Modeling Greenhouse Gas Emission in Louisiana

PREPARED FOR

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PREPARED BY

The Center for Energy Studies
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Introduction

As carbon dioxide (CO_2) and other "greenhouse gases" accumulate in the atmosphere they act like a blanket to insulate and warm the planet. Monitoring has established a build up of six core greenhouse gases – carbon dioxide, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexaflouride (SF_6)–which is expected to increase the degree of global warming. The consequences of the build up are controversial as are policy alternatives to deal with it. The focus of this report is to model Louisiana's contribution to the greenhouse gas build up over the next fifteen years. Four different scenarios are used to model the magnitude and pattern of emissions and emission-producing activities. The forecasts are heuristic and illustrative. The model results presented are not forecasts in the usual sense of the term since more data and analysis are required to select one forecast over another.

The four scenarios analyzed are based on different assumptions about the rate and pattern of future growth. The first uses the growth rates of greenhouse gases from fossil fuel consumption in Louisiana observed over the 1990 to 1996 period. The assumption is made that these growth rates will be maintained over the entire 2000 to 2015 period. The other three scenarios are based on emission and production forecasts from the U.S. Department of Energy, Energy Information Administration's *Annual Energy Outlook* (EIA 2000). The first gives emission levels for the State if its emissions grew at the same rate as those of the nation as a whole. The second uses EIA's forecast for the West South Central Census Division, which includes Texas, Arkansas, Oklahoma and Louisiana. The third forecast shows the consequences for Louisiana if emissions were subject to "best control technology" as forecast by EIA.

Greenhouse gases have differential impacts on atmospheric build up. Emissions of some contribute to the greenhouse gas build up much more than do equal quantities of others. To account for this, emissions of the other greenhouse gases are usually expressed as CO_2 equivalents, a convention that we will follow here. Although the other greenhouse gases can be important contributors in some regions and industries, CO_2 which comes mainly from the burning of fossil fuels, has been and continues to be mankind's largest contribution to global warming on an aggregate basis.

During the first stage of this research, inventories of Louisiana's greenhouse gases were collected. The United States Environmental Protection Agency's state workbook entitled *Methodologies for Estimating Greenhouse Gas Emissions, Third Edition* (1998a)was used as a guide for gathering the inventory. The workbook provided guidelines for determining greenhouse gas emissions in *metric tons per year* from many different manufacturing and agricultural industries. These inventories are the reference point for forecasting future emissions, but are not discussed here as they were the subject of the earlier companion report. These relationships in Louisiana are summarized in Tables I, II, and III, which are taken from the inventory (CES 2000). Not all of the sectors shown are used in the modeling exercise because either data are not available from the EIA forecasts or the sector's contribution is so small that it does not materially affect the forecast. Table I summarizes the source of greenhouse gases, their volume, the emissions' global warming potential and CO_2 equivalent and the percentage share of total emissions.

Table I - Summary of the Inventory Estimates by Source

Source	Greenhouse Gas	Emissions (thousand metric tons)	Global Warming Potential	CO_2 Equivalent Emissions (thousand metric tons)	MMTCE*	Percent of Total Emissions
1. Fossil Fuel Combustion	CO_2	214,270.5	1	214,270.5	58.437	98.61
2. Production and Consumption Processes	CO_2	1,447.4	1	1,447.4	0.395	0.67
	N_2O	5.4	310	1,662.8	0.453	0.77
	HFC-23	0.5	11,700	5,307.1	1.447	2.44
	SF_6	0.0	23,900	97.7	0.027	0.04
	All			8,515.0	2.322	3.92
3. Natural Gas and Oil Systems	CH_4	384.6	21	8,077.5	2.203	3.72
4. Coal Mining	CH_4	0.5	21	10.4	0.003	0.00
5. Municipal Waste Management	CH_4	199.2	21	4,183.7	1.141	1.93
6. Domesticated Animals	CH_4	68.4	21	1,435.6	0.392	0.66
7. Manure Management	CH_4	7.3	21	153.3	0.042	0.07
8. Flooded Rice Fields	CH_4	108.3	21	2,275.0	0.620	1.05
9. Agricultural Soil Management	N_2O	3.4	310	1,058.5	0.289	0.49
	CO_2	22.0	1	22.0	0.006	0.01
	All			1,080.5	0.295	0.50
10. Forest Management and Land Use Change	CO_2	-22,774.9	1	-22,774.9	-6.211	-10.48
11. Burning of Agricultural Crop Waste	CH_4	0.2	21	3.8	0.001	0.00
	N_2O	0.0	310	1.1	0.000	0.00
	All			4.8	0.001	0.00
12. Municipal Wastewater	CH_4	1.3	21	27.0	0.007	0.01

