c.1

KPMG Peat Marwick Stevenson & Kellogg
Management Consultants

Executive Summary

THE ECONOMICALLY ATTRACTIVE POTENTIAL FOR ENERGY EFFICIENCY GAINS IN CANADA

MAY 1991

Prepared for

Efficiency and Alternative Energy Branch
Energy, Mines and Resources Canada
580 Booth Street
Room 1557
Ottawa, Ontario
K1A 0E4

Submitted by

Peat Marwick Stevenson & Kellogg

In association with:

Marbek Resource Consultants
Torrie Smith Associates
WATSRF

Toronto
May 15, 1991
MR/8966/cw-f

FOREWORD

This document summarizes the findings of a study completed for the Efficiency and Alternative Energy Branch by Peat Marwick Stevenson and Kellogg Management Consultants in association with Marbek Resource Consultants Limited, Torrie Smith and Associates, and WATSRF at the University of Waterloo. The views expressed in the report are those of the authors, and do not necessarily reflect the position of Energy, Mines and Resources Canada (EMR).

The primary objective of the study was to estimate the economically attractive energy efficiency potential in Canada. For the purpose of this study, energy efficiency potential is a precisely defined term specified on page 1 of the attached Executive Summary. To estimate the potential, the authors adopted a case study approach in which a number of areas of energy use were analysed in depth. The results of these studies and general estimates of potential for the remaining end use areas were aggregated to obtain an overall estimate of the potential for energy efficiency in Canada. The list of case studies prepared for this project is presented on page 2 of the attached summary report. The main report as well as the ten case studies, arranged into eight separate appendices, are available on request.

As the authors point out in the report, estimating energy efficiency potential is a complex task, frequently constrained by a paucity of good quality data. In some areas, it is difficult to establish an analytical framework that effectively separates energy efficiency potential from industrial processes or lifestyle changes. It is important that the reader understand these caveats, and ensure they are given appropriate weight in interpreting study results. Nonetheless, EMR believes the study offers a useful reference point from which future work in this area can evolve.

In an effort to gain a better appreciation of the concept of energy efficiency potential, the Efficiency and Alternative Energy Branch and the Energy Policy Branch of EMR Canada hosted a *Workshop on the Potential for Energy Efficiency in Canada* on April 16, 1991 for the benefit of senior federal government policy advisors. The objective of the workshop was twofold: to introduce the audience to some of the current thinking on the subject of energy efficiency potential and to present the findings of a preliminary version of the Peat Marwick study. The workshop was organized for EMR by The Conference Board of Canada, who provided Rapporteur's notes on the day's proceedings. These notes are also available on request.

Efficiency and Alternative
Energy Branch, EMR Canada

Contents
Executive Summary

Executive Summary

A. Introduction

Despite significant gains in energy efficiency since the early 1970's, there appears to be a considerable further untapped, cost-effective potential for energy efficiency gains in Canada. This study is intended to provide estimates of the economically attractive potential for such energy efficiency gains.

The objectives of this study are as follows:

- To estimate the remaining economically attractive energy savings potential in the Canadian economy from improved energy efficiency.
- To estimate the net environmental benefits (expressed in terms of reductions in emissions) of realizing the economical potential.
- To identify some of the key market barriers impeding the commercialization of economically attractive energy efficient technologies.

To the extent possible, the study results are disaggregated by region, sector and fuel type, and are presented in five year intervals to 2020.

The following definitions are useful in understanding the study results:

- The **economically attractive potential** for energy efficiency gains refers to energy savings which can be achieved at a favourable social benefit-cost ratio, i.e., at a cost below the social opportunity cost of the energy saved.
- The base case against which economically attractive energy efficiency gains are defined is the **frozen efficiency scenario.** Conceptually, this scenario assumes that all future investment is put in place at the same energy intensities as the actual investment put in place in the base year (1988).
- The **market case** scenario is a forecast of the levels of energy use which are likely to actually occur, given an outlook for economic growth and energy prices, and without any changes in government policy intervention.

B. Approach

The level and type of disaggregation required for this study have led us to use an end-use orientation to the energy efficiency analysis, rather than the econometric approach embodied in the InterFuel Substitution Demand ("IFSD") model used by Energy, Mines and Resources Canada ("EMR").

The study approach focuses on case studies of a number of "loci of analysis". Loci of analysis are clusters of energy efficiency opportunity areas, defined in a multi-dimensional matrix with axes of sector/end use/technology.

Case studies were undertaken of the ten loci of analysis described in Exhibit A, **below**.

Exhibit A
Loci of Analysis Selected as Case Studies

Sector	Locus	Case Study Appendix
Residential	New Single Family Space Heating	#1
	Retrofit Single Family Space Heating	#1
	Appliances Including Lighting	#2
Commercial	New Office and Retail	#3
	Retrofit Office and Retail	#3
Transportation	Light Vehicles	#4
Industrial	Chemical Industries	#5
	Forest Industries	#6
	Iron & Steel Industries	#7
	Drivepower	#8

A case study was conducted for each of the ten loci described above. Essentially, a case study involved four basic components:

- Collection of detailed historical energy use data for the locus of analysis.
- Review of all available published reports of relevance.
- Where feasible, analysis of cost and performance data to determine potential.
- A series of discussions with those knowledgeable in the field.

For reporting purposes, some case studies have been grouped; eight separate case study appendices have been produced.

Since the case study approach is selective, it is also necessary to have a comprehensive framework to ensure that the required global estimates of energy efficiency potential reflect 100% of the projected energy baseline.

We have used the SERF model to move to this baseline, as follows:

- Case studies of the potential for energy efficiency gains were undertaken for the ten loci of analysis described above.

