valid=1;
        }
        return num;
}/* getlowerlimit */
```

Sample Input for EMISSION

```
Welcome to the Coal-fired Power Plant Emissions
Calculation Program.

Enter percent carbon, sulfur, and nitrogen content in
the fuel.
Valid values are between 0 and 100.
Percent carbon content?  Typical values are 70-90
percent.
70
Percent sulfur content?  Typical values are 0.5-5
percent.
3
Percent nitrogen content?  Typical values are 1-2
percent.
2
Enter tons of fuel used by plant in desired timeframe
or enter 0 to calculate fuel usage based on plant
generation, heat rate of fuel and heat content of fuel.
800000
Enter percent efficiency of C02 removal technology.
Valid values are between 0 and 100 percent.
90
Enter percent efficiency of S02 removal technology.
Valid values are between 0 and 100 percent.
90
Enter percent efficiency of N02 removal technology.
Valid values are between 0 and 100 percent.
90

Would you like to run the program again?  Enter Y or N.
n
```

Sample Output for EMISSION

FUEL USAGE (tons)	CARBON CONTENT (percent)	CO2 PRODUCED (tons)	C02 REMOVAL EFFICIENCY (percent)	CO2 SAVED (tons)
8e+005	70	2.06e+006	90	1.85e+006

FUEL USAGE (tons)	SULFUR CONTENT (percent)	SO2 PRODUCED (tons)	S02 REMOVAL EFFICIENCY (percent)	SO2 SAVED (tons)
8e+005	3	4.8e+004	90	4.32e+004

FUEL USAGE (tons)	NITROGEN CONTENT (percent)	NOx PRODUCED (tons)	N0x REMOVAL EFFICIENCY (percent)	NOx SAVED (tons)
8e+005	2	5.26e+004	90	4.74e+004

Bye!

DECRESE -- DEveloping Country Resource for Emission Reduction StrategiEs

Contents:

Sources of Funding for United States Initiative on Joint Implementation (USIJI) Projects

Joint projects between developing countries and the US to reduce net greenhouse gas emissions

For more complete details about funding sources for USIJI projects refer to the World Wide Web at http://www.ji.org/usiji/conf/funding.htm

1) Export-Import Bank of the US	(800)565-EXIM
2) Overseas Private Investment Corporation	(202)336-8799
3) Edison Electric Institute	
Utility Forest Carbon Management Program	(202)508-5711
International Utility Efficiency Partnerships	(202)508-5507
4) World Bank	(202)473-1819
International Finance Corporation	
Investment Guarantee Agency	
International Bank for Reconstruction and Development	
International Development Association	

DECRESE -- DEveloping Country Resource for Emission Reduction StrategiEs

The World Bank's Energy Policy (1993)

In addition to continuing to promote energy efficiency and economically justified fuel switching, the World Bank will follow a four-point program when funding energy projects:

1) Better Integration of energy efficiency issues into its country policy dialogue so that they are addressed at an earlier stage
2) Be more selective in lending to energy supply enterprises, avoiding those poorly performing ones whose governments are unwilling to carry out fundamental reforms
3) Identify, support, and give high-level, in-country visibility to issues of demand management and end-use intermediation
4) Give greater attention to the transfer of more energy efficient and pollution reduction technologies in its sector and project work

For more information see:

World Bank, Energy, Efficiency and Conservation in the Developing World: A World Bank Policy Paper, The World Bank, Washington, D.C., 1993.

World Bank, The World Bank's Role in the Electric Power Sector: A World Bank Policy Paper, The World Bank, Washington, D.C., 1993.