* Million metric tons of Carbon equivalent

Table II - Summary of Inventory Estimates by Type of Emission

Source	Greenhouse Gas	Emissions (thousand metric tons)	Global Warming Potential	CO_2 Equivalent Emissions (thousand metric tons)	MMTCE	Percent of Total Emissions
All Sources	CO_2	192,965.0	1	192,965.0	52.627	88.81
	CH_4	769.8	21	16,166.3	4.409	7.44
	N_2O	8.8	310	2,722.4	0.742	1.25
	HFC-23	0.5	11,700	5,307.1	1.447	2.44
	SF_6	0.0	23,900	97.7	0.027	0.04
	All			217,285.4	59.260	100.00

Table II shows the distribution of greenhouse gases by type. CO_2 is by far the largest contributor, accounting for almost 89 percent on a CO_2 equivalent basis.

Table III compares Louisiana's greenhouse gas emissions with national totals. It shows amounts and a percentage distribution for each major sector for the state and the nation. The major difference is that fossil fuel combustion contributes a larger share in Louisiana than is true nationally.

Table III - Comparison of Total U.S. and Total Louisiana Greenhouse Gas Emissions

Sectors	Louisiana		U.S. Total		Louisiana Emissions as a Share of U.S. Emissions
	Emissions (MMTCE)	Sectoral Distribution	Emissions (MMTCE)	Sectoral Distribution	
Fossil Fuel Combustion	58.437	98.612%	1,450.300	93.792%	4.03%
Production and Consumption Processes	2.322	3.919%	61.500	3.977%	3.78%
Natural Gas and Oil Systems	2.203	3.717%	35.600	2.302%	6.19%
Coal Mining	0.003	0.005%	18.900	1.222%	0.01%
Municipal Waste Management	1.141	1.925%	65.200	4.217%	1.75%
Domesticated Animals	0.392	0.661%	34.500	2.231%	1.13%
Manure Management	0.042	0.071%	16.600	1.074%	0.25%
Flooded Rice Fields	0.620	1.047%	2.500	0.162%	24.82%
Agricultural Soil Management	0.295	0.497%	68.600	4.436%	0.43%
Forest Management and Land Use Change	-6.211	-10.482%	-208.600	-13.490%	2.98%
Burning of Agricultural Crop Waste	0.001	0.002%	0.300	0.019%	0.44%
Municipal Wastewater	0.007	0.012%	0.900	0.058%	0.82%
Total	59	100.000%	1,546.300	100.000%	3.83%

Figure I compares the share of national emissions for each state that has completed an emissions inventory with the corresponding share of gross product and the share of the nation's population. Louisiana has the largest discrepancy from the national average (producing more emissions than its share) if the comparison is made with the state's share of the nation's population and the third largest if the comparison is made with output.

The economic impact of global warming may be far reaching for energy-producing and energy-intensive manufacturing states such as Louisiana. Industrial output, as well as employment, are likely to be affected by efforts to mitigate emissions. Investigating these impacts is beyond the scope of this project. The project's objective is to provide and illustrate a forecasting model that can be used to analyze emission scenarios as a prerequisite for studying their consequences and policies that may be used to mitigate them. An interactive forecast modeling spreadsheet is developed to allow users the ability to analyze potential greenhouse gas emissions for the years 2000, 2005, 2010, and 2015 under different scenarios.