- As the next step, preliminary "sector roll-ups" were developed, estimating the aggregate energy efficiency potential in each of the four basic energy sectors. (These estimates are for the year 2020.)

- The four sector roll-ups and their underlying case studies have been incorporated into the SERF format. Judgements have been made by sector as to the appropriate way of "moving to" 2020 levels of potential, and estimates of economically attractive potential have been made for five-year intervals from 1995 to 2020.

C. Economic potential in the case studies

Below we summarize the estimates of economic potential developed in the ten case study loci of analysis. First, however, we summarize some of the major assumptions and caveats which affect the interpretation of study results.

1. Major assumptions and their impact on results

a) Frozen efficiency scenarios

The frozen efficiency scenarios have been made consistent with the Energy Mines and Resources ("EMR")/Environment Canada ("EC") Reference Case of July, 1990, in two aspects:

- Base year (1988) energy use has been made consistent.

- Economic/demographic projections have been made consistent.

To develop the frozen efficiency scenario, marginal energy intensities were frozen at 1988 levels. In practice, it is not possible to implement the marginal frozen efficiency perspective in the three industry sub-sectors which were studied, and average frozen efficiencies were used. The use of average rather than marginal frozen efficiency tends to overstate the magnitude of economic potential.

b) Economically attractive scenarios

Once a frozen efficiency scenario had been developed for a locus of analysis, the case study focused on identifying and evaluating individual energy efficiency technologies. The following guidelines were employed:

- We sought to restrict ourselves to those energy efficiency technologies which can increase energy efficiency without any adjustment in the actual service levels provided to energy users. This is a narrower definition that is sometimes used in studies of energy conservation potential.

- Generally speaking, only currently available technologies were considered (there are exceptions to this in the light vehicles case study).

- Although we explored circumstances in which prices of technology might be expected to decline over time, in practice we have assumed constant real prices for virtually all technologies over the analysis period. Both this and the prior guideline can be viewed as conservative with respect to the ultimate level of potential.

- In the residential appliance and light vehicle case studies, it was necessary to assume that potential efficiency measures are adopted on a North American scale, because of the nature of these industries. There are clearly limits on the realization of this potential, which can be achieved by purely Canadian policy initiatives.

c) Energy prices and discount rates used

As estimates of social opportunity costs, the study uses the energy price projections from the EMR/EC Reference Case. The price projections represent market prices, rather than true social opportunity costs for the energy forms analyzed. In evaluating the energy efficiency technologies, a 7% real discount rate was used. The discount rate represents a social rate, rather than those rates actually used by businesses and consumers to make energy efficiency decisions in Canada. Because we have not yet developed or reviewed up-to-date estimates of true social opportunity costs for various energy forms in Canada, we do not know what the impacts of using such assumptions would be on the results.

The sensitivity of results to higher energy prices was considered in some of the case studies. However, data limitations did not permit us to extend these sensitivity analyses to the aggregate results.

Although in principle the assessment of economically attractive technology depends on the year in which the technology is assumed to be implemented, we have focused our analysis on energy prices in the year 2020. The energy price projections used are unchanged after the year 2000, and are relatively stable for many energy types in the 1990's.

2. Case study results

a) How the case studies worked out

Our methodology was designed around an "ideal" case study, in which:

- The bulk of the energy efficiency potential is in the form of "pure" energy conservation measures, which can be identified and costed.

- There is a good deal of available information which permits the identification and costing of such measures.

In fact, only the residential appliance and light vehicle case studies fell into this broad category. The residential space heating, and new and retrofit office and retail case studies, relied extensively on detailed databases in the files of the consultants, in many cases arising from earlier or concurrent studies.

The case study process was not satisfactory for the forest products and iron and steel, and to a lesser extent, chemical industry case studies. This reflects both weaknesses in the case study methodology as applied to these industrial subsectors, as well as unavailability of relevant data. In particular:

- We found little information of relevance to the study.
- The concept of the frozen efficiency scenario was clearly less valid than for other sectors.
- There was inadequate population data to permit results to be scaled up.

As a consequence, the results for the industrial sector are the weakest of those developed in this study.

b) Summary of case study results

Exhibit B, **overleaf**, summarizes the key case study results.

The results are presented in terms of the magnitude of economic potential for energy efficiency savings in the year 2020, in relation to the frozen efficiency scenario appropriate to each case study. For two of the industry sub-sectors, the case studies did not develop quantitative estimates of potential. The drive power case study estimated drive power savings potential in the three industry subsectors which were case studied, and the range of results presented in the table are for these three sub-sectors.

Exhibit B
Summary of Case Studies
2020 Economically Attractive Potential for Energy Efficiency

Locus	Potential	
	PJ/Year	As % of Frozen Efficiency Energy Use
New and Retrofit Single Family Space Heating	321	44%
Residential Appliances	51	11%
New and Retrofit Office and Retail	212	36%
Light Vehicles	645	44%
Chemical Industries	210	37%
Forest Industries	NA	NA
Iron & Steel Industries	NA	NA
Drivepower	25,000 GWh	20% (15% - 21%)

NA = No estimate made in this case study

D. Aggregating economic potential

The SERF model was used to develop estimates of aggregate economically attractive energy efficiency improvements, at five year intervals to the year 2020. SERF "frozen efficiency" and "economic potential" cases were developed, based on the case studies and sector roll-ups. It was necessary to make assumptions as to the phase in of the intensity improvements determined in the case studies and sector roll ups. The following assumptions were made:

- All building retrofit potential would be available by 1995
- New residential and commercial potential would be available as the new buildings are constructed
- There are explicit stock replacement models in the appliance and transportation sectors of SERF, and the phase-in potential was tied directly to stock replacement.
- Potential in the industrial sector primarily represents replacement, rather than retrofit. In the absence of models of stock replacement, it was assumed that the potential year 2020 intensities would be phased in on a linear basis, over the period to 2005.

