AIR POLLUTION PROJECTION METHODOLOGIES: INTEGRATING EMISSION PROJECTIONS WITH ENERGY FORECASTS

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This paper describes extensions of end-use energy demand forecasting models to project air pollution emissions. Energy demand forecasting is a maturing field in which the end-use forecasting model is becoming the standard tool. Air pollution emission projection techniques have developed independently of energy demand forecasting even though a considerable portion of air pollution emissions comes from fuel combustion. Considerable benefits can be obtained by jointly producing energy demand and emission projections from common data bases using an integrated modeling system. Such integrated modeling allows better understanding of the growth of energy-related emissions over time, and of the role of demand-side management in reducing these emissions.

This paper presents results of initial efforts at the California Energy Commission to integrate emission projections and energy demand forecasting models. The Los Angeles basin, which is regulated by the South Coast Air Quality Management District, is used to assess three control strategies. These efforts have resulted in successfully projecting that portion of air pollution emissions arising from stationary fuel combustion by end-users. The stationary fuel combustion portion (excluding powerplants) of total emission sources is over 30 percent for NO_x, but lesser amounts for other criteria pollutants.

Full integration of energy demand forecasting and emission projections from stationary sources requires additional research in emission inventories, improved emission factors, and integrated model development. Some follow-up efforts which seem promising are recommended.

INTRODUCTION

Demand-side management (DSM) is increasingly being offered as a partial solution to ambient air quality problems in portions of the nation. Dispersed sources of emissions, from residential and commercial buildings and equipment, from vehicles, or other small sources not regulated in the past, must be controlled if ambient standards are to be achieved in these areas. This proposed solution is difficult to link directly with likely emission reductions because emission projections have not been made using energy consumption as a basis. Linkage of this "solution" to the air quality planning process requires improvement in emission projection methodologies and data. This paper describes initial progress in developing a new methodology for projecting air pollution emissions that relies directly on energy demand forecasts as a basis for fuel combustion emission projections.

Energy demand forecasting models are an intriguing starting point for emission projections, since they are, by design, methods for projecting fuel consumption into the future as a function of economic and demographic growth, shifts among energy forms, and changes in energy use per unit of activity as a result of price-induced behavior and DSM programs. This paper demonstrates that extensions of demand forecasting models to produce emission projections and energy demand forecasts simultaneously is readily accomplished, and that such models allow coordinated and consistent energy and air pollutant planning.

Application of the energy demand-based emission projection model has been successfully accomplished for an assessment of three emission reduction strategies for the utilities of the South Coast Air Basin in the Los Angeles region. This work directly links energy demand with emission projections in a modeling framework that allows "what if" scenarios to be evaluated. California Energy Commission (CEC) efforts have been coordinated with the South Coast Air Quality Management District (SCAQMD) via an interagency working group assessing energy/emission linkages in preparation for the next revision of SCAQMD's air quality management plan (AQMP). A summary of the results is presented.

CURRENT PRACTICE IN EMISSION PROJECTIONS

Air pollution emissions in California are projected by the Air Resources Board (ARB) using data and information prepared jointly by ARB and individual air quality management districts (ARB 1988). This method is used for individual air basin planning and as an input to photochemical air shed modeling to determine ozone formation. California has not emphasized the broad assessments of the type used in the National Acid Precipitation Assessment Project because of the absence of coal burning powerplants or other extremely large point sources. The ARB/SCAQMD method is simple, and has no direct role for energy consumption as the intermediary between economic activity and the emissions resulting from fuel combustion. Emissions are projected using a large number of separate source control categories on a small area geographic basis. Because air shed models are used to compute ambient concentrations in small geographic areas, emission projections have emphasized a fine level of disaggregation. For example, the South Coast Air Basin (SCAB), administered by SCAQMD, prepares emissions data for about 150 control categories in each of 600 grid areas. This approach is needed for ozone, which requires elaborate air shed modeling of the photochemical reactions of NO_x (nitrogen oxides) and ROG (reactive organic gases) to determine its formation, distribution, and concentration.

