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BARRIERS TO THE USE OF ENERGY EFFICIENT RESIDENTIAL VENTILATION DEVICES

Barriers to the Use of Energy Efficient Residential Ventilation Devices

A Survey of Industry Opinion,
and
A Review of Strategies for Change

Prepared for:
Research Division
Canada Mortgage and Housing Corporation

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June, 1992

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act. This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result , the Corporation has interests in all aspects of housing and urban growth and development.

Under Part IX of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make widely available, information which may be useful in the improvement of housing and living conditions. This publication is one of the many items of information published by CMHC with the assistance of federal funds.

This project was funded by CMHC. However, the views expressed are those of the authors, and no responsibility for them should be attributed to the corporation.

SUMMARY

Changes to Canadian building codes and standards are likely to increase the use of residential ventilation systems by homeowners. This has raised concerns about operating and maintenance costs, particularly because much of the existing residential equipment is not designed for longevity, or energy efficiency. The technical potential for improving the longevity and efficiency of ventilation systems has been documented in other research reports by CMHC. The objectives of this report are to document what key stakeholders say are the barriers to the availability and use of more energy-efficient residential ventilation devices, and to indicate what various actors can do to improve the situation.

Industry opinion was sampled by means of an open-ended telephone questionnaire, delivered to 31 individuals, representing a cross-section of the industry. The responses were summarized and analyzed, so as to better understand the key barriers to change. The report concludes with a number of suggested strategies for increasing the energy efficiency of residential ventilation devices. The strategies draw upon the responses from industry representatives who participated in the survey, and attempt to incorporate frequently voiced or strongly felt suggestions.

Although all respondents claimed to be aware that most residential ventilation devices are extremely inefficient, only a few indicated real understanding of the physical limitations to improved energy efficiency. Several respondents argued that efficiency, per se, is irrelevant, and that concern should be directed towards functional design, total energy consumption, or heat recovery issues. Air moving efficiency was frequently confused with heat recovery efficiency. Most respondents referenced CMHC reports as their source of information on energy efficiency of fans.

Opinions about potential for technical improvements varied to an extreme. Apparently no common understanding exists in regards to the kinds of technical changes that are possible, or desirable. Responses tended to focus on one or two types of devices, and indicated a need for separately surveying each sector of the industry, including HRVs, central exhaust fans, bathroom fans, furnace blowers, and so on. The most commonly cited technical design changes were the use of energy-efficient motors with furnace blowers, and the use of permanent split capacitor motors with small, continuously-operating, fans.

Industry plans for change appeared to be poorly defined, with the notable exception of the work by Ontario Hydro and General Electric on replacing furnace blower motors with high efficiency models. Few respondents considered the cost of operating ventilation fans to become a major issue in the near future.

The most common barriers to supply and use of energy efficient fans mentioned by respondents were the lack of a national standard, and the current low electricity prices. Many other interesting and diverse barriers were mentioned. Respondents seemed to support almost all possible strategies for improving energy efficiency, although doubts were frequently expressed about the potential for educating homeowners in this area, or for influencing manufacturers by means of a simple one-time standard, unsupported by more research and planning.

An examination of life-cycle costs of typical residential ventilation systems indicated that energy efficiency could be very cost effective, particularly because current equipment is so inefficient. First costs were shown to a poor basis for making choices. Accurate estimates of life-cycle costs are difficult because of the ambiguity around the actual time periods that fans will be used, and because of the unknown replacement periods - both key variables.

The largest single barrier to achieving energy efficiency in this area appears to be the consumers emphasis on reducing first costs. The other major barrier is that the decision-makers tend to be people who do not bear the consequences.

Strategies for improving the demand for energy-efficient ventilation devices are described in detail, and include: preparing a standard for testing and rating the air moving efficiency; creating a process of establishing limits and targets; incorporating limits into enforceable codes and regulations; and, developing methods for verifying compliance and for facilitating enforcement. Strategies for improving the availability of energy-efficient ventilation devices are also described in the report, and include: sponsoring innovation by manufacturers; targeting research support to Canadian companies; involving electrical utilities; and, transferring information to trade training programs. Four research projects are proposed, including: monitoring of system usage in situ; life time testing; optimizing furnace blower system designs; and, developing a portable fan test rig.

RÉSUMÉ

Les changements apportés aux codes du bâtiment et aux normes feront vraisemblablement augmenter l'utilisation, dans les habitations, d'installations de ventilation par les propriétaires-occupants. Cette situation a soulevé des préoccupations quant à leurs coûts d'utilisation et d'entretien, surtout du fait que la majorité des installations résidentielles existantes n'ont pas été conçues pour être très durables ou éconergiques. D'autres rapports de recherche de la SCHL ont déjà documenté le potentiel technique d'amélioration de leur longévité et de leur efficacité énergétique. Le présent rapport vise plutôt à déterminer quels sont, de l'avis des principaux publics cibles, les facteurs qui nuisent à l'existence et à l'utilisation de dispositifs de ventilation résidentiels éconergiques et à indiquer ce que les intervenants de ce milieu peuvent faire pour améliorer la situation.

L'opinion des membres de l'industrie a été recueillie par sondage téléphonique à questions ouvertes posées à 31 personnes représentatives de l'industrie. Leurs réponses ont été résumées et analysées de manière à cerner les principaux facteurs qui entravent le changement. Quelques stratégies sont recommandées en conclusion afin d'accroître l'efficacité énergétique des dispositifs de ventilation résidentiels. Ces stratégies sont fondées sur les réponses des représentants de l'industrie qui ont participé au sondage et comprennent les suggestions fréquentes ou celles auxquelles les répondants accordaient beaucoup d'importance.

Bien que tous les répondants affirment savoir que la plupart des dispositifs de ventilation résidentiels sont très peu efficaces, quelques-uns seulement manifestent une réelle compréhension de leurs limites quant à l'amélioration éventuelle de leur efficacité énergétique. Plusieurs répondants allèguent que l'efficacité, en tant que telle, est hors de propos et que les efforts devraient être dirigés vers les questions de conception fonctionnelle, de consommation énergétique totale ou de récupération de chaleur. La capacité de ventilation est souvent confondue avec l'efficacité de la récupération de chaleur. La plupart des répondants mentionnent la SCHL comme source d'information en matière d'efficacité énergétique des ventilateurs.

Les opinions concernant les possibilités d'amélioration technique varient d'un extrême à l'autre. Il n'existe apparemment pas de compréhension commune à l'endroit des améliorations techniques possibles ou souhaitables. Les réponses ont tendance à être centrées sur un ou deux genres de dispositif et révèlent qu'il faudrait sans doute sonder séparément chaque secteur de l'industrie (VRC, ventilateurs-extracteurs centraux, ventilateurs de salle de bains, ventilateurs de générateur de chaleur et ainsi de suite). Les changements conceptuels techniques les plus fréquemment mentionnés ont trait à l'utilisation de moteurs éconergiques pour les ventilateurs de générateur d'air chaud ainsi que le recours aux moteurs à condensateur permanent dotés de petits ventilateurs fonctionnant continuellement.

L'industrie ne semble pas avoir de plan de changement bien défini, à l'exception du travail remarquable mené par Ontario Hydro et la compagnie Générale Électrique en ce qui concerne le remplacement des moteurs de

générateurs d'air chaud par des modèles à haut rendement énergétique. Peu de répondants estiment que le coût d'utilisation des appareils de ventilation pourrait, dans un proche avenir, devenir une question d'importance.

Les répondants indiquent que les obstacles les plus fréquents s'opposant à la disponibilité et à l'utilisation de ventilateurs éconergiques sont l'absence d'une norme nationale et le prix peu élevé de l'électricité. Bien d'autres facteurs aussi intéressants que variés sont aussi mentionnés. Les répondants semblent appuyer presque toutes les stratégies possibles visant à améliorer l'efficacité énergétique, quoique des réserves soient souvent exprimées quant à la sensibilisation des propriétaires-occupants à cette question ou l'incitation des fabricants à l'amélioration par une norme unique non fondée sur davantage de recherche et de planification.

Un examen des coûts globaux des dispositifs de ventilation résidentiels typiques révèle que l'efficacité énergétique pourrait être très efficiente surtout du fait de la grande inefficacité des appareils actuels. Les coûts de revient de base sont peu utiles pour arrêter les choix. Il est difficile de réaliser des estimations précises des coûts globaux à cause de l'ambiguïté qui entoure deux variables importantes dans l'équation, c'est-à-dire la période d'utilisation réelle des ventilateurs et le moment où ceux-ci sont remplacés.

Le facteur qui nuit le plus à l'atteinte de l'efficacité énergétique dans ce domaine semble être le désir des consommateurs à réduire les coûts de revient de base. Un autre facteur très important est le fait que les décideurs ont tendance à ne pas avoir à subir les conséquences de leurs décisions.

Les stratégies qui suivent, destinées à accroître la demande de dispositifs de ventilation éconergiques, sont décrites en détail dans le rapport : élaborer une norme d'essai et d'évaluation de la capacité de ventilation; mettre au point un procédé permettant de tracer des limites et des cibles; transformer ces limites en codes et en règlements applicables; concevoir des méthodes permettant de vérifier la conformité et de contrôler le respect de la réglementation. Le rapport décrit également des stratégies qui visent à améliorer la disponibilité des dispositifs de ventilation éconergiques, à savoir : encourager l'innovation chez les fabricants; diriger les ressources appuyant la recherche vers les entreprises canadiennes; solliciter la participation des services publics d'électricité; diffuser de l'information pouvant être utilisée dans le cadre des programmes de formation des gens de métier. Quatre projets de recherche sont proposés : le contrôle de l'utilisation in situ des dispositifs; l'essai de la durée de vie utile; l'optimalisation de la conception des ventilateurs de générateurs d'air chaud; la mise au point d'un appareil d'essai portatif pour ventilateurs.

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1. INTRODUCTION

1.1 Background

The need for changing ventilation technology
In an attempt to ensure adequate indoor air quality, standards writing organizations and building code committees have recently revised the ventilation requirements for residences in Canada. It is now probable that all new houses will require ventilation systems capable of distributing fresh air on a continuous basis throughout the home, and capable of exhausting moisture and odours from kitchens and bathrooms.[1] In this context the ventilation system refers to any combination of ducting and devices intended to assist in the supply and distribution of fresh air within a home, and the removal of stale air, odours, and humidity. In most houses the system will be composed of a ducting system connected to a whole house ventilator, with supply and exhaust fans, or a combination of one or more exhaust fans drawing air from the wet rooms in the house, with a fresh air supply duct connected to a forced air distribution system.

For the average new home buyer, these ventilation system requirements imply additional costs. Initially, capital costs will increase to cover the purchase and installation of a more sophisticated ventilation system; later the carrying costs will increase in order to operate motors, to heat and cool the fresh air[2], and to periodically maintain, repair and replace the components of the system over the lifetime of the home.

All these additional investments have raised an important question:

> *Are existing ventilation technologies and installation practices capable of satisfying the new goal of maintaining indoor air quality?*

In many cases the answer is certainly NO. Research conducted by the CMHC Research Division has indicated many serious problems with existing technologies, especially the lower priced fans and distribution systems. For example:

- a majority of kitchen range hoods in Canada are not used because occupants find they are too noisy;
- forced air ductwork typically looses 30 to 50 % of the air flow through unintended leakage;

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[1]**Report on the Activities of the Joint NBC/OBC Part Task Group on Mechanical Ventilation Requirements**, 13 October 1992, National Research Committee
[2]Amounts of fresh air entering a house may not increase substantially if extra care is given to airtight construction techniques. However the fresh air delivered by ventilation systems is concentrated and will require tempering in order to avoid discomfort.

- installed exhaust fans typically move only 50% of the manufacturers rated flow; and,
- many bathroom fans have an expected life span of 3500 hours - requiring replacement after only 5 months of continuous usage.

For these reasons, it is necessary to consider the types of policies, programs and regulations that will be needed to facilitate changes in residential ventilation technology.