The concept of economically attractive potential used in the study is based on purely economic calculations. We have not considered how rapidly this potential might be realized under various scenarios. The practical constraints on implementation can be viewed as barriers to the achievement of potential.

1. Barriers

A continued barrier to the achievement of economically attractive levels of energy efficiency is the so called private-social gap. Historically, this has comprised two elements:

- There have been gaps between the private and social costs of energy. This gap does not exist in the current study, because we have used projections of actual market prices as proxies for social opportunity costs.

- Typically, decision makers in both the private and public sectors use more stringent decision making criteria than those implicit in the net present value decision making criterion, with a social discount rate in real terms of 7%, which was used to calculate economic attractiveness.

Other sector-specific barriers identified in the study include the following:

- In international industries such as passenger vehicles and appliances, products are designed and manufactured to meet the needs of a market which is much broader than the Canadian market. This limits the ability of Canadian consumers and governments to achieve economically attractive levels of potential in Canada alone.

- The magnitude of economically achievable potential in many cases dwarfs the capability of existing infrastructure. For example, there are limited numbers of trained construction trades to implement energy saving measures in residential housing. These constraints limit the rate at which potential could in fact be captured, particularly in the near term.

- In the residential and, more particularly, the commercial sectors, the structure of the development, ownership, and operation of buildings provides a pervasive environment of split incentives. These are barriers not only to the achievement of the "social optimum" efficiency, but even to the achievement of the optimal level of energy efficiency, when viewed from the private financial perspective of the ultimate owners or tenants.

- There is still to some extent an uneven playing field for energy efficiency measures, in which there is no agreement as to the true social or even avoided costs of conventional fuels. There is some distance to go before public utilities provide a set of such signals consistent with the social cost of energy supply in Canada.

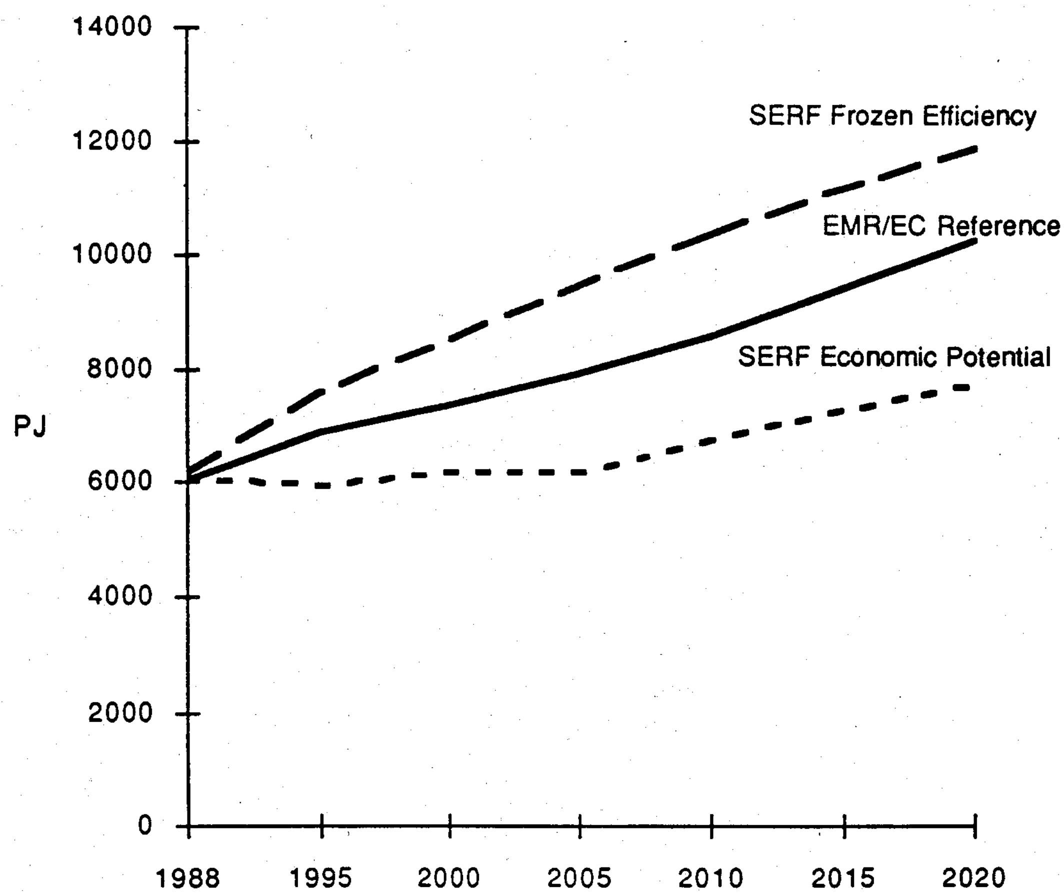
2. Aggregate results

Exhibit C, **overleaf**, provides the aggregate results in graphical form. The three lines on Exhibit C represent, for the period to 2020:

- The SERF frozen efficiency case

- The SERF economically attractive efficiency potential case, and
- The EMR/EC Reference Case of July 1990, which can be considered the "market case".

