Emissions Trading: A Feasibility Analysis for UBC

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I. Introduction

The GVRD's Draft Emission Regulation for Gas-Fired Boilers and Heaters will impose, when it comes into effect, a new emission limit on gas-fired boilers and heaters. The draft regulation is a typical example of so-called 'command and control' environmental management.

Command and control policies are often economically inefficient because they are not sensitive to cost. In the case of the GVRD draft boiler regulation, 55 parts per million by volume of nitrogen oxides (NO_x) at tailpipe *must* be achieved regardless of whether this costs five dollars or five million dollars.

An alternative (or complementary) class of policies currently gaining popularity is that of market-based instruments. Market-based instruments create economic signals or incentives that affect resource users, and generally allow greater flexibility in the way environmental objectives are achieved. Emissions reduction credit trading (or emissions trading) is an example of a market-based instrument that is increasingly being applied to the regulation of atmospheric pollutants.

In the context of UBC's steam plant NO_x emissions, a more flexible style of regulation, allowing internal emission offsets and / or external trading, would support solutions that are more cost-effective for UBC, and could potentially achieve greater environmental protection.

The UBC steam plant emits a high volume of NO_x, but little of any other pollutant. Achieving an equivalent reduction in NO_x from other sources such as commuter vehicles, which are major sources of greenhouse gases, volatile organic compounds (VOCs), sulphur oxides (SO_x), carbon monoxide (CO), and particulate matter (PM), would therefore be superior, in terms of overall emissions reduction, to strict regulation of the steam plant.

Section II of this paper provides information on the effects of NO_x pollution in general and its characteristics in the Lower Fraser Valley (LFV). Section III describes the market-based instruments of emissions trading and facility bubbles, provides examples of how these instruments have been implemented elsewhere, and outlines the local policy context in the LFV. Section IV examines the feasibility of using a reduction in commuter traffic to UBC to offset the required reduction in NO_x emissions by UBC's steam plant boiler. The reduction in carbon dioxide (CO_2) emissions achievable through transportation demand management is also calculated. Finally, Section V considers how a program of automobile emissions credits and trading among individual commuters to UBC might be implemented as a transportation demand management tool.

II. Nitrogen Oxides (NO_x)

NO$_x$, Ozone, and their Effects

Among atmospheric pollutants, urban ozone has been identified as one of the most persistent health concerns (NRC 2000, 19). Tropospheric ozone (O_3) forms through a complex series of chemical reactions involving NO$_x$, VOCs and sunlight (Ahrens, 455). It has been determined that exposure to ambient levels of more than 82 parts per billion of O_3 is detrimental to human health (GVRD 1993, I-8). Effects range from short-term consequences such as chest pain, decreased lung function, and increased susceptibility to respiratory infection, to possible long-term consequences, such as premature lung aging and chronic respiratory illnesses (NRC, 19).

It should be noted that much of the epidemiological evidence supporting these conclusions describes the health effects of an array of pollutants emitted by an identifiable source. There remains scientific uncertainty over the role of specific pollutants (for example, O_3 versus particulate matter) within emissions from such a source (Vedal 2001). Further, the relationship of NO$_x$ and total suspended particulates in the process of O_3 formation is unclear (Steyn 2001). Reducing mobile sources, which contribute a variety of pollutants, including all of those involved in the formation of O_3, may therefore be more protective of health than specifically regulating the NO$_x$ emitted by the UBC steam plant.

Although the environmental effects of air pollutants receive less attention than their impact on human health, these are also significant. Short-term exposure to elevated concentrations of O_3 can damage crops, natural vegetation, and buildings (NRC, 20).

A challenge particular of NO$_x$ regulation is the importance of timing and seasonality. The environmental and health impacts of ozone occur during short episodes of high concentration, measured in hours or days, after which ozone breaks down into oxygen. Trading NO$_x$ credits across time may not achieve the objective of reducing time-specific effects. If O_3 is the pollutant of primary concern, then strong seasonal controls are necessary (Sholtz *et al.*, 5-18).

