

**ADVANCED HOUSES PROGRAM  
PROGRAMME DE MAISONS PERFORMANTES**

**Advanced Houses  
Technology Assessment  
Supporting Documentation**

**Prepared For:**

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Buildings Group - Energy Sector  
Department of Natural Resources Canada  
Ottawa, Ontario, Canada, K1A 0E4  
SSC File No. 007SQ.234440-94-1408  
December 1995

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## **CITATION**

Scanada Consultants Limited. *Advanced Houses Technical Assessment, Supporting Documentation*, DSS Contract No. 007SQ.23440-94-1408. Buildings Group, Energy Sector, CANMET Energy Technology Centre – Ottawa, Department of Natural Resources Canada, Ottawa, Ontario, 1995. (259 pages).

Copies of this report may be obtained through the following:

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## **NOTE**

Funding for this project was provided by the Federal Panel on Energy Research and Development, Department of Natural Resources Canada.

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Supporting Documentation  
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## **Introduction**

The Advanced Houses Program has been the most ambitious and successful demonstration of energy-efficient and environmentally responsible housing undertaken to date, either in Canada or internationally. Characterized by an unprecedented level of industry participation and leveraged financing, the Program fostered the development of numerous innovative technologies which have the potential to drastically reduce energy consumption and greenhouse gas emissions from the housing sector, while creating the opportunity for domestic and export business growth.

This assessment of Advanced House technologies was commissioned by CANMET/NRCan, with funding from the Panel for Energy Research and Development (PERD), in order to identify the most promising technologies (according to CANMET priorities) emerging from the Program and to determine appropriate action by the federal government to capitalize on the opportunities presented.

Scanada Consultants Ltd. of Ottawa undertook the study, with a team consisting of Kevin Lee, Anil Parekh, Terry Robinson and Bob Platts. Tim Mayo served as CANMET's project manager, with Mark Riley, Robin Sinha and Tom Hamlin also providing input.

The "Summary Report: Advanced House Technologies Assessment", which is published separately, highlights the study's findings. Please refer to the Summary Report for all conclusions and recommendations.

This report, "Supporting Documentation: Advanced House Technologies Assessment", is a compendium of the appendices which provide more detailed information on the study. The following summarizes the contents of the five appendices.

### **Appendix A: The Assessment Framework and Process**

This Appendix documents the study's first major task, which was the development of an assessment framework which would identify the most promising technologies, while reflecting CANMET's priorities. The assumptions underlying the Detailed Assessments and the two Preliminary Assessments are described. The issues and limitations relating to the assessment framework are also outlined.

### **Appendix B: Preliminary Assessments**

This section documents the results of the two screening assessments, Energy/Environment Benefits and Business Potential, and briefly summarizes the recommendations emerging from the March 15/95 Experts' Meeting. Summary assessments are provided for the approximately forty technologies screened. Additional technologies which were not assessed but which are worthy of further study are also listed.

**Appendix C: Preliminary Assessment Sheets for Advanced House Technologies**

This Appendix contains the assessment sheets used to document and rank technologies during the screening steps. These sheets describe the technologies, provide energy/environment and business potential scores and explanations, and include an overall assessment and recommendation.

**Appendix D: Detailed Assessments**

The complete Detailed Assessments undertaken of nine promising technologies are provided in this Appendix. These include descriptions, current status, energy and environmental performance, cost analysis and market potential, national energy/greenhouse gas and environmental benefits, issues affecting adoption and recommended actions to accelerate commercialization.

**Appendix E: Energy and Environmental Assessment of Advanced House Technologies**

This Appendix contains the background data utilized in performing the Preliminary and Detailed Assessments. Included are housing stock data, energy performance characteristics of thermal archetypes, greenhouse gas emission factors and market penetration scenarios. Also included are the spreadsheets and graphical summaries used in the Detailed Assessments to model the potential annual energy/greenhouse gas reductions of each technology by fuel type, house era and region.

## **Introduction**

Le Programme de la Maison performante s'est avéré la plus ambitieuse et la plus réussie des démonstrations d'efficacité énergétique et de responsabilité environnementale dans le domaine de l'habitation jamais entreprise jusqu'à maintenant, et ce tant à l'échelle nationale qu'internationale. Caractérisé par un niveau sans précédent de participation du secteur industriel, ainsi que de financement spéculatif, le Programme a permis le développement de plusieurs techniques révolutionnaires qui sont aptes à réduire d'une façon substantielle la consommation énergétique et les émissions de gaz à effet de serre dans le secteur de l'habitation, tout en suscitant des possibilités de croissance dans les affaires intérieures et le commerce extérieur.

CANMET, à Ressources naturelles Canada, a sollicité la présente évaluation, profitant d'un financement provenant du Programme de recherche et de développement énergétiques (PRDE), dans le but de déterminer quelles sont les techniques les plus prometteuses (en fonction des priorités de CANMET) du Programme de la Maison performante et les mesures à prendre pour que le gouvernement fédéral puisse bénéficier des possibilités qu'il offre.

La société Scanada Consultants d'Ottawa a entrepris l'étude en question en faisant appel à une équipe composée de Kevin Lee, Anil Parekh, Terry Robinson et Bob Platts. Tim Mayo a agi en tant que gestionnaire de projet pour CANMET, avec l'aide de Mark Riley, Robin Sinha et Tom Hamlin qui ont également participé à la réalisation de cette entreprise.

Un rapport publié séparément, intitulé *Summary Report: Advanced House Technologies Assessment*, donne les grandes lignes des conclusions de l'étude. Veuillez donc vous y référer pour prendre connaissance de l'ensemble des conclusions et des recommandations.

Le présent rapport, intitulé *Supporting Documentation: Advanced House Technologies Assessment*, constitue un abrégé des annexes qui contiennent des informations plus détaillées sur l'étude. Voici donc un résumé des cinq annexes en question :

### **Annexe A : Le procédé et le cadre d'évaluation**

Cette annexe recèle les documents relatifs à l'objectif premier de l'étude qui consistait à l'élaboration d'un cadre d'évaluation permettant de préciser les techniques les plus prometteuses tout en prenant en compte les priorités de CANMET. On y décrit les hypothèses qui sous-tendent les évaluations détaillées et les deux évaluations préliminaires. Il en va de même des questions et des restrictions reliées au cadre d'évaluation.

**Annexe B : Les évaluations préliminaires**

Cette partie contient les résultats des deux évaluations de sélection, soit les avantages en matière d'énergie et d'environnement, ainsi que les possibilités d'affaires, en plus de fournir un bref résumé des conclusions qui ont suivi la tenue d'une réunion d'experts le 15 mars 1995. On y donne le résumé des évaluations d'une quarantaine de techniques sélectionnées. Finalement, y apparaît la liste d'autres techniques qui n'ont pas fait l'objet d'évaluation, mais qui mériteraient plus ample considération.

**Annexe C : Des formules d'évaluation préliminaire pour techniques de Maisons performantes**

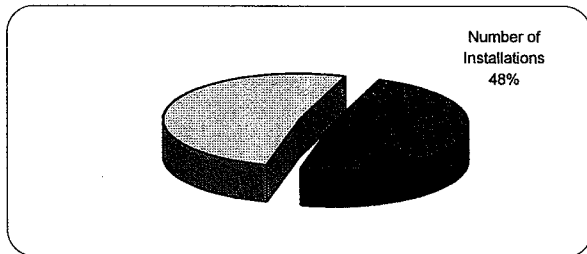
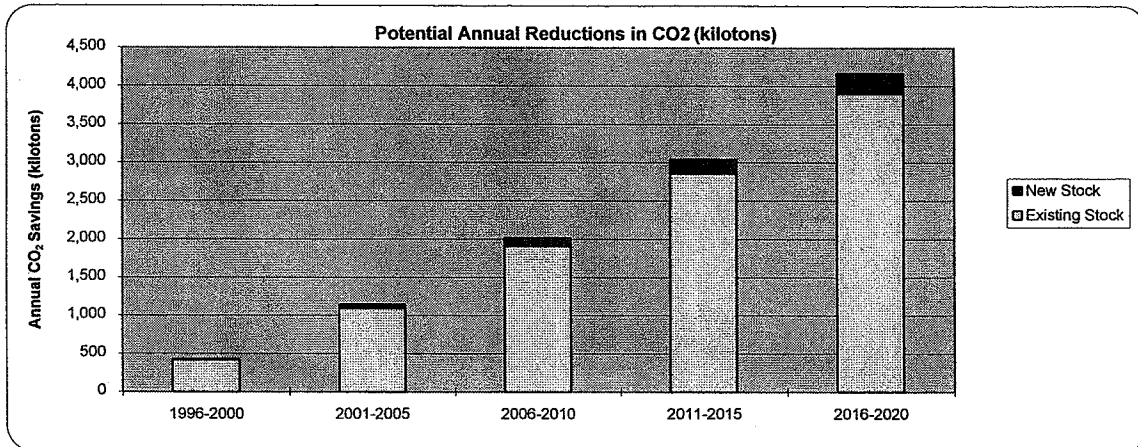
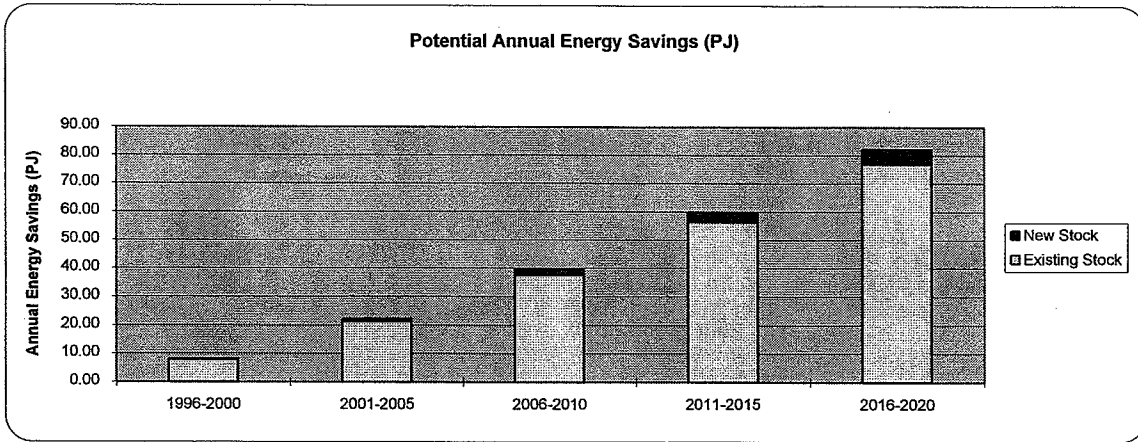
Cette annexe contient les formules d'évaluation utilisée pour expliquer et classer les techniques au cours des étapes de sélection. Ainsi, ces formules décrivent les techniques, fournissent l'évaluation chiffrée et les explications relativement aux possibilités énergétiques, environnementales et de mise en marché, et rendent compte de l'évaluation globale et des recommandations.