Exhibit C
Secondary Energy Use — 1988-2020
Comparison of SERF Frozen Efficiency and Economic Potential Cases and EMR/EC Reference Case (excluding biomass)

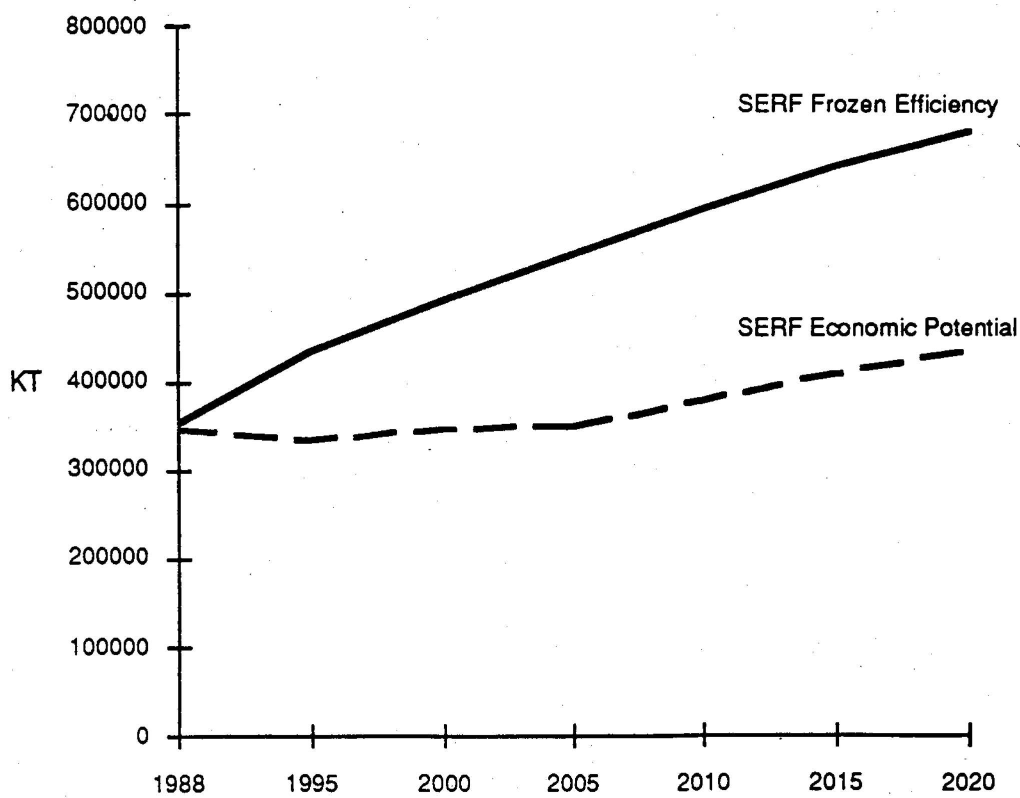


The difference between the frozen efficiency and economic potential cases is the estimated magnitude of economically attractive potential for energy efficiency. The market case, although derived through a different approach than that used in this study, lies between the other two cases in aggregate. Conceptually, the gap between the market case and the economically attractive potential case can be considered the magnitude of the area within which policy might conceivably operate.

E. Environmental impacts

We translated the estimates of economically achievable potential, expressed in secondary energy terms, into associated estimates of reductions in environment emissions. Emissions are estimated by converting the economically attractive energy efficiency demand potential, expressed in primary energy terms, into reductions in environmental emissions, using a series of emissions coefficients provided by EMR. Thus, it was necessary to make a number of assumptions to convert from secondary to primary energy. The most important of these, from the perspective of aggregate results, was the assumption that the fuel shares of electrical generation are frozen at 1988 shares, by region, over the projection period. This probably understates the environmental benefits of efficiency improvements. Exhibit D, **below**, summarizes the impact of achieving conservation potential to 2020. Note that, apart from the adjustment for electricity noted above, Exhibit D reflects CO_2 emissions associated with energy demand - the energy supply industries are excluded from the analyses.

Exhibit D
Carbon Dioxide Emissions — 1988-2020
Comparison of SERF Frozen Efficiency and Economic Potential Cases, and EMR/EC Reference Case



F. Lessons learned

The thrust of this study was to draw on available information on a number of industry sectors, end uses, and energy efficiency technologies, to develop a comprehensive estimate of energy efficiency potential in Canada. The following observations represent some of the major "lessons learned" in this exercise:

- The focus provided by the case study of particular loci of analysis was a key element of the study. In a number of sectors, the approach was very successful. However, it was difficult to apply the case study concept across the board. In particular, in the industrial sector, a more detailed focus, and perhaps a different set of questions, is necessary.

- The conduct of the study required us to compare results from the econometric modelling of energy demand, embodied in the EMR/EC Reference case, with the more disaggregated end use focus of the SERF model. Contrasting these two approaches yields a number of insights into energy efficiency issues.

- The concept of energy efficiency potential applied to the economy as a whole, is not straightforward. Its practical application requires a number of arbitrary analytical assumptions, such as freezing industry output mix, fuel shares, etc. Also it requires specific assumptions as to the appropriate definition of energy efficiency, such as the social benefit/cost perspective implicit in this study. The specific definition used clearly influences the results, and must be selected with care.

- Not surprisingly, the study was most effective in areas for which data of appropriate quality were most readily available. Because there is no adequate database of end use information in the public domain, data availability tended to be best in those areas in which members of the consulting team had done prior work. Without better and more comprehensive data, other researchers exploring this issue will be forced to "reinvent the wheel" to an inappropriate extent.