NO$_x$ in the Lower Fraser Valley

In 1998, NO$_x$ emissions in the Greater Vancouver Regional District (GVRD) were estimated at 48,264 tonnes. Of these, 76.8% were from mobile sources, 13.9 % from point sources, and the remainder from area sources. The largest contribution to mobile source emissions came from light duty vehicles, which produced 35.9% of total NO$_x$ (GVRD 1999, S-3).

When baseline emissions are large, the incremental costs of reduction are smaller than when baseline emissions are small (Kosobud 2000, 286). The current breakdown of regional NO$_x$ sources therefore favours focusing reduction efforts on mobile sources, where each dollar spent has the potential to yield greater returns. By focusing its efforts on managing commuter traffic, UBC might be able to achieve overall NO$_x$ reductions equivalent to those required by the GVRD's *Draft Regulation for Boilers and Heaters* at a lower cost than that of retrofitting its steam plant, estimated to be in the neighbourhood of $1,275,000.

III. Emissions Trading

Use of the environment as a sink for pollutants has traditionally been open to free and universal access. Emissions trading programs establish a market for the right to release pollutants into the environment through the allocation of tradable permits to pollute. These permits may be traded externally (among firms within an airshed) or internally (among operations or plants within a single firm). Internal trades may also be referred to as emission offsets, and occur within what is sometimes called a 'facility bubble'.

Economists have long pointed out that creating a market for emissions can lower the cost of meeting emission reduction targets (Harrison 1999, 63). An emissions-trading program allows for flexibility in the achievement of mandated emissions reductions, enabling the application of least-cost solutions. Firms that are able to reduce emissions at low cost can profit by selling reductions in excess of the regulation limit to other firms, for which achieving the required reductions is more expensive. Including many sectors in an emissions trading program tends to magnify the potential gains from trade, because different sectors are likely to have widely different control costs (*ibid*, 75).

Emissions Trading in Practice: The RECLAIM Program

Planning for California's Southern Coast Air Quality Management District's (SCAQMD) Regional Clean Air Incentives Market (RECLAIM) program began in 1990. By 1994 after a full feasibility study and open and extensive consulting, the program was launched. The RECLAIM program, which includes mobile sources, satisfies the OECD's checklist for an effective marketable permit program (OECD 1997, 23).

The RECLAIM program eliminates traditional emission point regulations and opts instead for an emissions cap and reduction budget for *entire* facilities. Participants are then allowed to reduce emissions in their own fashion. If successful beyond minimum requirements, participants can sell excess reduction credits to businesses that find it uneconomical to meet their emissions reduction targets (Kosobud, 220). The strengths of the RECLAIM trading program are that it has reduced and simplified rule-making, given more autonomy and flexibility in long-term compliance planning, and created incentives for over-compliance (OECD, 22).

The RECLAIM program allocates credits in weight per year for a 12-month period. Banking credits is not allowed, ensuring that emissions in any given year are in compliance with set limits. Facilities under different ownership are divided into two different annual cycles six months apart so that all credits associated with a single year do not "die" simultaneously at the end of a year (Kosobud, 222).

At the beginning of the RECLAIM program, businesses were allocated starting emissions allowances based on their highest year of production in the most recent four years to prevent recession impacted facilities from being locked into their lower production emissions (*ibid*, 223). Future allocations were calculated assuming that the control measures set out in the 1991 Air Quality Management Plan (AQMP) were applied to the source operating at its peak production year. Because this resulted in overall emissions greater than the AQMP attainment allocation, these allocations were then proportionally reduced to achieve allocations set out in the AQMP (*ibid*, 224).

The final RECLAIM system provided for an annual program, with facilities required to report their emissions to the SCAQMD each quarter. Facilities were given a one-month reconciliation period after the first three quarters and a two-month reconciliation period at the end of the year in which to complete records and trades (Harrison, 73). Trading partners are required to inform the SCAQMD about a trade and how near-term credits were generated, and the accuracy of each trade is checked before the it is recorded (Kosobud, 227).

Rather than setting up many different trading zones or trading ratios to deal with inequalities in geographical and temporal distributions, RECLAIM simply differentiates between coastal (upwind) and inland (downwind) sources, and trading is in terms of annual emissions. It is felt that these simplifying features lead to a workable program that avoids collapsing from the weight of program details (Harrison, 77). The context of the Fraser Valley, however, may be more conducive to a system with seasonal and geographical weighting ratios, as was suggested in the Fraser River Action Plan (Scholtz *et al*., 1995). In the context of emissions which have the potential to do the most damage during only a part of the year a seasonal cap system with an off-season constraint would be most effective (*ibid,* 5-7).