SCAQMD Emission Projections

The ARB/SCAQMD method relies upon a base year emission inventory, and projects future emissions from that base. Essentially, the method can be represented as:

$$EP(p,c,t) = EI(p,c,base)*GF(c,t)*CF(p,c,t) \qquad (1)$$

where EP(p,c,t) = emission projection for pollutant p in control category c in year t.
EI(p,c,base) = emission inventory in the base year.
GF(c,t) = growth factor for control category c for year t.
CF(p,c,t) = control factor for category c for pollutant p for year t.

Total emissions for any pollutant in any year is simply the sum of emissions over the entire set of source control categories.

Base Year Emission Inventory

As shown above, the current ARB/SCAQMD emission projection methodology requires a firm understanding of base year emission inventory of each pollutant. These data are developed jointly between ARB and each district from "point" sources that are regulated and for which reasonably reliable information is obtained routinely, and from "area" sources whose emissions are estimated through secondary information such as statewide fuel consumption, emission factors, and population distribution. Overall, emission inventories are known less precisely than energy consumption although research studies (Lawson 1990) are attempting to improve knowledge of emissions and ambient concentrations of the criteria pollutants.

The inventory for SCAB was obtained from ARB with SCAQMD's cooperation and has been processed to provide emissions from classifications of sources that exactly match Commission demand forecasting models. Further, these emissions have been categorized into those from fuel combustion and those from other sources. Evaporation of organic chemicals, natural decay and decomposition processes, and dust are the major sources of emissions other than fuel combustion. Table 1 (Part A) provides emissions from fuel combustion and other sources for the two most important pollutants--NO_x and ROG--the precursors to ozone. Clearly, fuel combustion is the dominant source of NO_x, and an important source for ROG. The stationary sectors commonly addressed in utility-delivered fuel planning models are important for NO_x, but secondary for ROG. Table 1 (Part B) summarizes these emissions for each sector for the three fuel groups. Natural gas is the dominant stationary fuel, while petroleum is the dominant transportation fuel.

INTEGRATED ENERGY/EMISSION PROJECTIONS

In an effort to link energy demand forecasts with emission projections, the Commission is developing a new methodology that treats fuel combustion emissions as a byproduct of energy demand. Energy

Table 1. 1987 Emission Inventory by Sector and Source

Part A: Combustion Share of Emissions
(tons/day)

	Fuels		Non-Fuels		Total		Fuel Share(%)	
	NOx	ROG	NOx	ROG	NOx	ROG	NOx	ROG
Residential	34.7	7.4	0.0	74.2	34.7	81.6	100.0%	9.1%
Comm. Bldg	24.1	5.7	3.9	80.4	28.0	86.1	86.2%	6.6%
TCU	42.3	15.0	0.5	32.5	42.8	47.5	98.9%	31.5%
Process Ind	68.4	5.1	15.4	35.6	83.8	40.6	81.6%	12.5%
Assemb Ind	33.3	2.6	4.2	183.2	37.5	185.8	88.8%	1.4%
Other Ind	29.5	3.0	0.7	43.2	30.2	46.2	97.7%	6.5%
Ag & Water	0.3	0.5	0.2	39.7	0.5	40.2	58.5%	1.1%
Other	68.4	45.3	0.2	82.2	68.6	127.5	99.8%	35.5%
Transportation	596.2	475.9	0.0	0.0	596.2	475.9	100.0%	100.0%
Elec Generation	42.1	2.7	0.0	0.1	42.1	2.8	100.0%	95.9%
Total	939.4	563.2	25.1	571.0	964.4	1134.2	97.4%	49.7%

Part B: Combustion Emissions by Fuel Type
(tons/day)