The potential for improving the energy intensity of ventilation equipment
The performance problems described above are compounded - and to some degree related - to the inefficient use of electricity. The average household exhaust fan is only about 1 to 6 % efficient (absolute) in using electricity to move air[3]. In this context, efficiency is defined as:

$$\% \text{ Efficiency} = \frac{W_{absolute}}{W_{actual}} \times 100$$

Where:

$W_{absolute}$ is the absolute power (Watts) required to move a given volume of air against a pressure difference; and,

W_{actual} is the actual power (Watts) consumed by the fan as measured, or as per manufacturers specifications.

Stated another way, the low efficiencies of residential fans mean that between 99% and 94% of the input power is simply wasted and dissipated as heat. The technical potential for increasing electrical efficiency of residential ventilation devices has been documented in a separate research report for CMHC[4]. The extremely low efficiencies that typify most fans now used in housing are in marked contrast to the 60 and 70 % efficiencies obtained by many commercial ventilation devices. The research into alternate technology is indicating that off-the-shelf components exists which could greatly improve electrical efficiencies, allowing residential ventilation devices to equal and exceed the efficiencies normally found in commercial buildings. Many recent advances in technology appear to create additional opportunities for improving efficiency.

Given the discrepancy between what appears to be possible at the technical level, and what is actually occurring in housing, there would appear to be a

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[3]White, Jim, The Energy Efficiency of Residential Ventilation Fans and Fan/Motor Sets, CMHC, 1991

[4]Allen and Associates, "Efficient and Effective Residential Air Handling Devices", prepared for CMHC Research Division, 1993

great opportunity for Canadians to conserve energy and other environmental resources. At the same time the potential exists for reducing the lifecyle costs of ventilation, improving ventilation system performance, creating additional skilled jobs and opening new manufacturing opportunities for Canadian businesses. In order to affect change in these directions, it is first necessary to determine the barriers to the supply of energy-efficient residential ventilation devices.

1.2 Objectives

The objectives of this project are:

i) to identify and document what key stakeholders say are the barriers to the availability and use of more energy-efficient residential ventilation devices; and,

ii) to indicate what various actors could do to rapidly change the situation, so that ventilation can be a significantly more energy and cost efficient service.

2. RESEARCH METHOD

In order to sample the opinion of industry representatives, a questionnaire was developed. A copy of the questionnaire can be found in Appendix A. The questionnaire was designed to be delivered by means of an open-ended telephone interview. Questions were intended to solicit information and opinion from each respondent on the following subject areas:

- awareness of the problem;
- sources of information on residential ventilation device efficiency;
- technical understanding;
- plans to improve the situation (if any);
- future expectations of serious problems occurring related to inefficiency;
- views on what constitutes the biggest barriers to change;
- opinions on the relative effectiveness of 10 different strategies for change;
- opinions on how quickly the best strategies can be implemented; and,
- advice on where else to obtain useful opinion and information on this subject.

The principle interest of this opinion survey was the respondents' viewpoints on barriers to change. However, many additional questions were included in the questionnaire, as a means of collecting information that could prove helpful in preparing strategies for change.

The questionnaire was delivered by phone to 31 individuals representing a broad cross-section of the housing industry. The respondents included:

8 manufacturers;
4 distributors;
7 designers/technical consultants;
7 government or utility personnel;
3 builders; and,
2 Realtors.

Most of these representatives were selected because of their prior involvement in related activities, or because of their stake in the outcome of this research. An exception was the choice of two Realtors, both of whom manage real-estate companies and who are, on the one hand, extremely well informed about the economics of home buying, and on the other hand, totally uninformed about the role of residential ventilation devices in affecting housing performance or operating costs.

A list of the respondents and their affiliation can be found in Appendix II. Interviews were sometimes lengthy, with discussion on related topics and a detailed exchange of information on technical projects and programs.

After completion of the interviews, the responses were collated and summarized. The results are presented as Chapter 3 of this report. Confidential information has been excluded, and so has any reference to specific individuals. Chapter 3 is intended to reflect only the range of views within the industry, and does not claim to be comprehensive. Particular attention has been given to reporting strongly held opinions, and to reproducing comments considered - by the writer - to be especially useful or insightful. Respondents have not been given an opportunity to review or edit the report prior to this printing. Their participation in this research, and their donation of time and thought, is greatly appreciated by the author of this report.

3. RESULTS OF THE INDUSTRY SURVEY

3.1 QUESTION: Are you aware of the problem?

All respondents claimed to be aware that most residential ventilation devices are extremely inefficient in the way in which they use electrical power to move air.

Only three of the 31 respondents indicated any real understanding of the fundamental physical limits on the energy required to move air.

Several respondents were quick to make an argument that efficiency, per se, is a non-issue. More to the point, they argued, is:

1. the design and functioning of the whole system relative to specific ventilation needs; or
2. the absolute amount of energy consumed ("who cares about efficiency for intermittent devices!"); or,
3. the relative efficiency between different approaches to heating and ventilating; for example the difference between using exhaust only ventilation systems and using Heat Recovery Ventilators (HRVs), with proper accounting for all household energy costs.

One respondent claimed to find numbers quoted by J. White, (1 to 6 %), to be hard to believe. Yet he had concluded they must be accurate since no one was strongly disputing his calculations.[5]

Most HRV manufacturers had difficulty discussing the concept of air moving efficiency without reference to recovery of sensible heat. It was virtually impossible to avoid confusion between the inefficiencies in fan and motor design, and the efficiency calculations required for the CSA 444 Standard.

3.2 QUESTION: What Are Your Sources of Information?

Eight of the respondents referred to J. White's reports, and CMHC research, as a key source of information on energy efficiency of residential ventilation devices.

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[5]It is interesting to note that Jim White himself has reported difficulty in believing the poor performance of residential equipment. He kept his calculations private for about 12 months, and only released his report after receiving independent verification.

The most common other sources of information were:

i) HRV monitoring and evaluation reports completed for the R2000 program;
ii) Committee work and research related to Energy Efficiency Acts and regulations.
iii) Design calculations for prototype HRVs and Central Exhaust Ventilators, make-up air devices, and integrated appliances.

A number of respondents mentioned specific research projects related to Watts per Cubic Feet per Minute (W/CFM) of flow:

i) Investigating small residential ventilation devices for use in Canada's far north, or for use in remote communities;
ii) Developing flow vs. pressure curves (ORTECH).

3.3 QUESTION: What Technical Changes are Required?

Opinions about potential for technical improvements varied to an extreme. As a generalization it is fair to say that no common understanding exists in regards to the kinds of technical changes that are possible, or desirable.

The variety of residential ventilation devices, and their potential for integration as part of an overall ventilation system, leads to a tendency to discuss technology for all residential ventilation devices at the same time. The opinion survey of industry representatives indicated that individuals immediately focus on the types of residential ventilation devices with which they are most familiar. The kinds of improvements suggested were, in general, specific to the type of residential ventilation device under discussion. For these reasons it would have been preferable to conduct separate surveys for each market sector. In retrospect, the technical issues are quite separate for each of the following groups of residential ventilation devices:

1. HRVs;
2. Central Exhaust Ventilators and Supply Fans;
3. Intermittent bathroom fans;
4. Range hood and stove top fans;
5. Furnace blowers used intermittently;
6. Furnace blowers used continuously; and,
7. Ceiling fans.

Packaged ventilators

The most frequently cited technical design change (11 respondents) was the potential for using more energy-efficient motors for furnace blowers, along the lines of the new General Electric (GE) energy-efficient series.

The second most commonly mentioned technical improvement was to simply replace shaded pole motors with permanent split capacitor motors in all small fans intended for continuous operation.

Other technical changes were suggested, covering a wide range of options. Several individuals refused to comment due to a lack of expertise, or because they felt the issue was too political and should be addressed through the Heating Refrigeration and Air-conditioning Institute, or because they felt the technical improvements could not be separated from the larger issues of system design and performance objectives. On average, each respondent suggested between two and three improvements, with some respondents suggesting as many as eight.

A sampling of the suggested improvements is listed below:

Furnace Blowers:

1. Backward curved blades;
2. Ball bearings;
3. Aerodynamically designed housing/box;
4. Removing the motor from the air flow;
5. Use of plastic parts;
6. More thorough specifications;
7. Better blade design;
8. Greater use of direct drive assemblies;
9. Loosening belts (saves 20 W continuous);
10. Use electronically commutated motors when available; and,
11. Better mating of speed to load for motors.

HRVs

1. Alternative motors (DC? or back to an energy efficient type of shaded pole);
2. Better matching of motor to load; and,
3. Addition of an extra small motor just for low speed air distribution only.

Household fans

1. Better aerodynamic design;
2. Less restrictive ductwork;
3. Elimination of shaded pole motors in favour of permanent split capacitor;

4. Brushless, DC, variable reluctance motors; and,
5. Improved speed control technologies, (e.g. use resistors to reduce voltage w/o distorting the harmonics).

Several respondents argued that the issue was not so much a need to change existing technologies, but rather the choice of policy and regulations required to ensure the use of appropriate technology for specific applications. In particular, people are using equipment continuously that was not designed for continuous use, or was designed without any thought for energy efficient operation.

Two respondents suggested a solution might be to require that all small residential ventilation devices intended for continuous use incorporate the German made *EBM* style European motor/fan sets, until other fully variable, efficient systems are available.

3.4 QUESTION: What plans exist for improving the situation?

Each individual's plans for improving the energy efficiency of residential ventilation devices was limited by his or her position within the industry:

Manufacturers and Distributors

- One distributor is waiting until customer demand warrants making a change in his product line. However he will, in the meantime, research small, energy efficient ventilation systems, - an area where he believes the market is likely to grow.

- Another manufacturer of Central Exhaust Ventilators has concluded that, at current electrical rates, there is no justification to move beyond the 29% efficiency level they claim to have already achieved, (using the *EBM* style of fans). They feel that the move towards more ducted supply systems will change the market, however, and encourage more manufacturers to consider major innovations such as fractional horsepower DC motors.

- A manufacturer of HRVs announced plans to acquire and test some energy efficient DC motors.

- A large manufacturer of a full range of residential ventilation devices said that their strategy was to work through the Heating Refrigeration and Air-conditioning Institute and to vigorously oppose any energy efficiency ratings for bathroom fans, as inappropriate and unnecessary.

- A manufacturer of HRVs and packaged ventilators plans to oppose utility plans for electrical efficiency standards until a more comprehensive approach is followed, less biased against integrated systems such as HRVs.

- Another manufacturer feels that the entire aerodynamic part of systems is the problem, and that no need exists to target HRVs, since energy efficiency is already taken into consideration by the existing CSA standard.

- A manufacturer of residential fans explained that his company was not planning any changes until after labeling was in place for the types of equipment they manufacture. Based on his understanding of the situation, such labeling - if it includes both energy use and expected dollar costs annually - will actually encourage consumers to continue using the existing technology, because operation costs will seem so insignificant.

- GE is planning a two stage approach to upgrading furnace blowers. Initially their plan is to promote changes to an energy efficient motor for all belt driven blowers, (the energy efficient motor is just a well designed version of current technology, using capacitor start and run, split phase start, all copper wiring and more laminations). Later, depending upon the economics, they will promote the use of higher priced synchronous motors, with electronic controls.

- One HRV manufacturer is planning to become as informed as possible, to investigate the use of European motors and fans, and to discuss the situation with local manufacturers.

Government / Utility / Standards Writing Organizations

- Ontario Hydro has implemented a furnace blower rebate program. They are also conducting tests of blowers and alternate technology. They are planning to work closely with GE. to support the marketing of an electronically commutated motor that can sense blockage - permitting a much more efficient blade design.

- The American Measurement and Control Association (AMCA) has no additional plans beyond distribution of the new energy efficiency standard developed for agricultural fans.

- Provincial government representatives claimed to be waiting for publication of a national standard, so they can then call up this standard through provincial energy efficiency acts, or the building code.

Builders / Designers / Consultants

- A builder of R2000 homes plans to install the GE energy efficient motors as soon as they become available for use in air handling systems.

- A consultant who researches energy efficient technology feels that the key area for future research is improved fan housings.

- Most designers are waiting for customer demand to appear. One claimed to be waiting for options to expand in the area of residential ventilation devices with greatly reduced air flow ranges.

- One consultant is excited about the potential market that will open up for energy efficient systems, and is hoping that a Canadian province will volunteer to work with local manufactures to create a market, while boosting the local industry and economy.