RECLAIM allows facilities to meet their cap targets with the use of mobile source emission reduction credits (Harrison, 70). Employers may gain emission reduction credits for mobile sources by reducing employee commuter trips during peak traffic hours, reducing commute vehicle miles traveled, using "alternative fuel vehicles" for commute or other work-related trips, and through parking management programs (SCAQMD, regulation XXII). Individual operators may earn emission credits through the voluntary repair of on-road motor vehicles, old-vehicle scrapping, and for the use of clean on-road vehicles, off-road mobile equipment, and lawn and garden equipment (SCAQMD, regulation XVI)

<u>Facility Bubbles</u>

Under a 'facility bubble' policy multiple emission points are treated as if they were contained within an imaginary bubble, and only the amount leaving the bubble is regulated (Tietenberg, 375). A legal limit (or *cap*) is established specifying the total allowable emissions for a facility, while the facility designs the emissions reduction strategy required for compliance with this limit. Changes in emission levels within a bubble are treated in the aggregate rather than on an individual source basis. Relaxing controls at emission points that are expensive to control and increasing control for those that are inexpensive allows for greater efficiency and reductions. There must be no net decline in air quality or the facility must decrease emissions within its 'bubble' by the prescribed amount, as determined by the terms of the relevant regulatory body. The bubble strategy allows reductions to be met in the most cost-effective manner, given a facility's individual circumstances and characteristics (Sholtz *et al*., 3-15). The facility bubble approach has been credited as an important factor in the success of the RECLAIM program (*ibid*, 3-25).

<u>The Local Policy Context</u>

Under Section 24 of the BC Waste Management Act, the Greater Vancouver Regional District (GVRD) is responsible for managing air quality within its boundaries. In 1992 the GVRD Board of Directors passed the GVRD Air Quality Management Bylaw No. 725 to promote regional initiatives to improve air quality (GVRD 1994b, 2:1). The Air Quality Management Plan (AQMP) set out in this bylaw establishes ground level ozone (O_3) as a "Level 1 Priority", indicating that ozone levels were not meeting air quality objectives and that current or projected impacts were significant enough to justify reduction measures as soon as possible (*ibid.,* 6-4). Because the goals of the AQMP include a reduction of ozone, the program must control the emissions that form ozone: NO_x and VOCs (Sholtz *et al*., B-4).

Site-specific permits issued under the GVRD Air Quality Management Bylaw are the main regulatory mechanism currently used to restrict stationary source emissions (GVRD 2000b). Currently, these permits cannot be met through the purchase of external emission reduction credits or the use of alternative internal reductions (offsetting). However, the GVRD is committed to building flexibility into its air quality regulations (1994b, 8:2, I-7). In 1995, a report was prepared for the GVRD, B.C. Ministry of Environment Lands and Parks and Environment Canada on economic instruments for air quality management in the Lower Fraser Valley (Sholtz *et al*., 1995). A guiding principle of the GVRD Emission Regulation program is that "regulatory programs are developed on the basis of simplicity and *cost-effectiveness*" (GVRD 2000b, 1, emphasis added). The GVRD is committed to seeking cooperative partnerships during both the development and implementation of regulatory programs (*ibid*).

IV. Trading Cars for Steam: A Quantitative Feasibility Analysis

In the absence of a GVRD emissions trading program, and in the spirit of a pilot initiative, it is proposed that the GVRD consider applying a facility bubble policy to UBC for the purpose of regulating NO_x.

Such a policy could be based on previously established programs such as RECLAIM, with the necessary changes given local conditions and characteristics. Through this initiative, UBC would provide a model, expertise and experience to other institutions and facilities implementing pollution reduction measures while reducing its own compliance costs. This experience could pave the way toward a general GVRD program for internal and perhaps external emissions trading.