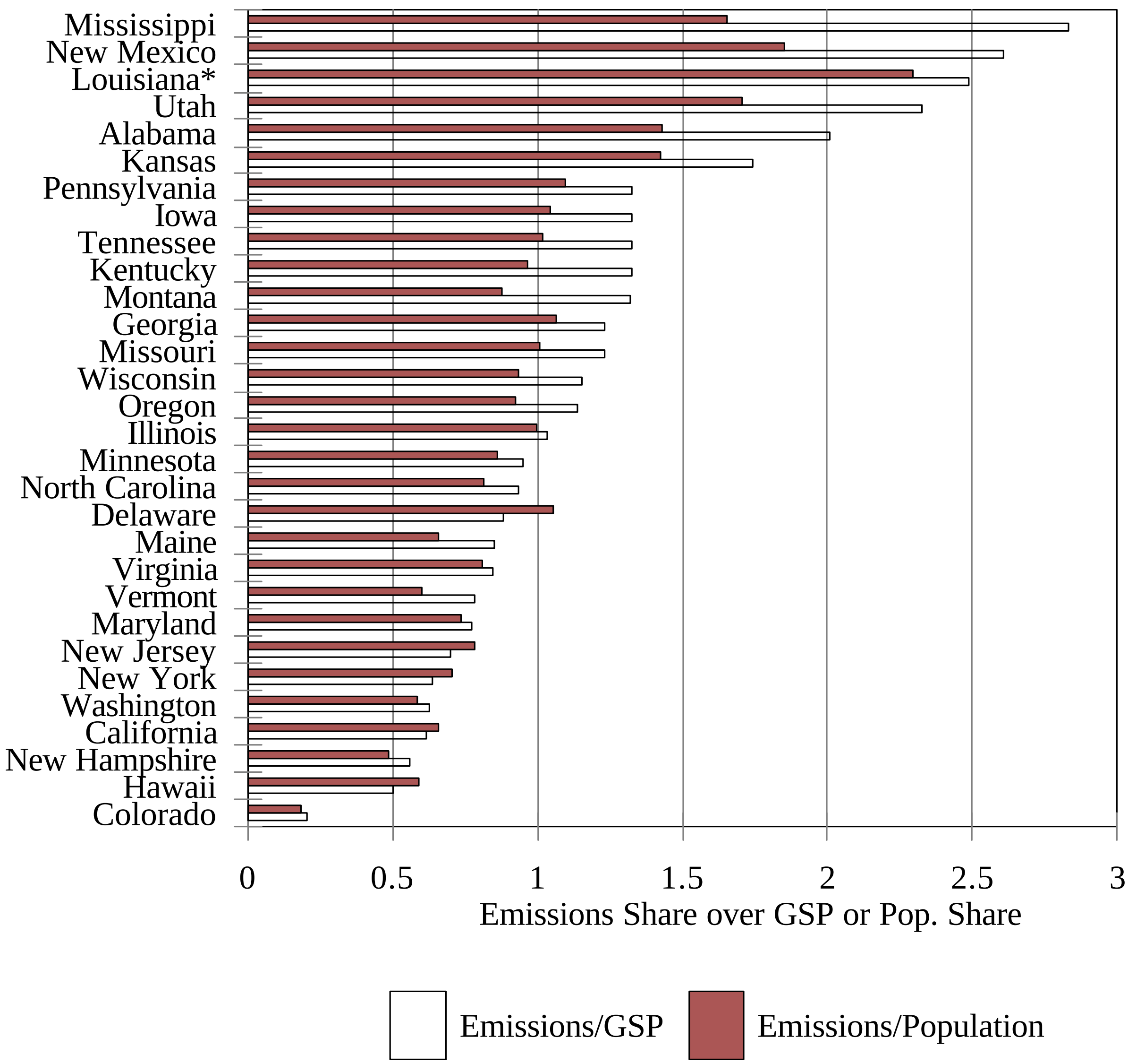


Figure I. **Share of greenhouse gas emissions standardized by shares of gross domestic product and population.**

Historical Inventory Data

The models developed here are constrained by a single observation for each of the inventoried emissions in the year 1996. To provide some historical context, we also gathered data for the fossil fuels section of the inventory for the year 1990 and calculated annual growth rates for the 1990 to 1996 period.

One of the projections discussed below was made by assuming that the 1990 to 1996 growth rate was maintained over the 2000 to 2015 period. Three other projections were also made. The first assumes that the rate of growth in Louisiana over the 2000 to 2015 period in each of the principal modeling categories was identical to the rate for the nation as a whole. The second scenario is based on the assumption that the relevant growth rates for Louisiana were the same as those projected for the West South Central Census region, which includes Louisiana, Texas, Arkansas and Oklahoma. The final projection is based on the national forecast from EIA, which attempts to incorporate "Best Available Control Technology" in the forecast. Better data with more precise empirical content can be incorporated into the modeling exercise as they become available.

Components of the Modeling Workbook

The emissions model consists of eight separate spreadsheets created within the inventory workbook. Each supports specific greenhouse gas emissions inventories and emissions and economic forecasts. A brief description of each spreadsheet is given below. Bold lettering signifies a tab title.

1. **MODEL –** includes user specified inputs for growth, consumption, and technology improvement rates that are required for forecasting future emissions. It also includes totals for all forecasted greenhouse gas emissions.

2. **COSTS –** includes user specified inputs for interest (the societal cost of capital), inflation, and tax rates that are required for forecasting future emission costs/revenues. It also includes totals for all forecasted emission costs/revenues. This spreadsheet is not used in the scenarios analyzed in this report but can be used for such purposes as estimating revenues from control or mitigation policies such as carbon taxes.

3. **CO_2 –** includes all carbon dioxide related emissions activities having been inventoried and forecasted.

4. **CH_4 –** includes all methane related emissions activities having been inventoried and forecasted.

5. **N_2O –** includes all nitrous oxide related emissions activities having been inventoried and forecasted.

6. **HFCs** – includes all hydrofluorocarbon related emissions activities having been inventoried and forecasted.

7. **PFCs** – includes all perfluorocarbons related emissions activities having been inventoried and forecasted.

8. **SF_6** – includes all sulfur hexaflouride related emissions activities having been inventoried and forecasted.