**Annexe D : Des évaluations détaillées**

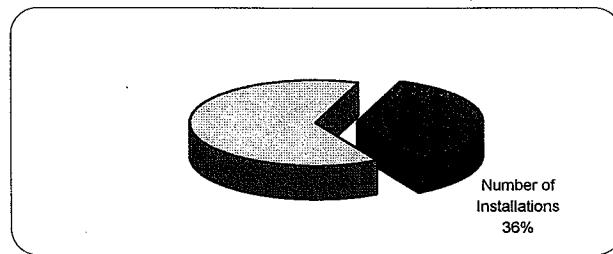
Dans cette annexe, on retrouve les évaluations détaillées des neuf techniques les plus prometteuses. Sont ainsi fournis la description de la technique, sa condition actuelle, son rendement énergétique et environnemental, l'analyse de ses coûts et ses possibilités commerciales, ses avantages en matière d'énergie, de contrôle des gaz à effet de serre et d'environnement sur le territoire canadien, les enjeux relatifs à son adoption et les mesures recommandées pour en accélérer la commercialisation.

**Annexe E : Évaluation énergétique et environnementale des techniques liées aux Maisons performantes**

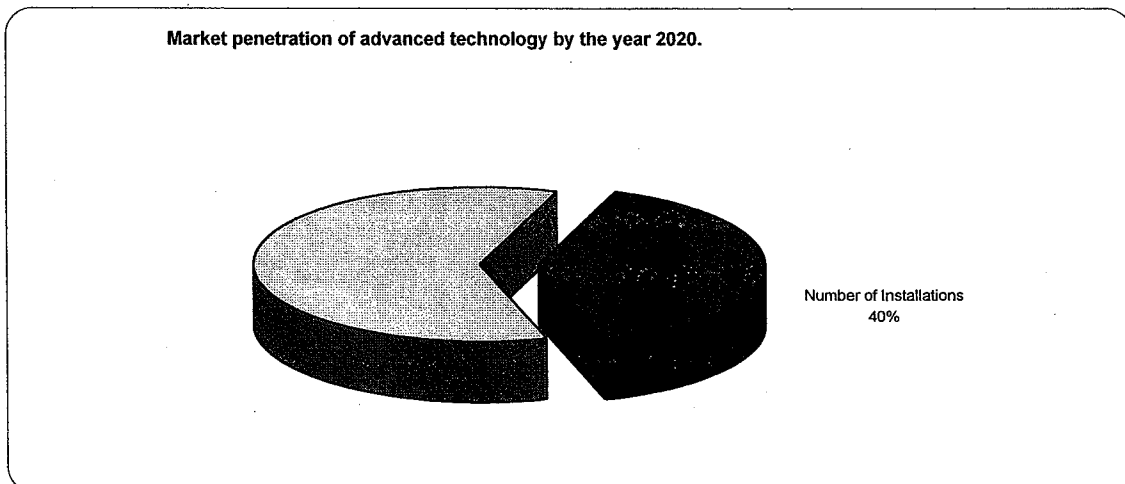
Cette annexe présente les données de base ayant servi à la réalisation des évaluations préliminaires et détaillées. Parmi celles-ci, on retrouve les données concernant le stock d'habitations, les caractéristiques du rendement énergétique des prototypes thermiques, les facteurs d'émission de gaz à effet de serre et les plans de pénétration des marchés. Y apparaissent également des tableaux numériques et des aperçus graphiques utilisés dans les évaluations détaillées pour modéliser les possibilités annuelles de réduction de la consommation énergétique et des gaz à effet de serre dans le cas de chacune des techniques et ce, selon le genre de combustible, ainsi que le secteur et la région où se trouve l'habitation.



Market penetration in new housing stock built during 1994-2020 by the year 2020.



Market penetration in existing housing stock built up to 1993 by the year 2020.





## HOT-2000 Simulation Runs

**20. Simulation Results**

Base Systems and Fuels:	All fuels
New Fuels:	All fuels

**Energy consumption for the "typical" houses (kWh)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	102,953.5	115,751.9	91,025.2	136,367.7	88,056.4
	Upgrade	93,787.4	105,441.2	82,688.8	124,487.5	61,660.6
1946-1960	Base	69,546.1	78,245.6	61,472.5	91,114.7	46,842.7
	Upgrade	60,377.3	67,841.4	52,985.9	79,167.4	40,601.7
1961-1980	Base	60,598.6	67,587.8	52,948.4	78,704.5	40,392.6
	Upgrade	56,038.2	62,456.2	48,728.4	72,830.8	37,365.9
1981-1993	Base	34,214.7	37,990.6	29,396.3	44,382.0	22,414.1
	Upgrade	30,632.2	33,949.0	26,133.7	39,738.2	20,163.4
National Energy Code / new R-2000	Base	25,541.4	29,275.9	23,191.5	35,095.0	14,490.3
	Upgrade	24,531.8	28,093.2	22,256.6	33,690.6	14,015.6

Floor Area 155.00 sqm

**Energy consumption per unit floor area (kWh/m<sup>2</sup>)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	664.2	746.8	587.3	879.8	439.1
	Upgrade	605.1	680.3	533.5	803.1	397.8
1946-1960	Base	448.7	504.8	396.6	587.8	302.2
	Upgrade	399.5	437.7	341.8	510.8	261.3
1961-1980	Base	390.8	436.1	341.6	507.8	260.6
	Upgrade	361.5	402.9	314.4	469.9	241.1
1981-1993	Base	220.7	245.1	189.7	286.3	144.6
	Upgrade	197.6	219.0	168.6	256.4	130.1
National Energy Code / new R-2000	Base	164.8	188.9	149.6	226.4	93.5
	Upgrade	158.3	181.2	143.6	217.4	90.4

**Energy Savings per Unit Floor Area, kWh/m<sup>2</sup>**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		59.14	66.52	53.78	76.65	41.26
1946-1960		59.15	67.12	54.75	77.08	40.91
1961-1980		29.23	33.11	27.23	37.89	19.53
1981-1993		23.11	26.07	21.05	29.96	14.52
NEC / new R-2000		6.51	7.63	5.97	9.06	3.06

**Percentage reduction in space heat and DHW energy consumption per house, %**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		8.9%	8.9%	9.2%	8.7%	9.4%
1946-1960		13.2%	13.3%	13.8%	13.1%	13.5%
1961-1980		7.5%	7.6%	8.0%	7.5%	7.5%
1981-1993		10.5%	10.6%	11.1%	10.5%	10.0%
NEC / new R-2000		4.0%	4.0%	4.0%	4.0%	3.3%

## Detailed Calculations

**21. New Construction - Housing stock projections (Single, semi-detached and row) - VISION 1992-2020**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	7,961,544	617,289	1,396,232	3,285,382	1,462,551	1,200,090
2000	8,378,640	649,628	1,469,379	3,457,499	1,539,173	1,262,961
2005	8,897,720	689,874	1,560,411	3,671,701	1,634,529	1,341,205
2010	9,470,970	734,320	1,660,943	3,908,256	1,739,836	1,427,614
2015	10,073,990	781,075	1,766,696	4,157,096	1,850,612	1,518,511
2020	10,686,303	828,550	1,874,079	4,409,771	1,963,095	1,610,808

**22. New Construction - Housing stock projections (Single, semi-detached and row)**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	310,955	28,163	71,489	110,594	59,135	41,575
2000	417,096	37,776	95,891	148,344	79,320	55,766
2005	519,080	47,012	119,337	184,616	98,714	69,401
2010	573,250	51,918	131,791	203,882	109,016	76,644
2015	603,020	54,615	138,635	214,470	114,677	80,624
2020	612,313	55,456	140,771	217,775	116,444	81,866
<b>Total</b>	<b>3,035,714</b>	<b>274,940</b>	<b>697,913</b>	<b>1,079,681</b>	<b>577,305</b>	<b>405,875</b>

**23. Existing Housing Stock (Single) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,351,153	176,173	220,592	537,691	279,452	137,245
1946-1960	1,356,041	116,284	235,390	523,527	294,130	186,710
1961-1970	875,044	77,904	185,087	291,760	186,788	133,505
1971-1980	1,156,834	123,055	227,748	318,531	275,851	211,649
1981-1993	1,248,212	111,103	246,432	449,462	226,026	215,189
<b>Total</b>	<b>5,987,284</b>	<b>604,519</b>	<b>1,115,249</b>	<b>2,120,971</b>	<b>1,262,247</b>	<b>884,298</b>

**24. Existing Housing Stock (semi-detached and row) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	507,552	29,932	261,940	179,050	22,520	14,110
1946-1960	308,440	14,910	174,255	66,735	33,715	18,825
1961-1970	249,519	15,775	99,200	83,660	30,359	20,525
1971-1980	308,931	14,779	47,276	158,968	59,112	28,796
1981-1993	288,863	12,986	60,956	111,623	46,968	56,330
<b>Total</b>	<b>1,663,305</b>	<b>88,382</b>	<b>643,627</b>	<b>600,036</b>	<b>192,674</b>	<b>138,586</b>

## 25. Existing Housing Stock (Single, semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC	%age of total
Pre-1945	1,858,705	206,105	482,532	716,741	301,972	151,355	24.3%
1946-1960	1,664,481	131,194	409,645	590,262	327,845	205,535	21.8%
1961-1970	1,124,563	93,679	284,287	375,420	217,147	154,030	14.7%
1971-1980	1,465,765	137,834	275,024	477,499	334,963	240,445	19.2%
1981-1993	1,537,075	124,089	307,388	561,085	272,994	271,519	20.1%
Total	7,650,589	692,901	1,758,876	2,721,007	1,454,921	1,022,884	100.0%
%age of total		9.06%	22.99%	35.57%	19.02%	13.37%	
Single/Total		7.75%	17.54%	41.27%	18.37%	15.07%	