The two major sources of NO_x under the jurisdiction of UBC are its steam plant facility and commuter traffic flows (GVRD 1994c). The following analysis examines the feasibility of using a reduction in commuter traffic to and from campus to offset the reduction in NO_x emissions required under the GVRD Draft Regulation on Gas-fired Boilers and Heaters.

A) Steam Plant Facility

The single point source (defined as a source of pollution for which a permit is required) of NO_x at UBC is the steam plant facility. This facility generates the steam that heats most buildings on campus.

In response to the GVRD's Draft Emission Regulation for Gas-fired Boilers and Heaters, UBC commissioned a study of the amount of NO_x currently emitted by its three operational steam plant boilers. This report provides three separate estimates of emissions levels based on actual test data, and two variants of USEPA emissions factors (Tam and Duo 2000). For each case, NO_x emissions were calculated based on natural gas consumption during the years 1997, 1998, and 1999. The results show average emissions over three years (in kg/yr) at 85,978, 110,581, and 123,951. The average emissions under the GVRD draft regulation must be 27,877 kg/yr. The reduction necessary to comply with the regulation therefore lies between 58,101 and 96,074 kg/yr.

To achieve this reduction, UBC must retrofit its three main boilers. The cost of this is estimated at $1,275,000, or between $1,327 and $2,145 per tonne of NO_x. While UBC generally supports the GVRD's efforts to reduce air pollution, there is some concern over the cost-effectiveness of achieving the desired emission reduction through the particular mechanism of upgrading the steam plant.

Minor improvements to the steam plant boilers, potentially capable of achieving a 20-30% reduction in NO_x emissions, could be carried out at a much lower cost than the retrofit described above (Mazzi 2001). This reduction is considerably less than the 68-78% reduction in NOx emissions required under the draft regulation. While a detailed cost estimate has not been carried out, such improvements are thought to cost an order of magnitude less than the full retrofit.

The GVRD draft regulation specifies an implementation period for retrofitting or replacement of existing boilers, according to the number of operational boilers owned by the affected party. UBC plans to retrofit either three or four of its five boilers, depending upon cost and operational issues. The implementation period allowed for both four and three boilers is four years after the draft regulation becomes law.

B) Transportation Demand Management

Whether a reduction of commuter traffic to campus could potentially be used to offset the required reduction in NO_x emissions from the steam plant facility depends upon both the volume of NO_x emitted by the commuter fleet, and the level of potential reductions from transportation demand management.

In 1999, UBC committed to a Strategic Transportation Plan (STP), which established the goal of reducing single occupancy vehicle traffic to campus by 20% over five years (UBC 1999a). Implementation of some key programs recommended in the STP, including a universal transit pass, or 'U-TREK' program, have been delayed due to funding difficulties. However, UBC remains committed to the targets set out in the STP, and is taking steps to achieve these.

A major barrier to incorporating mobile source emissions in offset and trading programs are the difficulties inherent in quantification and verification of emission reductions by the numerous and diverse mobile sources involved. Past research and practice has for this reason focused on regulating the more manageable large stationary sources of NO_x (NTREE 1993, NO_x / VOC Working Group, 2). However, due to the significant contribution of mobile sources to air pollution, the importance of including these in emissions trading programs is increasingly recognized (Sholtz *et al.*, B-3).

Because UBC already has monitoring of traffic flows and transportation behaviour in place, the University is in a unique position in the GVRD to claim emission credits for mobile source reductions. The following analysis focuses on quantifying NO_x emissions. It is clear, however, that UBC's potential ability to pioneer mobile source emissions trading applies to other pollutants as well, including greenhouse gases, for which active national and international emissions trading markets exist.

Temporal Considerations

As noted above, temporal considerations, both seasonal and diurnal, are extremely relevant to the effective regulation of NO_x. It is fortunate for the purpose of the emission offset discussed here that the annual variation in NO_x emissions from the UBC steam plant and commuter fleet are roughly synchronized. Both the bulk of steam plant and commuter traffic emissions are produced during the academic year. There is some difference in annual patterns; while traffic is assumed to be fairly constant throughout the academic year, steam plant activity peaks markedly in December and November (Marques 2001).

