C08

Developing Future Year Regional Emissions Inventories for Ozone Precursors

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ABSTRACT

Photochemical modeling analyses require a gridded, hourly, speciated inventory of ozone precursor emissions. A base year inventory is developed first to support basecase modeling. The purpose of the basecase modeling is to evaluate model performance. Future year inventories are then developed to support control strategy modeling. The purpose of this modeling is to assess the effectiveness of alternative control strategies and, eventually, to demonstrate attainment of the National Ambient Air Quality Standards (NAAQS) for ozone. This paper addresses the Lake Michigan region's experience in developing these future year modeling inventories.

INTRODUCTION

As part of the Lake Michigan Ozone Control Program (LMOP), regional emissions inventories were developed to support photochemical grid modeling for two future years. The future year inventories were derived from the base year inventory which was developed for the Lake Michigan Ozone Study (LMOS). Three adjustments were made to the base year inventory to generate the future year inventory. First, a baseline inventory was prepared by replacing the day-specific emissions with typical summer day (or hot summer day) emissions for point sources. (The base year emissions for area, mobile, and biogenic sources were carried over to the baseline inventory.) Second, the baseline inventory was projected to 1996 and 2007 conditions by applying scaler growth factors. Third, the projected baseline inventory was reduced to reflect various control measures by applying scaler control factors. More complete discussion on each of these adjustments is provided in the following sections.

The processing of emissions information was performed using the EMS-95 emissions model.[1] EMS-95 was developed as part of a collaborative effort by the sponsors of the San Joaquin Valley Air Quality Study and the Lake Michigan Ozone Study to create a "next-generation" emissions modeling system. This new emissions model was designed to:

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1 The development of the emissions model, originally named GEMAP (Geocoded Emissions Modeling and Projections System), was performed in the 1991-1993 timeframe by Radian Corporation. Since then, the model has undergone extensive modification and enhancement by the Lake Michigan Air Directors Consortium and its contractor (Alpine Geophysics). Given the magnitude of these changes, the model was renamed to EMS-95.

* modify emission parameters efficiently and rapidly;

* account for variations in emissions as a function of time and location due to several factors, including meteorological conditions;

* spatially distribute, temporally allocate, and speciate emissions, as required for photochemical grid modeling; and

* project emissions to future year conditions.

BASELINE EMISSIONS

Baseline emissions were prepared for one or two days from each of the four LMOS episodes. The inventory and modeling days selected for each episode are as follows:

Episode	Inventory Day	Day of Week	Modeling Days "Ramp-Up"	Study
1	June 26	Wednesday	June 24, 25	June 26-28
2	July 18	Thursday	July 15, 16	July 17-19
3	Aug 25	Sunday	Aug 23, 24	Aug 25, 26
	Aug 26	Monday		
4	June 20	Thursday	June 18, 19	June 20, 21

One set of baseline emission files was prepared for the Grid B portion of the modeling domain (Figure 1). This set included one point/area source inventory for weekdays; one point/area source inventory for Sunday; and five mobile and biogenic source inventories (one for each inventory day).

The point source volatile organic compound (VOC) baseline inventory is based on typical summer day emissions, as reported by the States. Day-specific and typical summer day emissions were similar, except for a few sources. Overall, the use of typical summer emissions on all days resulted in only a slight change in total point source VOC emissions compared to the day-specific emission estimates.

The point source oxides of nitrogen (NOx) baseline inventory is based on hot summer day emissions. Hot summer day emissions were used instead of typical summer day emissions because the major NOx-emitting facilities are power plants. Power plant operation (and emissions) are strongly dependent on weather conditions. Because the LMOP modeling is focused on certain hot summer days (i.e., days with maximum daily temperatures generally in excess of 95°F), it is more appropriate to use hot summer day conditions for these facilities. Each State acquired facility-specific information on hot summer day operation from their utility companies. As a default, the day-specific data for July 18, 1991 was assumed to be representative of hot summer day conditions. Overall, the use of hot summer day emissions on all days resulted in anywhere from a 10 - 30% increase in total point source NOx emissions on some days compared to the day-specific emission estimates.