## 26. Existing Housing Average Floor Space (m2) (Single, semi-detached and row) - STAR-Housing

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	159	147	160	174	130	146
1946-1960	165	161	168	183	133	157
1961-1970	170	176	160	184	151	179
1971-1980	164	176	147	172	149	181
1981-1993	156	153	153	160	150	160

## 27. Existing housing stock potential energy savings (GWh) assuming 100% market penetration

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	17,542	1,797	5,136	6,696	3,004	909
1946-1960	16,472	1,253	4,622	5,905	3,373	1,319
1961-1970	11,444	977	3,046	3,772	2,523	1,127
1971-1980	7,025	709	1,340	2,230	1,894	852
1981-1993	5,409	437	1,223	1,887	1,229	632
Total (GWh)	57,891	5,174	15,367	20,489	12,022	4,840
Total (PJ)	208.41	18.62	55.32	73.76	43.28	17.42

## 28. Fuel Use Summary % (1993 - Statistics Canada)

	Electricity	Oil	Natural Gas	Wood	Propane
Atlantic	41.14	51.58	0.00	3.57	3.71
Quebec	65.00	22.90	8.60	3.50	0.00
Ontario	18.00	16.50	62.70	2.80	0.00
Prairies	17.24	15.41	67.09	0.26	0.00
BC	27.30	11.20	56.20	5.30	0.00
Canada	32.00	20.24	44.55	2.88	0.34

## 29. Potential Energy Savings by Fuel Type - Existing Stock - assuming 100% market penetrations, PJ

	Electricity	Oil	Natural Gas	Wood	Propane	Total
Atlantic	7.66	9.61	0.00	0.66	0.69	18.63
Quebec	35.96	12.67	4.76	1.94	0.00	55.32
Ontario	13.28	12.17	46.25	2.07	0.00	73.76
Prairies	7.46	6.67	29.04	0.11	0.00	43.28
BC	4.76	1.95	9.79	0.92	0.00	17.42
Canada	69.12	43.07	89.83	5.70	0.69	208.41

## 30. Residential Energy Demand by Fuels (VISION 1992-2020)

	Electricity	Oil	Natural Gas	Wood	Other	Total
1996-2000	34.0%	12.0%	46.0%	3.0%	5.0%	100.0%
2001-2005	35.0%	11.0%	47.0%	3.0%	4.0%	100.0%
2006-2010	37.0%	10.0%	47.0%	3.0%	3.0%	100.0%
2011-2015	38.0%	9.0%	48.0%	3.0%	2.0%	100.0%
2016-2020	39.0%	9.0%	48.0%	3.0%	1.0%	100.0%

## 31. Electricity Production by Fuels (VISION - 1992-2020)

	Coal	Oil	Natural Gas	Hydro	Nuclear	Other
1996-2000	16.8%	2.6%	2.3%	62.0%	15.3%	1.1%
2001-2005	13.2%	2.1%	4.4%	60.1%	17.9%	2.2%
2006-2010	12.5%	1.7%	5.5%	61.1%	17.2%	2.0%
2011-2015	13.2%	1.0%	5.2%	59.7%	18.9%	1.9%
2016-2020	13.9%	0.3%	4.9%	58.4%	20.7%	1.7%
Thermal efficiency	30.0%	33.0%	36.0%	48.0%	42.0%	33.0%

## 32. Emission Conversion Factors (Environment Canada)

Combustion source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
Natural Gas	49.68	1.14	0.62
Wood	81.47	0.02	8.89
Fuel Oil	73.11	5.53	6.85
Coal	83.00	0.00	13.40
Propane	49.68	1.14	0.62

**33. Electricity Generation Equivalence**

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	55.41	0.51	8.09
2001-2005	47.49	0.50	6.44
2006-2010	45.96	0.46	6.03
2011-2015	46.00	0.33	6.21
2016-2020	46.05	0.21	6.38

**34. Environmental Emissions Equivalence**

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

Fuel switching

0

**35. Environmental Emissions Equivalence, after retrofit**

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

**36. Environmental Emissions Equivalence, net benefits**

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

# Environmental Assessment of Advanced House Technologies

**1. Technology**  
**2. Description**

**Super-Advanced Windows (TG)**

**3. Assumptions**

- 1 Assumed high E.E. window is a TG with 2 low-e, krypton filled, insulated spacer. RSI 0.647
- 2 Retrofits: Pre-1945 windows - RSI 0.18; 1946-60 - RSI 0.22; 1961-80 - RSI 0.32; 1981-93 - RSI 0.35
- 3 There are approximately 203000 retrofits a year.

**4. Type of fuel affected with the application of technology:**

	Retrofit		New Construction		Legend:				
	Existing	New Fuel	Conventional	New Fuel					
Electricity	1	1	1	1	<table border="1"> <tr> <td>1</td> <td>Yes</td> </tr> <tr> <td>0</td> <td>No</td> </tr> </table> Input data field	1	Yes	0	No
1	Yes								
0	No								
Natural Gas	1	1	1	1					
Oil	1	1	1	1					
Wood	1	1	1	1					
Propane	1	1	1	1					

**5. Scope of Technology**

		Legend:				
Atlantic	1	<table border="1"> <tr> <td>1</td> <td>Yes</td> </tr> <tr> <td>0</td> <td>No</td> </tr> </table> Input data field	1	Yes	0	No
1	Yes					
0	No					
Quebec	1					
Ontario	1					
Prairie	1					
BC	1					

**6. Energy Savings (kWh/m<sup>2</sup> of floor area)**

	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	71.26	80.87	65.41	93.32	49.42
1946-1960	70.57	80.64	65.81	93.18	48.48
1961-1980	34.57	39.61	31.78	45.52	23.25
1981-1993	28.02	32.04	25.87	37.04	18.08
NEC / new R-2000	11.35	13.61	10.69	16.43	5.75

**7. Applicable New Construction Stock Per Period Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	417,100	37,777	95,891	148,344	79,323	55,766
2001-2005	519,085	47,014	119,337	184,616	98,718	69,401
2006-2010	573,256	51,920	131,791	203,882	109,020	76,644
2011-2015	603,026	54,616	138,635	214,470	114,681	80,624
2016-2020	612,319	55,458	140,771	217,775	116,449	81,866

**8. Market Penetration by Period (New Construction) - Enter fraction of applicable stock using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	1.9%	2.0%	2.0%	2.0%	2.0%	1.0%
2001-2005	4.7%	5.0%	5.0%	5.0%	5.0%	3.0%
2006-2010	7.6%	8.0%	8.0%	8.0%	8.0%	5.0%
2011-2015	11.5%	12.0%	12.0%	12.0%	12.0%	8.0%
2016-2020	14.6%	15.0%	15.0%	15.0%	15.0%	12.0%

Comments: Penetration rates assume competition with advanced double glazed windows.

**9. Number of Related Retrofits/year**

203,000

**10. Applicable Existing Stock Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,858,723	206,112	482,532	716,741	301,983	151,355
1946-1960	1,664,496	131,198	409,645	590,262	327,857	205,535
1961-1970	1,124,574	93,682	284,287	375,420	217,155	154,030
1971-1980	1,465,782	137,838	275,024	477,499	334,976	240,445
1981-1993	1,537,089	124,093	307,388	561,085	273,004	271,519
Total	7,650,666	692,924	1,758,876	2,721,007	1,454,975	1,022,884

**11. Market Penetration by Period (Existing) - Enter fraction of related retrofits using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	3.8%	4.0%	4.0%	4.0%	4.0%	2.0%
2001-2005	9.4%	10.0%	10.0%	10.0%	10.0%	5.0%
2006-2010	12.3%	13.0%	13.0%	13.0%	13.0%	8.0%
2011-2015	15.3%	16.0%	16.0%	16.0%	16.0%	12.0%
2016-2020	19.1%	20.0%	20.0%	20.0%	20.0%	15.0%

Comments: There are 203000 retrofits and additions every year. Assumed that a portion of these houses would use this technology.

**12. Market Penetration by Period (New Construction) - Net fraction of all new housing using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	1.9%	2.0%	2.0%	2.0%	2.0%	1.0%
2001-2005	4.7%	5.0%	5.0%	5.0%	5.0%	3.0%
2006-2010	7.6%	8.0%	8.0%	8.0%	8.0%	5.0%
2011-2015	11.5%	12.0%	12.0%	12.0%	12.0%	8.0%
2016-2020	14.6%	15.0%	15.0%	15.0%	15.0%	12.0%

## 13. Market Penetration by Period (Existing) - Net fraction of existing stock retrofitted with AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.5%	0.5%	0.5%	0.5%	0.5%	0.3%
2001-2005	1.2%	1.3%	1.3%	1.3%	1.3%	0.7%
2006-2010	1.6%	1.7%	1.7%	1.7%	1.7%	1.1%
2011-2015	2.0%	2.1%	2.1%	2.1%	2.1%	1.6%
2016-2020	2.5%	2.7%	2.7%	2.7%	2.7%	2.0%

## 14. Summary of Market Penetration Scenario

Effects of above scenario on new housing up to 2020	Number of Installations	240,245	
	Number of New Houses	3,035,714	from 1994 to 2020
	Percentage of New Stock by 2020	7.9%	
Effects of above scenario on existing housing up to 2020	Number of Installations	610,952	
	Number of Existing Houses	7,650,589	up to 1993
	Percentage of Existing Stock by 2020	8.0%	

## Summary of Results

## 15. Summary of market penetration by the year 2020

Technology effects on housing stock by 2020	Number of Installations	851,197
	Number of Houses	10,686,303
	Percentage of stock	8.0%

## 16. Energy Savings Benefits for the Advanced House Technology with Above Market Penetrations, PJ

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	1.28	1.28	0.05	0.05	1.33	1.33
2001-2005	3.20	4.47	0.17	0.22	3.36	4.69
2006-2010	4.20	8.67	0.30	0.52	4.49	9.19
2011-2015	5.22	13.90	0.47	0.98	5.69	14.88
2016-2020	6.53	20.43	0.60	1.58	7.13	22.01