3.5 QUESTION: Is this a real Issue? Will cost and efficiency become significant problems?

Few respondents had opinions about the future extent of problems related to energy efficiency of residential ventilation devices. Most manufacturers feel that HRVs are already energy efficient, that bathroom fans and range hoods don't need to be, and that continuously operating ventilation fans are only a problem in aggregate (i.e. for the utilities electrical base load).

Consultants feel that it is likely to be a creeping issue, slowly gaining momentum over the next 5 years. Problems will be confined to the use of energy inefficient furnace blowers as part of continuous ventilation systems.

One respondent pointed out that in the longer term, almost all of the energy used in houses (with the exception of lights and electronics) will be used by fans and pumps, which is certain to create major forces for achieving efficiency.

Several respondents considered the problem to be insignificant, and the solution - if required - to be a simple technical fix.

3.6 QUESTION What are the perceived barriers to change?

Without any prompting or suggestions, respondents were asked what they perceived to be the biggest barriers to the development and use of more energy efficient residential ventilation devices. The responses were diverse and are not easily summarized. A number of people emphasized the absence of a national standard for efficiency of residential ventilation devices, and the lack of motivation resulting from low electricity prices. Otherwise, it is the diversity of responses which is perhaps most interesting result of the opinion survey. Also of note, and some concern, are the responses that are actually incorrect - reflecting the state of knowledge of the respondees.

Most of the replies have been reproduced in the list below, in abbreviated form, to provide a record of the scope and number of arguments. Multiple responses from a single person have been grouped together.

Perceived Barrier: Standards

- *The lack of a standard for energy efficient fans is the greatest barrier.*
- *Without standards for energy efficiency, the industry is caught in a Catch 22: energy efficient motors are too expensive for major market penetration; the reason they are so expensive is because production is limited to a small market.*
- *No CSA standard yet addresses this issue, which means that consumers can't be properly informed (through labels, for example), which means that market forces cannot be harnessed.*
- *Existing standards for energy efficiency are misleading. An energy efficient furnace is in reality very inefficient at moving air.*
- *A national energy efficiency act is required.*
- *Residential ventilation device efficiency is too complex an issue for consumers to cope with; we need to simply mandate levels of efficiency in a similar fashion to refrigerators.*
- *Purchase costs are burying all other concerns, and will continue to do so until legislation sets limits.*

Perceived Barrier: Difficult Transitions for Manufacturers

- *The biggest barrier is the cost of retooling for manufacturers, and the delay and hassle in obtaining new approvals. A related problem is the current need for implementing revolutionary design changes, instead of incremental changes.*
- *Trades are highly skeptical about new products that have no track record.*
- *Once you are using a permanent split capacitor motor, the next step in achieving greater energy efficiency is a big step, involving expensive and unproved technology.*

- *The opportunity for addressing direct drive furnace blower motors is lost because CSA approves these systems as a package.*

Perceived Barrier: Consumers are Ignorant, or Concerned only with First Costs

- *Consumers don't know or care about this issue.*
- *No market exists for energy efficient products.*
- *The market is heavily biased towards reducing first costs of residential ventilation devices, especially in the case of motor technology.*
- *The investment in efficient residential ventilation devices is only attractive to the electrical utilities.*
- *The market is insensitive to differences in the area of energy efficiency.*
- *The biggest market for residential ventilation devices is the builders, and yet this group is making selections based only on lowest first cost, without any regard for operating performance and operating costs.*
- *The complexity of the issue exceeds the ability of typical consumers, and requires simple labels.*
- *The greatest barrier is the lack of education materials for both purchasers and sellers.*
- *New, simpler, terms are needed to raise this issue in the marketplace.*
- *Demonstrations are needed in order to show how small changes in the design of residential ventilation devices can lead to large and positive impacts; we need to demystify the technology and clarify the cost/benefit trade-offs.*
- *A lack of knowledge and understanding amongst the consuming public means that nobody cares.*
- *Consumers are, in any case, unwilling to treat energy efficiency as an investment.*

Perceived Barrier: Outstanding Technical Problems

- *Energy efficiency requires a trade-off with noise output.*
- *The focus is still on other issues that actually conflict with energy efficiency, such as the use of direct drive furnace blowers as a way to save space.*
- *No agreement exists on appropriate levels of aggregation - when ventilation systems consist of multiple parts, what combination of parts is included in the definition of energy efficiency?*
- *System design requirements are poorly understood.*
- *The factors affecting lifecycle cost are not well appreciated. For example, the premature breakdown of EBM style sub-slab ventilation fans, in certain applications, pointed to the importance of keeping the fan motor out of the air stream.*
- *There is a difficulty of making corrections for space heating gains; if the inefficient motors used in a ventilation (and distribution) system are operating*

primarily in winter time, the energy can be just a slightly more expensive source of space heating and is therefore a non-issue.

- *Information is also required on how to obtain some heat recovery in ventilation systems without at the same time creating excess static pressure.*
- *No good information exists on the options for improving the blade/blower designs.*
- *A conflict exists between the energy efficiency goal and the need for tempering air or recovering heat.*
- *It is hard to make design changes without good comparison data on how changes affect: i) durability; ii) noise; and, iii) affordability.*
- *Larger, integrated "air side" systems will increasingly become the norm in houses, as standards force better system design onto builders; this makes it much more difficult to simply test residential ventilation devices for energy efficiency, as if they were stand-alone appliances.*
- *Noise output directly conflicts with energy efficiency objectives.*
- *No good information exists on the usage of fans in the field, especially furnace run times.*

Perceived Barrier: The Objective of Ventilation Efficiency is Not Well Understood

- *The entire industry is tooled up to produce equipment with the wrong flow range. The technology can't be optimized without knowing the relevant flow requirements for specific ventilation modes.*
- *We need a way to integrate the tempering energy required with the fan energy so we aren't being penny wise and pound foolish.*
- *The entire industry, including the standards writing groups, is preoccupied with issues related to energy and capital costs, and not to health costs. In fact, the health lobby is non-existent.*
- *The industry has yet to agree on a definition of continuous use equipment: does continuous use refer to a residential ventilation device that may be used continuously for a long period (e.g. a week or two), but is expected to operate only one hour per day on average over a year?; or, does continuous use refer to systems that are expected to operate only when occupants are at home?, or to systems used only during certain seasons?*
- *The requirements for ventilation of houses are also not well understood, especially in the context of static pressure variables (e.g. the use of an electronic filter in the air stream completely changes the operating static pressure for the residential ventilation device).*
- *Confusion exists over whether specific types of fans should be considered as continuous or intermittent devices.*
- *The focus is now on motor & blade efficiency; however some ventilation system achieve efficiency through intelligent control systems which require flat fan curves that allow for dampers to increase or decrease flow without any impact on*

sound output. In such cases the system design is far more relevant to energy efficiency than is the choice of a particular residential ventilation device.

- *It is difficult to differentiate between products that will be used continuously, and therefore warrant a limit on energy consumption, and products that will be used rarely or intermittently.*

Perceived Barrier: Lack of Innovation, R&D Investments, Technical Acumen

- *The largest and best financed residential ventilation device manufacturers seem to lack any innovative spirit or drive.*
- *The industry is determined to try to satisfy multiple objectives (like supplying oxygen and removing odours, controlling humidity and condensation, removing building pollutants, and so on) with crude and simplistic ventilation systems.*
- *Inadequate attention is given to fan design and engineering.*
- *A misconception exists among manufacturers that the engineering is sound.*
- *There is a lack of serious competition.*
- *The extremely high potential for making improvements is not understood within most of the industry.*
- *Regulation and standards activities are occurring in the absence of solid technical understanding, because the individuals involved in promoting the new standards and funding the committees are "purposeful idiots".*
- *No good information exists for manufacturers interested in small motor technologies that can significantly improve performance of residential ventilation devices.*
- *HVAC contractors are very slow to learn and to adapt, despite good programs offered by the Heating Refrigeration and Air-conditioning Institute, and have a quality of workmanship that lies well behind the European standards.*
- *The ventilation system designs are crude even in R2000 houses, and can lead to uncomfortable dryness, unless the systems are designed to recover both sensible heat and moisture.*

Perceived Barrier: Low Energy Costs and a Focus on First Costs

- *Energy costs are very low, and ignore social costs.*
- *Excessive cost cutting exists in the design specifications for residential ventilation devices.*
- *The price of electricity is too low to influence market forces.*
- *Market forces cannot be harnessed because of incorrect electricity prices. Prices must first be corrected by means of taxes, and by internalizing all of the costs of energy consumption, through such means as applying "environmental adders", and the removal of subsidies. Only through market forces can we unleash the creativity of millions of decision makers, and achieve significant innovation and improvements.*

- *Manufacturers are under constant pressure to minimize the costs of equipment, not of ventilation services.*
- *No clear incentive yet exists for manufacturers of small motor systems to thoroughly investigation the options for improved energy efficiency.*
- *No certainty exists in the area of future electricity costs.*
- *The industry is concerned only with producing an inexpensive product.*

Perceived Barrier: Lack of Planning and Cooperation

- *There is a lack of an overall strategy for achieving efficiency, including both motors and fans.*
- *The Demand Side Management policies of electrical utilities are not part of any industrial policy; consequently there is* **zero** *coordination between the plans of utilities and the plans of manufacturers.*
- *No coordination seems to exist between the activities of standards writing groups and the development plans of Canadian manufactures.*
- *Nobody is taking charge of this issue; we need more dedicated people and dollars.*
- *No coordination exists between the groups who are looking closely at the issue at present (CSA, AMCA, utility R&D divisions, CMHC, and so on).*

3.7 QUESTION: What strategies are likely to prove most effective at improving efficiency of residential ventilation devices over the next 10 years?

Respondents were requested to judge the effectiveness of 10 general strategies that could be used to improve efficiency of residential ventilation devices. Briefly, the strategies described in Appendix A, include:

- research,
- test procedure standards,
- labels,
- design guides,
- installer training,
- home buyer education,
- minimum efficiency standards,
- revised housing programs, and
- financial incentive schemes.

They were also asked to identify priorities, to indicate the amount of time required, and to suggest other worthwhile strategies. Responses to all these questions tended to overlap. They have been summarized in the lists below, and, once again, grouped by topic area.

Strategic Advice: Overall Approach to the Problem

- *The public is not really concerned now about fan energy, so why are we? All that is needed is an affordable product that keeps everyone happy by providing the kinds of ventilation needed. CSA F326 is confusing the issue considerably by producing what is in essence an HRV code. You can't bring 0.3 ACH into a house without an HRV. However most houses and ventilation systems don't need these high ventilation rates on a regular basis.*
- *Strategies have not yet been well described for the industry. Until a coordinated approach is agreed upon, the best strategy is probably to begin with the greatest potential savings that can be found, and then move on. At present this probably means concentrating solely on encouraging efficient furnace blower motors. Later we can look at the blower itself, and at other residential ventilation devices.*
- *The best strategy is that followed by Ontario Hydro: work with manufacturers and trades to eliminate the conventional, low-efficiency belt-driven motors, and make the standard motor a high efficiency model, with capacitor start & run, split phase start, copper wiring and more laminations.*
- *It is important to clearly differentiate in the marketplace between bathroom fans and ventilation systems.*
- *A strategy that includes developing efficiency standards is problematic, because manufacturers have too little power, and too little involvement, in the deliberations of CSA committees. Manufacturers should be much more involved in helping CSA obtain the base data on Watts/CFM, and costs, relative to the economic analysis. In contrast, the DOE approach seems to produce better defined appliance standards, with appropriate levels of inputs from the largest manufacturers at every step in the process. In the DOE process, the initial levels established for appliances allow everyone to stay in the market. However the process then leads to additional rounds. The second round produces much more restrictive levels, pushing the worst products off the market quite quickly.*
- *A good example of an effective strategy is the approach now being used by B.C. Hydro (Power Smart Home Improvements Program). A specification was prepared with extensive involvement by the manufacturers themselves. The specification that was produced was carefully designed to meet the objectives of B.C. Hydro, and was mandated by their energy retrofit program. This process created an instant market for a product line that is custom designed to satisfy all the parties.*
- *Since the trend is towards more integration of mechanical systems in houses, any strategy must address the variety of tasks or services to which an residential ventilation device contributes.*
- *Standards are needed but the key is to set targets for the industry, stepping forward in performance requirements every two years. The first phase would address only the motor efficiency. In later phases it is possible to address the entire assembly.*

