# AN AIR QUALITY MANAGEMENT STRATEGY FOR THE VAAL TRIANGLE PART III

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FINAL REPORT ON THE VAAL TRIANGLE INTERVENTION PROJECT
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## INTRODUCTION

The purpose of this investigation was to develop intervention strategies applicable to improving poor air quality over the Vaal Triangle region. The recognition of the need for such an intervention strategy arose out the Vaal Air Pollution Health Study (VAPS). The air quality problem in the Vaal Triangle and the resultant adverse impacts on human health have been widely documented arising from the VAPS and other studies [VA95, TE94, MU92].

The starting point for the investigation was to examine the policies, legislation and implementation of air quality control in countries that could serve as a role model for South Africa. In Part I of this report (AN97) we reviewed urban air management stratefgies in the European Union, the United Kingdom and the United States of America. The review section concluded with an evaluation of air pollution control and legislation in South Africa.

This contribution constitutes Part III of the report, in which we develop a proposed air quality management strategy for the Vaal Triangle. Although this report was completed before the finalisation of the White Paper on Environemntal Management Policy for South Africa (GO97), it is still directly relevant. The White Paper sets the policy. This paper proposes a way of implementing air quality management systems under this policy, and under the broad environmental rights of the new Constitution.

We start off by describing the physical and air pollution characteristics of the Vaal Triangle region. From a synthesis of ideas from the international review in Part I (AN97), we propose the formation of a Metropolitan Air Quality Authority, a council of elected representatives, industry and community groups. The area of jurisdiction would span the entire Vaal Triangle region. The structure and functions of the MAQA are explored in detail.

Existing baseline studies in the Vaal Triangle are discussed. Actual implementation strategies from the US State Implementation Plan (SIP) documents are analysed as a basis for a Particulate Matter SIP for the Vaal Triangle. Administrative issues and community involvement issues relating to the proposed SIP are discussed in the concluding section.

The ideas in this document have been developed over a period of time, and presented to several different audiences of municipal and central government regulators. While there has by no means been universal acceptance of the proposed regulatory model, we are convinced that the approach presented here for urban air quality management is basically sound, appropriate for South Africa now. Either these proposals, or something essentially similar, will in due course be adopted as official policy within the Environmental Management Policy framework (GO97).

## EXISTING BASELINE STUDIES FOR THE VAAL TRIANGLE

The purpose of this section is to review some of the recent air quality studies conducted in the Vaal Triangle. Further details of the substance of the investigation may be found in a recent review of atmospheric research: "Air pollution and its impacts on the South African Highveld" [HE96].

### *EMISSION INVENTORY*

The Chief Air Pollution Control Officer of the Department of Environment and Tourism currently responsible for the compilation of a national atmospheric emission inventory of scheduled process emissions. The first inventory, which included the Vaal Triangle was established in 1989. Subsequent work in this sphere has included the compilation of a rapid survey source inventory for the Vaal Triangle [MU92], and the establishment of a comprehensive emission inventory of particulate matter for the region for the year 1992 [VA95].

The 1992 Vaal Triangle Emission Inventory was based on US EPA emission factors and inventory techniques. US EPA emission inventory technology is well established and documented and provides a sound methodology for local inventory compilation [VA95]. Despite the existence of such a comprehensive emission inventory for the Vaal Triangle, staff is currently needed to update the inventory in order to keep it complete, accurate and current. The inventory excluded wind blown dust sources (due to resource limitations). Submissions from certain large industries did not contain information in the required format or detail and revisions are required to ensure the overall validity of the inventory. The inventory was compiled using the PC software database "Paradox" for DOS.

*AMBIENT AIR QUALITY MONITORING AND RECEPTOR MODELLING*

There are currently several agencies active and several sites in the Vaal Triangle at which ambient monitoring is being undertaken. Groups are involved in such monitoring, including DEAT, Eskom TRI, Mintek and AER (Pty) Ltd. Several industries monitor ambient conditions adjacent to their own operations.

A summary of continuous gaseous and particulate monitoring results was conducted as part of the VAPS study, covering the period 1990 to 1993 [BU94]. In 1996, all available monitoring data for the Vaal Triangle (and five other cities) for the period 1985 to 1995 was assembled in a PC-computer database as part of the Vehicle Emissions Study of the Department of Minerals and Energy [TE96]. Results are available in the PC software database "Microsoft Access". The data base includes results of criteria pollutants from ambient stations operated by local Vaal Triangle companies. One of the disappointing findings was that there was little uniformity or intercomparison in the calibration procedures and reference materials used for gaseous pollutant analysers.

During 1994 Mintek conducted a year long receptor model ambient air study campaign in the Vaal Triangle. Samples of particulate matter (PM-10 size range) were collected for week long periods at three sampling stations in the commercial centers of Vereeniging, Vanderbijlpark and Sasolburg [EN95]. Following the physical and chemical analysis of the samples, receptor modeling was undertaken to quantify the contribution of various source types to the ambient particulate concentrations.

An agency is currently needed to coordinate such monitoring efforts, and facilitate the more frequent collection and collation of the data generated. Furthermore attempts should be made to extend ambient monitoring into the coal-burning residential suburbs of the Vaal Triangle.

Calibration procedures and reference materials should be determined by at a national level, and coordinated at local level by a body such as the proposed MAQA.

*PERSONAL MONITORING AND EXPOSURE ASSESSMENT*

The monitoring of the exposure of individuals to pollutants has been undertaken in various parts of the Vaal Triangle as part of the Vaal Air Pollution Health Study. Results are contained in the reports of that project [TE94].