Diurnally, emissions from the steam plant and traffic flows are also roughly synchronized. Commuter traffic is characterized by a pronounced diurnal variation, peaking between the hours of 7:30 to 9:30 am and 3:30 to 5:30 pm (UBC 1999b, Appendix C). Steam plant production is also characterized by a peak around 8:00 am. (Johnstone 2001). These morning peak periods for both the steam plant and commuter traffic flows coincide unfortunately with a diurnal sea breeze that blows air from the Point Grey Peninsula across downtown Vancouver and up the Fraser Valley.

Estimating Commuter Emissions

In 1995, the GVRD estimated the spatial distribution of on road vehicle emissions in the Lower Fraser Valley, and found that traffic on the roads of the UBC Endowment Lands (UEL) was emitting 137 tonnes of NO_x, or 0.7% of total on-road emissions. This estimate did not include the portion of commuter trips traveled outside the boundary of the UEL. If the full length of commuter trips were included, UBC commuters' share of regional air pollution would be much greater.

The following paragraphs detail our methodology in quantifying the amount of pollution generated by full-length commute trips to UBC. Data from the Year 2000 UBC Transportation Survey and normalized for screen-line traffic counts was obtained from Dr. Ken Denike, Professor of Geography at UBC.

The Year 2000 UBC Transportation Survey was made available to students, staff and faculty via a website address in March 2000, with an email request for participation sent to all with a UBC-based email account. The website was also publicized for those without a UBC email account. A total of 5,686 responses were recorded. Of these, 2040 had only partial information, reasons for which include giving up, losing connection, or refusing to answer critical questions. These critical questions were used to weight the sample to match key attributes of the university population: faculty/staff/student ratios, faculty, part/full-time status, gender, off/on-campus ratio, and mode split (matched to an external data source, the GVRD cross-screen counts). (Denike 2001a)

Distances

Student survey respondents were classified in 21 zones of residence according to postal code information. The geographical centre of each of these zones was estimated manually, and the shortest distance from this point to UBC using major roads was measured using GIS software. This provided an average distance from each zone to UBC. The residential zone breakdown of faculty and staff respondents was not available at the time of writing. All faculty and staff are assumed to travel of 17.3 km, which is the average commute distance for students.

Vehicle Kilometers Traveled

To estimate the total vehicle kilometers traveled by the UBC commuter fleet, the average distance from each zone was multiplied by the weekly number of single- and high-occupancy vehicle trips to campus made by that zone's residents, as reported in the 2000 UBC Transportation Survey. This number was then divided by the average number of persons / vehicle, 1.3. The same procedure was followed to calculate weekly transit kilometers traveled to campus from each zone, assuming an average bus occupancy of 20 (calculated from 1999 weekday transit loads, Urban Systems 2000, 9).

Emission Factors

Estimating the pollution generated by mobile sources is complicated by a wide variety of factors including vehicle condition, type, age, performance of the emissions-control systems and fuel composition; as well as local meteorological conditions, traffic patterns, and travel activity (NRC, 2).

In 1998, the GVRD conducted an emission inventory of the Lower Fraser Valley (LFV) airshed. The inventory included an assessment of mobile source emissions using the MOBILE 5C model. Standard emission factors for the LFV fleet were derived according to the composition of the fleet by vehicle age and type, local meteorological conditions, traffic patterns, fuel properties, and other factors.

The following analysis uses emission factors derived by the GVRD in the 1998 assessment, obtained from the GVRD Air Quality Department. The NOx emission factors for light duty gas vehicles, light-duty gas trucks, and Translink diesel buses are 1.1208, 1.0756 and 7.8 grams per kilometer respectively (GVRD Air Quality Department 2001). The mix of commuter vehicles is assumed to be two-thirds light duty gas vehicles and one-third light duty gas trucks, as recommended by GVRD Air Quality Department staff (Der, 2001). We use an average commuter vehicle emission factor assuming these proportions, of 1.1057 grams per kilometer.

The GVRD is currently undertaking a new emission inventory, which will be completed later in 2001. The 2001 inventory will use the new MOBILE 6C model, and 2001 data on the LFV fleet composition. The estimates generated in this report may be updated using the GVRD's 2001 estimates when these become available.