The anthropogenic area, motor vehicle, and biogenic baseline emissions were assumed to be the same as the base year emissions.

GROWTH FACTORS

There are several factors which should be considered in projecting emissions, including expected growth (positive and negative) at existing facilities, shutdown of existing processes or facilities, start-up of new facilities, and societal or socioeconomic changes (e.g., urban sprawl). The first two factors can be accounted for by the growth module in EMS-95, which applies scaler adjustments to the base year emission levels to derive future year emissions. To account for the other two factors (i.e., new facilities and societal changes), revised model inputs are required (e.g., additional point source listings and modified land use/land cover data). Unfortunately, except for data on new power plants in Illinois and Wisconsin, this information is not available here. Thus, the LMOP modeling was generally only able to consider expected growth and shutdowns at existing facilities in deriving the future year inventory.

The growth factors used in the LMOP modeling for each source sector are as follows:

* Point Sources

  electric utilities - company-specific information provided by each State. Wisconsin and Illinois also provided data on a few new plants.

  certain individual point sources - a growth factor of "0" was applied to reflect the shutdown of these facilities

  other point source emission categories - based on USEPA's Economic Growth Analysis System (EGAS)

* Area Sources

  emission categories based on population - based on population projections

  gasoline marketing emission categories - based on gasoline sales projections

  other area source emission categories - based on EGAS

  (Note, the EGAS growth factors were found to be inappropriate for a few of these area source emission categories - e.g., crosswalk in EGAS was not valid. Alternative surrogates were used for determining growth factors for these categories.)

* Motor Vehicles

  VMT projections based on transportation modeling performed by the local planning agencies in Northeast Illinois, Southeast Wisconsin, and Northwest Indiana and growth factors supplied by the state DOTs for the rest of the modeling domain (off-network)

  The % increases in future year VMT are as follows:

STATE	1996	2007
Illinois	5	13
Indiana	7	30
Michigan	13	34
Wisconsin	18	32
Grid B Total	9	22

* Biogenics — no growth
(This assumption is appropriate given the lack of information on land use projections.)

Note that while the growth factors for certain source categories are likely to vary State-to-State, there is consistency in the methodology used to derive these factors.

CONTROL FACTORS

Several control strategies were identified for modeling by the Lake Michigan States. These strategies are built on the mandatory control measures required by the Clean Air Act Amendments of 1990 ("the Act") and certain additional control measures. Additional emission reductions (beyond those due to the mandatory controls) are necessary to meet the Reasonable Further Progress requirements of the Act and, also, to demonstrate attainment. A brief description of these strategies is provided below:

* Strategy 1 — All control measures mandated by the Act to be in place by 1996, including Federal mandatory controls and the States' 15% VOC Reasonable Further Progress (RFP) plans

* Strategy 2 — All control measures mandated by the Act to be in place by 2007, including Federal mandatory controls and the States' 15% VOC RFP plans (but not certain NOx controls - i.e., NOx RACT and I/M NOx standards)

  The reason for excluding these NOx controls is that previous photochemical modeling runs have shown that additional reductions of NOx emissions showed certain negative impacts (i.e., increased domain-wide peak ozone concentrations and increased ozone concentrations in and immediately downwind of major urban areas). Strategy 3 is designed to assess model response for specific NOx controls.

* Strategy 3 — All control measures mandated by the Act to be in place by 2007, including Federal mandatory controls, the States' 15% VOC RFP plans, and all NOx controls

* Strategy 4 — Strategy 2, plus certain additional "doable" controls in the severe nonattainment counties

The results for Strategies 1, 2, and 4 are presented in this document. The specific national and nonattainment area control measures in each of these three strategies are listed in Table 4. (Work on Strategy 3 has been deferred for the time being.)