- *Because of the difficulty in knowing how residential ventilation devices will actually be used, a good policy is to promote better technology for all types of devices, rather than quibble about actual use in the field.*
- *Legislators need to present the energy-efficiency concerns as an opportunity for manufacturers. A positive attitude is key if the industry is to play ball.*
- *It is important to develop a strategy that allows a multitude of different approaches to achieving energy efficiency in ventilation systems. Especially important is to include the increasingly popular Morflow type systems (i.e. a small, high-efficiency, direct-vent water heater, combined with an air handler and recirculating forced air system, for efficient, low-temperature space heating and water heating and fresh air tempering).*

Strategic Advice: Research and Technology Transfer

- *Furnace manufacturers may have an incorrect perception of their market (since it is changing), and may also need help with understanding the role their appliance must play.*
- *Special R&D is needed to assist manufacturers incorporate plastic components.*
- *Special assistance is needed for the small, innovative manufacturing firms - because they typically lack the marketing expertise and infrastructure needed to survive, regardless of how valuable their innovations may be to the industry. A catch 22.*
- *Background research on fractional HP motor fan systems is an essential strategy.*
- *Research is important as a way of identifying the natural trends in technology and systems, and predicting how these trends will affect residential ventilation devices. Research is also required on duty cycles of equipment, including convincing in-field data that can be used to estimate actual energy consumption.*
- *Until at least two years of careful research are completed, everyone should move carefully.*
- *Special assistance should be considered for the retrofit businesses, that will need procedures and kits to allow them to effectively reinstall residential ventilation devices in houses to achieve improved performance.*
- *Industry needs help to directly hire consultants who can inform them of their options, and help them develop new designs. CMHC (for example) should consider placing several key consultants on retainer so that their services can be used by keen Canadian manufacturers. Once manufacturers are better informed about the costs and options, it is reasonable to bring them together to discuss minimum standards. Where 75% of the manufacturers are agreed, go with the new standard.*
- *The strategy for energy-efficient residential ventilation device assemblies should be dovetailed with an industrial policy, working closely with specific Canadian manufactures to ensure that local product will be available to satisfy some or most of the new market. Energy-efficiency standards are not restricted by the Free Trade Agreement.*

- *Research is needed to help manufactures change the way in which blowers and blower assemblies are provided to the OEMs (Original Equipment Manufacturers). At present, the OEMs simply source a motor and patch it together with the air handling components. Because the whole assembly will need to meet minimum energy-efficiency standards, a better approach is to purchase it as a package. This would quickly facilitate some of the key design changes that are required, such as allowing for more space for the larger, energy efficient motor bodies, moving motors out of the air stream, converting to direct drive, and so on. By moving really quickly in this area, we can create an important opportunity for Canadian manufactures to become world leaders in this product area, while at the same time improving the performance and affordability of Canadian houses. This type of strategy should replace the current 'attack strategy' adopted by some Canadian utilities.*
- *Research is needed to establish which design features of residential ventilation devices contribute to longevity (for example, it appears very important to keep motors out of the air stream when the residential ventilation device is located in an unheated area, due to the high potential for condensation damage).*
- *Additional opinion surveys should be conducted of manufacturers, to follow-up on the recommendations of this survey, to "spread the word", and to help identify opportunities.*
- *Research should be commissioned that involves prototyping a furnace system and optimizing, in stages, each of the components, from an air moving perspective. Once a reasonable design is achieved, some progressive utility should bite the bullet and order 5000 of them from a Canadian manufacturer.*
- *Research of appropriate technology is the key strategy. There is no point in pushing the marketplace until the products are fully developed. Programs like R2000 should be encouraged to play a bigger role in experimenting with better air moving efficiencies, and in validating and communicating their successes and failures.*
- *An important strategy is to develop more prototypes of the technology that we want to promote. This should be done in a joint venture with local business.*

Strategic Advice: Efficiency Standards and Regulations

- *Labeling of residential ventilation devices is valuable only as a support for code requirements.*
- *Education of home buyers won't work; the subject is just too detailed to be of interest or value to homeowners.*
- *Higher efficiencies than those stipulated in a standard should be promoted through labeling and public education programs.*
- *Many problems can be solved once a true market exists for energy-efficient residential ventilation devices. To ensure some market in the resale area, a label or other rating system is essential to influencing consumer buying decisions. Standards must require, therefore, some labeling of resale equipment.*

- *In the short term what is most required is a W/CFM rating label on every piece of equipment, at specified pressure differentials.*
- *The costs of using conventional fans to provide fresh air is still very low. All that is warranted is a SIMPLE single number labeling system for residential ventilation devices. The approach being recommended by the Heating Refrigeration and Air-conditioning Institute is too detailed and complex. It is especially inappropriate for homeowners purchasing replacement motors and replacement fans. This replacement market is currently a very small market that must be handled carefully and with simplicity, if people are to get involved in energy efficient products.*
- *A good strategy for the standards is to apply two labels for every residential ventilation device, one indicating performance on a continuous basis, and the other for intermittent use. Existing products are capable of satisfying many ventilation needs in housing, without a significant energy penalty.*

Strategic Advice: Design Guidelines and Installer Training

- *System designers really need information on control strategies for ventilation systems. How, for example, can you effectively slow down residential ventilation devices without adversely affecting noise, and motor longevity? (One quick fix, that is almost never used, is to route power through a 225 Ohm resistor.)*
- *An information guide for* **distributors** *of equipment is more important than for the trades.*
- *Training should start with system design and energy efficiency, not motors and fans.*
- *When standards are called up by code it places a greater load on the inspectors, who already have a difficult job and suffer from inadequate resources. Consequently the energy utilities should help to fund the process of developing inspection procedures and skills at the field level.*
- *Training programs are especially needed to help duct bangers understand their impact on pressure drops through a ventilation system; otherwise they will defeat the best deigns and product engineering.*
- *Trade training is needed but is unlikely to be any more successful than previous efforts to reach these trades.*
- *Research and training is required, especially in the used of low-resistance duct design (including take-offs and floor registers), and the use of plastic ducting.*

Strategic Advice: Homeowner Education and Labeling

- *Some amount of education is needed for everyone to appreciate the true costs of the ventilation services in a house. Combining an HRV with a furnace distribution fan and duct system entails costs that may not be well understood at present. It is important in such situations to include the furnace blower operation as part of the residential ventilation system costs. This "total cost"* *perspective may not lead to investments in electronically commutated motor technology, since this technology also has high costs that are often ignored (- a replacement control board for the Carrier furnace costs $500). However alternative solutions may be available, - for example, a separate, continuous low-HP, 12 pole motor.*

- *A labeling strategy can do as much good, or more, as a minimum efficiency standard that is poorly defined, or lacks guts. The method of rating performance is key.*

Strategic Advice: Minimum Efficiency Standards

- *An important strategy is to get more of an environmental perspective into the standards and codes groups, since environmental impact is not always equivalent to energy efficiency, and is increasingly a determining factor for correctly establishing costs and benefits for society.*
- *Don't research residential ventilation devices in isolation from the system changes that need to take place.*
- *Energy efficiency standards are an essential component of the new ventilation standard (i.e. CSA F326). We can't force ventilation on all new homes for reasons of health, if the available systems aren't also comfortable and affordable.*
- *Reasonable levels of efficiency for all ventilation equipment should be defined in a standard. The standard should then be referenced in the upcoming Federal Energy Code, or in the CGA codes, as appropriate. A standard could also be supported by the new Federal Energy Efficiency Act, which can require manufacturers to report the energy use of products, and can, through regulations, reference provincial standards (if these are developed), or a CSA energy efficiency standard.*
- *The key is to produce a standard that provides a rating scheme for ventilation fan mechanical energy and space conditioning energy.*
- *A key strategy is just to get manufacturers thinking about the issue by beginning a standards writing process. Initially the standard may produce only a rough first cut, addressing only the gross inefficiencies, but after that you can trust the process to affect significant changes over time.*
- *Since standards will address different combinations of equipment and system components, it is important that any "micro-standards" developed for residential ventilation devices are overruled by macro standards, where appropriate.*
- *The first and most important step is to simply ban the use of cheap, shaded-pole motors, and double the efficiency for a small expense.*
- *Ratings might be a preferred strategy, but it is tricky to include ratings that work for all combinations of systems. Is there any point in requiring minimum performance for HRVs if imbalance systems are permitted? What if the HRV achieves the same efficiency as the non-HRV, once the heat recovery module is removed? How do you account for the heat recovery occurring in dynamic wall*

systems? The solution to these types of problems is to develop different standard levels of efficiency for different system types.

- *For HRVs, a seasonal efficiency level of >50% would eliminate only two products from the marketplace. Is this worth considering, if some amount of heat recovery is better than none?*
- *An effective energy efficiency standard for residential ventilation devices will require 2 to 3 years to develop, or 4 to 5 years if manufacturers are forced to fight.*
- *Air moving efficiency standards for residential ventilation devices should be less demanding of intermittent devices, and for devices that are intended for connection to a distribution system, or to a heat recovery core.*
- *Despite the complexity of system designs, it is still possible to establish a useful minimum efficiency for any motor used to move air in a house.*
- *From a philosophical perspective, it is important to leave as much choice as possible to the consumer. This means we should avoid legislation.*
- *The only strategy that is economically justifiable at present is to use standards to eliminate use of the shaded pole motors in all the residential ventilation devices.*
- *Standards for remotely mounted fans need to consider the high static pressures required to permit fine tuning by installers. The Home Ventilating Institute is currently debating this issue, since 0.2 inches WG (50 Pa.) is proposed, but some manufacturers prefer 0.25 or 0.3 WG (60 or 75 Pa.). Remotely-mounted multi-point fans pull air from right across the house, and the static pressure has to be sufficient at the most distant inlet to permit air flow balancing. If this argument is sound, then we may need to consider different air moving efficiency test procedures for multi-point, remotely-mounted exhaust systems than we use for single-point exhaust fans.*
- *Different standards are required for residential ventilation devices incorporating heat recovery.*
- *Definitions of energy-efficiency should be developed that give appropriate credit to energy recovered in a heat recovery system. It will be important that the ratings we develop allow everyone to interpret and compare improvements in air moving efficiency with other types of energy efficiency investments. Ultimately the builder and designer will be making trade-offs between packages of measures, like air tightness and heat recovery ventilation, vs. better insulation and demand controlled ventilation. The energy-efficiency rating must be compatible, therefore, with energy modeling programs.*

Strategic Advice: Housing Programs

- *All strategies suggested are worth pursuing, except for the use of market driven programs like R2000. These programs are better used to promote leading edge technologies, helping to validate performance and optimize the costs. As the leading-edge technologies are proven and move down the cost curve, they can* *then get captured by the standards and codes, and become part of general information and training programs.*

- *Another key strategy is to somehow make builders more accountable for how their product performs, similar to most other types of manufacturers.*

Strategic Advice: Financial Incentives and Compensation

- *Rebates are the key to getting trades to use more efficient furnace blowers motors.*
- *The incentives approach used by groups like Ontario Hydro is fundamentally wrong. While they may create short term demand for better products, they are an inappropriate use of utility and society wealth.*
- *The only acceptable solution to achieving energy efficiency is to use the price mechanism. Electricity prices should be increased through taxes based on resource use and waste emissions, so that the price accurately reflects the real costs to society. The market for energy efficient residential ventilation devices will expand accordingly. The energy supply sector itself needs to be opened to true competition (e.g. Demand Side Management, renewables), and made more efficient through regulatory reform and improved information systems.*
- *Manufacturers should receive incentives from the utilities if they are to be forced to abandon technology that has been developed at great expense. HRV manufacturers using electric preheat defrost systems, for example need both time and funding to make the changes that Ontario Hydro is requesting. Utilities should not expect to achieve their objectives at the expense of entrepreneurs.*
- *Motor manufacturers need incentives to produce low-cost, high-efficiency units for use in small residential ventilation devices.*

4. STRATEGIES FOR CHANGE

4.1 The Economics of Energy Efficiency

In the ideal world fondly envisioned by economists, investments in energy efficiency features extend to the point where marginal benefits equal marginal costs. Beyond this point, energy efficiency becomes 'uneconomic', since the benefits from further investment are less than the discounted stream of future savings. From this perspective, the current, extremely low, demand for energy efficient ventilation systems is an indication that benefits must be very low relative to costs, or that something has gone wrong with the marketplace ideal.