	Natural Gas		Petroleum		Other Fuels		All Fuels	
	NOx	ROG	NOx	ROG	NOx	ROG	NOx	ROG
Residential	32.0	0.7	0.2	0.0	2.5	6.8	34.7	7.4
Comm. Bldg	11.1	0.5	11.0	0.5	2.0	4.7	24.1	5.7
TCU	12.1	1.0	28.0	0.9	2.2	13.0	42.3	15.0
Process Ind	18.8	1.1	8.4	0.6	41.1	3.4	68.4	5.1
Assemb Ind	22.8	1.4	7.6	0.4	2.9	0.8	33.3	2.6
Other Ind	19.9	1.7	1.7	0.1	7.9	1.2	29.5	3.0
Ag & Water	0.1	0.0	0.0	0.0	0.2	0.4	0.3	0.5
Other	0.0	0.0	42.7	4.6	25.7	40.7	68.4	45.3
Transportation	0.0	0.0	172.2	29.9	424.0	446.0	596.2	475.9
Elec Generation	36.4	1.6	5.4	0.3	0.3	0.8	42.1	2.7
Total	153.3	8.0	277.2	37.4	508.8	517.8	939.4	563.2

Source: ARB/SCAQMD 1987 Emission Inventory Data Base analyzed by Commission Staff, April 1990.

demand is forecasted first, and emissions projections are computed from the demand forecast using emissions factors associated with the nature of the fuel combustion process. The modeling approach used in this analysis will be described in both energy and emissions terms.

Energy Demand Forecasts

Energy demand forecasts serve a variety of roles in utility and energy agency planning. Over the past two decades techniques used have evolved from simple linear trending to complex simulation models as computers, and the ability to use them, have become ubiquitous.

Utility Forecasting. Utility energy demand forecasting is gradually standardizing the types of models used for various purposes, although lots of variety continues to exist. Long run forecasting for electricity and natural gas is now emphasizing end-use simulation models for the residential, commercial, and even industrial sectors defined by economic activity. The Electric Power Research Institute has made contributions to the development and commercialization of such models for the electric utility industry. Econometric modeling continues to dominate short run forecasting for rate setting purposes where the opportunity for structural change is limited. Spreadsheet-based simulation models are becoming important for assessing the possible consequences of demand-side management programs.

California Energy Forecasting. CEC Staff routinely prepare electricity and natural gas demand forecasts for use in electricity and natural gas resource planning. These forecasts are prepared using very complex simulation models for each customer sector (CEC 1989). Customer sectors are aggregations of customers into similar groupings based on the nature of the economic activity taking place on the customer's premise. In all cases, these models project energy demand for individual subsectors as a function of economic and demographic projections of the growth of subsector activity within a given geographic area. California utilities use similar modeling techniques.

Table 2 enumerates the eight distinct consumer sector energy models used to project electricity, natural gas, coal, and stationary petroleum fuel energy requirements. The CEC produces a forecast of energy *consumption* (covering all use of each fuel type) rather than a forecast of *utility sales*; thus, the job of preparing emission projections is made easier because fuel use from all sources is already included. As Table 2 suggests, the eight sectoral models are highly disaggregate. Residential, commercial building, and assembly industry models use end-uses in developing overall demand. This approach contrasts with the aggregate econometric models still used by some utilities across the country. Such aggregate models would not be as useful a starting point for emission projections.

Commission Emission Projection History

Prior to the emergence of SCAQMD's draft 1988 AQMP the Commission assessed emissions only in individual powerplant certification proceedings. Emission studies for each powerplant in question concentrated upon compliance with air quality regulations existing at the site of the proposed facility. Once the scope of SCAQMD's proposed 1988 AQMP became clear, the Commission realized that a more comprehensive emission projections capability was necessary in order to allow the

Table 2. Available Disaggregation in Summary Models

Customer Sector	Level of Disaggregation
Residential	3 housing types with 20 end-uses
Commercial Building	11 building types with 10 end-uses
Commercial Industries	18 industries
Process Industries	13 industries
Assembly Industries	20 industries
Other Industries	7 industries
Agriculture	2 industries with 10 crops
Water Supply	2 industries

Commission to include emissions of pollutants in its planning and policy decisions.