Point and Area Source Controls
A standard spreadsheet was developed to facilitate the reporting of information on point and area source controls. Each spreadsheet contains the following information:

* State Affected
* Area Affected
* Start Year of Control
* Year to Model
* Control Code
* SCC Affected
* Pollutant
* Rule Description
* Base Year Control Efficiency
* Future Year Control Efficiency
* Base Year Rule Effectiveness
* Future Year Rule Effectiveness
* Base Year Rule Penetration
* Future Year Rule Penetration
* Source Conversion Factor - SCF (e.g., ratio of new/old emission factor)
* Process Units Growth (e.g., increase in emissions due to a rule)

To ensure consistency, special attention was given to the derivation of control factors for the following federal measures, and nonattainment area measures which are common to at least two States:

* Nonroad Engines
* Architectural and Industrial Maintenance (AIM) Coatings
* Autobody Refinishing
* Commercial and Consumer Solvents
* On-Board and Stage II Controls
* Title IV NOx Controls

Mobile Source Controls
The MOBILE5a model (which is included in the MoVEM portion of EMS-95) was used to account for the following federal and nonattainment area motor vehicle and fuel control measures:

* National Measures	Federal Tier I standards Federal RVP standards (9.0 psi) Cal LEV program (Strategy 4 only)
* Nonattainment Area Measures	I/M RFG

A new specification profile for RFG, reflecting the lower reactivity of the fuel, was used for modeling gasoline marketing area source and motor vehicle source emissions.

EMISSION SUMMARIES

The net change in emissions for each strategy is as follows:

Strategy	VOC Emissions		NOx Emissions	
	Grid B	Severe NA Area	Grid B	Severe NA Area
1	-17%	-24%	- 5%	- 5%
2	-27%	-37%	-13%	-11%
4	-40%	-53%	-19%	-18%

A summary of the anthropogenic VOC and NOx emissions for Strategies 2 and 4 for each major source category is presented in Figure 2.

SPECIAL INVENTORIES

In addition to the future year strategy inventories, two special sets of inventories were developed to support model sensitivity tests. The first test was designed to examine the sensitivity of motor vehicle emissions to different control programs. The second test was designed to assess the culpability of individual states in causing high ozone concentrations in the Lake Michigan region. EMS-95 was able to process these multiple modeling inventories within a few days. The relatively fast and efficient development of these inventories demonstrates the power the EMS-95 emissions model.

Motor Vehicle Sensitivity Tests

A total of 15 scenarios involving alternative motor vehicle control measures were identified. These measures included the following tailpipe emission standards, I/M programs, and fuel programs:

Emission Standards	I/M	FUEL	
Tier I	Enhanced	CVG-C	
Tier I	Enhanced	CVG-B	
Tier I	Enhanced	RFG-C	(LMOP Strategy 2)
Tier I	Enhanced	RFG-B	
Cal LEV	Enhanced	RFG-C	
Cal LEV	Enhanced	RFG-B	
Cal LEV	Extreme	RFG-B	
Cal LEV	Specific	RFG-C	
Cal LEV	Specific	RFG-B	(LMOP Strategy 4)
Nat Car	Enhanced	CVG-C	
Nat Car	Enhanced	CVG-B	
Nat Car	Enhanced	RFG-C	
Nat Car	Enhanced	RFG-B	
Nat Car	Specific	RFG-C	
Nat Car	Specific	RFG-B	

Emission estimates were calculated for the year 2007 for the Grid B portion of the LMOS modeling domain using ambient temperatures for June 26, 1991. The tailpipe emission standards were assumed to apply statewide, while the I/M programs and reformulated gasoline (RFG) were assumed to apply only in the severe nonattainment areas in Illinois, Indiana, and Wisconsin. Attainment areas were modeled assuming no I/M program and Class C conventional gasoline (CVG).

The results of this test showed that the expected Clean Air Act controls (i.e., statewide Tier I tailpipe emission standards, and severe nonattainment area enhanced I/M and RFG-Class C) 2will reduce Grid B motor vehicle VOC emissions by about 450 tons per day (48% reduction). The most stringent combination of tailpipe emission standards, I/M program, and fuel program will yield an additional 180 tons per day reduction in Grid B motor vehicle VOC emissions.