## PARTICULATE MATTER STRATEGY IMPLEMENTATION PLAN FOR THE VAAL TRIANGLE

### Particulate Matter Standards

Ambient concentrations of suspended particulates measured in the Vaal Triangle regularly exceed both the guide-lines of the DEAT and US National Ambient Air Quality Standards (NAAQS):

| | | |
|---|---|---|
| **Total Suspended Particulates (TSP)** | | |
| DEAT Guide-lines: | < 300 ug/m³ | 24 hour average |
| | < 150 ug/m³ | annual average |
| **Particulate Matter less than 10 µmad (PM10)** | | |
| US NAAQS | < 150 ug/m³ | 24 hour average |
| | < 50 ug/m³ | annual average |

### Sources of Particulate Matter

The 1992 Vaal Triangle Emission Inventory identifies and quantifies the emissions of all sources of particulate matter in region [VA95]. The inventory includes percentage contributions of each source to total emissions (Table 1), and contributions classified by elevation of emission point above ground level (Tables 2, 3, 4). Although actual quantities emitted are not given, percentage contributions of each source to total emissions are included.

**Table 1. Percentage Contribution of Sources to Total TSP and PM-10.**

| | | TSP % | PM10 % |
|---|---|---|---|
| Point sources: | primary iron and steel | 16 | 13 |
| | open cast coal mining | 10 | 9 |
| | secondary iron and steel | 8 | 9 |
| | power generation | 6 | 10 |
| | fertilizer manufacture | 5 | 7 |
| | chemicals manufacture | 4 | 4 |
| | brick and tile manufacture | 4 | 3 |
| | other industries | 4 | 6 |
| Area sources: | domestic coal combustion | 2 | 2 |
| | paved roads fugitive dust | 20 | 18 |
| | unpaved roads fugitive dust | 13 | 12 |
| | industrial coal combustion | 3 | 3 |
| Other area sources <3% | | | |
| | domestic combustion - other fuel | | |
| | industrial combustion - other fuel | | |
| | veld fires | | |
| | agricultural activities | | |
| | heavy construction | | |
| | mobile (exhaust, brake and tire wear) | | |

**Table 2. Low Level (<10 m agl) Emissions**

| | | TSP % | PM10 % |
|---|---|---|---|
| Point sources: | open cast mining | 18 | 16 |
| | brick and tile manufacture | 3 | 3 |
| Area sources: | paved roads | 35 | 33 |
| | unpaved roads | 23 | 22 |
| | agricultural activities | 4 | 2 |
| | domestic coal combustion | 3 | 3 |
| | industrial coal combustion | 6 | 6 |

**Table 3. Medium Elevation (10 - 200 m agl ) Emissions**

| | TSP % | PM10 % |
|---|---|---|
| primary iron and steel | 42 | 32 |
| secondary iron and steel | 21 | 25 |
| fertilizer manufacturer | 15 | 18 |
| chemical manufacturer | 11 | 11 |
| brick and tile | 5 | 5 |
| paper and pulp | 2 | 2 |
| petroleum refining | 2 | 4 |

**Table 4. High Elevation (> 200 m agl) Emissions:**

| | TSP % | PM10 % |
|---|---|---|
| Electricity generation | 100 | 100 |

From the above figures it is apparent that a minority of sources contribute the majority of emissions. Although it is obvious that control plans need to focus on key sources for the greatest benefit, account should also be taken of height of emission and of the likelihood of human exposure to emissions [VA95].

*EXPOSURE ASSESSMENT*

An assessment of the spatial and temporal distributions of emissions forms an integral component in the evaluation of the likelihood of human exposure to such emissions. Sources in, or in close proximity to residential areas are more likely to affect levels of human exposure. Existing studies have found that emissions from domestic fuel combustion emitted directly into living space of people have a much larger impact than emissions at remote sites [VA95, TE94]. High spatial concentrations of emissions due to unpaved roads in residential townships are similarly a cause for concern.

Ground level emissions generally have the greatest local impact. Medium level emission are more important to average regional air quality, whereas high elevation emissions have subcontinental implications.

Temporal distributions of emissions are similarly important since emissions which are temporally concentrated (e.g. veld fires) have large, local impacts over short time periods, despite being less significant to average regional ambient air quality [VA95].

*SOURCES OF TSP AND PM-10: INTERNATIONAL EXPERIENCE*

Prior to the identification of sources to be controlled and air pollution reduction strategies to be adopted, it is beneficial to examine the experience of other countries.

Many urban areas in the USA have been unable to attain the primary air quality standards for TSP. This nonattainment status exists in these areas even after vigorous efforts to control particulate matter emissions from point sources as a result of the EPA mandated State Implementation Plans (SIP) of the early 1970s. Such experience serves to highlight the fact that industrial emissions from vented stacks and ducts, which were the targets of the SIP mandated regulations, form only a portion of the contribution to the TSP concentrations. Fugitive and other "nontraditional" sources of particulate matter were not addressed to any significant degree. Over the past 10 years it has been learned that such nontraditional sources account for most of the nonattainment problems since industrial sources have already been controlled [CH93, YO81].

Non-traditional sources of particulate matter include area-wide emitters such as fugitive dust from roads, construction, and agriculture, in addition to emissions from residential wood/coal combustion and prescribed biomass burning. Exhaust emissions from vehicle engines, and secondary sulphates, nitrates and organics formed from gaseous ammonia, SO2, NOx and reactive organic gas emissions also constitute non-traditional types of sources. The recognition and characterisation of such non-traditional sources of particulate matter is represent vital steps towards the control of such sources.

In the US, the study of non-traditional sources, and a commitment to the implementation of strategies aimed at the reduction of emissions from such sources is now mandatory. The EPA has an existing Fugitive Dust Policy. In a guidance on SIP development issued in 1977 the EPA states that "urban areas should receive the highest priority for development of comprehensive and reasonable programs to control fugitive dust" [EP87]. Since then the EPA has developed several options for revising the fugitive dust policy for application to the PM-10 National Ambient Air Quality Standard (NAAQS) [SC93, CH93, YO81].