Emission Projection Model Design Considerations

In developing an emission projection capability, the Commission had to consider the purpose to which the model would be employed.

Pollutants to be Included. Initially this effort focused on local air pollution problems and the fuel-sourced pollutants contributing to global warming. This led to an initial selection of pollutants to include within the model. These are: (1) NO_x, (2) ROG, (3) PM_{10} (particulate matter less than 10 microns), (4) SO_x (oxides of sulfur), (5) CO, and (6) CO_2. Additional efforts are possible through consideration of other greenhouse gases, such as: (1) N_2O, (2) methane, and (3) CFCs.

Scope of Emissions Included within the Model. Design of the model critically depends upon determining the scope of emissions which the model is intended to address. If the model is intended to be comprehensive and address all stationary emissions, then a design oriented around energy consumption is inadequate. If the results are able to be constrained to emissions from fuels combustion, then a design based on energy use should suffice.

The Commission is not an air quality management agency. Its charter is to balance several social considerations while determining the need for, and preferred mix of, new energy resource additions. Therefore, it does not appear proper for the Commission to "second guess" SCAQMD or any other air pollution control district in its control measures for non-energy consumption sources of emissions. On the other hand, the Commission needs to be cognizant of two factors. First, tradeoffs in emissions among the source categories, which SCAQMD has made, might be made differently by the Commission. Second, possible differences of economic and demographic projections may have implications in projecting non-energy consumption emissions, even if we accept SCAQMD's control measures. On balance, the Commission has decided, for now, to focus on fuel combustion emissions.

Level of Disaggregation. Whether or not to develop the model at the level of end-uses is an important question. By itself, the variation in emission factors across the residential and commercial building end-uses should not prove great. Therefore, little justification for end-use emission factors exists for these two sectors. For the industrial impacts of air quality control measures, it appears useful to have end-use level of detail, since considerable variation in emission factors can be anticipated. The first generation model should be developed at an "intermediate" level of end-use detail. For the residential and commercial sectors each end-use is not differentiated by building type. For the industrial and agricultural sectors, industries (see Table 2) are not differentiated by end-use. The design of the computer code implementing the model should recognize that the second generation of the model probably will need to have full industry and end-use emission detail.

Emission Projection Algorithms

The emissions computation algorithm is extremely simple and straightforward. There are only a few basic steps, some of which have been added to existing "summary model" subroutines and some of which take place in a new stand alone emissions integration computer code. Figure 1 illustrates how the existing Commission demand forecasting models have been adapted and augmented to project emissions. In this figure, dotted box outlines indicate new modules that have been added to prepare emission projections. Most of the modeling apparatus needed already exists. The greatest efforts are required for transportation fuels, since the transportation models are not as mature as those for the stationary consuming sectors.

Raw Emission Calculations. For natural gas-sourced emissions, the following equation defines the most disaggregate level of emission projection.

$$EMISSG(t,p,i,e) = EMFACG(t,p,i,e) * GAS(t,i,e) \qquad (2)$$

where
- EMISSG(t,p,i,e) = natural gas sourced emissions in year t for pollutant p for industry i for end-use e
- EMFACG(t,p,i,e) = emission factor for natural gas consumption (note the time dimension allows for change over time)
- GAS(t,i,e) = natural gas consumption.