The first section of this discussion takes a closer look at the economics of ventilation systems, and attempt to identify those types of systems which should be most affordable, from a homeowner's point of view. This economic analysis will reveal, not surprisingly, that current investments in low efficiency systems are a long way from the economic optimum, particularly for systems used on a continuous or frequent basis. This leads to the second section of this discussion - a look at the marketplace itself.

Proponents of energy demand-side management have argued that a number of barriers exist in the marketplace that prevent optimum investments in energy efficiency. These barriers will be summarized and reviewed. The focus of this review is to identify which of the barriers are most relevant to the supply and use of residential ventilation devices. Only by focusing on how to overcome such key barriers, it is argued, will it be possible to achieve significant changes in the types of investments made by homeowners.

The third section of this discussion describes a number of scenarios for overcoming barriers to the supply of greater efficiency systems. These scenarios are directed primarily at the role played by CMHC, and other institutional players, but the object is to outline a series of changes that, on the whole, will contribute net benefits to each sector of the industry.

4.2 How Cost Effective are Ventilation Systems with Low Air Moving Efficiencies?

A number of recent research papers have analyzed the economics of residential ventilation systems, in an effort to identify the most appropriate types of systems for meeting new building code requirements.[6] Although

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[6]**Rationalization of House Energy Systems,** 1992, by Caneta Research Inc., for CMHC Research

none have explicitly addressed the potential for improving air moving efficiency of the ventilation systems, they have revealed major problems with the levels of current investments in energy efficiency.

One analysis of ventilation life cycle costs has been well presented in the Ontario New Home Warranty Program's (ONHWP) **Study of Residential Mechanical Ventilation**[7]. This study evaluated the life cycle costs of different types of ventilation systems, including;

- continuously operating exhaust fans, with and without make-up air tempering;
- simplified HRVs with point exhaust fans, with and without recirculating furnace blowers;
- full HRV installations with kitchen range hoods; and,
- ventilating fans interlocked with a dampered duct to the furnace return plenum, combined with point exhaust fans.

The ONHWP life cycle analysis included capital costs, energy costs, maintenance costs, and repair/replacement costs. It also made allowances for heat gains from fan operation, modified according to the type of space heating equipment and fuel. The study concluded that "*Ventilation system choices made solely on the basis of first costs may not result in the most affordable alternative.*" In fact the study reveals that even when consideration is given to on-going replacement and maintenance costs, (but still not the operating energy requirements), decisions will be far from the optimum. For example, the system comprised of a duct connected to furnace return, with a motorized damper and an interlocked central ventilating fan, had both the lowest capital cost and the lowest repair and maintenance cost. Yet over a period of 25 years, the lifecycle cost of this system was found to be the highest - or second highest - of all systems analyzed, costing about $10,000, or more than three times the lifecycle cost of the most cost effective systems studied.

The ONHWP findings are consistent with other detailed evaluations of consumer spending on energy efficiency technology for buildings. However a thorough economic analysis is still required to determine the optimum investment in air moving efficiency upgrades for a variety of ventilation systems. Such an analysis would need to be based on new research into the installed costs, replacement rates, and operating efficiencies of the most efficient fan designs. In the absence of an economic analysis, some rough calculations have been completed as part of this report. The calculations

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Incremental Costs of Energy Conservation Systems. Report of the Flair Homes Enerdemo Canada/CHBA Flair Mark XIV Project, 1988, by G. Proskiw, for EMR Canada.
Study of Residential Mechanical Ventilation, 1992, by Habitechnica, for Ontario New Home Warranty Program
[7] IBID

serve to illustrate some general principles of life cycle analysis, as they apply to ventilation systems.

In Table 1, below, three types of ventilation fans are described in terms of their **air moving efficiency** and the factors that help to determine **life cycle costs.** In the near future it is likely that a majority of new ventilation systems will include two or more of these fan types. The fan types include:

1. a whole house ventilation fan;
2. a continuously operating furnace blower; and,
3. a kitchen range hood used to vent cooking odours and supplement the household ventilation system.

The table describes each fan type twice, first as a conventional model, as might be found in a typical new Canadian house, and second, as an energy efficient model using more expensive - but longer lasting - materials and designs.

Table 2 presents the life cycle costs for each fan type, using the input values listed in Table 1. In addition to the total costs, the table separately lists the

- **initial installed costs,** based on equipment and installation charges to the homeowner;
- **discounted operating costs,** based on the air moving efficiency and the electricity prices over time;
- **discounted maintenance costs,** based on an assumed annual maintenance charge[8];
- **discounted replacement costs,** based on a 'guestimate' of life span for the fan, and the costs of replacing the fan components at the end of each life span; and,

The lifecycle costing method used for this analysis is typical of the method used by recent utility DSM programs[9], and uses similar economic values for the lifetime of the investment (25 years), and the discount rates (5%), as the studies referenced previously. The input values listed for fan efficiency are based on Jim White's paper[10]; the installed costs of typical fans are primarily based on the ONHWP industry survey; the flow rates for ventilation fans are based on the proposed 1995 National Building Code ventilation section; the flow rates for kitchen and furnace fans are based on typical equipment specifications.

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[8]Recurring maintenance costs are mostly related to the time involved in cleaning inlet grilles, or obtaining an expert inspection, and are therefore very small. For calculation purposes, these costs have been annualized.

[9]For a review of lifecycle costing methods used for DSM, see **Residential Buildings Energy Code Life-Cycle Analysis,** 1991, by G.E. Bridges & Associates, for B.C. Hydro and Ministry of Energy Mines and Petroleum Resources.

[10]White, J., 1992, op cit

The capital costs of the more energy efficient equipment are based on discussions with manufacturers, and probably represent a worst case scenario. The costs are based on the current market dynamics, and do not account for the economies of scale and increased competition that would occur in the aftermath of energy efficiency standards for fans.[11]

No effort is made to account for space heating and cooling impacts related to motor and fan energy losses, or to the additional space heating requirements related to the air change rates. This analysis also ignores the potentially significant impact of overall ventilation system effectiveness.

TABLE 1: LIFE CYLCLE COSTS FOR STANDARD AND ENERGY EFFICIENT FANS

TYPE OF VENTILATION SYSTEM	*PRESENT VALUE OF LIFETIME VENTILATION COSTS ($)*	*INITIAL COSTS*	*DISCOUNTED OPERATING COSTS*	*DISCOUNTED REPLACEMENT COSTS*	*DISCOUNTED MAINTENANCE COSTS*
Whole house ventilation fan	$777	$130	$147	$332	$169
Energy efficient ventilation fan	$488	$165	$11	$143	$169
Continously operating furnace blower	$821	$15	$580	$15	$211
Continously operating furnace blower	$534	$100	$174	$48	$211
Kitchen range hood fan	$369	$215	$22	$103	$28
Energy efficient kitchen hood	$406	$265	$3	$110	$28

[11]Costs will certainly drop considerably if large volumes of energy efficient models are to be manufactured. The additional material and fabrication costs related to energy efficient design are minimal, in the order of several dollars for a small ventilating fan, up to about $50 for an electronically commutated ½ HP furnace blower. The current incremental cost for energy efficiency features embodies the transitional costs for manufacturers who must retool, and make adjustments in their economies of scale. Transitional costs frequently mislead the economic analysis of energy efficiency in the HVAC industry, because the industry is massively oriented towards high volume production of the minimum technology required by codes and standards. The costs of 'engineering prototypes', or imported equipment from Europe, or special 'energy efficient models', can be inflated by two or three times the long run cost. A recent example is the requirement for energy

A number of companion tables, with formats identical to Tables 1 and 2, were generated as part of the background research for this study, but are not included in this report. The input variables were varied to reflect the probable range of options that might be encountered in practice. This permitted judgments to be made about the sensitivity of the results shown in Table 2. Some insights from examining Table 2, and from the sensitivity analysis, are outlined below. It should be fairly easy for anyone with a computer spreadsheet to repeat this analysis, and presumably arrive at similar conclusions.

Insights from an examination of life cycle costs

Beware of first costs. - The differences in first costs are completely unrelated to the actual life cycle cost, and are consequently a poor basis for making choices.

The extremely low efficiencies of conventional designs help to justify major investments in energy efficiency. - The efficiency improvements of up to 40%, as listed in Table 2, are especially economic because, in relative terms, the impact is substantial. Efficiency improvements beyond this level should be possible, but the costs are difficult to estimate, and the benefits may be relatively less significant.

It will be difficult to be definite about cost effectiveness. - The economic benefits of improved air moving efficiency probably will vary greatly from one system to another. Each type of system will need to be analyzed separately. At the moment, the variables most likely to influence the lifecycle costs are:

- *the percentage of the time that a fan is operational, and*
- *the replacement period.*

Both of these inputs are largely unknown at present. The homeowner may have some idea of how much the fans will be, - or should be - used (although most homeowners are not experienced with systems designed for continuous or seasonal operation); the manufacturer may know the replacement period (although most will say "it depends..."); the home builder or fan installer will almost certainly know neither. More definite field data, based on extensive long term monitoring, may be essential before the industry can agree on what is justified on an economic basis.

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efficient gas furnaces in many provinces, which caused the average price of a mid-efficiency furnace to drop from about $1200, to $600.

Savings can be substantial. The benefits from air moving efficiency alone may represent hundreds of dollars to the consumer. Using the results from Table 2, for example, a house with 2 fans (i.e. a separate supply and exhaust fan operating for half the year) could save approximately $700 over a 25 year period; a house with an exhaust fan, interlocked to a continuously operating furnace, could save $223. If these systems are operated for more than 50% of the year, savings could increase proportionately. If the new ventilation requirements of the building code are implemented without consideration for air moving efficiency, the impact on the utility load could be very significant - especially in areas where new house starts are high.

Life cycle investments in ventilation are very sensitive to choice of discount rates.[12] The potentially large recurring costs from replacing ventilation systems, combined with the deferred savings in energy, means that discount rates can make all the difference to what is cost effective. At the discount rate of 5%, the energy efficient whole house fan is the more cost effective than the conventional model. At high discount rates (e.g. > 14%), however, the economies are reversed, with the conventional model costing less than the more efficient model.

Projected electricity prices can also have a major impact on cost effectiveness. A change in the growth of electricity prices by 1% can alter the relationship between initial capital costs and lifecycle costs, in a similar way to discount rates. If prices were to rise in the future due to energy taxes, or other policy changes, the arguments for improving the energy efficiency of fans become very powerful.

Changes in the rate of air flow of do not appear to have much impact on the lifecycle costs. Although the air flow rates may be important to health and comfort, they are not a major factor influencing the economics of fan efficiency. A more sophisticated analysis is required to assess how flow rates might affect the heat recovery and heat losses from fans. If fan efficiency is lost at lower fan speeds, the impacts on energy requirements may be insignificant. Also, a major reduction in furnace blower air flows could have significant impacts.

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[12]A DEFINITION OF DISCOUNT RATES: To permit a comparison of investments occurring at different times, a discount rate is needed to convert costs or revenues occurring in different future years to a current or present value. The use of a **high** discount rate reduces the weight of future values relative to **low** discount rates. A simple way to understand discount rates is to think of them as interest rates. If interest rates are low - say 3% - then investments made today grow slowly, and are not much smaller than their equivalent dollar value in future years. At high interest rates - say 10% - the present investment is worth much more money at a future date. Conversely, a future resource or cost value is worth more today at a low discount rate than at a high discount rate.

4.3 Key Barriers to the Supply and Use of Energy Efficient Residential Ventilation Devices

Some of the most common barriers to energy efficient technology are listed below and discussed in terms of their impact on residential ventilation devices.