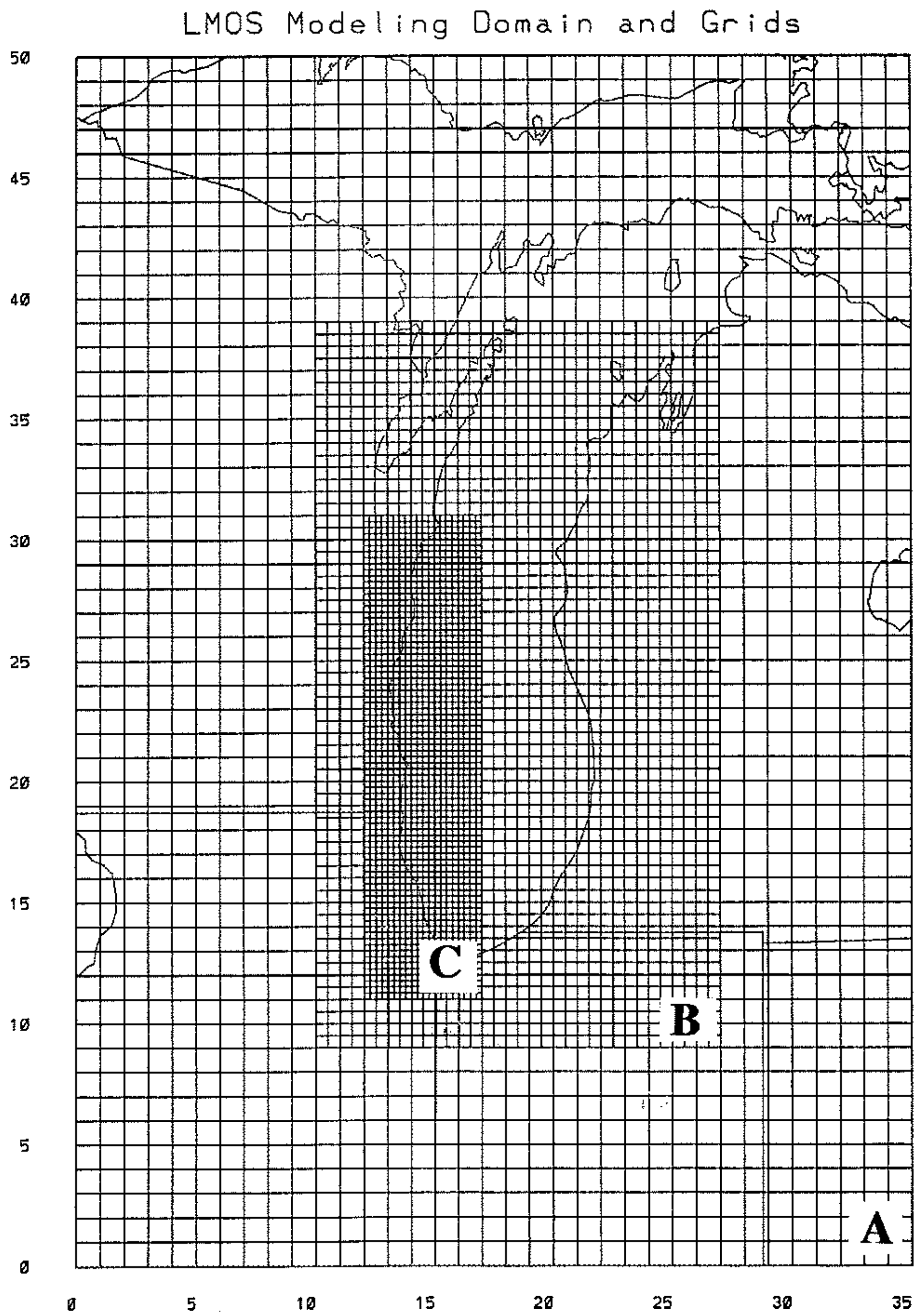
Culpability Tests

A total of 11 scenarios involving different combinations of controls in each of the four Lake Michigan States were identified. These measures included the following National and LMOP Strategy 4 nonattainment area controls:

Scenario	Description
1	Baseline (1990/1991)
2	Growth + National Controls (2007)
3	Growth + National Controls + IL Nonattainment Controls
4	Growth + National Controls + IN Nonattainment Controls
5	Growth + National Controls + MI Nonattainment Controls
6	Growth + National Controls + WI Nonattainment Controls
7	Growth + National Controls + IL and IN Nonattainment Controls
8	Growth + National Controls + IL and WI Nonattainment Controls
9	Growth + National Controls + IN and WI Nonattainment Controls
10	Growth + National Controls + IN and MI Nonattainment Controls1
11	Growth + National Controls + IL,IN,and WI Nonattainment Controls

The results of this test showed that National controls will reduce VOC emissions almost as much as local Strategy 4 nonattainment area controls (i.e., the two sets of controls produce about a 20% reduction in VOC emissions). The largest reduction in VOC emissions is from motor vehicles (almost a 70% reduction), with more than half of this reduction due to National controls.