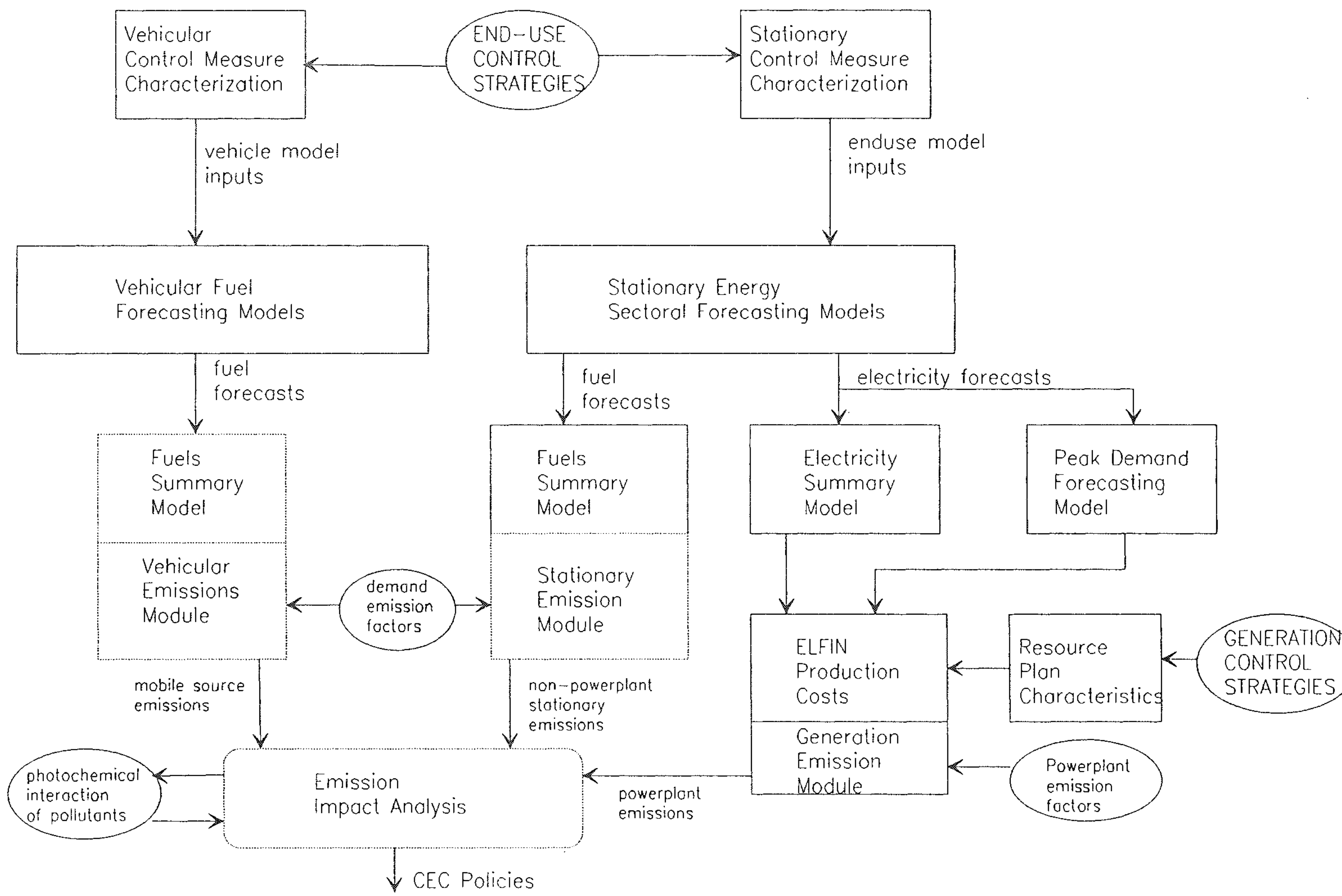

Figure 1. Schematic of the Integrated Energy/Emission Model

For petroleum sourced emissions, the following equation defines the most disaggregate level of emission projection.

$$EMISSO(t,p,i,e) = EMFACO(t,p,i,e) * OIL(t,i,e) \quad (3)$$

where EMISSO(t,p,i,e) = petroleum sourced emissions in year t for pollutant p for industry i for end-use e
EMFACO(t,p,i,e) = emission factor for petroleum combustion (note the time dimension allows for change over time)
OIL(t,i,e) = petroleum consumption.

Aggregate emissions for each fuel type for each pollutant are prepared by summing up over all industries and end-uses.