DECRESE -- DEveloping Country Resource for Emission Reduction StrategiEs

The World Bank's Energy Policy (1993) (cont'd)

Recommendations for Power Sector policies:

1) All World Bank lending for the power sector should require an explicit move by the borrower toward establishment of a legal framework and regulatory process that is transparent, country independent if power suppliers, and free from government interference

2) In countries with weak public and private sectors, undeveloped capital markets, and a relative lack of market forces, the World Bank should help finance importation of power services to increase efficiency

3) The Bank should pursue the commercialization and corporatization of state-owned power utilities as necessary first steps in the process of restructuring and attracting the participation of the private sector

4) World Bank lending for electric power should focus on countries with a clear commitment to improving sector performance

5) The Bank should use some of its financial resources to encourage private investment in the power sector by supporting the commercialization and corporation of state-owned utilities

Note: Beginning in 1993 and continuing through 1996, the World Bank's Operational Directives related to the environment are being updated and incorporated into a new system of operational policies and procedures. Guidelines for Environmental Assessment (EA) plans, required for all World Bank investment projects since 1989, are undergoing revision as well. These plans are used to assess the environmental impacts of power projects and power system expansion efforts. The World Bank World Wide Web site gives a very comprehensive discussion of EA guidelines and required considerations, and offers a software tool to assist in the assessment. See http://www.worldbank.org/html/fpd/em/

DECRESE -- DEveloping Country Resource for Emission Reduction StrategiEs

Thermal Generation Options

Emissions Characteristics of Selected Fossil-Fired Plants (in grams/kWh, based on US plant characteristics)

	Emission			
Plant / Technology	CO	CO2	NOx	SOx
Coal / Conventional	0.11	1090	3.54	9.26
Coal, Pulverized / Flue Gas Desulfurization	**	960	3	**
Coal / Atmospheric Fluidized Bed	0.644	873	2.15	2.58
Coal / Flue Gas Desulfurization	0.104	873	2.58	2.58
Coal / Integrated Gasification Combined Cycle	0.0408	852	0.862	1.42
Coal / Pressurized Fluidized Bed	**	860	1	**
Natural Gas / Combined Cycle	0.0798	445	0.685	0.0023
Natural Gas / Combustion Turbine	0.611	664	2.2	0.0034
Oil / 90% Steam, 10% Combustion Turbine mix	0.19	7.81	2.02	5.08

** -- Numbers unavailable

Sources: Customer Systems Division, "Technical Brief: Electric Van and Gasoline Van Emissions: A comparison", Electric Power Research Institute, 1989.

Kane, R.L. and Smith, D.W., "The Likely Roles of Fossil Fuels in the Next 15, 50, and 100 Years, With or Without Active Controls on Greenhouse-Gas Emissions", In: Limiting Greenhouse Effects: Controlling Carbon Dioxide Emissions, ed. Pearman, G.I., John Wiley and Sons, Chichester, 1992.

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DECRESE -- DEveloping Country Resource for Emission Reduction StrategiEs

Useful World Wide Web Sites

Organization or Topic	Site
Asian Development Bank -	http://asiandevbank.org/
Member countries, eligibilities for loans,	
current projects, and publications	
JI-Online -	http://www.ji.org/
Current information on developments in JI	
and USIJI, types of projects and locations	
Thermal Conversion Technologies -	http://www.worldbank.org/html/fpd/em/eminfo/EA/projdef/thrmtech
Lists typical sizes, efficiencies, and capital	
costs of thermal power plants, corresponding	
data for thermal plant alternatives, and	
World Bank -	http/://www.worldbank.org/
Current project information, list of	
publications, and current research activities	
Environmental Assessment process	http://www.worldbank.org/html/fpd/em/eminfo/EA/eaproc.htm
Integration of Environmental Assessment into power	http://www.worldbank.org/html/fpd/em/emhom.htm
sector planning	
suitability for use in developing countries	
World Health Organization Air Quality Standards -	http://www.worldbank.org/html/fpd/em/eminfo/EA/standard
-may be useful when planning projects in	
countries whose air quality standards are	
less strict than is acceptable by international standards	

JOINE -- JOInt Programs for Net Global Emissions Reductions

Contents:

Proposal Requirements for United States Initiative on Joint Implementation (USIJI) Projects

Joint projects between developing countries and the US to reduce net greenhouse gas emissions

For more complete details about USIJI refer to the World Wide Web at http://www.ji.org/usiji/guide.htm

1) Participants
- Give all information about domestic and foreign parties involved in the project.