- For the above reasons, it is necessary to interpret the results of the study with care. This is not because the results are neither interesting nor relevant. It is instead because, in order to derive the results, a number of specific assumptions had to be made. It is necessary to understand both these assumptions, and the specific question which is being addressed in this study, before the results can be understood.

c. 1

KPMG Peat Marwick Stevenson & Kellogg
Management Consultants

Executive Summary

THE ECONOMICALLY ATTRACTIVE POTENTIAL FOR ENERGY EFFICIENCY GAINS IN CANADA

MAY 1991

Prepared for

Efficiency and Alternative Energy Branch
Energy, Mines and Resources Canada
580 Booth Street
Room 1557
Ottawa, Ontario
K1A 0E4

Submitted by

Peat Marwick Stevenson & Kellogg

In association with:

Marbek Resource Consultants
Torrie Smith Associates
WATSRF

Toronto
May 15, 1991
MR/8966/cw-f

FOREWORD

This document summarizes the findings of a study completed for the Efficiency and Alternative Energy Branch by Peat Marwick Stevenson and Kellogg Management Consultants in association with Marbek Resource Consultants Limited, Torrie Smith and Associates, and WATSRF at the University of Waterloo. The views expressed in the report are those of the authors, and do not necessarily reflect the position of Energy, Mines and Resources Canada (EMR).

The primary objective of the study was to estimate the economically attractive energy efficiency potential in Canada. For the purpose of this study, energy efficiency potential is a precisely defined term specified on page 1 of the attached Executive Summary. To estimate the potential, the authors adopted a case study approach in which a number of areas of energy use were analysed in depth. The results of these studies and general estimates of potential for the remaining end use areas were aggregated to obtain an overall estimate of the potential for energy efficiency in Canada. The list of case studies prepared for this project is presented on page 2 of the attached summary report. The main report as well as the ten case studies, arranged into eight separate appendices, are available on request.

As the authors point out in the report, estimating energy efficiency potential is a complex task, frequently constrained by a paucity of good quality data. In some areas, it is difficult to establish an analytical framework that effectively separates energy efficiency potential from industrial processes or lifestyle changes. It is important that the reader understand these caveats, and ensure they are given appropriate weight in interpreting study results. Nonetheless, EMR believes the study offers a useful reference point from which future work in this area can evolve.

In an effort to gain a better appreciation of the concept of energy efficiency potential, the Efficiency and Alternative Energy Branch and the Energy Policy Branch of EMR Canada hosted a *Workshop on the Potential for Energy Efficiency in Canada* on April 16, 1991 for the benefit of senior federal government policy advisors. The objective of the workshop was twofold: to introduce the audience to some of the current thinking on the subject of energy efficiency potential and to present the findings of a preliminary version of the Peat Marwick study. The workshop was organized for EMR by The Conference Board of Canada, who provided Rapporteur's notes on the day's proceedings. These notes are also available on request.

Efficiency and Alternative
Energy Branch, EMR Canada

Contents
Executive Summary

Executive Summary

A. Introduction

Despite significant gains in energy efficiency since the early 1970's, there appears to be a considerable further untapped, cost-effective potential for energy efficiency gains in Canada. This study is intended to provide estimates of the economically attractive potential for such energy efficiency gains.

The objectives of this study are as follows:

- To estimate the remaining economically attractive energy savings potential in the Canadian economy from improved energy efficiency.
- To estimate the net environmental benefits (expressed in terms of reductions in emissions) of realizing the economical potential.
- To identify some of the key market barriers impeding the commercialization of economically attractive energy efficient technologies.

To the extent possible, the study results are disaggregated by region, sector and fuel type, and are presented in five year intervals to 2020.

The following definitions are useful in understanding the study results:

- The **economically attractive potential** for energy efficiency gains refers to energy savings which can be achieved at a favourable social benefit-cost ratio, i.e., at a cost below the social opportunity cost of the energy saved.
- The base case against which economically attractive energy efficiency gains are defined is the **frozen efficiency scenario**. Conceptually, this scenario assumes that all future investment is put in place at the same energy intensities as the actual investment put in place in the base year (1988).
- The **market case** scenario is a forecast of the levels of energy use which are likely to actually occur, given an outlook for economic growth and energy prices, and without any changes in government policy intervention.

B. Approach

The level and type of disaggregation required for this study have led us to use an end-use orientation to the energy efficiency analysis, rather than the econometric approach embodied in the InterFuel Substitution Demand ("IFSD") model used by Energy, Mines and Resources Canada ("EMR").

The study approach focuses on case studies of a number of "loci of analysis". Loci of analysis are clusters of energy efficiency opportunity areas, defined in a multi-dimensional matrix with axes of sector/end use/technology.

Case studies were undertaken of the ten loci of analysis described in Exhibit A, **below**.

Exhibit A
Loci of Analysis Selected as Case Studies

Sector	Locus	Case Study Appendix
Residential	New Single Family Space Heating	#1
	Retrofit Single Family Space Heating	#1
	Appliances Including Lighting	#2
Commercial	New Office and Retail	#3
	Retrofit Office and Retail	#3
Transportation	Light Vehicles	#4
Industrial	Chemical Industries	#5
	Forest Industries	#6
	Iron & Steel Industries	#7
	Drivepower	#8

A case study was conducted for each of the ten loci described above. Essentially, a case study involved four basic components:

- Collection of detailed historical energy use data for the locus of analysis.
- Review of all available published reports of relevance.
- Where feasible, analysis of cost and performance data to determine potential.
- A series of discussions with those knowledgeable in the field.

For reporting purposes, some case studies have been grouped; eight separate case study appendices have been produced.

Since the case study approach is selective, it is also necessary to have a comprehensive framework to ensure that the required global estimates of energy efficiency potential reflect 100% of the projected energy baseline.

We have used the SERF model to move to this baseline, as follows:

- Case studies of the potential for energy efficiency gains were undertaken for the ten loci of analysis described above.