Calibrating Emissions to Known Inventories. Within the fuels summary model (integration, calibration, and report writing code), a series of calculations is required. Total emission of a given pollutant is simply the sum over each fuel type.

$$AGEMS(t,p) = AGEMSG(t,p) + AGEMSO(t,p) \quad (4)$$

where AGEMS(t,p) = total raw stationary emissions in year t for pollutant p.

These raw emission projections for each pollutant must be calibrated to the level representing emissions inventory as defined by ARB for the district in question. Given the softness of the emissions factors, our reliance upon energy consumption as the precursor for emissions, and a host of other factors, it is obvious that some level of calibration will be needed; the principal question is how much. Since multiple years of reliable emission inventories do not exist, the calibration procedure simply scales "backcast" emissions to the actual 1987 estimates shown in Table 1 (Part B).

Known Limitations of This Model. The initial generation of an integrated energy demand/emission model has two limitations that require additional work in the future. First, the level of disaggregation is not sufficient to capture the impacts of many existing air quality control measures. For example, each industry is represented by a single emission factor multiplied by energy demand for each fuel type. SCAQMD Rule 1102.1 requires replacement of internal combustion engines by electric motors; this rule cannot be easily assessed within the model, because the emissions from the natural gas used to fire such engines is not projected separately from that of the much larger process heat use of gas. Second, emission inventories have been developed in a manner that relies heavily on annual permit fee data for regulated point sources, and merely estimates emissions for non-regulated sources from aggregate energy demand data. Part of the explanation for this data problem lies in California's air pollution regulatory structure which maintains 41 distinct air pollution control districts, each of which require emission inventory data from ARB. The "area" source emission estimates are suspect, but of considerable importance because of the large amount of fuel burned by non-permitted sources. The first of these limitations can be corrected in another generation of the model, but fundamental data problems of area sources will take much longer to resolve.

AIR QUALITY SCENARIOS PROJECT

The CEC's *1990 Electricity Report* (ER-90) proceeding motivated examination of air quality scenarios for SCAQMD sooner than was been possible with the emissions projection model described above. A simplified model developed at a more aggregate level, but still based on energy demand, was prepared for this purpose. Results of this interim model are available for three scenarios based on control strategies presented in SCAQMD's adopted plan (SCAQMD 1989). This exploratory analysis is intended to illustrate consequences, and to motivate additional analyses of greater depth and rigor where emission reduction strategies are integrated with energy planning.

Three scenarios were developed and analyzed:

- high levels of demand-side management program savings,
- very extensive industrial electrification, and
- high penetration of electric vehicles.

For each scenario for each of the three Southern California utility planning areas, a demand forecast and associated resource plan were prepared to determine the energy demand and generation resource requirements of the scenario in comparison to a baseline forecast and resource plan. In addition, the emission implications of each of these three scenarios were assessed to determine the relative change in emissions, compared with the baseline, associated with these three quite different approaches to emission reductions.

The purpose of this analysis is to explore the magnitudes of changes in key descriptors of the energy system and air quality of the South Coast region as a result of scenarios that are significant departures from the baseline. All of these scenarios go well beyond what the Commission is likely to include within the scope of ER-90 decisions, because the Commission uses evidentiary criteria to determine policy or resource addition commitments that SCAQMD's AQMP does not meet.

The energy demand results of these strategies (Jaske 1990) are decreases in traditional uses of natural gas and vehicle fuels, with increases in electricity usage relative to the baseline forecast. The success of SCAQMD's strategy depends strongly on the characteristics of the generating resources which supply the needed electricity (McAuliffe 1990).

Stationary Source Emission Projections

A simplified stationary source fuel combustion emission projection model that utilizes the 1987 base year emission inventory described above, along with fuel demand forecasts (natural gas, petroleum, and other) corresponding to each fuel source of emissions to project future emissions, was developed at the Commission. For each fuel and for each pollutant, this can be expressed as

$$EP(f,p,s,t) = EI(f,p,s,1987)*SCF(f,p,s,t) * [FUEL(f,s,t)/FUEL(f,s,1987)] \quad (5)$$

where $EP(f,p,s,t)$ = emission projections for fuel f for pollutant p in year t for sector s.
$EI(f,p,s,1987)$ = base year emission inventory.
$SCF(f,p,s,t)$ = sectoral emission control factor representing the influence of all *current control measures*
$FUEL(f,s,t)$ = amount of energy consumed in sector s for fuel f in year t.