Buses

The Translink bus fleet servicing UBC comprises both diesel-fueled and electric trolley buses. Electric buses are assumed to be emission-free. To determine the proportion of electric buses servicing UBC, we compare total bus miles traveled along routes terminating or originating at the UBC bus loop to bus miles traveled along the number 4 and 10 (electric trolley) routes. By this definition, 28.7% of bus-kilometers traveled to UBC are by electric trolley bus; the remaining 71.3% by diesel bus.

Transit Service Plan Discussion Paper #8 (Urban Systems 2000) outlines options for improving transit service to UBC. The routes listed as candidates for expansion are the 99 B-line, 41, 44, 480 to Richmond, 25, 49, all of which are diesel routes. A new route along 16th Avenue is also proposed. Neither the 10 nor the 4, the only trolley lines to UBC, are mentioned in the expansion plan. We therefore assume that the number of trolley buses will remain constant, while the number of diesel buses will increase, yielding a future share of diesel buses of 79.9%.

Seasonal Variation

The trip frequency data used are from a week in March, during the regular academic session. According to these data, a total of 319,903 student trips, or 4.5 trips per student, are made to campus per week. To calculate annual emissions, trip frequency must be adjusted to reflect lower levels of commuter traffic at other times of the year. Student trips during four non-peak periods are estimated: exam period, summer session, no classes (one week in winter and three in summer), and spring reading week. Faculty and staff behaviour is assumed to be constant throughout the year, except during the week of winter vacation, when zero trips are assumed.

To estimate the number of students commuting to campus during exams, we use the exam counts posted online by UBC Classroom Services (UBC Classroom Services 2000). The number of examinations written by individual students, plus an additional three trips to campus per week by each student (which is unsubstantiated but seems reasonable), gives a total of 320,283, or 42 % of the volume of a typical a March week.

During the summer months, transit ridership to UBC decreases to approximately 60% of ridership during the academic year (Urban Systems 2000, 7). Some of these trips may be by visitors to campus: tourists conference attendees, and others. We therefore look to the number of students enrolled in summer session, and compare this with enrollment during the regular academic year.

Full time equivalent (FTE) undergraduate enrollment in summer session is 2,526. This is 10.6 % of the regular academic year FTE enrollment. However, FTEs cannot be directly translated into trips to campus; in summer, attending one class three times per week will bring a student to campus as often as a full-time student with a convenient class schedule during the regular academic year. If we look instead at the number of students enrolled in summer session, the picture is quite different, with just over 50% of winter numbers.

The proportion of winter trips to summer trips should lie somewhere between these two bounds. Given the relatively high rate of transit ridership noted above, we conclude that the student trips during summer are closer to 50% than 10%. In our calculations, we assume 40% of the level of winter student commuting.

We acknowledge that slightly higher rates of cycling, walking, and transit use may be expected during Vancouver's fair weather summers. Because its magnitude is unknown, we do not attempt to adjust for this effect in our calculations.

Projecting Future Commuter Emissions

<u>Transit Use Projections</u>

Our estimate of the change in mode split under a U-Trek system relies heavily upon survey respondents' estimation of the number of additional transit trips they would take if a U-Trek program were implemented. The two major features of the U-Trek program, as it has been proposed by UBC, are that 1) each student would be charged a flat fee for, and enjoy the benefits of, unlimited transit use, and 2) major improvements in transit service to UBC would be implemented.

Although faculty and staff would be given the option of buying into the U-Trek program, the pass would only be mandatory for students. Further, the willingness of students to change modes is expected to differ significantly from that of faculty and staff. We therefore model these two populations separately.

A major goal of UBC Transportation Survey was to estimate the financial impact on Translink of the Trek Program. Respondents were therefore asked to estimate additional trips taken using transit for *all* purposes, rather than simply trips to UBC. The answers to this question do not correspond directly the question that this paper seeks to answer, which is the number of additional transit trips *to UBC*.

It is therefore not possible to derive future car commuter trips by subtracting the additional transit trips from current commuter car trips. To reconcile the projections of *total* extra transit trips under a U-Trek Pass reported in the 2000 Transportation Survey with the projected increase in transit *commuter* trips of 36% reported in the 1997 Benchmark Technical Report (UBC 1999b, 14), we assume that 45% of the total extra transit trips are commute trips to UBC.