The 1992 Vaal Triangle Emission Inventory has similarly revealed the importance of the contribution of non-traditional sources to total emissions of particulate matter. At present, however, non-traditional sources receive little consideration in South Africa. With many industrial sources now highly controlled, such sources will have to be dealt with in order to meet standards.

International experience has furthermore shown that public education and cooperation are essential for implementing nontraditional emissions reductions strategies, such as curtailing wood burning, modifying agricultural practices and reducing traffic related emissions [CH93].

*SOURCES OF PARTICULATE MATTER TO BE CONTROLLED*

Based on the experience of other countries attempting to reduce concentrations of particulate matter, and on the information presented in the 1992 Vaal Triangle Emission Inventory, it is possible to select the types of sources which need be controlled to ensure the cost-effective reduction of ambient concentrations.

The following sources need be controlled in the Vaal Triangle:

- paved roads
- unpaved roads
- domestic coal burning
- open cast coal mining
- primary iron and steel
- secondary iron and steel
- power station fly ash
- sources of secondary particulates (sulphates, nitrates)
- vehicle emissions

Although vehicle emissions represent a small proportion of the total particulate emissions, huge increases in vehicle numbers and vehicle kilometers traveled are expected in the future.

**Potential Intervention Strategies**

In this section potential intervention strategies which may be adopted for each of the sources of particulates are listed and their implementation described. Qualitative estimates are then made as to the extent to which the implementation of each strategy would reduce ambient concentrations of particulate matter. The quantification of reductions in ambient particulate levels resulting from the adoption of strategies would require extensive dispersion modelling. Such modelling is beyond the scope of the current study.

An assessment of the characteristics of each source (e.g. percentage contribution, likelihood of human exposure, and height of emission and spatial distribution), in addition to the qualitative estimates of the reductions in ambient concentrations resulting from the implementation of each strategy, facilitates a rather crude cost-benefit analysis.

In addition to the quantification of ambient concentrations reductions, a comprehensive cost-benefit analysis would require a detailed assessment of each strategy's socio-economic impact. Such an assessment is similarly beyond the scope of this study. The cost-benefit analysis undertaken includes the evaluating of the potential socio-economic implications of each measure, based on a general understanding of the socio-economic characteristics of the Vaal Triangle and on the experience of other countries implementing similar measures.

*PAVED AND UNPAVED ROADS*

Re-entrained road dust results from dust, dirt and residual road sand that is deposited on roads. Such dust from paved and unpaved roads represents a substantial source of TSP emissions in the Vaal Triangle. Controlling the emissions from such roads can therefore significantly reduce TSP concentrations. Since re-entrained dust is related to both the amount of particulate loading on the road and the amount of travel on the roadway, abatement strategies adopted should include both measures aimed at reducing the availability of dust on roadways, and traffic control measures. In order for such control measures to be successful close cooperation is needed between the Metropolitan Air Quality Authority and local public works and street maintenance officials, and between the Metropolitan Council and transportation authorities.

**Possible Control Measures for Reducing Fugitive Emissions from Paved and Unpaved Roads [CO95]:**

1. Pave, vegetate, or chemically stabilize access points where unpaved traffic surfaces adjoin paved roads.
2. Require dust control plans for construction or land clearing projects.
3. Require haul trucks to be covered.
4. Provide for traffic rerouting or rapid clean up of temporary sources of dust on paved roads.
5. Prohibit permanent unpaved haul roads, and parking or staging areas at commercial, municipal, or industrial facilities.
6. Develop traffic reduction plans for unpaved roads.
7. Limit use of recreational vehicles on open land.
8. Require curbing and pave or stabilize shoulders of paved roads.
9. Pave or chemically stabilize unpaved roads.
10. Pave, vegetate or chemically stabilize unpaved parking areas.
11. Provide for storm water drainage to prevent water erosion onto paved roads.

12. Require revegetation, chemical stabilization, or other abatement of wind erodible soil.

13. Enhanced street sweeping practices by:

    - maintaining sweeping equipment so that it operates effectively
    - sweeping as soon as possible after each storm
    - expanding the use of vacuum and air machines that are more effective at picking up fine particulate matter

*Implementation and Enforcement*

Such control measures should be undertaken at local levels by public works departments. The effectiveness of these measures may be evaluated at the regional level, and additional measures implemented if necessary.

A higher priority should be given to measures aimed at preventing silt from getting on the road surface in the first place, rather than relying extensively on street cleaning.

Control measures which would involve the planning of transportation networks or traffic flow controls are discussed in a subsequent section.

*DOMESTIC COAL BURNING*

Bituminous coal is burnt in the townships mainly for cooking, space heating and boiling water [AS95]. The Air Pollution Prevention Act incorporates various regulations aimed at regulating the manufacture, import and installation of fuel burning appliances in dwellings, alterations made to existing fuel burning appliances, and the construction of chimneys. Despite provisions for declaration of smoke free urban zones in the current legislation, there is virtually no mechanism any township to control emissions from coal-burning.

Although electrification was at one stage widely believed to be the solution to coal smoke pollution, experience has shown that even after electrification coal burning continues to be a preferred energy source, specifically for space heating in winter. Explanations offered for retention of the domestic coal stove even after electrification include: affordability, security of supply, and social preferences. Cleaner sources of energy have been suggested. Such sources include anthracite, low-smoke coal, and an integrated energy approach.

In the evaluation of control measures to reduce emissions from domestic coal burning the experience of foreign countries, and investigations and initiatives undertaken locally, are considered. Control measures fall within three main groups.