- As the next step, preliminary "sector roll-ups" were developed, estimating the aggregate energy efficiency potential in each of the four basic energy sectors. (These estimates are for the year 2020.)

- The four sector roll-ups and their underlying case studies have been incorporated into the SERF format. Judgements have been made by sector as to the appropriate way of "moving to" 2020 levels of potential, and estimates of economically attractive potential have been made for five-year intervals from 1995 to 2020.

C. Economic potential in the case studies

Below we summarize the estimates of economic potential developed in the ten case study loci of analysis. First, however, we summarize some of the major assumptions and caveats which affect the interpretation of study results.

1. Major assumptions and their impact on results

a) Frozen efficiency scenarios

The frozen efficiency scenarios have been made consistent with the Energy Mines and Resources ("EMR")/Environment Canada ("EC") Reference Case of July, 1990, in two aspects:

- Base year (1988) energy use has been made consistent.

- Economic/demographic projections have been made consistent.

To develop the frozen efficiency scenario, marginal energy intensities were frozen at 1988 levels. In practice, it is not possible to implement the marginal frozen efficiency perspective in the three industry sub-sectors which were studied, and average frozen efficiencies were used. The use of average rather than marginal frozen efficiency tends to overstate the magnitude of economic potential.

b) Economically attractive scenarios

Once a frozen efficiency scenario had been developed for a locus of analysis, the case study focused on identifying and evaluating individual energy efficiency technologies. The following guidelines were employed:

- We sought to restrict ourselves to those energy efficiency technologies which can increase energy efficiency without any adjustment in the actual service levels provided to energy users. This is a narrower definition that is sometimes used in studies of energy conservation potential.

- Generally speaking, only currently available technologies were considered (there are exceptions to this in the light vehicles case study).

- Although we explored circumstances in which prices of technology might be expected to decline over time, in practice we have assumed constant real prices for virtually all technologies over the analysis period. Both this and the prior guideline can be viewed as conservative with respect to the ultimate level of potential.

- In the residential appliance and light vehicle case studies, it was necessary to assume that potential efficiency measures are adopted on a North American scale, because of the nature of these industries. There are clearly limits on the realization of this potential, which can be achieved by purely Canadian policy initiatives.

c) Energy prices and discount rates used

As estimates of social opportunity costs, the study uses the energy price projections from the EMR/EC Reference Case. The price projections represent market prices, rather than true social opportunity costs for the energy forms analyzed. In evaluating the energy efficiency technologies, a 7% real discount rate was used. The discount rate represents a social rate, rather than those rates actually used by businesses and consumers to make energy efficiency decisions in Canada. Because we have not yet developed or reviewed up-to-date estimates of true social opportunity costs for various energy forms in Canada, we do not know what the impacts of using such assumptions would be on the results.

The sensitivity of results to higher energy prices was considered in some of the case studies. However, data limitations did not permit us to extend these sensitivity analyses to the aggregate results.

Although in principle the assessment of economically attractive technology depends on the year in which the technology is assumed to be implemented, we have focused our analysis on energy prices in the year 2020. The energy price projections used are unchanged after the year 2000, and are relatively stable for many energy types in the 1990's.

2. Case study results

a) How the case studies worked out

Our methodology was designed around an "ideal" case study, in which:

- The bulk of the energy efficiency potential is in the form of "pure" energy conservation measures, which can be identified and costed.

- There is a good deal of available information which permits the identification and costing of such measures.

In fact, only the residential appliance and light vehicle case studies fell into this broad category. The residential space heating, and new and retrofit office and retail case studies, relied extensively on detailed databases in the files of the consultants, in many cases arising from earlier or concurrent studies.

The case study process was not satisfactory for the forest products and iron and steel, and to a lesser extent, chemical industry case studies. This reflects both weaknesses in the case study methodology as applied to these industrial subsectors, as well as unavailability of relevant data. In particular:

- We found little information of relevance to the study.
- The concept of the frozen efficiency scenario was clearly less valid than for other sectors.
- There was inadequate population data to permit results to be scaled up.

As a consequence, the results for the industrial sector are the weakest of those developed in this study.

b) Summary of case study results

Exhibit B, **overleaf**, summarizes the key case study results.

The results are presented in terms of the magnitude of economic potential for energy efficiency savings in the year 2020, in relation to the frozen efficiency scenario appropriate to each case study. For two of the industry sub-sectors, the case studies did not develop quantitative estimates of potential. The drive power case study estimated drive power savings potential in the three industry subsectors which were case studied, and the range of results presented in the table are for these three sub-sectors.

Exhibit B
Summary of Case Studies
2020 Economically Attractive Potential for Energy Efficiency

Locus	Potential PJ/Year	Potential As % of Frozen Efficiency Energy Use
New and Retrofit Single Family Space Heating	321	44%
Residential Appliances	51	11%
New and Retrofit Office and Retail	212	36%
Light Vehicles	645	44%
Chemical Industries	210	37%
Forest Industries	NA	NA
Iron & Steel Industries	NA	NA
Drivepower	25,000 GWh	20% (15% - 21%)

NA = No estimate made in this case study

D. Aggregating economic potential

The SERF model was used to develop estimates of aggregate economically attractive energy efficiency improvements, at five year intervals to the year 2020. SERF "frozen efficiency" and "economic potential" cases were developed, based on the case studies and sector roll-ups. It was necessary to make assumptions as to the phase in of the intensity improvements determined in the case studies and sector roll ups. The following assumptions were made:

- All building retrofit potential would be available by 1995
- New residential and commercial potential would be available as the new buildings are constructed
- There are explicit stock replacement models in the appliance and transportation sectors of SERF, and the phase-in potential was tied directly to stock replacement.
- Potential in the industrial sector primarily represents replacement, rather than retrofit. In the absence of models of stock replacement, it was assumed that the potential year 2020 intensities would be phased in on a linear basis, over the period to 2005.