\* Annual — Energy saved at the end of the period, PJ/year

## 17. Environmental Benefits, Carbon Dioxide Emissions, kilotons

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	67.6	68	2.8	3	70.5	70
2001-2005	161.3	229	8.4	11	169.7	240
2006-2010	210.3	439	14.8	26	225.1	465
2011-2015	263.1	702	23.5	50	286.6	752
2016-2020	332.0	1,034	30.4	80	362.4	1,114

\* Annual — Emissions reduced at the end of the period, kilotons/year

18. Environmental Benefits, Methane CH<sub>4</sub>, tonnes

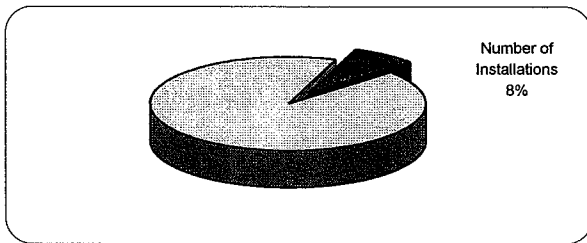
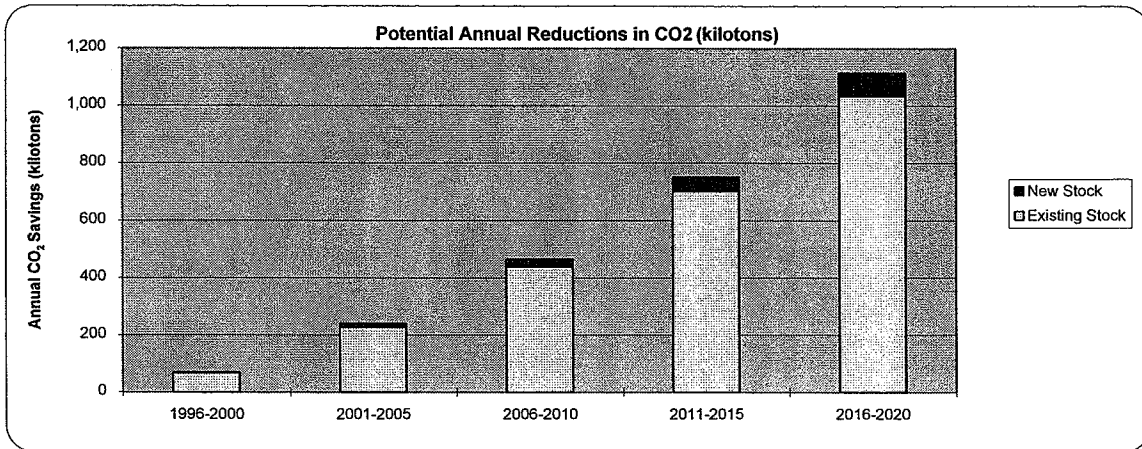
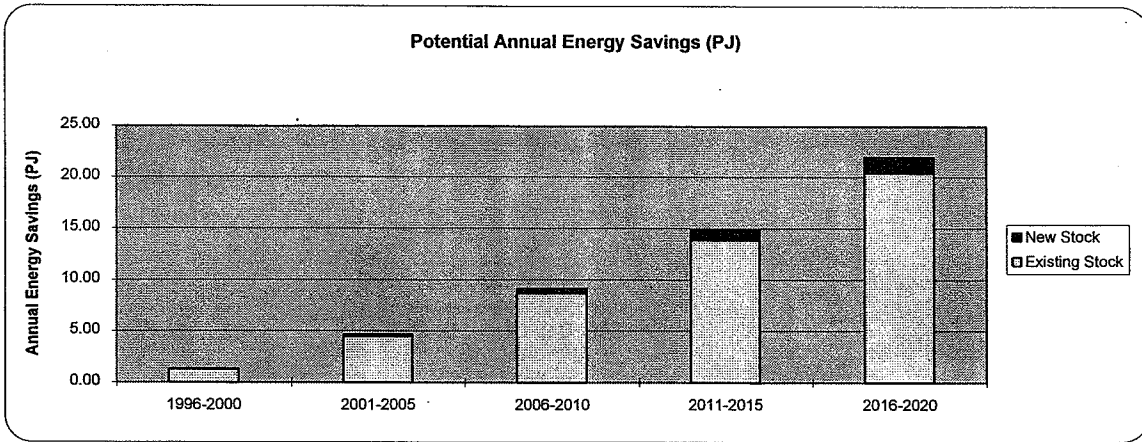
	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	1.7	2	0.1	0.1	1.8	2
2001-2005	4.2	6	0.2	0.3	4.4	6
2006-2010	5.3	11	0.4	0.7	5.7	12
2011-2015	6.1	17	0.5	1.2	6.7	19
2016-2020	7.4	25	0.7	1.9	8.1	27

\* Annual — Emissions reduced at the end of the period, tonnes/year

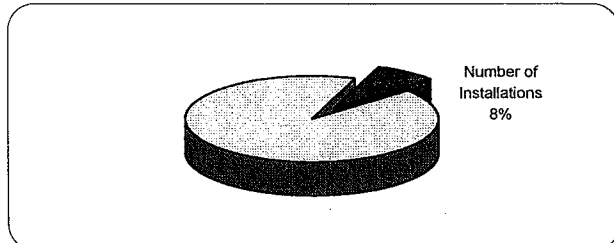
19. Environmental Benefits, N<sub>2</sub>O, tonnes

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	5.28	5.28	0.22	0.22	5.49	5.49
2001-2005	11.39	16.67	0.59	0.81	11.99	17.48
2006-2010	14.58	31.25	1.03	1.84	15.60	33.09
2011-2015	18.49	49.74	1.65	3.49	20.15	53.23
2016-2020	23.97	73.71	2.12	5.61	26.09	79.32

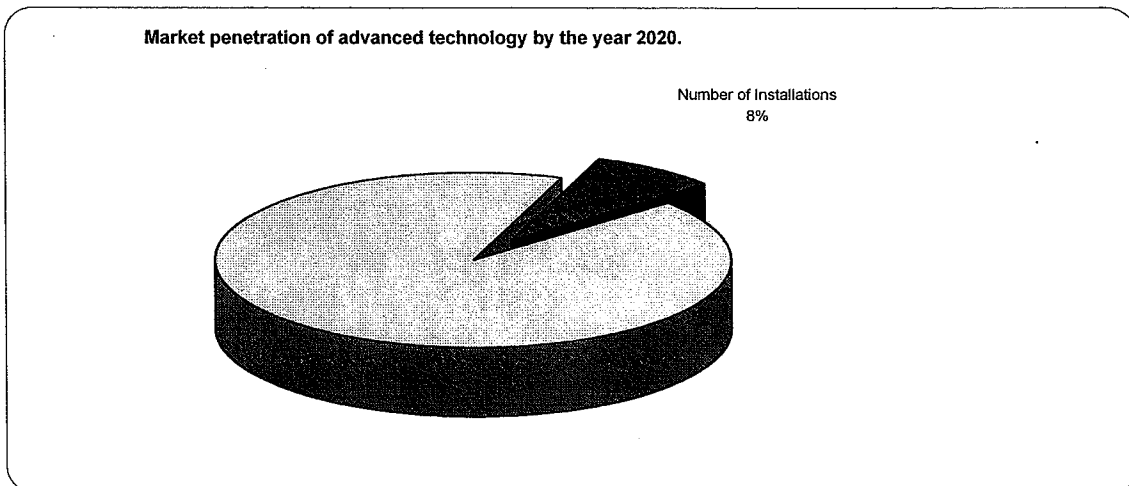
\* Annual — Emissions reduced at the end of the period, tonnes/year



Market penetration in new housing stock built during 1994-2020 by the year 2020.



Market penetration in existing housing stock built up to 1993 by the year 2020.



## HOT-2000 Simulation Runs

**20. Simulation Results**

Base Systems and Fuels:	All fuels
New Fuels:	All fuels

**Energy consumption for the "typical" houses (kWh)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	102,953.5	115,751.9	91,025.2	136,367.7	68,056.4
	Upgrade	91,907.6	103,217.5	80,886.3	121,903.3	60,396.3
1946-1960	Base	69,546.1	78,245.6	61,472.5	91,114.7	46,842.7
	Upgrade	58,608.4	65,746.3	51,272.4	76,671.4	39,328.8
1961-1980	Base	60,568.6	67,587.8	52,948.4	78,704.5	40,392.6
	Upgrade	55,210.2	61,448.9	48,022.1	71,649.1	36,789.4
1981-1993	Base	34,214.7	37,990.6	29,396.3	44,382.0	22,414.1
	Upgrade	29,670.9	33,024.7	25,386.3	38,640.9	19,611.8
National Energy Code / new R-2000	Base	25,541.4	29,275.9	23,181.5	35,095.0	14,490.3
	Upgrade	23,782.9	27,166.1	21,524.2	32,549.1	13,599.0

Floor Area 165.00 sqm

**Energy consumption per unit floor area (kWh/m<sup>2</sup>)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	664.2	746.8	587.3	879.8	439.1
	Upgrade	593.0	665.9	521.8	786.5	389.7
1946-1960	Base	448.7	504.8	396.6	587.8	302.2
	Upgrade	378.1	424.2	330.8	494.7	253.7
1961-1980	Base	390.8	436.1	341.6	507.8	260.6
	Upgrade	356.2	396.4	309.8	462.3	237.4
1981-1993	Base	220.7	245.1	189.7	286.3	144.6
	Upgrade	192.7	213.1	163.8	249.3	126.5
National Energy Code / new R-2000	Base	164.8	188.9	149.6	226.4	93.5
	Upgrade	153.4	175.3	138.9	210.0	87.7

**Energy Savings per Unit Floor Area, kWh/m<sup>2</sup>**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		71.26	80.87	65.41	93.32	49.42
1946-1960		70.57	80.64	65.81	93.18	48.48
1961-1980		34.57	39.61	31.78	45.52	23.25
1981-1993		28.02	32.04	25.87	37.04	18.08
NEC / new R-2000		11.35	13.61	10.69	16.43	5.75