Measures aimed at reducing emissions from current devices:

***Encouraging the improved performance of coal burning stoves.***

Implementation: Educate and inform the public about:

- stove sizing
- effective installation of stoves
- proper operation and maintenance
- general health risks of coal smoke

***Conversions of existing devices to cleaner burning technology, including gas, electric and cleaner coal burning devices.***

- Implementation: The conversion program and supporting public information campaign may consist of the following components [CO95]:

- Financial Incentive Program - The Metropolitan Air Quality Authority could work with various organisations and groups to initiate a public-private sector incentive program that will provide homeowners with financial incentives to convert exiting coal burning devices. A package of financial incentives may be put together that will partially subsidize the purchase of new devices and will be sufficient to spur accelerated conversions. Financial commitments may be obtained from a variety of sources, including utilities, appliance manufacturers, retailers, and financial institutions.
- Discouraging the resale of used stoves through taxes, fees or other disincentives. Perhaps even prohibit the resale or installation of used, uncertified stoves.
- Discourage the availability of inexpensive coal
- Cleaner coal burning device exemptions during emission curtailments on high pollution days may provide further incentive for homeowners to convert to cleaner-burning technology
- Conversion tracking procedures - retailers have to notify local government of purchasers which have converted to cleaner devices

## *Conversions to cleaner fuel (low smoke coal).*

The implementation of low-smoke fuel to ameliorate air quality in the townships is explicitly proposed in the RDP document [AS95]. Cleaner sources of energy include anthracite, low-smoke coal, and an integrated energy approach. Anthracite, which is found largely in Kwazulu/Natal, is believed to be to be too limited in terms of reserves and too expensive to represent a feasible alternative to coal.

In June 1994 the Dept of Minerals and Energy Initiated the Low-Smoke Coal (LSC) Programme in its attempt to provide a cleaner energy source. The programme incorporates a number of projects, workshops and field tests. The LSC Programme includes the development of low smoke fuel alternatives and an evaluation of the technical, social and economic feasibility of each of these. The low-smoke fuels believed to be successful will be used in a macro-scale experiment schedules proposed for winter 1997. The outcome of the LSC Programme will contribute to national policy development [AS95].

To date thirteen low-smoke fuels have been sourced in South Africa. These fuels may be classified into the following categories according to the manufacturing process and raw materials: devolatilised lump coal; briquetted coal discards; discard coal and cement mixture; and the mixing of organic waste (e.g. paper) with wax binders; briquetted pine saw dust [AS95].

It is estimated that the total domestic sector coal usage is 3 Mt per year. Only the devolatilised coals have the raw material availability at present to satisfy a significant fractionof this market as a replacement low smoke fuel.

Implementation: The successful implementation of low-smoke fuels would necessitate education and awareness campaigns, demonstrations, possible government intervention and policy, and endorsements [CO95]:

Education and Awareness: It is believed that should the attitudes of people to the new products not be taken into account, and attempts made at changing the mind-sets of people, the intended fuels would be rejected outright.

Demonstrations: can be done through the organisation of a road show or the use of the media to demonstrate the use of low-smoke fuels.

Possible government intervention: Economic evaluation of low-smoke coals reveal that their cost can be up to twice as much as that of bituminous coal [AS95]. In order to overcome the financial barrier for a low-smoke coal entry into the market several options need be considered, including pollution tax, price support, tax incentives, access to finance and legislative support.

**Strategies aimed at curtailing the use of coal burning devices during adverse meteorological conditions [CO95].**

Implementation: Such an episodic curtailment program would include:

- real-time, on-line monitoring of meteorological conditions and pollution levels (including CO, particulate, and visibility levels)
- an information program to inform public of the need for an episodic curtailment program and hopefully encourage public acceptability of the program
- high pollution day warnings
- communication strategy to implement plan - people are notified through the media - newspapers, radio, television. Local governments may have their own information and/ or complaints hotline and may circulate information by means of newsletters, bulletin boards or local press campaigns.
- mandatory or voluntary coal burning restrictions to reduce coal burning on days when adverse weather conditions coupled with poor air quality could lead to exceedances of air quality standards
- exemptions from emission curtailment where coal burning represent primary energy source.

Enforcement:

- Surveillance or enforcement plan
  The Metropolitan Air Quality Authority may contract with local health departments to provide enforcement. Enforcement efforts by local governments may be based on complaints. Local governments publicize the restrictions and numbers to call to lodge complaints with are verified by enforcement officers. If the violation is confirmed, a warning letter is issued for the first offense. Citations are issued for subsequent offenses. Local governments may also augment this with observations by police and/or personnel during their routine patrols.
- Enforcement provisions including fines, penalties, warnings, and authorization for inspections

International Experience:

- In the US high pollution day warnings are issued twice daily, at 5:45 am and again at 4:15 p.m. Use is made of a series of coloured symbols to communicate the status of air quality ranging from a red stop sign for poor air quality and mandatory restrictions on wood burning, to a blue circle for acceptable air quality and no restrictions [CO95].

**Measures designed to limit future growth in the number of domestic coal burning devices.**

Require fireplaces in new or remodeled construction to employ cleaner burning technology

Implementation: Any new dwelling may only be allowed to include a gas appliance, an electric device, or a coal burning device which meets stringent emission standards [AN95].

Enforcement: Since the new fireplace restrictions must be adopted as building code revisions by each local government, the requirement will be enforced through normal, well-established code enforcement programs.

**Reduce need for coal burning in construction of new dwellings**

Implementation: In line with the RDP many new houses are currently under construction or are being planned. In the planning and construction of such houses measures may be taken to reduce the need for coal-burning, through the consideration of:

- housing installation
- orientation of houses
- provision of fire places and chimneys

Liaison between housing, energy and town-planning authorities would ensure that new houses are proactively fitted with devices that would promote cleaner energy use, energy efficiency and an appropriate energy mix.

**Contingency measures to be implemented should the Vaal Triangle fail to attain standards [CO95]:**

- Charging a fee for residents of dwellings who wish to burn coal in an uncertified stove or fireplace and using the fee for conversion incentives, monitoring and enforcement efforts.
- Requiring conversion to cleaner burning devices upon sale of a dwelling unit containing a conventional fireplace or uncertified stove.
- Removing the exemption for primary heat source on no-burn days.
- Instituting a permit-to-burn program with a maximum number of permits issued in a random but proportional manner throughout the metropolitan region.
- Increasing enforcement of episodic coal burning restrictions.