4.3.1 The consumer's emphasis on reducing first costs

To the extent that homeowners are involved with the choice of residential devices, reducing initial costs of the investment will be the primary concern. There are many reasons why homeowners ignore life-cycle economies. Because this is such a major barrier, each explanation is separately evaluated:

- **Lack of access to capital**
  Similar to other building technology, no credit is given by lending groups for the reduction in monthly operating costs from an investment in energy efficient ventilation services. Since most home purchases are based on access to borrowed capital, the home buyer is prevented from making the best choice. In the case of ventilation devices, the extra initial capital is quite small, and the benefits of energy efficiency often coincide with other benefits (better air quality control, more effective air movement, less hassle in maintenance and replacement). Consequently, the capital access problem is probably only a barrier for housing built at the lowest end of the market.

- **More profitable uses for limited capital**
  Savings from small investments in ventilation devices could bring very high returns, since most existing technologies have so much room for improvement. This is probably not a major barrier, at least until a new generation of equipment becomes standard.

- **Concern about cash flow and cost recovery**
  Most homeowners want to get all their money back in 3 years or less, if they are expected to make investments purely on the basis of energy savings. This is equivalent to a return on investment of more than 30%, and is likely a major factor in explaining a preoccupation with first costs. This expectation has been documented in the literature on Demand Side Management, and reflects the use by individuals of discount rates higher than would be applied to most other investments, and far higher than would be used by society, or by utilities, in capturing energy resources. These high discount rates reflect the presence of significant transaction costs (as outlined elsewhere in this section), and also reflect the

uncertainty about recovering the cash flows. Limited tenure is especially a problem in this context. If the homeowner moves homes in 5 years, the value of the investment must translate into increased resale value for the home. Since this is unlikely, the higher than normal discount rates may be justified.

- **Uncertainty about technology**
  At present the motivated homeowner has no way of knowing the installed efficiency of a ventilation system, since testing procedures are not available at a cost the homeowner can afford, and since procedures are not yet standardized in a way that can be intelligible. Nor is it possible to know how concerns over energy efficiency might overlap with concerns about comfort, reliability, health and safety, and system compatibility. These uncertainties are not likely to be a major barrier at present, due to a general lack of awareness, but could become a problem if homeowners are encouraged to become more involved.

- **Uncertainty about future energy prices**
  Energy conservation investments are influenced by the expected price of electricity and other fuels. At present the public perception of energy prices appears to be heavily influenced by stable or falling oil prices. Electricity is tarred with the same brush of energy surpluses and low price expectations. In reality, electricity prices projected by utilities in most parts of Canada are fairly stable. When these prices are used to calculate the costs of continuous mechanical ventilation, many homeowners are likely to be surprised by the low annualized costs for the service . Without some degree of uncertainty, (expectations of price hikes or shortages or environmental taxes), the value of electricity reductions lose value as a safeguard. Thus to some extent the public perception of falling energy prices, and the apparently stable electricity price projections, represents a barrier to small investments at the homeowner level.

- **Inadequate or unreliable information**
  Homeowners cannot currently obtain useful advice on how to reduce the costs of ventilation through air moving efficiency. For that matter, neither can installers, builders or other key decision makers. Even within the industry, the information available is unreliable because of the controversy over how much the ventilation fans are needed, and the confusion over the meaning of "efficiency". Based on the industry opinion survey results, it is likely that these informational problems will become a major barrier.

- **Opinion not substantiated by fact**
  Opinions based on false or inadequate information represent a barrier not just for homeowners, but for all sectors contacted during the opinion survey. Some of the strongly held opinions that represent barriers include:
  - mechanical ventilation systems will seldom be used, or are not really needed, in new houses;
  - it is impossible to increase efficiency without encountering offsetting problems (from noise, total cost, space requirements, servicing, loss in flow);
  - fans seldom wear out;
  - continuous ventilation is an extravagance due to the costs of running the fans;
  - air moving efficiency is not an issue for HRVs because the heat recovery system is a major air flow restriction that prevents efficiency, and because the current efficiency standards for HRVs give consideration to fan operation.

- **Lack of expertise**
  Many consumers certainly lack expertise, but as argued by a number of respondents to the opinion survey, it is unlikely that this barrier can be overcome through communications and education. The best case scenario is for consumers to recognize **distinct** categories of ventilation equipment (e.g. continuous vs. intermittent), and the **potential** for cost effective investments. Installers and designers need to become aware of the relative efficiencies of system designs, and the factors that are likely to most influence performance. The lack of expertise within this latter group is likely to become a barrier, when, and if, demand can be created for energy efficient systems.

- **Time and effort required for investment**
  At present the complexity of the issue is such that most consumers, should they become aware of the potential, would probably still be unwilling to devote the time and effort required. The existing data on system performance is not intelligible to the lay person. No easy and credible information source is available. The marketplace is strongly oriented towards the low capital cost options. For all these reasons, the homeowner most likely needs to locate and employ an HVAC specialist, - a significant investment in time and money.

4.3.2 Decision makers do not bear the consequences

This market failure is commonly referred to as the landlord/tenant problem, although it is more complicated and varied than implied by the different forms of ownership between landlords and tenants. The problem occurs because the demand for reductions in lifecycle costs seem to have trouble translating into increased market values for those lower cost goods and services. In other words, if the purchaser - that is the individual who decides what equipment to install - is **not** the same person who incurs the costs (or benefits) related to future operation and maintenance, it is difficult for the purchaser to get fully compensated for the value of life cycle investments. To cite one example only, it is for this reason that new rental housing in British Columbia is sometimes constructed with single-glazed windows, (a practice that may only be eliminated if the recently revised provincial energy efficiency requirements are adopted in the 1993 Building Code). To the extent that the buyers are unsophisticated, or desperate, or overwhelmed with other financial decisions, the decision-maker is better off ignoring the life-cycle costs.

In the case of residential ventilation devices, this landlord/tenant failure is especially problematic because homeowners are so seldom involved in the purchase decision. Even a new home, built to custom specifications, is likely to have fans selected by the electrician or heating contractor, as opposed to the homeowner. The after sale market (i.e. sales made directly to homeowners), is a very small part of the business at present, and is largely ignored by manufacturers. Until homeowners are involved in selection of ventilation devices, it is likely that selections will be made on the basis of factors unrelated to operation and performance. Instead the focus will be on the first cost, cosmetics, local availability, mark-up and profitability, ease of installation and minimum code requirements.

4.3.3 Electricity prices that do not include full social costing

Electricity prices do not yet include the full social costs:

- Prices charged for operating the ventilation fans will be based on the average cost of supply for the utility. In reality, the additional electrical load of a continuous ventilation system in a new house will require electricity at marginal costs, (i.e. it must be provided from new sources, at costs well above the average).
- Because the ventilation fans will frequently be operating when other electrical loads are at their peak, the system will increase total demand, and require extra generating capacity.
- Electricity costs do not reflect all of the environmental damage that is related to the air emissions, transmission corridors, displaced communities, loss of natural functions; and so on. These represent environmental 'subsidies', and encourage the use of electricity by homeowners.

The extent to which electricity is under priced is difficult to calculate. Marginal costs are commonly double or triple the average costs, especially when estimated over a 25 year time horizon. The cost of new generating capacity is in the $1500 to $4000/kW range for most Canadian utilities, (or about $330 for a typical 120W ventilation system). Environmental externalities calculated by resource planners and economists typically result in 'adders', that increase the price of electricity by 15 to 50%. For all of these reasons it is likely that full social costing would double the operating cost of ventilation systems, and that **much greater investments in energy efficiency could be warranted.** Incorrect pricing of electricity represents a major barrier to investments by homeowners.

4.3.4 Absence of competitive forces in the marketplace

The ventilation fan market is still in a period of transition. Ten years ago, the market was dominated by a few large companies, mostly American-based. These companies continue to dominate the market for ceiling mounted exhaust fans and range hoods. The growth of the HRV market, and later a market for radon control fans and central exhaust ventilators, has since helped to foster over a dozen new fan suppliers for Canadian household ventilation. The HRV companies are mostly Canadian based, and are beginning to diversify into non heat recovery equipment, such as packaged ventilators with recirculation and fresh air features. The remote-mounted fan market is primarily based on European products, imported from Germany, Britain, and France, and is rapidly expanding. The furnace blower market is highly fragmented, with issues of blower efficiency falling through the cracks, (despite the notable exception of General Electric and Carrier/Bryant), and with fierce competition and growing American domination as a result of free trade.

The companies involved with manufacturing and distributing household fans and furnace blowers are faced with a growing and changing market. For each type of fan that might be installed in a house, at least two companies are in competition. However on the local scene the degree of active competition may be extremely limited. Large wholesalers may stock only a single brand, which greatly limits the effective choice. The largest ventilation companies have not yet responded to the emerging markets for energy-efficient, continuous ventilators, and their rate of technological innovation does not match the pace of change in codes and standards. None of the fan manufacturers contacted in this study indicated they were planning extensive R&D investments. In summary, competitive forces are probably strong, but the fragmented nature of the industry, and the growing dominance of American companies in some sectors, limits the ability of the fan suppliers to respond to changing Canadian market conditions.

4.4.5 Limitations to technology

The full potential for technological advances in ventilation efficiency is still being explored. However the recent work by CMHC consultants suggests that this in itself, should not represent a major barrier to change.[13] The outstanding issues are more related to the cost and performance trade-offs, and to the technological limits for air moving efficiency at low air flows.

4.4.6 Administrative and Institutional barriers

A need for CSA approvals restricts access to some energy efficient European fans. Annual Fuel Utilization Efficiency (AFUE) ratings for furnaces have ignored the impact of furnace blowers, with the effect of rewarding inefficient designs.[14]

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[13]Allen and Associates, 1993, Op Cit.

[14]AFUE ratings will likely be revised to incorporate the fan power requirements. In preparation for such a change , the Gas Association Manufacturers Association (GAMA) have this year begun publishing fan power requirements for all furnaces.

5 STRATEGIES FOR INCREASING THE ENERGY EFFICIENCY OF RESIDENTIAL VENTILATION FANS

A strategy for change is presented in this section. Wherever possible, the strategy draws upon the responses from industry representatives who participated in the opinion survey. Discretion was required where viewpoints were widely divergent, but in some areas it has been possible to address the bulk of concerns, or to incorporate frequently voiced or strongly felt suggestions.

The strategy has been developed with the following objectives in mind:

- to facilitate a rapid and complete transition to higher quality, energy efficient ventilation systems that will be more affordable and less problem-prone than existing technology;

- to coordinate the development new ventilation standards with development and supply of new technology, so that the new ventilation requirements that have been developed by CSA, and are being incorporated into the National Building Code, lead to a minimum of hardship and hassle for homeowners, and for electrical utilities; and,

- to assist and encourage the manufacturing and supply of more energy efficient ventilation equipment by Canadian businesses.

A strategy for achieving these objectives will require two parallel activities:
1. creating a demand for the energy efficient fans and blowers; and,
2. creating an infrastructure for delivering this new technology.

In creating new demands and new products, the key to success is overcoming the key barriers identified previously. Also important is to design a strategy that takes advantage of synergies between each activity, and each participating group. And finally, these activities must be coordinated so that the essential ingredients are brought together at the right time and place.

5.1 Creating Demand

5.1.1 General Approach

On the basis of the foregoing analysis, it would appear the only option likely to create a real demand for energy efficient ventilation fans is to rapidly develop standards that can be enforced through the building codes and other regulations. The bulk of time and resources should therefore be concentrated primarily on developing and supporting the most effective standards process. It is typical to use energy efficiency standards to set a floor, that takes the least efficient equipment off the market, while other means, such as labeling, information programs, demonstrations, rebates, purchase taxes, housing rating programs, and so on, are used to encourage consumers to surpass the standards. In the context of residential ventilation, however, means other than standards should only be considered to the extent that they compliment the standards approach, and avoid drawing away limited resources. The remainder of this section will provide a rationale for focusing exclusively on the standards process, and elaborate on the ingredients of such a strategy.

For reasons listed in the discussion of barriers, it is difficult for consumers to influence this market because of the complexity of the issues, and because they are seldom involved directly in the purchase decision directly. The involvement by consumers is further complicated because fans serve a variety of functions, operate in different modes, may be integrated with other systems and are influenced by other features of house performance. . A majority of respondents to the opinion survey indicated little faith in driving the market through educating consumers, or through the incentive programs that have been used for other types of household appliances.