**Percentage reduction in space heat and DHW energy consumption per house, %**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		10.7%	10.8%	11.1%	10.6%	11.3%
1946-1960		15.7%	16.0%	16.6%	15.9%	16.0%
1961-1980		8.8%	9.1%	9.3%	9.0%	8.9%
1981-1993		12.7%	13.1%	13.6%	12.9%	12.5%
NEC / new R-2000		6.9%	7.2%	7.1%	7.3%	6.2%

## Detailed Calculations

**21. New Construction - Housing stock projections (Single, semi-detached and row) - VISION 1992-2020**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	7,961,544	617,289	1,396,232	3,285,382	1,462,551	1,200,090
2000	8,378,640	649,828	1,469,379	3,457,499	1,539,173	1,262,961
2005	8,897,720	689,874	1,560,411	3,671,701	1,634,529	1,341,205
2010	9,470,970	734,320	1,660,943	3,908,256	1,739,836	1,427,614
2015	10,073,990	781,075	1,766,696	4,157,096	1,850,612	1,518,511
2020	10,686,303	828,550	1,874,079	4,409,771	1,963,095	1,610,808

**22. New Construction - Housing stock projections (Single, semi-detached and row)**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	310,955	28,163	71,489	110,594	59,135	41,575
2000	417,096	37,776	95,891	148,344	79,320	55,766
2005	519,080	47,012	119,337	184,616	98,714	69,401
2010	573,250	51,918	131,791	203,882	109,016	76,644
2015	603,020	54,615	138,635	214,470	114,677	80,624
2020	612,313	55,456	140,771	217,775	116,444	81,866
<b>Total</b>	<b>3,035,714</b>	<b>274,940</b>	<b>697,913</b>	<b>1,079,681</b>	<b>577,305</b>	<b>405,875</b>

**23. Existing Housing Stock (Single) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,351,153	176,173	220,592	537,691	279,452	137,245
1946-1960	1,356,041	116,284	235,390	523,527	294,130	186,710
1961-1970	875,044	77,904	185,087	291,760	186,788	133,505
1971-1980	1,156,834	123,055	227,748	318,531	275,851	211,649
1981-1993	1,248,212	111,103	246,432	449,462	226,026	215,189
<b>Total</b>	<b>5,987,284</b>	<b>604,519</b>	<b>1,115,249</b>	<b>2,120,971</b>	<b>1,262,247</b>	<b>884,298</b>

**24. Existing Housing Stock (semi-detached and row) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	507,552	29,932	261,940	179,050	22,520	14,110
1946-1960	308,440	14,910	174,255	66,735	33,715	18,825
1961-1970	249,519	15,775	99,200	83,660	30,359	20,525
1971-1980	308,931	14,779	47,276	158,968	59,112	28,796
1981-1993	288,863	12,986	60,956	111,623	46,968	56,330
<b>Total</b>	<b>1,663,305</b>	<b>88,382</b>	<b>643,627</b>	<b>600,036</b>	<b>192,674</b>	<b>138,586</b>

25. Existing Housing Stock (Single, semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC	%age of total
Pre-1945	1,858,705	206,105	482,532	716,741	301,972	151,355	24.3%
1946-1960	1,664,481	131,194	409,645	590,262	327,845	205,535	21.8%
1961-1970	1,124,563	93,679	284,287	375,420	217,147	154,030	14.7%
1971-1980	1,465,765	137,834	275,024	477,499	334,963	240,445	19.2%
1981-1993	1,537,075	124,089	307,388	561,085	272,994	271,519	20.1%
<b>Total</b>	<b>7,650,589</b>	<b>692,901</b>	<b>1,758,876</b>	<b>2,721,007</b>	<b>1,454,921</b>	<b>1,022,884</b>	<b>100.0%</b>
%age of total		9.06%	22.99%	35.57%	19.02%	13.37%	
Single/Total		7.75%	17.54%	41.27%	18.37%	15.07%	

26. Existing Housing Average Floor Space (m2) (Single, semi-detached and row) - STAR-Housing

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	159	147	160	174	130	146
1946-1960	165	161	168	183	133	157
1961-1970	170	176	160	184	151	179
1971-1980	164	176	147	172	149	181
1981-1993	156	153	153	160	150	160

27. Existing housing stock potential energy savings (GWh) assuming 100% market penetration

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	21,299	2,166	6,243	8,144	3,657	1,089
1946-1960	19,786	1,495	5,553	7,097	4,078	1,563
1961-1970	13,743	1,165	3,659	4,533	3,050	1,336
1971-1980	8,334	839	1,603	2,603	2,275	1,014
1981-1993	6,659	530	1,503	2,320	1,519	787
<b>Total (GWh)</b>	<b>69,820</b>	<b>6,195</b>	<b>18,561</b>	<b>24,696</b>	<b>14,579</b>	<b>5,789</b>
<b>Total (PJ)</b>	<b>251.35</b>	<b>22.30</b>	<b>66.82</b>	<b>88.91</b>	<b>52.48</b>	<b>20.84</b>

28. Fuel Use Summary % (1993 - Statistics Canada)

	Electricity	Oil	Natural Gas	Wood	Propane
Atlantic	41.14	51.58	0.00	3.57	3.71
Quebec	65.00	22.90	8.60	3.50	0.00
Ontario	18.00	16.50	62.70	2.80	0.00
Prairies	17.24	15.41	67.09	0.26	0.00
BC	27.30	11.20	56.20	5.30	0.00
Canada	32.00	20.24	44.55	2.88	0.34

29. Potential Energy Savings by Fuel Type - Existing Stock - assuming 100% market penetrations, PJ

	Electricity	Oil	Natural Gas	Wood	Propane	Total
Atlantic	9.18	11.50	0.00	0.80	0.83	22.30
Quebec	43.43	15.30	5.75	2.34	0.00	66.82
Ontario	16.00	14.67	55.74	2.49	0.00	88.91
Prairies	9.05	8.09	35.21	0.14	0.00	52.48
BC	5.69	2.33	11.71	1.10	0.00	20.84
Canada	83.35	51.90	108.41	6.86	0.83	251.35

30. Residential Energy Demand by Fuels (VISION 1992-2020)

	Electricity	Oil	Natural Gas	Wood	Other	Total
1996-2000	34.0%	12.0%	46.0%	3.0%	5.0%	100.0%
2001-2005	35.0%	11.0%	47.0%	3.0%	4.0%	100.0%
2006-2010	37.0%	10.0%	47.0%	3.0%	3.0%	100.0%
2011-2015	38.0%	9.0%	48.0%	3.0%	2.0%	100.0%
2016-2020	39.0%	9.0%	48.0%	3.0%	1.0%	100.0%

31. Electricity Production by Fuels (VISION - 1992-2020)

	Coal	Oil	Natural Gas	Hydro	Nuclear	Other
1996-2000	16.8%	2.6%	2.3%	62.0%	15.3%	1.1%
2001-2005	13.2%	2.1%	4.4%	60.1%	17.9%	2.2%
2006-2010	12.5%	1.7%	5.5%	61.1%	17.2%	2.0%
2011-2015	13.2%	1.0%	5.2%	59.7%	18.9%	1.9%
2016-2020	13.9%	0.3%	4.9%	58.4%	20.7%	1.7%
<b>Thermal efficiency</b>	<b>30.0%</b>	<b>33.0%</b>	<b>36.0%</b>	<b>48.0%</b>	<b>42.0%</b>	<b>33.0%</b>

32. Emission Conversion Factors (Environment Canada)

Combustion source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
Natural Gas	49.68	1.14	0.62
Wood	81.47	0.02	8.89
Fuel Oil	73.11	5.53	6.85
Coal	83.00	0.00	13.40
Propane	49.68	1.14	0.62



## 33. Electricity Generation Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	55.41	0.51	8.09
2001-2005	47.49	0.50	6.44
2006-2010	45.96	0.46	6.03
2011-2015	46.00	0.33	6.21
2016-2020	46.05	0.21	6.38

## 34. Environmental Emissions Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

Fuel switching

0

## 35. Environmental Emissions Equivalence, after retrofit

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

## 36. Environmental Emissions Equivalence, net benefits

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

# Environmental Assessment of Advanced House Technologies

1. Technology  
2. Description

<b>Exterior Air Barriers</b>	
3. Assumptions	1 Assumed to achieve airtightness of exterior walls to 1.25 @ 50 Pa. 2 Retrofits can achieve: Pre-1945 - 5.12 ach; 1946-60 - 3.25 ach; 1961-80 - 3.10 ach; 1981-93 - 2.5 ach. 3 There are approximately 165000 siding replacement every year.

4. Type of fuel affected with the application of technology:

	Retrofit		New Construction		Legend:						
	Existing	New Fuel	Conventional	New Fuel							
Electricity	1	1	1	1	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">Yes</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">No</td> </tr> <tr> <td style="text-align: center;"> </td> <td style="text-align: center;">Input data field</td> </tr> </table>	1	Yes	0	No		Input data field
1	Yes										
0	No										
	Input data field										
Natural Gas	1	1	1	1							
Oil	1	1	1	1							
Wood	1	1	1	1							
Propane	1	1	1	1							

5. Scope of Technology

	Atlantic	Quebec	Ontario	Prairie	BC	Legend:				
Atlantic	1					<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">Yes</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">No</td> </tr> </table>	1	Yes	0	No
1	Yes									
0	No									
Quebec		1								
Ontario			1							
Prairie				1						
BC					1					

6. Energy Savings (kWh/m<sup>2</sup> of floor area)

	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	70.62	83.05	61.58	126.70	47.31
1946-1960	30.78	37.08	27.78	48.35	16.18
1961-1980	22.05	25.85	19.19	34.54	10.14
1981-1993	8.40	9.76	7.04	13.64	2.96
NEC / new R-2000	3.47	4.41	3.66	5.05	2.40

7. Applicable New Construction Stock Per Period Based on Fuels

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	417,100	37,777	95,891	148,344	79,323	55,766
2001-2005	519,085	47,014	119,337	184,616	98,718	69,401
2006-2010	573,256	51,920	131,791	203,882	109,020	76,644
2011-2015	603,026	54,616	138,635	214,470	114,681	80,624
2016-2020	612,319	55,458	140,771	217,775	116,449	81,866

8. Market Penetration by Period (New Construction) - Enter fraction of applicable stock using AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
2001-2005	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
2006-2010	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
2011-2015	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
2016-2020	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%

Comments:


9. Number of Related Retrofits/year

165,000

10. Applicable Existing Stock Based on Fuels

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,858,723	206,112	482,532	716,741	301,983	151,355
1946-1960	1,664,498	131,198	409,645	590,262	327,857	205,535
1961-1970	1,124,574	93,682	284,287	375,420	217,155	154,030
1971-1980	1,465,782	137,838	275,024	477,499	334,976	240,445
1981-1993	1,537,089	124,093	307,388	561,085	273,004	271,519
<b>Total</b>	<b>7,650,666</b>	<b>692,924</b>	<b>1,758,876</b>	<b>2,721,007</b>	<b>1,454,975</b>	<b>1,022,884</b>

11. Market Penetration by Period (Existing) - Enter fraction of related retrofits using AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
2001-2005	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
2006-2010	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
2011-2015	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
2016-2020	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%

Comments:

Siding replacements and additions are equivalent to 165,000 units per year.