Note:

All control measures requiring information or education campaigns would have to be sensitive to the fairly high levels of illiteracy in order to be successful. While many of these suggestions are obviously not applicable in South Africa now or in the future, they are quoted in full as examples of the comprehensive scope of the US SIPs. It is as important for credibility to examine and document rejected strategies as it is to justify the selected strategies.

**Emission Reductions Anticipated from Coal Burning Control Strategies:**

*Conversions to cleaner technology*

Estimates of the reduction of ambient concentrations due to the conversion of existing units to cleaner burning technology would require information on the approximate number of conventional stoves in operation, and the determination of the rate of conversion to cleaner burning technology. Such information is not currently available.

*Conversions to cleaner fuel*

The effectiveness of low-smoke fuels at reducing ambient concentrations has been questioned on the grounds that the removal of the smoke would result in the lowering of the ambient temperature, necessitating the combustion of more coal for space heating. This criticism could be extended to all measures aimed at the reduction of domestic coal burning emissions. Recent research has, however, estimated that reductions in the opacity of the atmosphere would only result in a decrease in ambient temperatures in the order of 0.5 degrees Celsius [WI95].

The degree to which low smoke fuels will reduce air pollution and health risks is still the subject of intensive investigation. It is not obvious that even under most favourable market penetration, that the inherent smoke emission reduction would reduce ambient smoke levels to acceptable levels. Low-smoke fuels are therefore proposed as a transitional form of energy until the use of electricity or other clean technologies in residential areas is economically and socially feasible [AS95].

*Episodic curtailment Program*

The success of episodic curtailment programs depends on the compliance rate of individual households. In assessing the compliance rate the number of exemptions granted must be taken into account. In Denver exemptions from restrictions are granted on the basis of low-income, or in instances where wood burning represents the sole or primary source of heat. Five percent of uncertified devices are therefore exempt from the mandatory restrictions during high pollution days [CO95]. Should similar exemptions be included in the strategy implementation plan of the Vaal Triangle, a much larger percentage of coal burning devises would remain exempt since a large sector of the population is reliant on coal burning as a primary source of heat. The implementation of an episodic curtailment program would thus hold limited benefits in terms a reduction in the levels of pollution for the townships of the Vaal Triangle. Episodic curtailment programs in electrified areas may, however, prove useful in phasing out the use of coal in households currently integrating the use of coal and electricity as an energy source.

**Require cleaner burning technology in new or remodelled constructions**

In order to establish the success of such measures one would need to know how many new dwellings are to be constructed - and be able the estimate the percentage of those dwellings which would have included a conventional stove or fireplace if it were not for the ban.

## ECONOMIC IMPACTS OF COAL BURNING STRATEGIES

Although some of the economic impacts of coal burning strategies are considered in this section, a full economic study need be conducted in order to assess the total monetary impact of these requirements on the Vaal Triangle.

**Conversion to cleaner technology and ban of conventional devices in new or remodelled buildings**

Consumer costs and savings will occur as a result of the ban on conventional fireplaces and the voluntary conversion of coal burning devices to cleaner burning units. The initial cost of replacing an existing stove with an alternative device is fairly large to the consumer, but it is possible that savings will be realized immediately in the lower operating costs associated with the cleaner and more efficient burning devices.

Manufacturers and retailers of gas appliances and cleaner coal burning devices will be beneficially impacted by the increased sales of their product. Businesses that produce and distribute conventional coal burning devices could be negatively impacted by these strategies, but since the majority of these producers and distributors may also sell gas or certified units, the negative impact should be mitigated in most instances.

Retailers which supply coal to conventional stoves will be negatively impacted by the strategies.

These costs should then be aggregated and compared to the cost saving benefits (in terms of fuel savings and avoided health costs) of the various alternatives.

**Conversion to cleaner fuel**

The current manufacturers of low-smoke coals may be apprehensive to invest too much in producing huge tonnages for fear of not being able to break into the household coal market successfully. Furthermore the relatively high price of low-smoke coals will make them non competitive with the bituminous coal [AS95]. Market intervention to promote low-smoke fuels would be needed.

**Episodic Curtailment Program**

The on-line, real-time monitoring of meteorological conditions and pollution levels required for the prediction of high pollution days would make such a program costly. Should the program comprise mandatory restrictions, the cost of enforcing such restrictions would also require considerable expenditure.

*STATIONARY SOURCES*

Various industrial sources have been shown to contribute to the Vaal Triangle's particulate problem. Sources which emit particulate matter include: iron arc furnaces, power station fly ash, sinter plant emissions, coking furnaces, and ferro-managanese arc furnace emissions.

In addition to sources which emit particulates directly into the atmosphere, are sources of precursor gaseous emissions (NOx and SO2). Such gaseous emissions undergo chemical reactions in the atmosphere to for particulates that are referred to as secondary particulates. According to Mintek's study secondary ammonium sulphate, and to a lesser extent secondary ammonium nitrate, contribute significantly to the Vaal Triangle's ambient concentrations of particulates [EN95].