Past experience with promoting energy efficient motors confirms this view, showing a very poor response by the market to labeling and incentives programs. Even businessmen in the commercial sector, who can more easily understand the financial arguments, seem unwilling to introduce new technology because of the high transitional costs (unknown reliability, different stocking requirements, associations with different suppliers and service companies, and so on). In a review of conservation potential in industry in British Columbia, M. Jaccard concluded that businesses use an effective discount rate of 50% when evaluating investments in energy efficient fans and motors.[15] In other words, they want all their investment in energy efficiency to be recovered in less than two years. It is unrealistic to expect an educated homeowner to act differently. Essentially, the market is stuck in a rut, where a perception of short term pain prevents any chance of long-term pleasure.

In their extensive report on **Energy-Efficient Motor Systems,**[16] the American Council for an Energy-Efficient Economy concluded that "*Education and technical assistance programs appear to have had little impact in improving motor*

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[15]**Conservation Potential Review, Industrial Sector,** 1993, by M. Jaccard and Associates, for the Collaborative Committee of B.C. Hydro.
[16]**Energy-Efficient Motor Systems: A Handbook on Technology, Program, and Policy Opportunities,** 1991, by ACEEE, for American Public Power Association.

system efficiency." They also warn against relying on labeling schemes, as did the United States Department of Energy (DOE). Their analysis indicated that DOE *"overestimated by a factor of two to three the penetration of high-efficiency motors in the absence of standards."* They recommend that this costly mistake be corrected: *"As a result of DOE's errors in analysis, and the fact that DOE did not monitor motor efficiency trends, as it had pledged in 1980, achievement of the substantial energy and dollar savings available from motor efficiency standards has been delayed by at least ten years. ... DOE should correct its previous error and....promulgate motor efficiency standards."*

One difficulty with using standards is that they impact only on new houses. However, ventilation systems are still quite rare in existing homes. Moreover, a replacement market should develop to supply energy-efficient fans, once these become available as a result of new standards. And standards can be referenced for existing houses by utilities, since their programs are now driving much of the retrofit work on existing houses.

5.1.2 Task Outline for Energy Efficiency Standards

The development of energy efficient standards involves four major tasks, each of which is outlined below:

Task 1. Prepare a standard(s) for testing and rating the air moving efficiency of residential ventilation equipment

The on-going effort to revise CSA 260 standard on residential ventilation equipment may be adequate for this purpose, certainly for stand-alone supply and exhaust fans.

Task 2. Create a process for establishing energy efficiency limits or targets.

The CSA C260 standard can only provide a method for rating fans, and a system for labeling. The methods chosen, and the terminology and calculations, can impact the acceptability of the ensuing regulations on energy efficiency. The method becomes complicated for a number of reasons:

- Ventilation systems employing heat recovery should not be penalized because of the added restrictions caused by a heat recovery core;
- Fans that are intended to become part of other systems in a house (recirculation, heating, cooling, filtration) may need to satisfy system specifications that conflict with energy efficiency requirements, or that already consider, to some extent, the energy efficiency of the fan..

To avoid the miring of CSA 260 committee in the political and jurisdictional issues, it may be necessary to convene a steering group that can establish a context for the committee. This steering group can establish policy questions about how much the fans can be "disaggregated" from other systems in the house. Consideration can be given to how the rating method can be graduated, to facilitate setting energy efficiency minimums. Separate agendas can be planned for each type of ventilation device, if necessary, and liaison can be established with other standards committees who are responsible for ventilation products. One interesting precedent is the Coordinating Committee on Combustion Venting (CCCV), a group organized by the Institute for Research in Construction, with a mandate to rationalize the approaches taken by different groups to ensuring venting safety. In the case of a 'Coordinating Committee on Ventilation Efficiency', the membership would need to include representatives from utilities and policy setting groups, in addition to the standards committees involved with ventilation products and the energy code.

Task 3. Incorporate the limits and/or targets into enforceable codes, standards, regulations, and specifications referencing CSA 260.

Once energy-efficient levels are established for ventilation devices, how can these be enforced? A number of options exist including:
changes to the provincial building code sections dealing with ventilation, changes to the recently finalized prescriptive requirements for ventilation in the 1995 National Building Code;

- as changes to the CSA F326 Ventilation Requirements standard as part of the revision now in progress;
- as part of an expanded section in the Energy Code now being finalized in preparation for review in 1994;
- as regulations in the new Federal Energy Efficiency Act;
- as regulations in any of the provincial energy efficiency acts; and,
- as part of the requirements for housing programs like the advanced house program and utility-sponsored energy efficient house programs.

The most appealing option at this time is to work the ventilation efficiency requirements into the Energy Code, since this is a logical place to address the issue and is currently overlooked, and since the Energy Code has potential for widespread enforcement by provincial authorities. Depending upon the National and provincial energy efficiency acts, is also a good option, and may be more compatible with a graduated approach, that alters the level of efficiency over time, to suit the pace of technological change and the energy priorities at the regional level.

Incorporating fan efficiency into the CSA F326 standard, in a similar manner to the sound output and pressure limits, could lead to many problems, and should be avoided. Revisions to the Provincial building codes are unlikely, with the possible exception of B.C..

Task 4. Develop methods for verifying conformity with the standard, and for facilitating enforcement.

In a similar fashion to air flow measurements, compliance testing standards and guidelines are also needed for verifying energy efficiency in situ. Labeling systems can assist building inspectors in enforcing requirements for minimum efficiency ratings for each component of a ventilation system.

5.1.3 Key Policies for Improving the Process

If the four tasks listed above are to be successfully accomplished, some key considerations for CMHC and other institutional groups that are in a position to facilitate the process.

Policy 1. Establish a firm schedule, that is coordinated with other activities, and communicate this to other groups.

A danger exists in permitting ventilation requirements to precede efficiency requirements. The initial impression created by poor quality and high cost systems can undermine the authority of code authorities at all levels, and breed intolerance towards mechanical ventilation system requirements in general. The initial use of noisy fans to satisfy British Columbia code and utility requirements, for example, has created a backlash, and forced both the province and the utility to reduce the maximum allowable sound output. The concerns of manufacturers over moving too quickly must be balanced against the need to rapidly synchronize the efficiency requirements with the up-coming ventilation requirements. The National Building Code will require distributed, balanced ventilation in 1995, and this will lead to enforcement at the provincial level by 1997. In Ontario and B.C., many of these ventilation requirements are already in place.

Policy 2. Develop a tiered approach to energy efficiency requirements.

A tiered or graduated approach was strongly recommended by a number of respondents to the opinion survey, and is consistent with other surveys recently conducted into the implementation of energy codes in Canada[17]. A tiered approach permits a less fractious process, with longer term agendas. In a similar fashion to automobiles, the industry can become more committed over time, and begin to position themselves in relation to targets that are set informally by the coordinating groups.. A regular and formal review schedule allows a ratcheting of minimum requirements. The

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[17]Hickling Corporation, **Energy Code Marketing and Implementation Study**, Final Report, January 28, 1992, submitted to EMR

direction of change causes upward trending expectations, and helps to stimulate innovation.

Another advantage to the tiered approach is that some jurisdictions can impose the more stringent energy efficiency requirements at an earlier date, where the technology is available and the economics are attractive.[18] This is likely to occur where electricity prices are relatively high (e.g. Maritimes, Northern Canada), or where it is critical to avoid increases in the utility load base, or where investments in housing technology are being made by the utilities themselves[19].

Policy 3. Permit different levels of aggregation for components of ventilation systems, while maintaining a floor level for fan efficiency.

If an entire ventilation system is to be tested on-site, then it may not be necessary for a specific ventilation device to satisfy the energy efficiency requirements developed in a standard such as CSA 260. An option may be to incorporate energy efficiency calculations in the air flow measuring test procedures developed for ensuring compliance to CSA F326 or the National Building Code. This is a preferred approach since it avoids the problem of trying to establish appropriate levels of aggregation for determining efficiency in integrated or multiple function systems. If on-site air flow testing procedures are developed into a new Canadian standard in the near future, consideration should be given to expanding the scope of such a standard - in a similar fashion to CSA C260, - to include air moving efficiency. In the meantime, and possibly even after such a field test procedure exists, it may be sufficient to specify floor level efficiencies for fan motors, as long as the motor is combined with specified types of system components.

Policy 4. Separate fans by function, and by their expected operating times.

Fans that meet dual functions, or that have unknown operating times, would be required to satisfy the most energy efficient levels. At a minimum, a

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[18]In 1990 the National Electrical Manufacturers Association had to issue a "Suggested Standard for Future Design" to permit more stringent specification writing by utilities concerned about energy efficiency.
[19]For example, the Power Smart Home Improvements Program, at B.C. Hydro, provides a loan and grant to homeowners who retrofit their electrically heated houses. The retrofits typically include air tightening and installation of new bath, kitchen and whole house fans. Although POWER SMART specifications for ventilation systems are currently focused on air flow, control and sound, they will no doubt want to include high levels of ventilation efficiency as soon as fans are rated for this purpose.

functional split should be consistent with the terminology of the NBC 9.32, which is separating fan(s) into 'continuous', and 'intermittent'.

The new approach adopted by the prescriptive requirements of the 1995 NBC does create some difficulties for the functional split in terms of energy efficiency. The "continuous" fan(s) need only satisfy 50% of the required ventilation capacity, with the remainder comprised of flow available from bath and kitchen fans. This approach leaves open the question of just how long a period of the year might typical homeowners use bath and kitchen fans as supplements to the household ventilation systems (as opposed to venting moisture and odor generated in the fan's room)? It would be nice to think that all intermittent fans are used for brief periods only, since this would translate into low cost and relatively minor changes to the technology (e.g. use of more efficient motors).

Policy 5. Labels on fans should reflect the needs of industry for design calculations and compliance testing.

Suggestions for labeling fans with $/year numbers and so on are not consistent with a strategy that relies primarily on the functioning of stringent energy efficiency standards. A better use of labeling information is to provide an indication of the units efficiency at various operating pressures and flows. This information would not assist the homeowner, but is still valuable. In the absence of packaging literature , as is often the case with wholesaled equipment or when retrofitting an existing system, or in the case of an inspection by an energy auditor or building inspector, the labels make it clear how to calculate the energy requirements of the system. The labeling information should facilitate compliance and maintenance activities.

Policy 6. Provide industry with a method for evaluating all of their equipment from an energy efficiency and lifecycle perspective.

A simple software package should be developed to assist in evaluating the impact of standards on specific equipment. Industry representatives can use a standard spreadsheet to input variables appropriate for their equipment. Several spreadsheet files may be warranted, to address different types of fans, and to allow varying levels of technical knowledge. Introduced quickly, this type of participatory analysis, and industry feedback, will allow more constructive input on what can be provided, at varying levels of efficiency. An invitation to manufacturers to use the software to rate all of their equipment should also involve more people in the discussion, without a need for attending the committee meetings.

5.2 Creating a Supply of Energy-Efficient Fans

A strategy to encourage supply and availability of efficient technology is the second activity area, and is needed to compliment the activities described above. In general, this strategy must focus on the major technical or organizational barriers to supply of technology, with a focus on research and demonstration work. Priority issues should be identified, based on the research recently conducted by CMHC, and by Ontario Hydro. An effort should be made to involve as many parts of the industry as possible in the new R & D program. Government sponsored research is warranted in areas where the industry is too undercapitalized, too focused on short term issues, or too fragmented to make capital intensive and risky investment.

5.2.1 Suggestions for Involving each Sector of the Industry

Based on the results of the industry opinion survey, a suggested list of research and communications tasks is outlined in two sections below.

Industry Research Proposal 1: Sponsor innovation by manufacturers

A small group of industrial representatives and economic development experts should be given the task of preparing and executing a strategy for sponsoring innovation within the private sector. Some of the tactics could include:

- requesting the Industrial Research Assistance Program (IRAP), to facilitate the preparation of research proposals by every Canadian manufacturer of ventilation equipment;
- suggesting how CMHC might issue a design challenge for each type of fan;
- proposing to utilities how conservation budgets could be used temporarily by preparing specifications, and purchasing product in bulk, and then selling the equipment as the market expands, just to get things moving; and,
- suggesting that CMHC financed housing developments be required to use an energy-efficient fan - perhaps a type compatible with the utility specifications, thereby creating an instant market for the new fan, and a showcase project for CMHC.