The total fuel combustion emissions for each pollutant is simply the sum over the three individual fuel type emissions. Recall from Table 1 (Part B) that natural gas provides the majority of energy used and emissions from the stationary sector. Petroleum fuel use and emissions are much smaller in this sector. Other fuel energy use and emissions are generally smaller still, although some unusual categories of emissions appear in this later grouping of fuels, e.g., use of catalytic coke in refineries.

Scenario Definitions

The three scenarios are closely related, but not identical to, components of the control strategy embodied in the SCAQMD 1989 AQMP. In the AQMP, all three elements are pursued simultaneously. Each of these scenarios pursues different emission targets and the combined case represents the influence of each of the three individual elements.

High DSM Scenario. This scenario is defined to be a 30 percent reduction in electricity and natural gas usage by the year 2009 for each of the residential, commercial building, and commercial industry (TCU) sectors compared to the baseline demand forecast. This is a major energy savings which is two to three times as much as will have been accomplished by that year by all California's building and appliance standards and all other programs now considered to be committed. CEC Staff are working with SCAQMD to prioritize feasible DSM actions given the DSM efforts already underway in California.

Industrial Electrification Scenario. This scenario assumes major fuel switching from natural gas to electricity and substantial combustion efficiency improvements. By the year 2009, industrial electricity usage is 50 percent higher than in the baseline, while natural gas consumption is 35 percent lower.

High Electric Vehicle Scenario. This scenario assumes that electric vehicles for the automobile, light truck, and medium duty truck classes achieve 20 percent penetration by 2000, and 70 percent penetration by 2010. The remainder is fueled by gasoline and diesel fuels.

Results

Table 3 provides summary results for the baseline forecast for several key energy and emission variables, and the impact of each of the three scenarios (and the combination of them) on this baseline. In each case the emissions reported are from the direct end-use consumption of fuels, and *do not include* the powerplant emissions associated with generation of the electricity consumed.

End-User Results. For the High DSM scenario, substantial savings of natural gas energy result in small reductions of emissions for the criteria pollutants and CO_2. The natural gas results, major changes in fuel usage with minimal change in emissions, may not seem proper. These can be reconciled with reality by observing that Table 1 reports very small proportions of emissions from the fuels sold by the utility; the bulk of emissions come from vehicle fuels. For the Industrial Electrification scenario, the natural gas reductions are only one half of the High DSM case, but the emission reductions for the criteria pollutants are nearly as large. Substantial electricity increases occur as a result of fuel substitution and powering of emission control equipment. This work reveals that the industrial electrification scenario achieves greater criteria pollutant emission savings in absolute magnitude than does the high DSM scenario for an equivalent level of natural gas reduction. Industrial combustion processes are currently "dirtier" per unit of natural gas combusted. The High EV scenario has electric energy increases somewhat greater than the industrial electrification case, but has essentially no peak demand impacts at all, and has far greater reductions in fuel combustion emissions. The small peak demand impacts relative to energy increases in the High EV scenario result from the highly optimistic assumption that utility load control will ensure that the great majority of the battery recharging load will take place at night. The combined case results in major flattening of the load duration curve as the peak demand is reduced and the annual energy is increased in comparison to the baseline.

The High Electric Vehicle case is the only scenario that achieves major reductions in criteria pollutants and CO_2 relative to total end-user levels for the basin. Transportation fuel demand forecasting merits greater attention due to the large share of emissions from vehicle fuel usage.