12. Market Penetration by Period (New Construction) - Net fraction of all new housing using AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
2001-2005	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
2006-2010	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
2011-2015	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
2016-2020	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%

## 13. Market Penetration by Period (Existing) - Net fraction of existing stock retrofitted with AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
2001-2005	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
2006-2010	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%
2011-2015	4.3%	4.3%	4.3%	4.3%	4.3%	4.3%
2016-2020	5.4%	5.4%	5.4%	5.4%	5.4%	5.4%

## 14. Summary of Market Penetration Scenario

Effects of above scenario on new housing up to 2020	Number of Installations	652,799	from 1994 to 2020
	Number of New Houses	3,035,714	
	Percentage of New Stock by 2020	21.5%	
Effects of above scenario on existing housing up to 2020	Number of Installations	1,237,500	up to 1993
	Number of Existing Houses	7,650,589	
	Percentage of Existing Stock by 2020	16.2%	

## Summary of Results

## 15. Summary of market penetration by the year 2020

Technology effects on housing stock by 2020	Number of Installations	1,890,299
	Number of Houses	10,686,303
	Percentage of stock	17.7%

## 16. Energy Savings Benefits for the Advanced House Technology with Above Market Penetrations, PJ

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	1.73	1.73	0.05	0.05	1.77	1.77
2001-2005	3.45	5.18	0.17	0.22	3.62	5.39
2006-2010	5.18	10.36	0.31	0.53	5.49	10.88
2011-2015	6.90	17.26	0.40	0.92	7.30	18.18
2016-2020	8.63	25.89	0.47	1.39	9.10	27.28

\* Annual — Energy saved at the end of the period, PJ/year

## 17. Environmental Benefits, Carbon Dioxide Emissions, kilotons

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	91.3	91	2.4	2	93.7	94
2001-2005	174.2	266	8.6	11	182.8	276
2006-2010	259.5	525	15.7	27	275.1	552
2011-2015	347.6	873	19.9	47	367.5	919
2016-2020	438.7	1,311	23.8	70	462.5	1,382

\* Annual — Emissions reduced at the end of the period, kilotons/year

18. Environmental Benefits, Methane CH<sub>4</sub>, tonnes

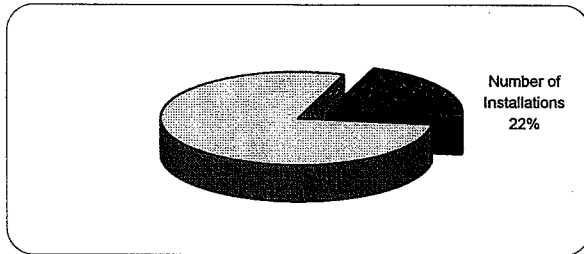
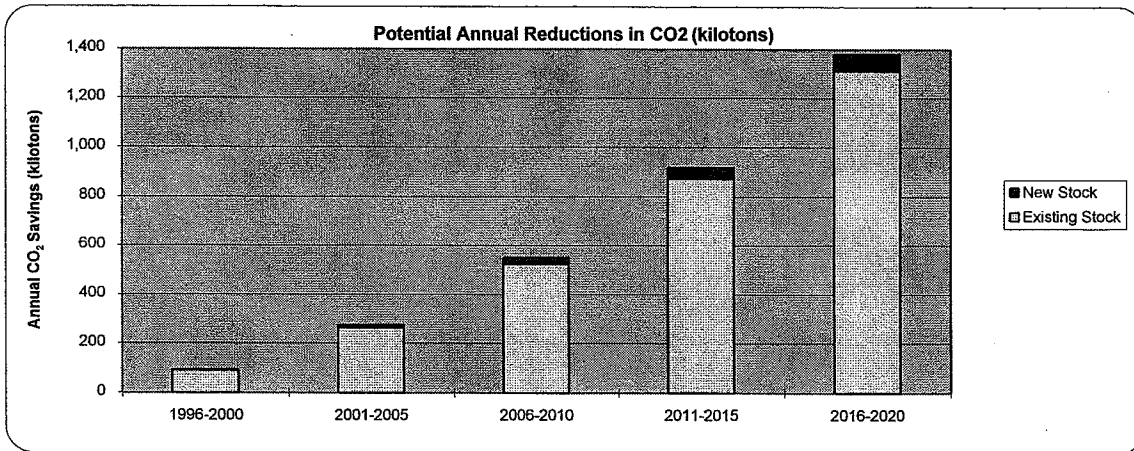
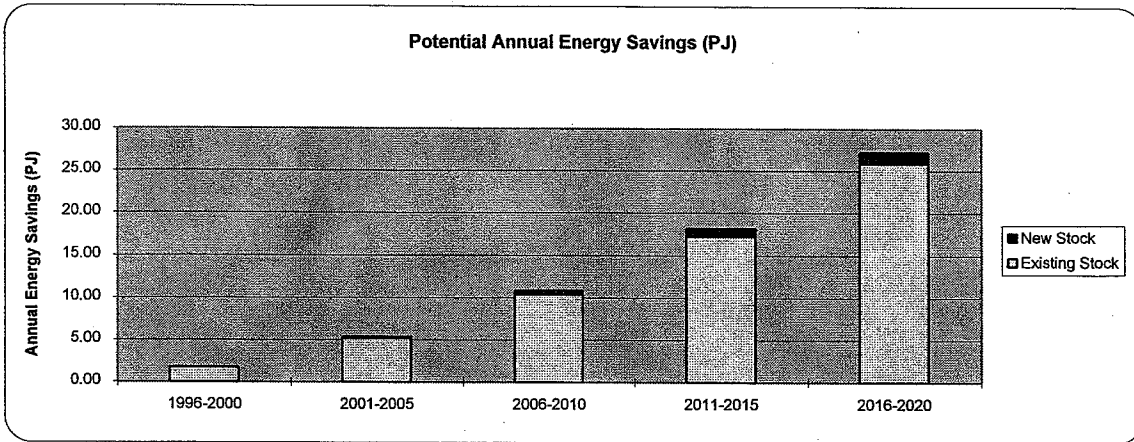
	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	2.3	2	0.1	0.1	2.4	2
2001-2005	4.6	7	0.2	0.3	4.8	7
2006-2010	6.5	13	0.4	0.7	6.9	14
2011-2015	8.1	22	0.5	1.1	8.6	23
2016-2020	9.7	31	0.5	1.7	10.3	33

\* Annual — Emissions reduced at the end of the period, tonnes/year

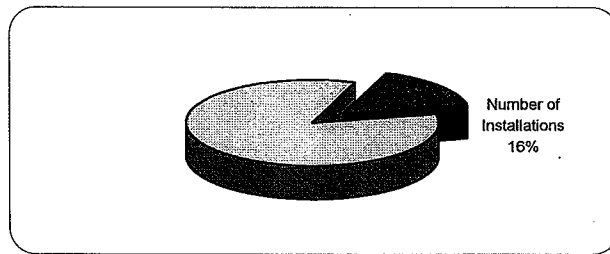
19. Environmental Benefits, N<sub>2</sub>O, tonnes

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	7.12	7.12	0.19	0.19	7.31	7.31
2001-2005	12.30	19.42	0.61	0.79	12.91	20.22
2006-2010	17.99	37.41	1.09	1.88	19.07	39.29
2011-2015	24.44	61.85	1.40	3.28	25.83	65.13
2016-2020	31.68	93.53	1.66	4.94	33.33	98.46

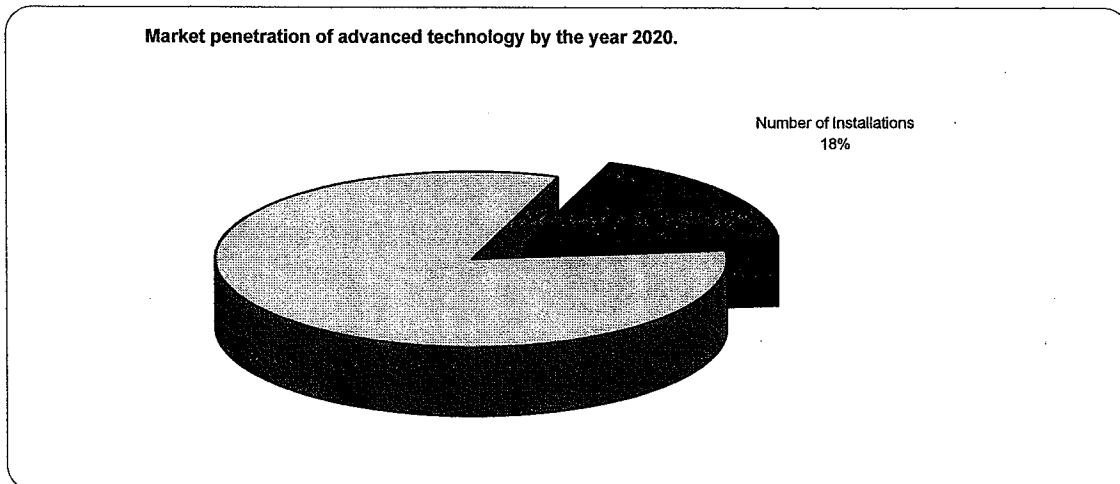
\* Annual — Emissions reduced at the end of the period, tonnes/year



Market penetration in new housing stock built during 1994-2020 by the year 2020.



Market penetration in existing housing stock built up to 1993 by the year 2020.