Industry Research Proposal 2: Develop a short term technology transfer program for Canadian companies

A short term technology transfer program could consist of simply a tour by a trainer, accompanied by local consultants, to a manufacturer's facilities. A seminar could cover all the research findings to date, and a follow-up discussion could focus on the expectations for changes in the manufacture's niche markets, and for technological opportunities unique to their equipment. This approach could lead to further sessions as called for. A tour and seminar series could also be combined with an offer to participate in a design challenge for manufacturers, or with a request for a price quote on new technology, or with an introduction to some simple lifecycle analysis software.

Industry Research Proposal 3: Involve electrical utilities in sponsoring innovation and providing technical support to the industry

An estimate needs to be made of how much the new ventilation standards are likely to change the shape and size of the electrical load of specific utilities over the next twenty years. This type of research could perhaps be sponsored by the Canadian Electrical Association (CEA). The sudden growth in a major new end use has alarming implications for some utilities, and it may warrant more involvement by these utilities in facilitating code changes, and funding supporting research. This 'utility impact assessment' could also augment the life cycle cost analysis, by considering the impact of ventilation fans on utility generation and distribution requirements.

Industry Research Proposal 4: Translate the research and standards work into information suitable for installation trades.

Heating and ventilating sub-trades will be increasingly taking over from electricians or builders in the area of purchasing and installing fans. They will become responsible for the overall performance of ventilation systems, and will need to fully understand the potential benefits and costs associated with ventilation efficiency. HRAI could be encouraged to incorporate fan efficiency information into their on-going training activities on ventilation systems, including the F326 courses, and the HRAI field manuals. This work should be coordinated with the Energy Code, so that information is received by their membership on a 'Just In Time' basis. The patchy nature of ventilation training in Canada means that some time should also be spent by HRAI, or others, in trying to reach trades at the sales counter. One possibility is to prepare a poster or brochure to help the wholesalers explain the changes to ventilation technology, and provide a rationale and an explanation of terms.

5.2.2 Research

Four specific research efforts are warranted to support the new standards on energy-efficiency. These projects are of value to the industry as a whole, and are suitable for sponsorship by CMHC, or other housing research groups. Each project is outlined below:

Public Research Project 1: Monitoring of actual systems

Duty cycles of equipment need to be established very quickly to assist in understanding the economics, from both a consumer and a utility point of view, and to assist in establishing the 'categories' of equipment for efficiency regulations. By working through distributors and installers, it may be possible to conduct a phone survey of homeowners with systems similar to what are required by the new codes and standards, and to conduct follow-up monitoring of the houses with variable usage patterns to establish the actual patterns of use in Canadian households. Such a study should include Central Exhaust and Supply Ventilators, Make-Up Air Systems, Furnace Blowers, as well as the HRVs, Bath Fan and Kitchen Fans.

Public Research Project 2: Lifetime testing

The issues related to lifetime of equipment are very important to the customer satisfaction and to life cycle costs. A research effort is required that breaks down the issue of lifetime into key variables, and identifies how these might change with evolution of equipment, and as a result of the proposed energy efficiency standards. This research would need input from manufactures of key components for each type of ventilation system, and input from people with field experience from related industries (e.g. radon control fan installers, European countries where continuous ventilation has been required for many years, etc.). Some accelerated product testing may be possible, for such variables as on/off cycles, moisture loading, freeze cycles, and so on. The outcome of this research should be directed at both the standards committees that must establish life-cycle cost parameters, and the manufactures who are establishing new warranty policies to accompany the efficiency standards, and who are changing designs to meet new markets.

Public Research Project 3: Experiment with furnace blower system designs

Use of furnace blowers as part of residential ventilation systems is probably the area where most technical research is warranted by CMHC and other institutional research bodies. There are several reasons :

i. More than 75% of Canadian houses have forced warm air furnaces. Based on the B.C. experience with requirements for mechanical ventilation systems, it is highly likely that houses with forced air systems will use the furnace blower and ductwork to satisfy the requirements for supply air and tempering/distribution. The large majority of standard furnace blowers are grossly inefficient, even on the so called low speed, and therefor the potential for savings is significant.
ii. New technology is already available that offers tremendous 'system' savings, by using programmable electronically commutated motors to provide efficient heating and whole house ventilation with the same motor.
iii. The fragmentation of the industry, and a historical bias toward combustion and heat transfer efficiency instead of ventilation, means that nobody is looking at the big picture: *How can we match the furnace heat exchanger, blower compartment, motor, blower, and controls so as to achieve optimum space heating **and** ventilation?*.

Public Research Project 4: Develop a portable fan test rig for Mocking-up systems

A variety of ventilation systems need to be mocked up for testing and demonstration purposes. A small, portable flow chamber (similar to CMHC's Duct Test Rig) could be combined with equipment for monitoring electricity consumption and sound output. Although the results may not duplicate the C260 standard in absolute terms, (especially for sound output), they would be fine for comparisons. The mock-up could be designed for easy switching of fans and assemblies, using a clamp-on, adjustable platform.

Using such a test rig in a lab setting it should be possible to address the key concern raised by manufacturers of household exhaust fans during this opinion survey: sound output. Traditionally, higher efficiencies have been achieved through higher static pressures, which have created higher air velocities and problems with excess noise. The test rig should be used to correlate sound output and energy efficiency for different technologies. The portability of the test rig could be used to great advantage in demonstrating principles of energy efficiency (seeing is believing), especially since the issue of fan efficiency is likely to remain fairly controversial. The test rig could be set up and operated by HRAI, or other groups involved with technology transfer, or loaned to Canadian manufacturers.

5.3 A Schedule for Implementation

A schedule for implementation of the suggested strategies is largely dependent upon the level of interest and the level of funding. Initially a process needs to be developed for shepherding the changes, and coordinating the related research and communications work. With such a process in place, the best scenario may be to institute energy efficiency standards in three big steps:

STEP 1: January, 1994.
Establish a floor level efficiency for all air moving devices in houses, based on tests and calculation specified in a revised version of CSA C260, and possible other revised CSA and CGA standards. The technical basis for the efficiency levels should primarily reflect the potential that is now available by means of more efficient motor technology, (i.e. no major hardship for most fan manufacturers). These floor level efficiencies can be called up the Energy Code in time for the 1995 release date. The intention would be to establish the principle of energy efficiency for all ventilation systems, so that future standards activities by various jurisdictions will be much more likely to address the issue. At the same time, the categories of equipment can be determined, and a review schedule for each category established.

STEP 2: January, 1997.
Review and revise the efficiency standards, to become more stringent , to permit varying levels of aggregation of system components. The level of technical improvements permitted will depend upon the feed back from researchers and industry participants involved in the R & D projects, and the response received from provincial and municipal jurisdictions. By issuing these revised and more stringent standards in 1997, it should be possible to coordinate the requirements for improved technology with the review and enforcement activities related to the 1995 NBC and Energy Code at the provincial level.

STEP 3: January, 1999.
Review and revise the efficiency standards, in coordination with the development of a Building Code and Energy Code for the year 2000.

APPENDIX A: TELEPHONE QUESTIONNAIRE

PREAMBLE

Hi, my name is.................. I am doing a small piece of research for CMHC on the efficiency of residential ventilation devices. Your name was suggested to me by .... I am hoping you have a few minutes now - or sometime later this week or next - to answer some questions I have prepared on this issue. I have 10 questions altogether. Is now a good time?

(if no, set a new time, and offer to send background information for them to read should they wish)

By residential ventilation devices I refer to all the equipment used to move air in houses; - bathroom fans, HRV, furnace blowers and so on. At present most of the devices used in Canadian homes operate at very low efficiences - in the range of 1 to 6 per cent, with furnace blower a bit better at around 10%. Industrial equipment used to handle air typically achieves efficiences in the range of 60 to 75%. So there is lots of room for improvement. CMHC is hoping to come up with some good strategies for improving the efficiency of ventilation devices - strategies that might be effective over the next 10 to 15 years. To begin with, we are collecting information and ideas from a range of key people. So here come the questions. First:

PHONE INTERVIEW QUESTIONS: E.E. RESIDENTIAL VENTILATION DEVICES

1. Were you aware that most RVDs are extremely inefficient in the way in which they use electrical power to move air?

   (If NO go to QUESTION 5.)

2. How did you become aware of these inefficiencies?

3. Could you briefly describe the kind of technical changes that you think might be needed to improve the overall air handling efficiency of RVDs?

4. Do you or your colleagues have plans to do anything about improving the efficiency of RVDs? (if YES...) Can you tell me briefly the kinds of activities you have in mind?

5. With the existing and upcoming building code requirements for installing RVDs in new houses, do you believe that the efficiency of RVDs - their total energy consumption and their cost of operation - is likely to become an issue? Where are the biggest problems likely to occur?

6. Based on your current understanding of the situation, what would you think might be the biggest barriers to the development and use of more energy efficient RVDs?

7. I would like to get your thoughts on what strategies might be most effective, in your opinion, in improving the efficiency of these devices over the next 10 years. First I will simply read through a list of 10 general strategies. Then I will read the list one more time, and ask you to rate each strategy in terms of whether it is:

   A BAD IDEA, or
   UNNECESSARY, or

A GOOD IDEA, or
VERY WORTHWHILE.

Please make other comments on the strategies if you wish, such as how it could be accomplished, and by whom.

i) *Research the fundamentals, to see how best to redesign the ventilation devices and the air distribution systems to optimize cost and performance.*

ii) *Developing a standard test for determining the efficiency of RVDs and installed systems.*

iii) *Rate and Label all RVDs for their predicted energy consumption.*

iv) *Develop more detailed design and installation guides for the trades.*

v) *Train installers about the issue, and how best to select equipment and test it performance.*

vi) *Educate homebuyers and homeowners.*

vii) *Develop energy efficiency standards for RVDs, similar to the standards that have been developed by some provinces for white goods.*

viii) *Incorporate minimum levels of energy efficiency for RVDs into either the National Building Code or the upcoming National Energy Code.*

ix) *Incorporate energy efficiency requirements into market driven programs such as R2000 and utility programs.*

x) *Provide financial incentives to homeowners who are willing to switch to more energy efficient RVDs (for example, buying back inefficient motors from furnaces).*

8. Please describe any strategies you think I might have missed.

9. Of all these strategies, what should be done first?

10. How quickly can the strategies you have identified as worthwhile be accomplished?

COMPLETION

Thank you very much for your time and your ideas. I enjoyed talking with you. Would you like to receive information on the results of this research if CMHC decides to publish the material? One final question:

11. Where would you recommend that I go for more advice and information in this area? Any key Reports or Journals you know of? Anybody particularly well versed in this subject?

APPENDIX B: LIST OF INDUSTRY RESPONDENTS

John Cockburn
Energy Mines and Resources Canada

John Haysom
Institute for Research in Construction

Steve Gertzman
Chief Building Inspector, Delta

Bob Sloat
Canadian Home Builders Association

Al Koelhi
Contractors Association, B.C.

Dennis Rogoza
Energy Mines and Petroleum Resources

Rob Dumont
Saskatchewan Research Council

Warren Jones
Cortez Energy Efficient Homes

Carl Tucker
Regal Motors

Bill Jones
Ontario Hydro

Ed Grezick
Ontario Ministry of Energy

David Hill
Eneready Products Ltd.

Brian Kilns/Iris Murray
Ontario Hydro

Peter Edwards
ORTECH

Greg Allen
Allen & Associates

Dan Fox
General Motors

Bob Henderson
Nutech Energy Systems

Dave Wolbrink
Broan Manufacturing Company

Doug Geddes
Geddes Enterprises

Dennis Deitz
American Aldes Ventilation Corp.

Mark Stevens
AMCA/HVI

Murray Ward
Aircare Inc.

Dan Les
Nutone Electrical Inc.

Neil Rutherford
Air Vector

Murray Wyryk
Energy Conservation Services Inc.

Chis Mattock
Habitat Design and Consulting

Daniel Forest
Venmar Ventilation Inc.

Frank Sadkowski
Energy Mines and Resources Canada

Bede Wellford
Airxchanger