The concept of economically attractive potential used in the study is based on purely economic calculations. We have not considered how rapidly this potential might be realized under various scenarios. The practical constraints on implementation can be viewed as barriers to the achievement of potential.

1. Barriers

A continued barrier to the achievement of economically attractive levels of energy efficiency is the so called private-social gap. Historically, this has comprised two elements:

- There have been gaps between the private and social costs of energy. This gap does not exist in the current study, because we have used projections of actual market prices as proxies for social opportunity costs.

- Typically, decision makers in both the private and public sectors use more stringent decision making criteria than those implicit in the net present value decision making criterion, with a social discount rate in real terms of 7%, which was used to calculate economic attractiveness.

Other sector-specific barriers identified in the study include the following:

- In international industries such as passenger vehicles and appliances, products are designed and manufactured to meet the needs of a market which is much broader than the Canadian market. This limits the ability of Canadian consumers and governments to achieve economically attractive levels of potential in Canada alone.

- The magnitude of economically achievable potential in many cases dwarfs the capability of existing infrastructure. For example, there are limited numbers of trained construction trades to implement energy saving measures in residential housing. These constraints limit the rate at which potential could in fact be captured, particularly in the near term.

- In the residential and, more particularly, the commercial sectors, the structure of the development, ownership, and operation of buildings provides a pervasive environment of split incentives. These are barriers not only to the achievement of the "social optimum" efficiency, but even to the achievement of the optimal level of energy efficiency, when viewed from the private financial perspective of the ultimate owners or tenants.

- There is still to some extent an uneven playing field for energy efficiency measures, in which there is no agreement as to the true social or even avoided costs of conventional fuels. There is some distance to go before public utilities provide a set of such signals consistent with the social cost of energy supply in Canada.

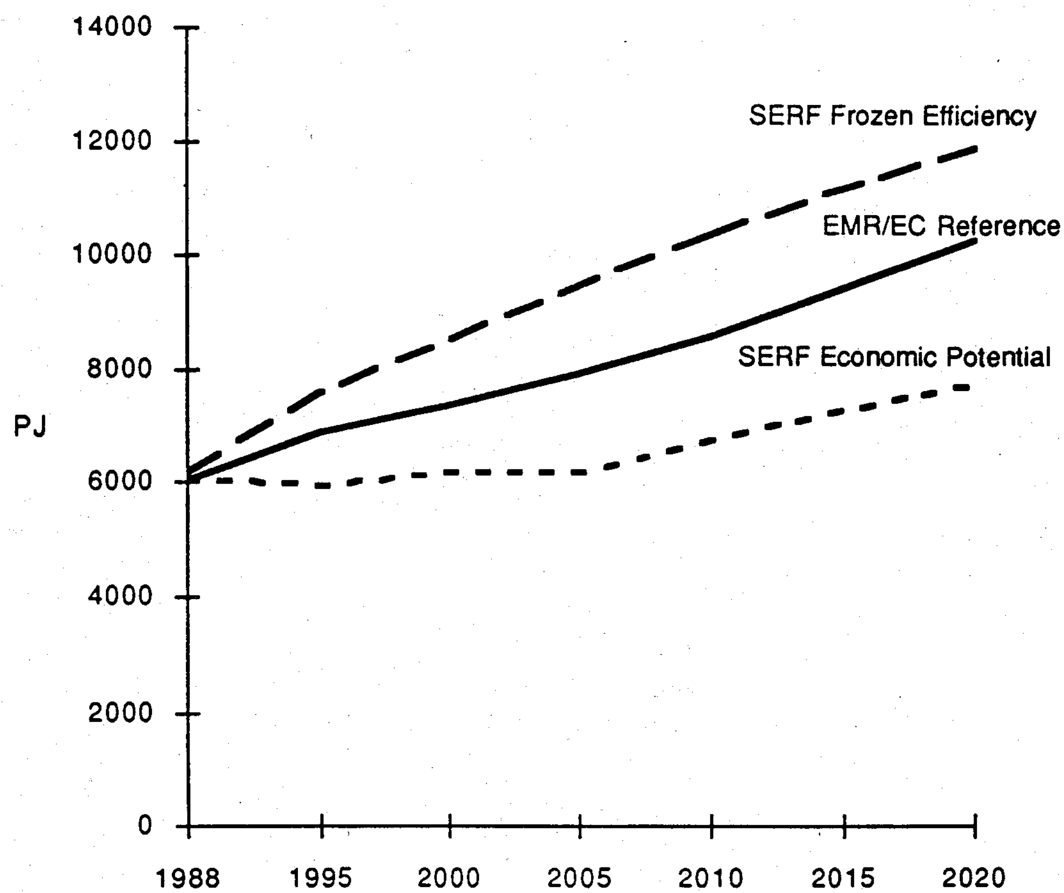
2. Aggregate results

Exhibit C, **overleaf**, provides the aggregate results in graphical form. The three lines on Exhibit C represent, for the period to 2020:

- The SERF frozen efficiency case

- The SERF economically attractive efficiency potential case, and
- The EMR/EC Reference Case of July 1990, which can be considered the "market case".