## HOT-2000 Simulation Runs

**20. Simulation Results**

Base Systems and Fuels:

All fuels

New Fuels:

All fuels

Energy consumption for the "typical" houses (kWh)

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	99,331.2	111,744.4	87,726.3	134,317.7	67,207.0
	Upgrade	88,384.8	98,871.3	78,181.5	114,678.7	59,873.7
1946-1960	Base	68,078.7	76,419.9	60,020.4	88,868.9	45,814.3
	Upgrade	63,308.1	70,672.7	55,714.3	81,375.3	43,305.9
1961-1980	Base	60,682.8	66,896.0	52,389.1	77,860.9	40,104.1
	Upgrade	56,665.5	62,888.8	49,414.1	72,507.7	38,533.1
1981-1993	Base	33,470.7	37,114.3	28,668.0	43,335.7	21,893.8
	Upgrade	32,168.6	35,601.3	27,577.2	41,221.2	21,435.1
National Energy Code / new R-2000	Base	25,909.3	29,652.1	23,437.5	35,458.9	14,550.3
	Upgrade	25,372.2	28,969.0	22,869.5	34,675.7	14,187.9

Floor Area

155.00 sqm

Energy consumption per unit floor area (kWh/m<sup>2</sup>)

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	640.8	720.9	566.0	866.6	433.6
	Upgrade	570.2	637.9	504.4	739.9	366.3
1946-1960	Base	439.2	493.0	387.2	573.3	295.6
	Upgrade	408.4	456.0	359.4	525.0	279.4
1961-1980	Base	387.6	431.6	338.0	502.3	258.7
	Upgrade	365.6	405.7	318.8	467.8	248.6
1981-1993	Base	215.9	239.4	185.0	279.6	141.3
	Upgrade	207.5	229.7	177.9	265.9	138.3
National Energy Code / new R-2000	Base	167.2	191.3	151.2	228.8	93.9
	Upgrade	163.7	186.9	147.5	223.7	91.5

Energy Savings per Unit Floor Area, kWh/m<sup>2</sup>

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		70.62	83.05	61.58	126.70	47.31
1946-1960		30.78	37.08	27.78	46.35	16.18
1961-1980		22.05	25.85	19.19	34.54	10.14
1981-1993		8.40	9.76	7.04	13.64	2.96
NEC / new R-2000		3.47	4.41	3.66	5.05	2.40

Percentage reduction in space heat and DHW energy consumption per house, %

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		11.0%	11.5%	10.9%	14.6%	10.9%
1946-1960		7.0%	7.5%	7.2%	8.4%	5.5%
1961-1980		5.7%	6.0%	5.7%	6.9%	3.9%
1981-1993		3.9%	4.1%	3.8%	4.9%	2.1%
NEC / new R-2000		2.1%	2.3%	2.4%	2.2%	2.6%

## Detailed Calculations

**21. New Construction - Housing stock projections (Single, semi-detached and row) - VISION 1992-2020**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	7,961,544	617,289	1,396,232	3,285,382	1,462,551	1,200,090
2000	8,378,640	649,628	1,469,379	3,457,499	1,539,173	1,262,961
2005	8,897,720	689,874	1,560,411	3,671,701	1,634,529	1,341,205
2010	9,470,970	734,320	1,660,943	3,908,256	1,739,836	1,427,614
2015	10,073,990	781,075	1,766,696	4,157,096	1,850,612	1,518,511
2020	10,686,303	828,550	1,874,079	4,409,771	1,963,095	1,610,808

**22. New Construction - Housing stock projections (Single, semi-detached and row)**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	310,955	28,163	71,489	110,594	59,135	41,575
2000	417,096	37,776	95,891	148,344	79,320	55,766
2005	519,080	47,012	119,337	184,616	98,714	69,401
2010	573,250	51,918	131,791	203,882	109,016	76,644
2015	603,020	54,615	138,635	214,470	114,677	80,624
2020	612,313	55,456	140,771	217,775	116,444	81,866
Total	3,035,714	274,940	697,913	1,079,681	577,305	405,875

**23. Existing Housing Stock (Single) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,351,153	176,173	220,592	537,691	279,452	137,245
1946-1960	1,356,041	116,284	235,390	523,527	294,130	186,710
1961-1970	875,044	77,904	185,087	291,760	186,788	133,505
1971-1980	1,156,834	123,055	227,748	318,531	275,851	211,649
1981-1993	1,248,212	111,103	246,432	449,462	226,026	215,189
Total	5,987,284	604,519	1,115,249	2,120,971	1,262,247	884,298

**24. Existing Housing Stock (semi-detached and row) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	507,552	29,932	261,940	179,050	22,520	14,110
1946-1960	308,440	14,910	174,255	66,735	33,715	18,825
1961-1970	249,519	15,775	99,200	83,660	30,359	20,525
1971-1980	308,931	14,779	47,276	158,968	59,112	28,796
1981-1993	288,863	12,986	60,956	111,623	46,968	56,330
Total	1,663,305	88,382	643,627	600,036	192,674	138,586

## 25. Existing Housing Stock (Single, semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC	%age of total
Pre-1945	1,858,705	206,105	482,532	716,741	301,972	151,355	24.3%
1946-1960	1,664,481	131,194	409,645	590,262	327,845	205,535	21.8%
1961-1970	1,124,563	93,679	284,287	375,420	217,147	154,030	14.7%
1971-1980	1,465,765	137,834	275,024	477,499	334,963	240,445	19.2%
1981-1993	1,537,075	124,089	307,388	561,085	272,994	271,519	20.1%
<b>Total</b>	<b>7,650,589</b>	<b>692,901</b>	<b>1,758,876</b>	<b>2,721,007</b>	<b>1,454,921</b>	<b>1,022,884</b>	<b>100.0%</b>
%age of total		9.06%	22.99%	35.57%	19.02%	13.37%	
Single/Total		7.75%	17.54%	41.27%	18.37%	15.07%	

## 26. Existing Housing Average Floor Space (m2) (Single, semi-detached and row) - STAR-Housing

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	159	147	160	174	130	146
1946-1960	165	161	168	183	133	157
1961-1970	170	176	160	184	151	179
1971-1980	164	176	147	172	149	181
1981-1993	156	153	153	160	150	160

## 27. Existing housing stock potential energy savings (GWh) assuming 100% market penetration

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	22,232	2,146	6,412	7,667	4,965	1,043
1946-1960	8,839	652	2,553	2,966	2,116	522
1961-1970	6,133	508	1,682	1,914	1,582	446
1971-1980	5,322	535	1,047	1,572	1,726	442
1981-1993	1,936	159	458	631	559	129
<b>Total (GWh)</b>	<b>44,462</b>	<b>4,000</b>	<b>12,152</b>	<b>14,779</b>	<b>10,949</b>	<b>2,581</b>
<b>Total (PJ)</b>	<b>160.06</b>	<b>14.40</b>	<b>43.75</b>	<b>53.20</b>	<b>39.42</b>	<b>9.29</b>

## 28. Fuel Use Summary % (1993 - Statistics Canada)

	Electricity	Oil	Natural Gas	Wood	Propane
Atlantic	41.14	51.58	0.00	3.57	3.71
Quebec	65.00	22.90	8.60	3.50	0.00
Ontario	18.00	16.50	62.70	2.80	0.00
Prairies	17.24	15.41	67.09	0.26	0.00
BC	27.30	11.20	56.20	5.30	0.00
Canada	32.00	20.24	44.55	2.88	0.34

## 29. Potential Energy Savings by Fuel Type - Existing Stock - assuming 100% market penetrations, PJ

	Electricity	Oil	Natural Gas	Wood	Propane	Total
Atlantic	5.92	7.43	0.00	0.51	0.53	14.40
Quebec	28.44	10.02	3.76	1.53	0.00	43.75
Ontario	9.58	8.78	33.36	1.49	0.00	53.20
Prairies	6.80	6.08	26.44	0.10	0.00	39.42
BC	2.54	1.04	5.22	0.49	0.00	9.29
Canada	53.27	33.34	68.79	4.13	0.53	160.06

## 30. Residential Energy Demand by Fuels (VISION 1992-2020)

	Electricity	Oil	Natural Gas	Wood	Other	Total
1996-2000	34.0%	12.0%	46.0%	3.0%	5.0%	100.0%
2001-2005	35.0%	11.0%	47.0%	3.0%	4.0%	100.0%
2006-2010	37.0%	10.0%	47.0%	3.0%	3.0%	100.0%
2011-2015	38.0%	9.0%	48.0%	3.0%	2.0%	100.0%
2016-2020	39.0%	9.0%	48.0%	3.0%	1.0%	100.0%

## 31. Electricity Production by Fuels (VISION - 1992-2020)

	Coal	Oil	Natural Gas	Hydro	Nuclear	Other
1996-2000	16.8%	2.6%	2.3%	62.0%	15.3%	1.1%
2001-2005	13.2%	2.1%	4.4%	60.1%	17.9%	2.2%
2006-2010	12.5%	1.7%	5.5%	61.1%	17.2%	2.0%
2011-2015	13.2%	1.0%	5.2%	59.7%	18.9%	1.9%
2016-2020	13.9%	0.3%	4.9%	58.4%	20.7%	1.7%
<b>Thermal efficiency</b>	<b>30.0%</b>	<b>33.0%</b>	<b>36.0%</b>	<b>48.0%</b>	<b>42.0%</b>	<b>33.0%</b>

## 32. Emission Conversion Factors (Environment Canada)

Combustion source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
Natural Gas	49.68	1.14	0.62
Wood	81.47	0.02	8.89
Fuel Oil	73.11	5.53	6.85
Coal	83.00	0.00	13.40
Propane	49.68	1.14	0.62

## 33. Electricity Generation Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	55.41	0.51	8.09
2001-2005	47.49	0.50	6.44
2006-2010	45.96	0.46	6.03
2011-2015	46.00	0.33	6.21
2016-2020	46.05	0.21	6.38

## 34. Environmental Emissions Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

Fuel switching

0

## 35. Environmental Emissions Equivalence, after retrofit

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

## 36. Environmental Emissions Equivalence, net benefits

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	52.91	1.36	4.13
2001-2005	50.46	1.32	3.56
2006-2010	50.11	1.26	3.47
2011-2015	50.35	1.17	3.54
2016-2020	50.83	1.13	3.67