User Specified Input Parameters for Emissions Forecasting

The top portion of the **MODEL** spreadsheet contains all required input parameters. These parameters include growth (g), consumption (c), and technology improvement (t) rates. Relevant growth and consumption rates are applied to each industrial or agricultural emitter category to forecast their emissions. Once totals from each contributor for each greenhouse gas are compiled, a technology improvement rate is applied to forecast total greenhouse gas emissions for the years 2000, 2005, 2010, and 2015. Descriptions of the various growth, consumption, and technology improvement rates can be found in the following subsections.

Growth Rates and Consumption Rates

As manufacturing and agricultural industries and state and animal populations grow, the greenhouse gas emissions they create will also continue to grow. The model forecasts future greenhouse gas (GHG) emissions using hypothetical or judgmental compounding factors for growth curve implementation. Such growth rates include the following:

1. *Natural Gas Production Growth Rate* – the rate of increase in the production of natural gas per year.
2. *Oil Production Growth Rate* – the rate of increase in the production of oil per year.
3. *Coal Production Growth Rate* – the rate of increase in the production of coal per year.
4. *Manufacturing/Production Growth Rate* – the growth rate per year for commodities manufactured or produced that emit greenhouse gases.
5. *Human Population Growth Rate* – the rate of increase in Louisiana's population per year.
6. *Animal Population Growth Rate* – the rate of increase in the population of domesticated farm animals per year.
7. *Farming Growth Rate* – the rate of increase in farm acreage per year.
8. *Tree Farming Growth Rate* – the rate of increase in the number of trees planted per year.

Greenhouse gases are also produced from the consumption of raw materials such as coal, oil, natural gas, or other intermediate goods. For example, the transportation and electric utility industries consume significant amounts of fuels and produce one of the fastest accumulating greenhouse gases, carbon dioxide. Such consumption rates include the following:

1. *Residential Fuel Consumption Rate* – the rate of increase in fuel consumption for

residential users per year.

2. *Commercial Fuel Consumption Rate* – the rate of increase in fuel consumption for commercial users per year.
3. *Industrial Fuel Consumption Rate* – the rate of increase in fuel consumption for industrial users per year.
4. *Transportation Fuel Consumption Rate* – the rate of increase in fuel consumption for all modes of transportation per year.
5. *Electric Utility Fuel Consumption Rate* – the rate of increase in fuel consumption for the generation of electricity per year.
6. *Manufacturing/Production Consumption Rate* – the consumption rate per year for commodities manufactured or produced which emit greenhouse gases.

To forecast emissions for each greenhouse gas (l), a growth rate *g* and consumption rate *c* are applied for each emissions contributor (m). The rates are then compounded for *n* years. Equation 1 below sums the forecasted emissions from all industrial and agricultural growth and consumption emission contributors to determine the total forecasted inventory for each greenhouse gas.

$$[\sum_{i=1}^{l} \sum_{j=1}^{m} \text{GHG Inventory}_{lm} * (1+ g_{lm} + c_{lm})^{n}] = \text{Total Forecasted Inventory}_{l}, \ \forall l, \ \forall m$$

(Equation 1)

Technology Improvement Rates

Creatively administered restrictions on greenhouse gas emissions could strongly encourage environmental technology to accelerate to a new regime that provides services both at lower costs under "business as usual" conditions and with much less environmental damage than at present. It could be extremely costly to wait for scientific certainty on the impact of greenhouse gases upon the global climate before committing to a vigorous research and development program (Manne and Richels, 1990a). New technologies require many years for market penetration. If it turns out that substantial reductions in greenhouse gas emissions are needed, it will be important to have the means available for achieving such reductions in a timely manner. This can only be accomplished through a sustained commitment to research and development.

To account for such an impact from technological improvements, the emissions-cost tradeoff model employs a technology improvement rate to project the effects of technology changes. Good judgment plays a pivotal role in forecasting greenhouse gas emissions into the uncertain distant future, and a technological forecasting rate is used to counter the growth of greenhouse gas emissions. Such rates include the following:

1. *CO_2 Emission Technology Improvement Rate* – the yearly rate of improvement in technology designed for carbon dioxide emission reduction.
2. *CH_4 Emission Technology Improvement Rate* – the yearly rate of improvement in

technology designed for methane emission reduction.

3. *N_2O Emission Technology Improvement Rate* – the yearly rate of improvement in technology designed for nitrous oxide emission reduction.
4. *HFC Emission Technology Improvement Rate* – the yearly rate of improvement in technology designed for hydrofluorocarbon emission reduction.
5. *PFC Emission Technology Improvement Rate* – the yearly rate of improvement in technology designed for perfluorocarbon emission reduction.
6. *SF_6 Emission Technology Improvement Rate* – the yearly rate of improvement in technology designed for sulfur hexaflouride emission reduction.