**Potential Control Measures for Existing Industrial Sources [CO95, CO94]:**

- Ensure that such sources are operating in accordance with their current emission standards as negotiated with CAPCO on issuance of their permit.
- Ensure compliance to all existing national regulations.
- Review the emission standards of both new industries or existing industries. The Metropolitan Air Quality Authority must be allowed to re-negotiate existing emission standards, and should be responsible for the establishment of emissions limits and the issuance of permits for new industries within the Vaal Triangle.
- Establish new allowable limits for major particulate sources and major NOx and SOx sources with modelled violations.
- Analyze the availability and feasibility of new technology being developed and utilised elsewhere, and ensure that industries reflect the process changes and the availability of additional control equipment.
- Consider the implementation of low-sulphur coal in industries to lower SO2 emissions.
- Review the feasibility of an episodic curtailment programme. For example the SO2 Management System for South Durban, initiated in 1992 by the Durban City Council. A computer model is used to allow government and industry to identify periods during which meteorological conditions prevail (inversions) which prevent the dispersion of emissions so that levels of production may be adjusted accordingly. It should be noted that the model has been criticised by the local community since it does not aim to reduce emissions on an on-going basis by requiring cleaner technology or the use of lower-sulphur coal [PE95]. The community favours reducing SO2 emissions over-all as a much safer option. Such an episodic curtailment program would obviously require a comprehensive meteorological monitoring network.

*CONTROL MEASURES FOR NEW AND MODIFIED STATIONARY SOURCES*

**New Stationary Source Review and Emission Offsets**

Emission offsets need be established so as to accommodate new industrial source growth without jeopardizing the attainment and maintenance of ambient standards. One example of an emission offset would be the modification of existing sources prior to issuing a permit to the new source.

**EPA Guidance and Clean Air Act Requirements for New Sources**

In the US in order for a new source to obtain a permit to operate in a non-attainment area, the source must first achieve the lowest achievable emission rate (LAER) that has been demonstrated for the particular source category. The source must then obtain emission reductions, or offsets, from existing sources within the area in an amount greater than the emissions that will result after the application of LAER [CO95].

The Clean Air Act of the US further requires that sources must provide, before the issuance of any permit, an analysis of alternative sites, sizes, production processes and environmental control techniques for such proposed source which demonstrates that the benefits of the proposed source significantly outweighs the environmental and social costs imposed as a result of its location, construction, or modification [CO95, CO94].

These regulations should not only be applicable to primary sources of particulate matter, but also to stationary sources of NOx and SO2.

*MOBILE SOURCES*

Mobile sources contribute less than 3 percent of the total emissions of TSP and PM-10 [VA95]. Despite their current marginal contribution to ambient particulate concentrations, control measures aimed at mobile sources should be considered due rapid rate at which vehicle numbers are increasing and the continual expansions in the transportation network.

In addition to particulate matter, exhaust emissions include carbon monoxide, carbon dioxide, nitrogen oxides and unburnt hydrocarbons (HC). These gaseous emissions are a cause for considerable concern in many developed countries. Photochemical smog and low level ozone are formed through the interaction of NOx and HCs in the presence of sunlight, various health risks are associated with CO and NOx inhalation, and the implications of elevated CO2 levels for global warming. Such gaseous emissions thus provides further motivation for the analysis of control measures aimed at the abatement of vehicle emissions.

## APPROACHES TO LEGISLATIVE CONTROL OF VEHICLE EMISSIONS:

Measures to control tail-pipe emissions from vehicle internal combustion engines

Emission Standards:

One way of reducing vehicle emissions is to establish tail-pipe emission standards or limits for specific pollutants, such as SO2, NOx, CO and hydrocarbons. Tailpipe emissions in the USA and the European Union are controlled through the implementation of standards on the permissible emissions for various pollutants per kilometer traveled, averaged over a defined driving cycle.

Attempts at reducing vehicle emissions may then be achieved through the imposition of more stringent emission standards. In Denver for instance new tailpipe particulate, NOx and SO2 standards for light-duty cars and trucks, urban bus standards, diesel fuel standards, and standards for other heavy duty vehicles have been introduced. Various buses have had to have their engines rebuilt or replaced in order to comply with more stringent standards for diesel particulate emissions for urban buses [CO94].

Tail-pipe Control Equipment

Catalytic converters and various other tail-pipe control equipment are currently in use in Europe, the US and Japan to reduce exhaust emissions and attain emission standards.

The US and EEC legislation does not prescribe the technology which should be attached to motor vehicle engines to attain emission limits. Vehicle manufacturers are responsible for the installation of such devices [DI95].

There are currently no regulations in force in South Africa which would compel the fitting of catalytic converters or other emission control devices to motor vehicles. It is recommended that South Africa follow the example set by the US and the EEC in not legislating specific control technology, so as to facilitate the prompt adoption of new technology when such technology becomes available.

Since lead residues from leaded petrol rapidly render catalytic converters inoperative, introduction of unleaded fuels should proceed the utilization of such control devises.

In California more stringent tailpipe emission regulations have necessitated the evaluation of the technological and commercial feasibility, and the environmental and economic benefits of low-emission vehicles. Emission control technology evaluated includes: sequential fuel injection, improved fuel preparation, heat-optimized exhaust pipes, leak free exhaust systems, greater catalyst loading and improved washcoats, and electrically-heated catalysts. It was estimated that low-emission vehicles are cost-effective, facilitating the reduction of emissions at less than one dollar per pound of emissions reduced. It is further believed that low-emission vehicle requirements will provide not only significant emission reductions, but will also promote more durable emission control systems [CA94].

Implementation: Based on tail-pipe emission standards various measures may be undertaken to further reduce vehicle emissions, including:

- the introduction of more stringent emission standards [CO94]
- regulations to ensure that vehicle manufacturers keep pace with the development of emerging control technologies
- retrofitting of particulate traps/catalysts to certain classes of vehicle [SA94]
- research aimed at improving existing control equipment and developing new control technology (Studies are being done in the UK on the use of on-board diagnostics (OBD) which is aimed at giving drivers an early indication of emissions control system malfunctions - hence encouraging remedial action) [AI95b]
- accelerated retirements of vehicles [SA94]
- tighter enforcement of emission regulations, targeting those vehicles doing the most damage

Enforcement may include:

- roadside emission testing (This was introduced in the UK in October 1994. Initially only done by the Vehicles Inspectorate, kerbside emission testing powers have since been extended to London local authorities [AI95b])
- the use of hotlines where the public reports vehicles not complying with emission standards (e.g. the smoky diesel hotline introduced in the UK - public reports smoky vehicles [AI95b])
- on-road identification of high emitting vehicles through the use of remote-sensing technology (Recently introduced in the UK [AI95b].)
- mandatory no-drive days for high-emitting vehicles [BR93]

**Measures to change the composition and properties of fuels**

Unleaded Fuel

In the US and the EEC the introduction of unleaded fuel was driven primarily by the need for a fuel compatible with the catalytic converters [SI94]. Lead residues form leaded petrol rapidly rendered the catalyst inoperative. In South Africa, the rapid phasing out of leaded petrol is currently perceived to be desirable since recent research has shown that lead toxicity may occur at much lower levels that previously believe, particularly with respect to children. The impending introduction of unleaded fuel on a national level is likely to impact significantly on air pollution levels.