Figure 1


LMOS Modeling Domain and Grids
50
45
40
35
30
25
20
15
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5
0
0
5
10
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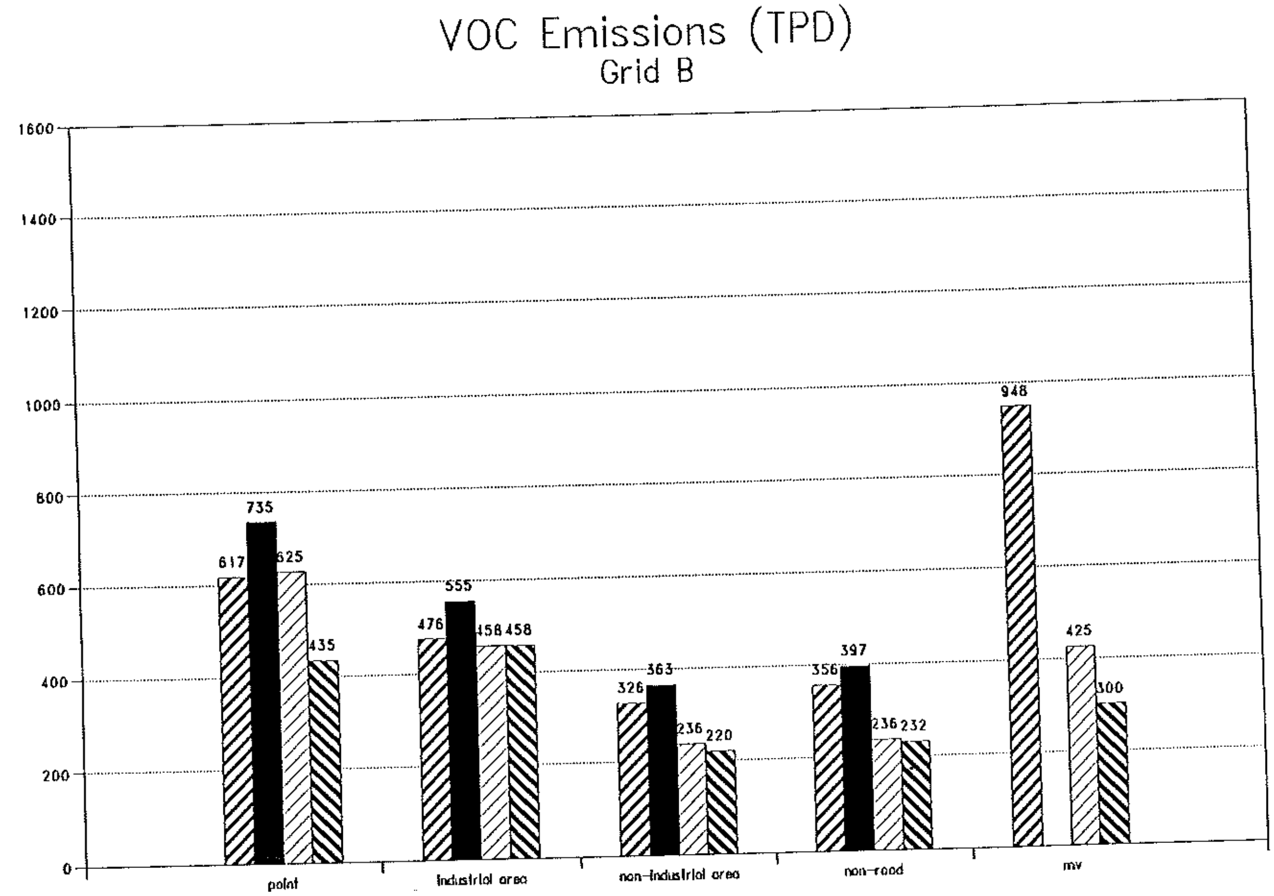
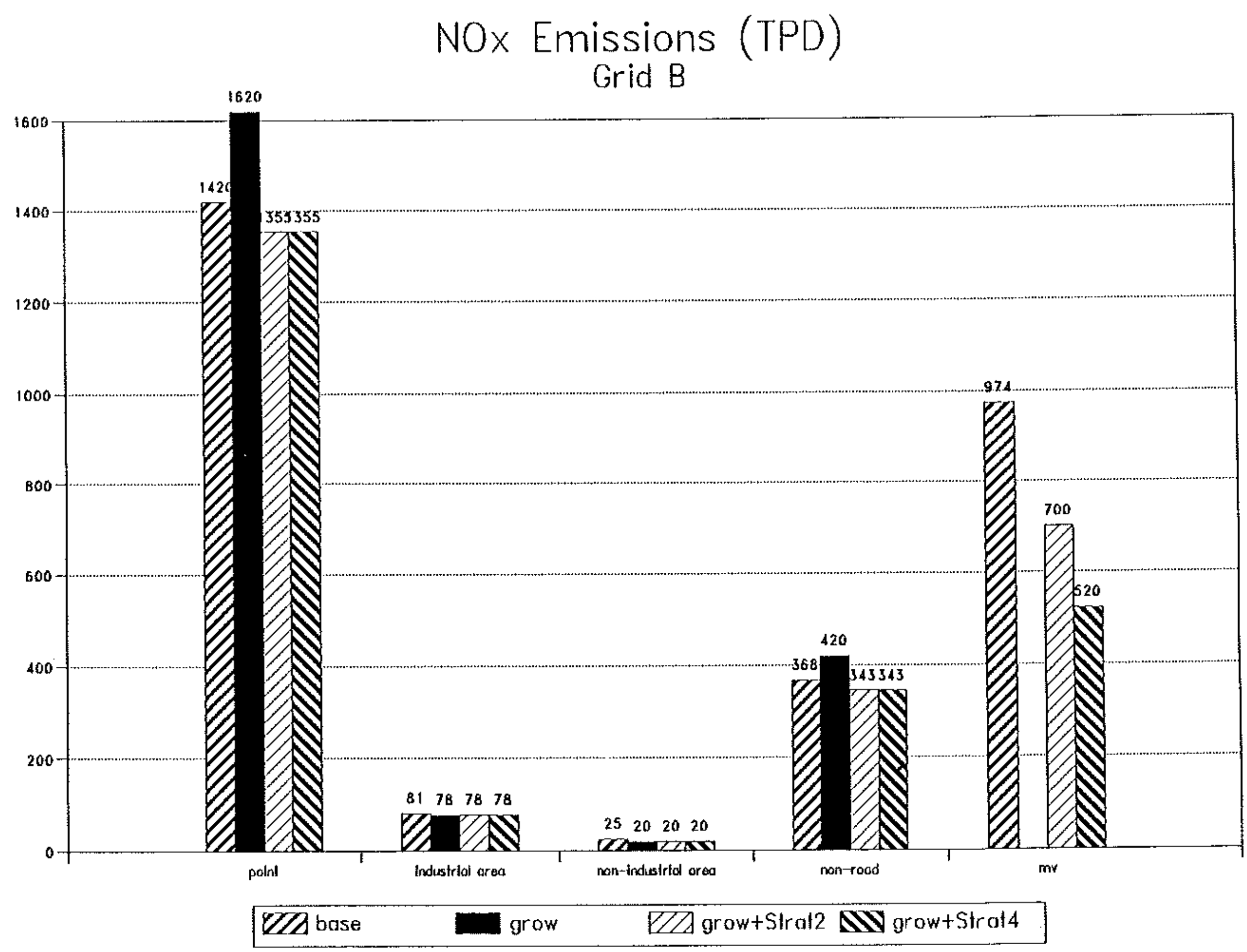
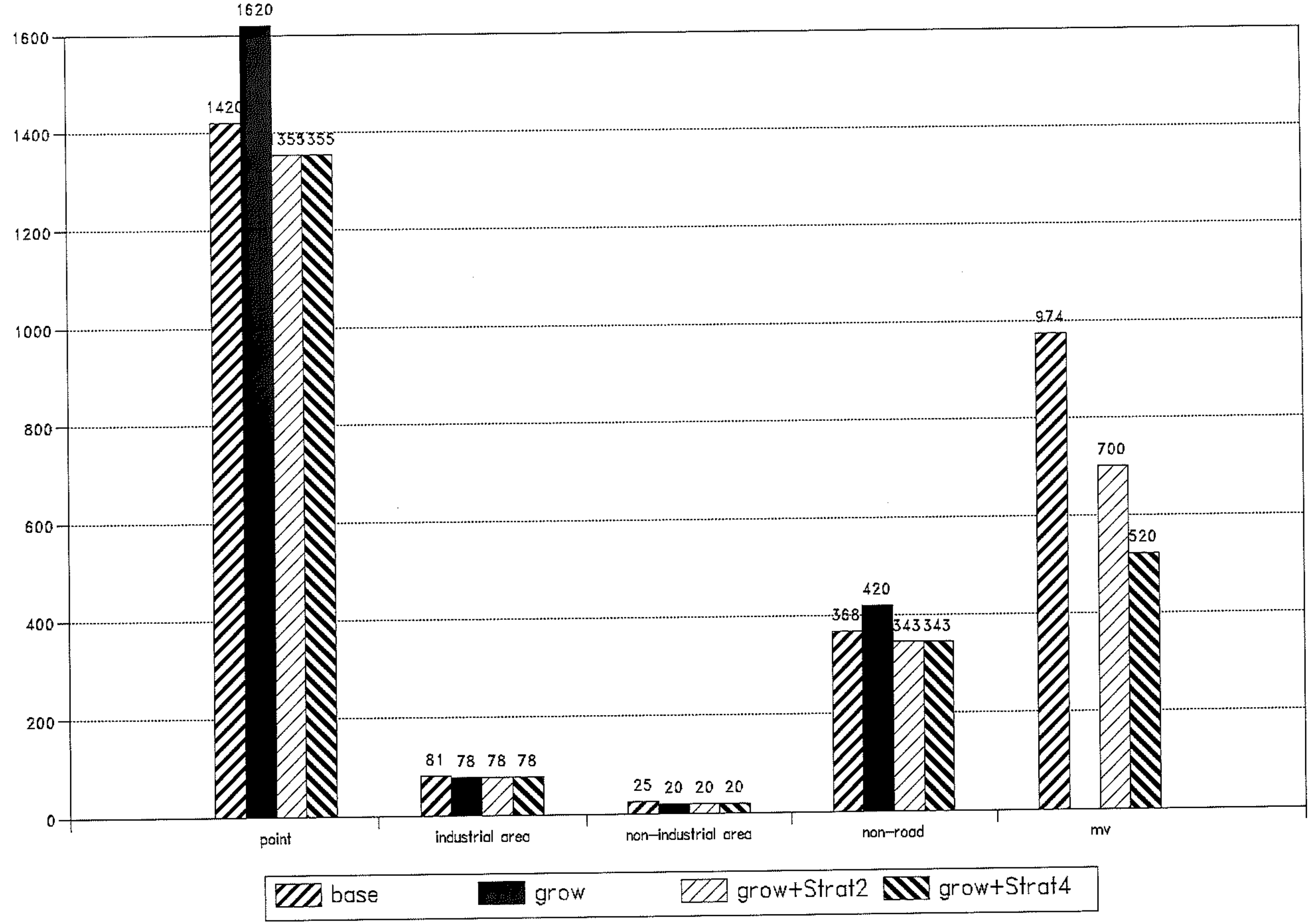
25
30
35
A
B
C

Figure 2. LMOP Strategy 2 and Strategy 4 Emissions





NOx Emissions (TPD)
Grid B



VOC Emissions (TPD)

Grid B