Mathematically, a technology improvement rate *t* is applied for each inventoried greenhouse gas (m). The improvement rate negatively affects the previous growth and consumption rates and is compounded yearly for *n* years. Equation 2 describes the effect of technological improvements to manufacturing and agricultural processes to determine total forecasted greenhouse gas emissions for each significant greenhouse gas.

$$[\sum_{i=1}^{l} \text{Total Forecasted Inventory}_l \ * \ (1 - t_l)^n] = \text{Total Forecasted GHG Emissions}_l, \ \forall l$$

(Equation 2)

Greenhouse Gas Emissions Forecast

Figure II summarizes the emissions inventory of the five greenhouse gases that are important in Louisiana and compares them to four forecasts based on different assumptions about the rate and pattern of future growth over the 2000 to 2015 period. The figure emphasizes Louisiana's challenge in dealing with greenhouse gases in the future since most greenhouse gas proposals involve maintaining 1990 emission levels or reducing emissions below 1990 levels. However, in the four cases considered, the increase in emissions ranges from a low of 22 percent to a high of 40 percent. More precisely,

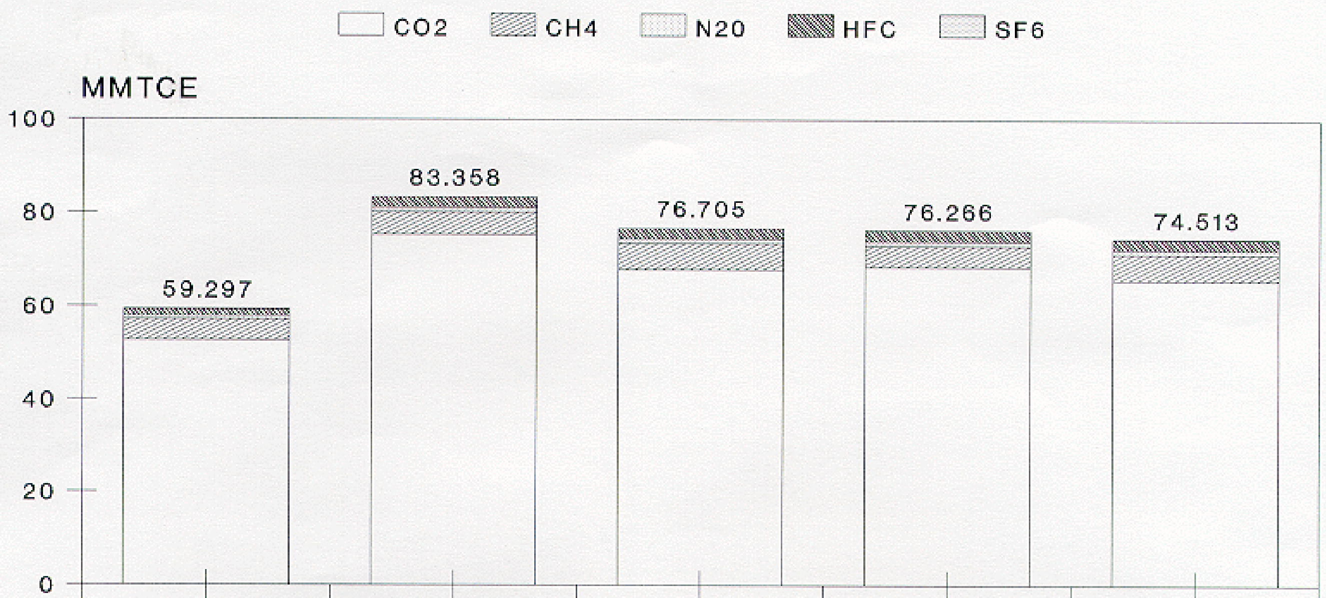
- If growth rates observed over the 1990 to 1996 period were to be maintained, by 2015 greenhouse gas emissions would be about 40 percent above 1996 levels.

- If emissions in Louisiana were to grow at the national average rate, by 2015 they would be 29.3 percent above 1996 levels.

- If Louisiana's emissions were to grow at the average rate of the states in the West South Central Census Division (Arkansas, Louisiana, Oklahoma and Texas), emissions would be 28.6 percent above 1996 levels.

- If technological improvements reflected primarily in more efficient energy use were made during the period, emissions would still be about 25.6 percent above 1996 levels.

Figure II - Emissions in 1996 compared to forecasts based on alternative growth rate assumptions.