The other 55% of additional transit trips are not "new" trips; these same trips were likely taken by some other mode in the past. If we assume that these trips were formerly taken by the average mix of single occupancy vehicle (SOV) and high occupancy vehicle (HOV) seen in the GVRD, UBC can claim credit for an additional reduction in emissions, even though these trips might not be to UBC.

We know how far commuters travel to UBC, but we have no data on the length of other trips they take. How long, then, are these extra transit trips if they are not to UBC? To estimate the average distance of non-commute additional transit trips, we look at the breakdown of current transit trips taken within one, and across two and three zones (Translink 2001, 41). Then, estimating the distance of typical trips in each of these categories, we calculate an average trip length of 16 km.

Faculty and Staff

Not all faculty and staff respondents were asked the number of additional transit trips they would take if they owned a U-Trek pass. This question was contained in an ancillary section, which was answered by just under 50% of the 3,500 faculty and staff answering the main part of the survey (Denike 2001b). In the Transportation Survey Summary, the number of additional trips demanded by the entire faculty and staff population of 8,135 were extrapolated from these responses (Denike 2001a, 3.1). In Projection 1, we use these estimates.

We note the likely selection bias inherent in Projection 1, since those faculty and staff who took the time to answer the ancillary section of the survey are probably more likely to be interested in purchasing a U-Trek pass. Projection 2 is intended to illustrate the degree to which this selection bias may affect the Projection 1 results. If all faculty and staff respondents who denied to answer the ancillary questions demanded zero trips, the true number of extra trips demanded could be as low as half of what is indicated by the sample. In Projection 2, the expected number of extra transit trips under a U-Trek pass is divided by two. The two projections are extreme bounds; the most likely scenario lies somewhere between them. In our conclusions, we use the midpoint between the two projections.

Transit Service Increase

The increase in bus service must also be reflected in the calculation of expected emissions. According to the Transit Service Plan commissioned by UBC, an additional 90,000 transit service hours will be required when the U-Trek pass is fully implemented (Urban Systems 2000, 16). This is equal to a 44% increase beyond the current 250,000 hours of service to UBC. To account for this increase in the expected scenario, we multiply current emissions from bus trips to UBC by 1.44, taking account also of the adjusted proportion of diesel buses in the fleet (see above).

High Occupancy Vehicles

The increase in high occupancy vehicle (HOV) ridership, projected at 15% (Urban Systems 1999, 8) is reflected in the average number of people per car in the future scenario. Because of the increase in HOV use, the average load per car is 1.485 in the future, up from 1.3 at present.

Increased carpooling will be motivated primarily by incentives such as preferential parking spaces and parking discounts, and through the development and promotion of a ride-matching service (UBC 2001). These services will most likely be available to faculty and staff commuters, regardless of ownership of a U-Trek pass. The rate of mode change to HOV is therefore assumed to be equal across students and faculty / staff.

Conclusions of the quantitative analysis

Our estimates (see Appendix A) show that the NO_x reduction anticipated through traffic management under UBC's Strategic Transportation Plan is equal to approximately 37 tonnes.

This is not sufficient, by itself, to offset the emission reduction required under the GVRD Draft Regulation on Gas-fired Boilers and Heaters. Even if the lowest estimate of current steam plant emissions is used, the traffic management reduction falls short of the required reduction in steam plant emissions by 21 tonnes. If the highest current emission estimate is used, the shortfall is 62 tonnes.

If a reduction in commuter traffic is combined with the minor improvements to the boilers described by Mazzi (see above), and the lowest estimate of current steam plant emissions is used, the total reduction achieved still falls short of the required reduction, but only by four tonnes.

This result is of course contingent upon the actual results of transportation demand management. Clearly, if transportation demand management were to be used for credit in an internal offset or an external emissions trading program, more appropriate data would be required. This data would be relatively inexpensive to collect, since additional surveys and traffic counts are already planned for the purpose of monitoring UBC's progress toward Strategic Transportation Plan targets (UBC 1999a, 38).

A certain conclusion to this analysis is also precluded by the uncertainty over the current level of the emissions by the steam plant, which may fall anywhere within the wide range of Tam and Duo's high and low estimates of 86 and 124 tonnes per year.