Electric Powerplant Impacts. Electric powerplant emissions are a small share of the base year emission inventory for SCAQMD, and the absolute value of these emissions is expected to decline for some years as a result of control measures imposed on utilities by SCAQMD rules. McAuliffe (1990) reports the corresponding electric power generation emission changes of these three scenarios. For each scenario a modified resource plan was developed to supply electricity at the level required. The baseline, and each scenario, were evaluated using the production cost model ELFIN to determine fuel usage and emissions. For example, in the High DSM scenario, emission savings are larger than the end-user natural gas reduction because electricity consumption is also reduced, thus reducing powerplant fuel usage and emissions. In the other two scenarios, power generation emissions increase as additional electricity is used to substitute for combustion of fuels by the end-user.

FURTHER DEVELOPMENT

The results of this exploratory analysis indicate that energy demand forecasts can be successfully used as a basis for emission projections, and that emission control measures now under discussion in Los Angeles would have a major effect on energy demand. Not surprisingly, changes in energy demand can have significant impacts on end-user emissions. The scenarios assessed here provided some preliminary indications of the consequences of SCAQMD's control strategies. DSM control strategies in the residential and commercial sectors appear to offer limited benefits because their share of the emission inventory is small. More in-depth analysis is needed to develop policy recommendations for these control strategies.

Follow-up Recommendations

As a result of this analysis, several additional steps need to be taken:

- Completion of the initial version of the integrated energy/emission projection model described above.

Table 3. Summary of Results for the SCAQMD Region

		Forecast Year 2001	Forecast Year 2009
Electric Energy (Gwh)			
	Baseline Forecast	128,260	147,962
	High DSM Impact	-15,661	-31,824
	Indust Elec Impact	+ 8,580	+16,277
	High EV Impact	+18,812	+29,438
	Combined Impact	+11,731	+13,891
Peak Demand (MW)			
	Baseline Forecast	29,521	34,682
	High DSM Impact	- 4,099	- 8,435
	Indust Elec Impact	+ 1,443	+ 2,766
	High EV Impact	+ 243	+ 380
	Combined Impact	- 2,413	- 5,288
Natural Gas (mill. therm)			
	Baseline Forecast	8,543	8,888
	High DSM Impact	- 726	- 1,317
	Indust Elec Impact	- 386	- 722
	High EV Impact	0	0
	Combined Impact	- 1,112	- 2,039
Transport Fuels (mill. gallons)			
	Baseline Forecast	6,135	5,422
	High DSM Impact	0	0
	Indust Elec Impact	0	0
	High EV Impact	-1,226	-2,645
	Combined Impact	-1,226	-2,645
NOx Emissions (tons/day)			
	Baseline Forecast	721.1	694.8
	High DSM Impact	- 8.1	- 14.8
	Indust Elec Impact	- 6.8	- 12.7
	High EV Impact	- 66.3	-142.6
	Combined Impact	- 81.2	-170.1
ROG Emissions (tons/day)			
	Baseline Forecast	337.0	305.8
	High DSM Impact	- 0.5	- 0.8
	Indust Elec Impact	- 0.6	- 1.2
	High EV Impact	- 51.1	-107.9
	Combined Impact	- 52.2	-109.9
CO2 Emissions (tons/day)			
	Baseline Forecast	320,990	308,275
	High DSM Impact	-11,779	-21,360
	Indust Elec Impact	- 6,272	-11,711
	High EV Impact	-31,970	-69,208
	Combined Impact	-50,023	-102,278

Note: Several different regions are used in this analysis. Electricity and natural gas are forecast at the level of planning areas for major utilities. NO_x and ROG are projected for the SCAB, while CO2 is projected from natural gas demand at the planning area level.

- Further communication between the CEC, SCAQMD, and ARB regarding base year emission inventories and development of improvements to the current SCAQMD/ARB method of projecting emissions for fuel combustion sources.
- Improved understanding of stationary fuels usage within the SCAQMD region, especially for petroleum and other liquid fuels.
- Improvements in the SCAQMD/ARB emission inventory to resolve ambiguities regarding the correlation of fuel combustion and emissions.

- Additional studies to assess the energy demand, emission, and cost implications of specific air quality control strategies.

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