	96 Invntry	90-96 to 2015	US Ave Grth	WSC Ave Grth	Techno improv
SF6	0.027	0.04	0.042	0.042	0.042
HFC	1.447	2.196	2.264	2.264	2.264
N20	0.742	1.004	0.975	0.975	0.975
CH4	4.409	4.855	5.575	4.546	5.575
CO2	52.672	75.263	67.849	68.439	65.657

Note: 1990-96 calculated, US Ave, WSC Ave, and Technology Improvement from EIA

Alternative Scenarios

The modeling parameters and resulting forecasts for the four scenarios summarized in Figure II are detailed in Tables IV through X. The growth rates shown for the five-year intervals are the average annual rate of growth ending with the year heading the column. The 1990 to 1996 extrapolation maintains the rate through each of the forecast periods. In the other scenarios growth rates change at five-year intervals for some variables.

Comparing Tables IV and V (which show modeling parameters and the corresponding forecast for the scenario, which continues the 1990 to 1996 growth rates throughout the period) with Tables VI and VII (which apply the Energy Information Administration's forecast for the U.S. to the Louisiana inventory) helps to identify the factors responsible for differences observed.

- The growth rates in the upper part of Table VI show that EIA expects healthy growth of 1.6 percent per year in natural gas production but a drop of 0.8 percent per year in oil production.

- The rates of growth observed in the 1990 to 1996 period for Louisiana in Table IV were a smaller (0.04 percent) annual growth for natural gas but increased oil production one percent per year.

- Manufacturing production in the U.S. average forecast exceeds the constant 1990-96 scenario in the first two periods but falls below it the last two periods.

- The state population would grow almost twice as fast as it did during the 1990 to 1996 period.

- The number of acres farmed in Louisiana grew modestly during the 1990 to 1996 period but would be expected to decline at about the same rate in the U.S. average case.

Consumption rates shown in the bottom part of the two tables also show differences.

- Residential fuel consumption grew at a rate of 1.45 percent per year in the 1990-96 period, but the U.S. average forecast declined from one percent per year to 0.58 percent over the period.

- Commercial fuel consumption would grow considerably faster in the U.S. average case during the initial three periods but would fall slightly below the historical rate in the last period.

- Industrial fuel consumption would grow only about half as fast in the U.S. average case as it did during the 1990-96 period.

- Transportation fuel was consumed at annual rate of 2.50 percent during the 1990-96 period, but its growth rate would fall from a rate of 2.13 percent in the initial period to 1.51 percent in the last period. Fuel consumed by electric utilities would grow considerably faster in the U.S. average case than it did during the 1990-96 period.

Table IV - Modeling Parameters for Greenhouse Gas Emissions
Case 1: Using 1990-1996 Louisiana Historical Data

Source: Input Year:	Parameters for 2000	Parameters for 2005	Parameters for 2010	Parameters for 2015
Growth Rates				
Natural Gas Production	0.04%	0.04%	0.04%	0.04%
Oil Production	1.01%	1.01%	1.01%	1.01%
Coal Production	0.49%	0.49%	0.49%	0.49%
Manufacturing/Production	2.22%	2.22%	2.22%	2.22%
State Population	0.43%	0.43%	0.43%	0.43%
Animal Population	0.50%	0.50%	0.50%	0.50%
Farming	0.47%	0.47%	0.47%	0.47%
Tree Farming	0.50%	0.50%	0.50%	0.50%
Consumption Rates				
Residential Fuel	1.45%	1.45%	1.45%	1.45%
Commercial Fuel	0.58%	0.58%	0.58%	0.58%
Industrial Fuel	1.64%	1.64%	1.64%	1.64%
Transportation Fuel	2.50%	2.50%	2.50%	2.50%
Electric Utility Fuel	0.52%	0.52%	0.52%	0.52%
Manufacturing/Production	2.22%	2.22%	2.22%	2.22%

Table V - Emissions Forecast, Case 1: Using 1990-1996 Louisiana Historical Data (MMTCE)

Greenhouse Gas: Year:	Forecast for 2000	Forecast for 2005	Forecast for 2010	Forecast for 2015
CO_2	57.120	62.838	68.601	75.263
CH_4	4.551	4.651	4.751	4.855
N_2O	0.790	0.854	0.925	1.004
HFC	1.580	1.764	1.968	2.197
PFC	0.000	0.000	0.000	0.000
SF_6	0.029	0.032	0.036	0.040
TOTALS	64.071	69.881	76.288	83.359

Table VI - Modeling Parameters for Greenhouse Gas Emissions
Case 2: Using EIA Forecast of U.S. Emission Averages