Exhibit C
Secondary Energy Use — 1988-2020
Comparison of SERF Frozen Efficiency and Economic Potential Cases and EMR/EC Reference Case (excluding biomass)

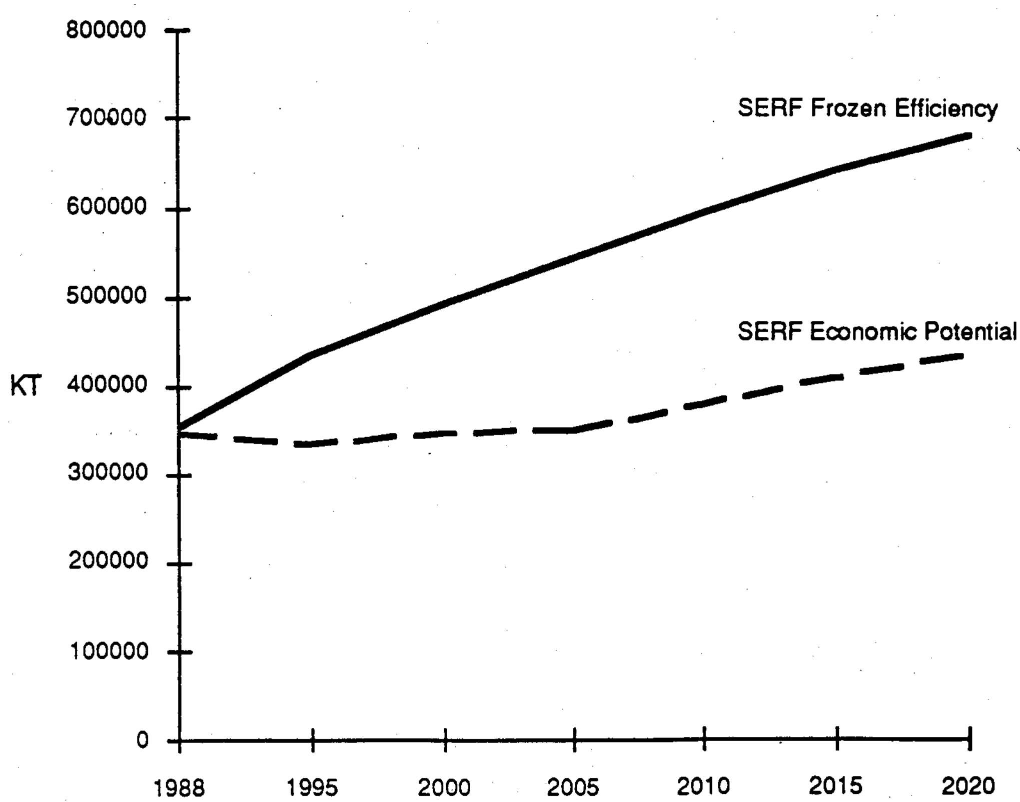


The difference between the frozen efficiency and economic potential cases is the estimated magnitude of economically attractive potential for energy efficiency. The market case, although derived through a different approach than that used in this study, lies between the other two cases in aggregate. Conceptually, the gap between the market case and the economically attractive potential case can be considered the magnitude of the area within which policy might conceivably operate.

E. Environmental impacts

We translated the estimates of economically achievable potential, expressed in secondary energy terms, into associated estimates of reductions in environment emissions. Emissions are estimated by converting the economically attractive energy efficiency demand potential, expressed in primary energy terms, into reductions in environmental emissions, using a series of emissions coefficients provided by EMR. Thus, it was necessary to make a number of assumptions to convert from secondary to primary energy. The most important of these, from the perspective of aggregate results, was the assumption that the fuel shares of electrical generation are frozen at 1988 shares, by region, over the projection period. This probably understates the environmental benefits of efficiency improvements. Exhibit D, **below**, summarizes the impact of achieving conservation potential to 2020. Note that, apart from the adjustment for electricity noted above, Exhibit D reflects CO_2 emissions associated with energy demand - the energy supply industries are excluded from the analyses.

Exhibit D
Carbon Dioxide Emissions — 1988-2020
Comparison of SERF Frozen Efficiency and Economic Potential Cases, and EMR/EC Reference Case



F. Lessons learned

The thrust of this study was to draw on available information on a number of industry sectors, end uses, and energy efficiency technologies, to develop a comprehensive estimate of energy efficiency potential in Canada. The following observations represent some of the major "lessons learned" in this exercise:

- The focus provided by the case study of particular loci of analysis was a key element of the study. In a number of sectors, the approach was very successful. However, it was difficult to apply the case study concept across the board. In particular, in the industrial sector, a more detailed focus, and perhaps a different set of questions, is necessary.

- The conduct of the study required us to compare results from the econometric modelling of energy demand, embodied in the EMR/EC Reference case, with the more disaggregated end use focus of the SERF model. Contrasting these two approaches yields a number of insights into energy efficiency issues.

- The concept of energy efficiency potential applied to the economy as a whole, is not straightforward. Its practical application requires a number of arbitrary analytical assumptions, such as freezing industry output mix, fuel shares, etc. Also it requires specific assumptions as to the appropriate definition of energy efficiency, such as the social benefit/cost perspective implicit in this study. The specific definition used clearly influences the results, and must be selected with care.

- Not surprisingly, the study was most effective in areas for which data of appropriate quality were most readily available. Because there is no adequate database of end use information in the public domain, data availability tended to be best in those areas in which members of the consulting team had done prior work. Without better and more comprehensive data, other researchers exploring this issue will be forced to "reinvent the wheel" to an inappropriate extent.

- For the above reasons, it is necessary to interpret the results of the study with care. This is not because the results are neither interesting nor relevant. It is instead because, in order to derive the results, a number of specific assumptions had to be made. It is necessary to understand both these assumptions, and the specific question which is being addressed in this study, before the results can be understood.