Following the introduction of unleaded petrol, it is likely that some catalyst equipped cars, either imported or locally manufactured, will appear on South African roads. The use of such catalysts is perceived to be beneficial since unleaded petrol used in the absence of exhaust control devices is liable to increase emissions of hydrocarbons [SI94].

Desulphurised Diesel

Diesel exhausts contain CO, NOx, HCs, particulates and SO2, in addition to producing odours. Diesel used in South Africa contains 0.5 % sulphur, which is considerably higher than elsewhere in the world and may be a contributory factor to the high SO2 levels in various urban centers [DI95]. Regulations which will reduce the sulphur content of diesel fuel represent one means of decreasing SO2 and particulate emissions.

In the US the EPA has promulgated a regulation that reduced the sulphur content of diesel fuel. Diesel fuel aromatics have also been reduced through the imposition of a diesel-fuel cetane index specification. These new diesel fuel standards are believed to have reduced SO2 emission from diesel vehicles by 80 % and particulate emissions by 2 % [CO94].

Oxygenated fuels program

The US EPA requires a minimum oxygen content of 2.7 % in gasoline. Although this measure has resulted in increased gasoline prices and reduced fuel economy, it has been responsible for a reduction in CO emissions of 20 percent from motor vehicles [CO94].

The use of oxygenated gasoline dilutes fuel sulphur, which also reduces CO emissions since sulphur acts to reduce the efficiency of catalytic converters.

In Colorado the adoption of an oxygenated fuels programme is estimate to reduce PM-10 by 14 % from closed-loop catalyst vehicles. Such vehicles compromise more than 90 % of the light-duty gasoline vehicles and more than 60 % of the light-duty gasoline tracks [CO95].

Implementation of Fuel Measures may include:

- the use of alternative fuels during inversion months [CO94]
- requiring the use of alternative fuels by fleets and public transit [CO94]
- a public education program to promote public support, cooperation and compliance with measures

Inspection and Maintenance Program

In addition to the establishment of emission limits and the introduction of cleaner fuel, inspection and maintenance programs may be adopted to reduce exhaust emissions.

Proper maintenance of diesel vehicles is considered to be one of the most important components in minimising emissions from such vehicles [BR93]. Repair and replacement of air and fuel filters, adjustment of primary emission-related engine components, and repair or replacement of any damaged or missing emission control equipment are several of the possible strategies which may be adopted.

An enhanced inspection and maintenance programme was adopted in Colorado to reduce NOx emissions and help maintain the PM-10 standard. The program contains the following major elements: testing of non-diesel cars and light-duty trucks once every two years, and in the case of pre-1982 model cars every year; emission-related repairs for vehicles failing the test; proof of passing emissions test prior to the annual registration of vehicles; self-inspection an repair for fleets of 20 or more vehicles; and on-road remote sensing tests on 0.5 percent of the vehicle fleet [CO95].

Colorado's diesel inspection and maintenance program for both light- and heavy-duty diesel vehicles is expected to reduce particulate emissions by about 15 % from light-duty vehicles and by about 7 % from heavy-duty vehicles.

Evaluation Control Strategies for Mobile Sources

A recent study concluded that although controls on vehicle emissions are likely to be needed at some time in the future, emissions from roads and domestic coal combustion currently have a greater priority [AN95]. In the Vaal Triangle there is no compelling reason on the basis of air quality or health why tailpipe and fuel measures should be introduced in the short term, by-passing the national consultation and planning processes already initiated. The IPC policy is needed to link vehicle emissions policy within the broader context of national environmental, transport and energy policies. Measures aimed at the implementation of tailpipe emission control equipment should therefore not be adopted at present, but should instead accompany national legislation regarding unleaded fuel and tailpipe emission reductions.

Air pollution problems which have a greater priority in the Vaal Triangle - i.e. domestic coal burning emissions and fugitive emissions from paved and unpaved roads - require the allocation of resources and crash programmes more than the issue of vehicle emissions [AN95]. It is therefore recommended that measures aimed at reducing vehicle emissions be confined to improvements in the transportation system, traffic flow control, and the promotion of public transportation. Such measures would reduce vehicle travel in the region and promote cooperation between air quality and transport agencies, thus providing the context for the effective implementation of future vehicle emission control measures.

## TRANSPORTATION CONTROL MEASURES (TCM)

Rapid growth in regional vehicle travel is expected, such growth would cancel out air quality gains achieved through tailpipe control measures and reductions in fugitive dust emissions from paved and unpaved roads. Measures aimed at the reduction of vehicle travel and vehicle kilometers traveled are therefore crucial to assure a decrease in mobile source pollution. Transportation Control Measures may incorporate both long-term and short-term strategies.

### Land Use Development and Urban Design Measures [CO94].

Regional growth strategies that address the relationship between land use and transportation, and between urban form and travel behaviour are included in this category. These strategies are essentially aimed at reducing the need of people to travel and encouraging the use of less polluting modes of transport. A good example of such planning strategies involves the promotion of new developments in locations accessible by public transport.