Input Year: Source:	Parameters for 2000	Parameters for 2005	Parameters for 2010	Parameters for 2015
Growth Rates				
Natural Gas Production	1.60%	1.60%	1.60%	1.60%
Oil Production	-0.80%	-0.80%	-0.80%	-0.80%
Coal Production	1.78%	1.78%	1.78%	1.78%
Manufacturing/Production	2.91%	2.53%	2.11%	2.09%
State Population	0.86%	0.81%	0.81%	0.82%
Animal Population	0.50%	0.50%	0.50%	0.50%
Farming	-0.45%	-0.45%	-0.45%	-0.45%
Tree Farming	0.50%	0.50%	0.50%	0.50%
Consumption Rates				
Residential Fuel	1.00%	0.92%	0.79%	0.58%
Commercial Fuel	2.31%	1.14%	0.87%	0.51%
Industrial Fuel	0.50%	1.29%	0.82%	0.88%
Transportation Fuel	2.13%	2.08%	1.82%	1.51%
Electric Utility Fuel	1.72%	1.30%	0.87%	0.70%
Manufacturing/Production	2.91%	2.53%	2.11%	2.09%

Table VII - Emissions Forecast, Case 2: Using Average U.S. Emission Forecast (MMTCE)

Year: Greenhouse Gas:	Forecast for 2000	Forecast for 2005	Forecast for 2010	Forecast for 2015
CO_2	55.831	60.524	64.234	67.849
CH_4	4.681	4.958	5.256	5.575
N_2O	0.792	0.853	0.911	0.974
HFC	1.623	1.839	2.041	2.264
PFC	0.000	0.000	0.000	0.000
SF_6	0.029	0.033	0.037	0041
TOTALS	62.958	68.210	72.480	76.705

Comparing Tables VI and VI I (the U.S. average case) with Tables VIII and IX (the West South Central Census Region Case) shows less difference in total emissions than one might expect. In fact, emissions in the energy producing WSC case in the year 2015 are one half of one percent *lower* than the level forecast for the nation considered as a whole. Comparing the two modeling parameter tables indicates some of the factors behind this result.

- Natural gas production in the U.S. average case grows at a healthy 1.6 percent per year rate, but declines in the energy-producing WSC states at an annual rate of 0.9 percent.

- Similarly, oil production declines in the U.S. average case but declines more rapidly in the WSC case (negative 0.80 percent per year as compared to a negative 2.39 annual rate).

- As a consequence of the rates of decline in the WSC case, emissions of methane increase more slowly, increasing by only 1.6 percent over the 15-year period. In contrast, in the U.S. average case methane emissions grow by almost 20 percent.

This difference underscores the importance of modeling and forecasting when designing regulations or mitigation strategies. In Louisiana's case, targets or requirements reflecting historic growth or current shares probably would be considerably more demanding than if they were based on a forecast, like that for the WSC states, showing a convergence to the national average emission rate over time.

Table VIII - Modeling Parameters for Greenhouse Gas Emissions
Case 3: Using EIA Forecast for West South Central States

Input Year: / Source:	Parameters for 2000	Parameters for 2005	Parameters for 2010	Parameters for 2015
Growth Rates				
Natural Gas Production	-0.93%	-0.93%	-0.93%	-0.93%
Oil Production	-2.39%	-2.39%	-2.39%	-2.39%
Coal Production	-0.19%	-0.19%	-0.19%	-0.19%
Manufacturing/Production	2.91%	2.53%	2.11%	2.09%
State Population	1.20%	1.13%	1.11%	1.13%
Animal Population	0.50%	0.50%	0.50%	0.50%
Farming	-0.45%	-0.45%	-0.45%	-0.45%
Tree Farming	0.50%	0.50%	0.50%	0.50%
Consumption Rates				
Residential Fuel	0.00%	0.51%	0.99%	0.95%
Commercial Fuel	0.55%	0.65%	1.04%	0.50%
Industrial Fuel	0.20%	1.19%	1.00%	0.88%
Transportation Fuel	2.40%	2.34%	2.17%	1.78%
Electric Utility Fuel	1.74%	0.51%	0.99%	0.76%
Manufacturing/Production	2.91%	2.53%	2.11%	2.09%

Table IX - Emissions Forecast, Case 3: Using West South Central Averages (MMTCE)

Year: / Greenhouse Gas:	Forecast for 2000	Forecast for 2005	Forecast for 2010	Forecast for 2015
CO_2	55.574	59.922	64.406	68.439
CH_4	4.472	4.485	4.508	4.545
N_2O	0.792	0.853	0.911	0.974
HFC	1.623	1.839	2.041	2.264
PFC	0.000	0.000	0.000	0.000
SF_6	0.029	0.033	0.037	0.041
TOTALS	62.492	67.134	71.906	76.265

Comparing the U.S. average case with the technology improvement case shows that most greenhouse gas emission methods work by reducing the consumption of fossil fuels. The technology improvement case applies the most-emission-reducing EIA forecast to each of the sectors in the case using the U.S. average growth rates. As comparison of the top and bottom parts of the tables makes clear, the difference between the two forecasts comes about by decreases in the relevant fuel consumption rates.