If we insert the emission factors for CO_2 (GVRD 2001) into the calculations explained above, we find an expected reduction of approximately 11,000 tonnes of CO_2 per year (see Appendix B). Since CO2 pollution has global effects, firms in distant corners of the country, or even the world, may buy and sell CO2 reduction credits; there need be no local market. In fact, there is a Canadian market for CO2, administered by the Greenhouse Gas Emission Reduction Trading Pilot (GERT 1998). At the current price of 50 cents to $2 per tonne of CO_2 (PERT 2000), UBC's anticipated reduction could potentially sell for between $5,500 and $22,000 dollars each year on this market.

Because the effects of NO_x pollution are local, NO_x emission reduction credits can only be traded locally. No local NOx trading program currently exists. Based on the price of NO_x on other markets, UBC's reduction might be worth around $37,000 annually if a local market were established (PERT 2000).

IV. Individual Commuter Emissions Trading

Although traditionally considered as a single source, the control methods for mobile source emissions are so varied and allow for such creativity that any single control cost is likely to be misrepresentative. The actual methods adopted to reduce emissions are independent from the design of the mobile sector program (Scholtz *et al*., 5-10).

One mechanism for reducing mobile source emissions would be to establish an emissions market among individual mobile source emitters (in this case, commuters to and from UBC). Under such a program, vehicle emissions cap may be set (based on previous or current rates, or on the basis of modeling). Each individual vehicle is credited with a particular emissions limit, the sum of these being equal to the baseline emissions inventory attributable to mobile sources. To reduce emissions the vehicle allocation is decreased by the prescribed amount. Excessive emitters must purchase additional coupons, and the excess coupons of low emitters may be sold to any other motor vehicle owner or facility. Sources in any sector may obtain coupons generated by reductions in the mobile source sector. Coupons are generated when emissions are reduced, the value of these coupons, when sold, represents a subsidy to the individual from the purchaser (Sholtz, 5-11).

<u>Tracking and enforcement</u>

In the RECLAIM program a combination of automated emissions monitoring for large emission points and record keeping requirements for small emission points was used to avoid extensive monitoring requirements that might make the command and control approach economically preferable (Kosobud, 226). For UBC's situation, effective monitoring could come from parking records and residence addresses, these would be used to calculate the number and distance of individual vehicle trips to UBC in a given year. A GIS could be designed to calculate precise distances of residences to UBC by linking a table of the residential addresses of students, faculty and staff to a map of Vancouver streets. This would provide the basis for an accurate allocation of emission credits. Parking records could be used to verify the number of trips per vehicle per year.

V. Conclusions

We conclude that greater flexibility in GVRD emissions regulations would be beneficial in helping UBC and other regional bodies to meet their environmental obligations in a cost-effective manner.

According to our quantitative analysis, a decrease in commuter traffic would most likely not be adequate to offset the reduction of NO_x emissions required of the UBC steam plant. However, under a more flexible regulatory scheme, traffic management could be combined with other measures, including minor upgrades to the steam plant, and (under an external emissions-trading program) the purchase of credits from other local polluters, to achieve the necessary overall NO_x reduction.

A decrease in commuter traffic translates into the reduction of a variety of atmospheric pollutants aside from NO_x. These include greenhouse gases, for which there exists an active Canadian market (GERT 1998). UBC is in a unique position to claim credit for reducing these mobile source emissions, since the reduction in traffic levels to campus is already being monitored. If an emissions trading program among individual commuters were to be implemented, additional monitoring instruments, such as a GIS database of commuter residences and tracking of individuals' parking records would be necessary.

Claiming emission reduction credits for reductions achieved through transportation demand management could provide benefits to both UBC and the general community. The sale of these credits could provide a source of revenue to the university of up to $60,000 annually. Mobile source emission credits have never, to our knowledge, been traded on the Canadian CO_2 market. Working toward the acceptance of such credits by the Greenhouse Gas Emission Reduction Trading Pilot Technical Committee could be a worthwhile pursuit for UBC.

By pioneering the use of commuter transportation management to earn emission credits, UBC and the GVRD would be taking a leadership role in an environmental policy area of increasing local and global importance. Their initiative would provide a model for other institutions to follow, contributing to the development of effective and efficient environmental management policy.

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