  - -officer responsible for project, contact person, contact information, category of eligibility, be it US citizen, resident alien, or company, and proof of that eligibility

2) Project Information
- a) Project description
  - 1) summary, location and alternate sites
  - 2) greenhouse sources and sinks of base case (with no activity) and with proposed project
  - 3) description of specific proposed measures to reduce net greenhouse gases
  - 4) timeline of project - initiation, project completion, lifetime
- b) Funding sources
- c) Assignment of reductions - The parties which will be credited with the emissions reductions
- d) Demonstration that actions will result in greenhouse gas reductions or sequestering that would not otherwise have occurred

3) Estimates of greenhouse gas emissions and sequestration due to project
- -provide estimate timeframes for net emissions reductions or sequestration to take place

JOINE -- JOInt Programs for Net Global Emissions Reductions

Climate Challenge Program

Partnerships between the US Department of Energy and electric utility companies to limit greenhouse gases

For more information consult the World Wide Web at http://gcrio.gcrio.org/USCCAP/toc.htm or Clinton, W.J. and Gore, A. Jr., The Climate Change Action Plan, US Government Publication, Oct 1993.

Purposes:
1) Accountability for power plant generated emissions
2) Flexibility in allowing electric utilities to experiment with and demonstrate cost-effective emissions reduction options

Technology options being experimented with:
1) Efficiency enhancements to generation and transmission of electricity
2) Fuel switching to lower carbon fuels
3) Investments in renewable generation
4) Performance enhancements to existing hydroelectric and nuclear plants
5) Expansion of Demand- Side Management (DSM) programs
6) Forestry Projects
7) Involvement in international projects through USIJI

JOINE -- JOInt Programs for Net Global Emissions Reductions

Useful World Wide Web Sites

Organization or Topic	Site
Climate Challenge Program	http://gcrio.gcrio.org/USCCAP/toc.htm
EEI-Online -	http://www.eei.org/
Edison Electric Institute - includes a utility	
policy watch site for legislation and policies	
affecting electric utilities	
International Utility Efficiency Partnerships	http://www.ji.org/iuep/iuep.htm
JI-Online -	http://www.ji.org/
Current information on developments in JI	http://www.ji.org/usiji/usiji.htm
and USIJI. Information on USIJI includes	
projects underway and their locations,	
projects in need of funding, and case studies	
of ongoing projects	
Thermal Conversion Technologies -	http://www.worldbank.org/html/fpd/em/eminfo/EA/projdef/thrmtech/
Lists typical sizes, efficiencies, and capital	
costs of thermal power plants, corresponding	
data for thermal plant alternatives, and	
suitability for use in developing countries	
World Health Organization Air Quality Standards-	http://www.worldbank.org/html/fpd/em/eminfo/EA/standard/
-may be useful when planning projects in	
countries whose air quality standards are	
less strict than is acceptable by international	
standards	

Vita

Concha Maria Callwood was born and raised on the tiny Caribbean island of St. Thomas in the United States Virgin Islands, the fifth child of eight born to Gloria and Richard Callwood Jr. Her brothers and sisters include Richard, Karl, Francis, and Fern of St. Thomas, Yvette Spencer of Gainesville, Florida, Austell of Alexandria, Virginia, and Elena of Hampton, Virginia. She graduated from Charlotte Amalie High School on St. Thomas. After a short stay at the University of Tampa in Tampa, Florida, she transferred to Louisiana State University in Baton Rouge from where she obtained a bachelor of science degree in electrical engineering in 1991. Upon graduation, she began working with the Central Intelligence Agency (CIA), where she had been a cooperative education student since 1988. In August of 1993, Concha took a leave of absence from her job to pursue the greater challenge of graduate studies in electrical engineering at Virginia Tech. In January of 1993 she was awarded an academic fellowship for her Master's degree from the CIA which allowed her to work part-time at the CIA while continuing full-time at Virginia Tech. She has begun Ph.D. studies in electric power engineering at Virginia Tech. Concha is the proud aunt of three nephews, Johnathon Christopher Callwood, Mark Callwood, and Kaleab LaRon Spencer; one niece, Katherine Karlene Callwood; and one niece or nephew due in April 1996.