- Residential fuel consumption grows about half as fast as the U.S. average case in the first two periods and then declines in the last two.

- In the best technology cases, commercial fuel consumption grows at roughly a third of the corresponding U.S. average rates.

- Industrial fuel consumption is much closer in the two cases. This may reflect an assumption that industrial consumers look for and exploit energy efficiency opportunities more aggressively than other consumers.

- Similarly, the consumption of fuels for transportation grows at about two-thirds the U.S. average case in the technology improvement scenario.

- Apparently reflecting a view that technology improvement will involve more electrification, fuel consumption in the electric utility case grows at a faster rate in the technology improvement scenario than in the U.S. average case in three of the four forecast periods.

- Finally, it is worth noting that despite the injection of rather ambitious assumptions about fuel consumption rates, the technology improvement scenario reduces total emissions by only three percent below the U.S. average case, and, as noted earlier, total emissions rise by 30 percent above the 1996 inventory level in the best technology case. Since most greenhouse gas reduction goals call for maintenance, or reduction below 1990 levels, the challenge is apparent.

Other scenarios can be modeled with the spreadsheets enumerated above. Although the model is a simplification of the organization of the inventory, it does include the major greenhouse gas generators and can easily be expanded or reorganized to focus on scenarios or strategies of particular interest.

Table X - Modeling Parameters for Greenhouse Gas Emissions
Case 4: Forecast Averages Using U.S. Growth Rates with Technology Improvements

Input Year: Source:	Parameters for 2000	Parameters for 2005	Parameters for 2010	Parameters for 2015
Growth Rates				
Natural Gas Production	1.60%	1.60%	1.60%	1.60%
Oil Production	-0.80%	-0.80%	-0.80%	-0.80%
Coal Production	1.78%	1.78%	1.78%	1.78%
Manufacturing/Production	2.91%	2.53%	2.11%	2.09%
State Population	0.86%	0.81%	0.81%	0.82%
Animal Population	0.50%	0.50%	0.50%	0.50%
Farming	-0.45%	-0.45%	-0.45%	-0.45%
Tree Farming	0.50%	0.50%	0.50%	0.50%
Consumption Rates				
Residential Fuel*	0.48%	0.48%	-0.35%	-0.38%
Commercial Fuel*	0.65%	0.65%	0.20%	0.12%
Industrial Fuel**	0.80%	0.80%	0.80%	0.68%
Transportation Fuel**	1.64%	1.64%	1.64%	0.85%
Electric Utility Fuel***	1.57%	1.57%	1.57%	1.09%
Manufacturing/Production	2.91%	2.53%	2.11%	2.09%

Notes:
* - Using Best Available Technology Improvement
** - Using High Technology Profile Improvement
*** - Using Renewable Portfolio Standard Improvement with No Cap and No Sunset

Table XI - Emissions Forecast, Case 4: Using U.S. Growth Rates Technology Improvements

Year: Greenhouse Gas:	Forecast for 2000	Forecast for 2005	Forecast for 2010	Forecast for 2015
CO_2	55.786	59.314	63.027	65.656
CH_4	4.681	4.958	5.256	5.575
N_2O	0.792	0.853	0.911	0.974
HFC	1.623	1.839	2.041	2.264
PFC	0.000	0.000	0.000	0.000
SF_6	0.029	0.033	0.037	0.041
TOTALS	62.913	67.000	71.274	74.512

Conclusions and Implications

Although more accurate and detailed modeling may yield more definitive results, two aspects of the four preliminary forecasts discussed here stand out.

First, the four forecasts illustrate the substantial increases in total greenhouse gas emission that should be anticipated. Each of the forecasts would require significant reductions from the forecasted level, ranging from 40 percent to 25 percent, in order to maintain 1996 levels. Since most targets in greenhouse gas policy discussions revolve around maintaining or reducing 1990 emission levels, the magnitude of the task is apparent.

The second implication is not as straightforward. Recall that Case 3, based on EIA's forecast for the energy-producing and energy-using states in the West South Central Census Region, showed emissions in 2015 in Louisiana slightly below the Case 2, which was based on U.S. average rates of growth for emissions. Further, Case 3 emissions were almost 10 percent below emissions in Case 1, which was based on maintaining historic growth rates. The reason for this unexpected result was the inclusion of a mature, declining oil and gas sector, which is expected to continue to trend downward in the future. Such a view may not fit offshore oil and gas activity, but it does describe activity within Louisiana's jurisdiction, especially onshore. The implication is that a regulatory strategy for greenhouse gases that recognizes future trends may be much less demanding than a strategy based on current conditions or historical growth rates. Indeed, a strategy implicitly based on a continuation of historic growth by a large emitting sector, which subsequently experiences slower growth or a decline, would place a progressively more disproportionate and inequitable burden on other sectors of the state's economy.

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