### Transportation planning and management measures

- traffic calming measures, e.g. shopping centers may be predestianised [CO94]
- traffic light synchronization to smooth traffic flows on congested routes (improved traffic flow in congested areas can reduce localized emissions of CO and particulate matter) [CO94]
- parking management - evaluate additional time of day parking restrictions, including fees and fines to discourage single occupant vehicle commute parking and 90 minute re-parking activity [SA94]
- where new roads are being planned - it must be ensured that increased emissions do not threaten to breach air quality standards

### Provide transportation alternatives to reduce reliance on single-occupation vehicles.

Such measures could include:

- improvements in public transit systems, such as additional bus services or light-rail lines [CO94, MA93]
- the construction and dedication of bus or high-occupancy-vehicle (HOV) lanes in congested areas [CO94, MA93]
- a carpool matching service which provides marketing and consulting assistance to the public and employers on all alternative modes of transport (e.g. RideArrangers Program in Denver [CO94]).
- the funding of bicycle projects - which includes for example an the provision of racks and lockers in the commercial area [CO94]
- facility improvements, including bus shelters, carpool drop-off zones, bicycle facilities, and carpool parking [CO94]
- enhanced bicycle and pedestrian access programs [MA93]
- park and ride fringe parking. Parking lots on the fringe of urban areas or at remote sites along freeways in order to promote higher commuter vehicle occupancies and reduce trips [SA94]
- public education programs to promote public support for measures listed above

### Employer-based travel reduction programmes

May similarly be used to attracting new riders to public transport [CO94]. Examples include:

- employer-based travel reduction programs where:
- an employer provides a voucher valued at a certain amount per month toward the cost of the employee's monthly bus pass (e.g.. CommuterCheck in Denver)
- an employer buys an unlimited bus pass for all full-time employees (e.g.. EcoPass in Denver). This program has been very successful in Denver with an estimated 38 000 passes being issued in 1994.
- programmes in which Universities pays for student's bus transportation on local levels (e.g.. CU Student Pass Program)
- work schedule changes [SA94]

Development of environmental responsibilities in partnership with public service and other fleet operators. For example:

- buses and taxis should ensure that their vehicles comply with emission standards [CO94, SA94]
- extension of statutory nuisance to cover exhaust fumes from business premises

Implementation:

The feasibility and effectiveness of the above mentioned measures necessitate a cooperative effort between air quality and transportation agencies, land use planners, local governments, and the business community. Employer-based travel reduction programmes would for example require considerable support from the business community in the Vaal Triangle. Public support and cooperation would similarly be essential to the success of transportation management strategies, particularly measures aimed at reducing the reliance on single-occupant vehicles.

Effectiveness:

The formulation of transportation and land use strategies which produce long term solutions to the growth in vehicle use and vehicle kilometers traveled is essential to ensure that reductions in air pollution achieved through cleaner cars and fuels are maintained.

## ADMINISTRATION REQUIRED FOR SIP ADOPTION

The formulation and adoption of the Strategy Implementation Plan should include the following processes:

### COMMUNITY INVOLVEMENT AND PUBLIC PARTICIPATION

Throughout the development of the Strategy Implementation Plan the Metropolitan Air Quality Authority should seek input from the public, local governments, and the industrial and business sectors.

Information and education campaigns are essential to ensure meaningful public participation in the SIP development process. The actual process of public participation may be facilitated through public workshops, organised to inform public of developments, answer questions and record public comments.

*International Experience*

In Utah the closed nature of the SIP development process in 1993 was criticised [BR93]. The public were denied involvement in the development of specific PM10 reduction strategies, particularly in those strategies which deal with industry. It was believed that the closed nature of the SIP process was responsible for not succeeding in complying with national standards, and it was proposed that the process be revised.

In Colorado community involvement was made a priority in the development of state's SIP [CO95]. In Denver, for example, elements of the strategies being evaluate were presented to local governments, school districts and community groups throughout the region through the Regional Air Quality Council's Local Government Initiative.

Public participation in the SIP development process was facilitated in Santa Barbara through the establishment of a Community Advisory Committee (CAC). The CAC provides advice to the Air Pollution Control Officer (APCO) and the Board of the Air Pollution Control District (APCD) on matters relating to attainment planning, development and promulgation of air pollution control measures. The feasibility of control measures are evaluated by the CAC taking into account public health, the local economy, cost to industry and the public. CAC members may reflect community interests, in addition to professional, business or technical experience [SA94].

### PUBLIC HEARING PROCESS

Once an SIP has been drafted a public hearing process should be held. Following the public hearing the SIP can be revised and finalised.

The public hearing process should not signal an end to public involvement in the SIP process. Public participation should be extended to include an opportunity to monitor the implementation of the SIP and the progress made in reaching air quality standards.

### AUTHORITY AND RESOURCES

It must be ensured that agencies involved in implementation of the SIP have sufficient personnel, funding and authority to implement the plan efficiently and to undertake SIP commitments, including:

- ambient monitoring (air quality and meteorological)
- personal monitoring and exposure assessment
- receptor and dispersion modelling
- continual review of control strategies

Where the necessary abilities does not exist at the local or metropolitan level, capacity building should be undertaken.

Sufficient authority and an effective functional structure is essential for agencies responsible for air quality, particularly since air pollution does not adhere to political boundaries. Should there be a substantial increase in background levels, due to an increase in the amount of pollution being transported into the Vaal Triangle region from external sources, the maintenance of the region's air quality will depend on the ability of the Metropolitan Authority to negotiate with various provincial, metropolitan and local authorities.

## CONCLUSION

The ideas expressed in this paper cover a broad range of issues related to the management, technology and social governance related to the atmospheric environment. These ideas, distilled out of several years of study of the topic and several submissions to various environmental commissions, are offered as a starting point and contribution to the debate. From the ensuing debate, we hope that a viable, sustainable and just air quality management system will eventually evolve.

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