# Environmental Assessment of Advanced House Technologies

**1. Technology**  
**2. Description**

**Advanced Oil Heating System**

**3. Assumptions**

- 1 Oil - Base system with AFUE of 71%, DHW energy factor of 0.59
- 2 Oil - Retrofit with Advanced Oil System AFUE 85% and DHW energy factor of 0.75
- 3 Applicable only to systems using fuel oils

**4. Type of fuel affected with the application of technology:**

	Retrofit		New Construction						
	Existing	New Fuel	Conventional	New Fuel					
Electricity	0	0	0	0					
Natural Gas	0	0	0	0					
Oil	1	1	1	1	<b>Legend:</b> <table border="1" style="display: inline-table; margin-left: 10px;"> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">Yes</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">No</td> </tr> </table>	1	Yes	0	No
1	Yes								
0	No								
Wood	0	0	0	0					
Propane	0	0	0	0	Input data field				

**5. Scope of Technology**

Atlantic	1	<b>Legend:</b> <table border="1" style="display: inline-table; margin-left: 10px;"> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">Yes</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">No</td> </tr> </table>	1	Yes	0	No
1	Yes					
0	No					
Quebec	1					
Ontario	1					
Prairie	1					
BC	1					

**6. Energy Savings (kWh/m<sup>2</sup> of floor area)**

	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	95.07	108.04	85.24	127.70	60.79
1946-1960	64.43	73.09	58.10	85.90	42.59
1961-1980	56.73	63.69	50.73	74.55	37.59
1981-1993	39.50	43.30	35.16	50.52	26.29
NEC / new R-2000	20.32	28.74	19.80	24.97	14.36

**7. Applicable New Construction Stock Per Period Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	84,392	19,484	21,959	24,477	12,226	6,246
2001-2005	105,027	24,249	27,328	30,462	15,215	7,773
2006-2010	115,987	26,779	30,180	33,641	16,803	8,584
2011-2015	122,010	28,170	31,747	35,388	17,676	9,030
2016-2020	123,891	28,604	32,237	35,933	17,948	9,169

**8. Market Penetration by Period (New Construction) - Enter fraction of applicable stock using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2001-2005	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
2006-2010	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
2011-2015	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
2016-2020	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%

**Comments:**

**9. Number of Related Retrofits/year**

36,000

**10. Applicable Existing Stock Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	398,566	106,308	110,500	118,262	46,544	16,952
1946-1960	332,423	67,669	93,809	97,393	50,532	23,020
1961-1970	226,086	48,319	65,102	61,944	33,470	17,251
1971-1980	291,421	71,094	62,980	78,787	51,630	26,930
1981-1993	299,463	64,004	70,392	92,579	42,078	30,410
<b>Total</b>	<b>1,547,961</b>	<b>357,394</b>	<b>402,783</b>	<b>448,966</b>	<b>224,254</b>	<b>114,563</b>

**11. Market Penetration by Period (Existing) - Enter fraction of related retrofits using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2001-2005	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
2006-2010	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
2011-2015	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%
2016-2020	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%

**Comments:**

There are 36,000 oil furnace replacements every year. Assumed that a portion of these houses would use this technology. Rate is reduced since two systems have to be replaced.

**12. Market Penetration by Period (New Construction) - Net fraction of all new housing using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2001-2005	1.0%	2.6%	1.1%	0.8%	0.8%	0.6%
2006-2010	2.0%	5.2%	2.3%	1.7%	1.5%	1.1%
2011-2015	5.1%	12.9%	5.7%	4.1%	3.9%	2.8%
2016-2020	10.1%	25.8%	11.5%	8.3%	7.7%	5.6%



## 13. Market Penetration by Period (Existing) - Net fraction of existing stock retrofitted with AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2001-2005	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
2006-2010	0.1%	0.3%	0.1%	0.1%	0.1%	0.1%
2011-2015	0.3%	0.7%	0.3%	0.2%	0.2%	0.2%
2016-2020	0.7%	1.8%	0.8%	0.6%	0.5%	0.4%

## 14. Summary of Market Penetration Scenario

Effects of above scenario on new housing up to 2020	Number of Installations	109,298	from 1994 to 2020
	Number of New Houses	3,035,714	
	Percentage of New Stock by 2020	3.6%	
Effects of above scenario on existing housing up to 2020	Number of Installations	90,000	up to 1993
	Number of Existing Houses	7,650,589	
	Percentage of Existing Stock by 2020	1.2%	

## Summary of Results

## 15. Summary of market penetration by the year 2020

Technology effects on housing stock by 2020	Number of Installations	199,298
	Number of Houses	10,686,303
	Percentage of stock	1.9%

## 16. Energy Savings Benefits for the Advanced House Technology with Above Market Penetrations, PJ

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.00	0.00	0.00	0.00	0.00	0.00
2001-2005	0.18	0.18	0.07	0.07	0.24	0.24
2006-2010	0.35	0.53	0.15	0.21	0.50	0.74
2011-2015	0.88	1.41	0.38	0.59	1.26	2.00
2016-2020	2.11	3.51	0.78	1.37	2.89	4.89

\* Annual — Energy saved at the end of the period, PJ/year

## 17. Environmental Benefits, Carbon Dioxide Emissions, kilotons

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.0	0	0.0	0	0.0	0
2001-2005	1.4	1	0.5	1	1.9	2
2006-2010	2.6	4	1.1	2	3.6	6
2011-2015	5.8	10	2.5	4	8.3	14
2016-2020	13.9	24	5.1	9	19.0	33

\* Annual — Emissions reduced at the end of the period, kilotons/year

18. Environmental Benefits, Methane CH<sub>4</sub>, tonnes

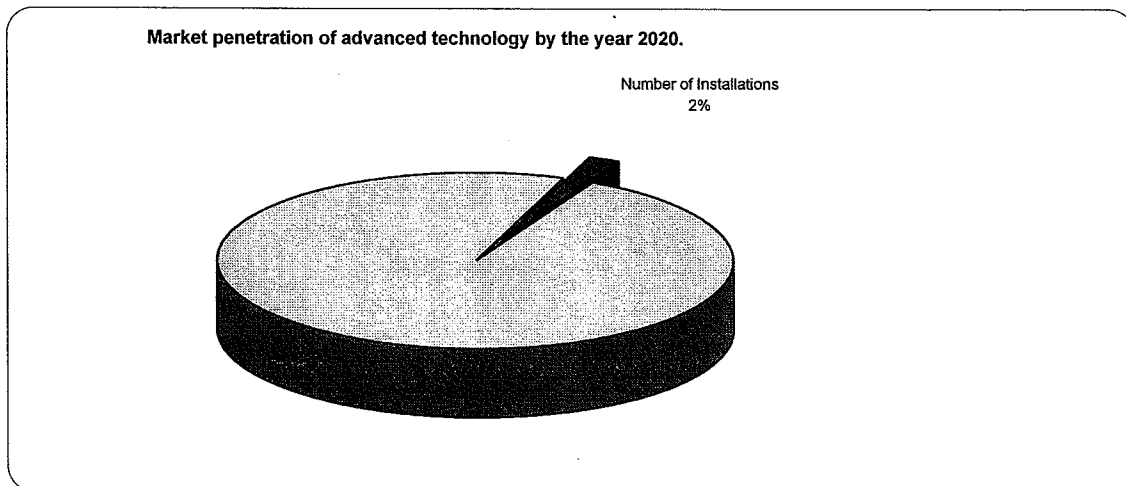
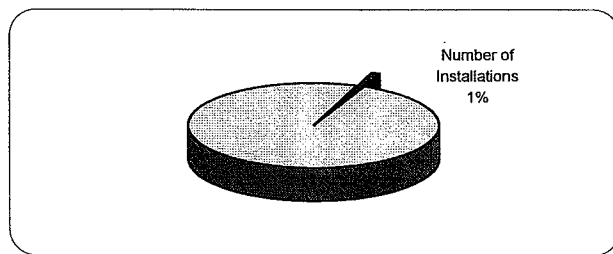
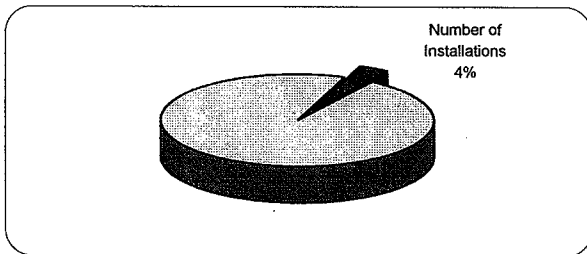
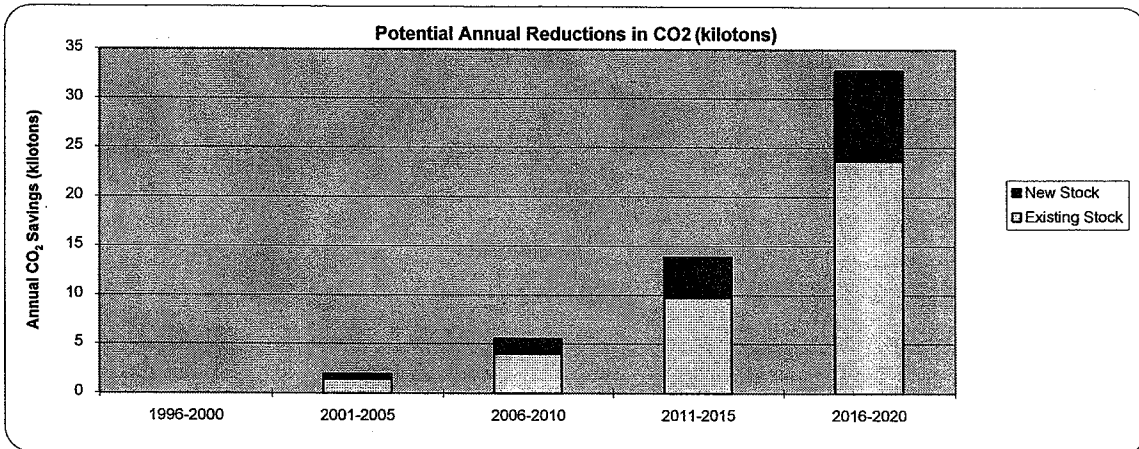
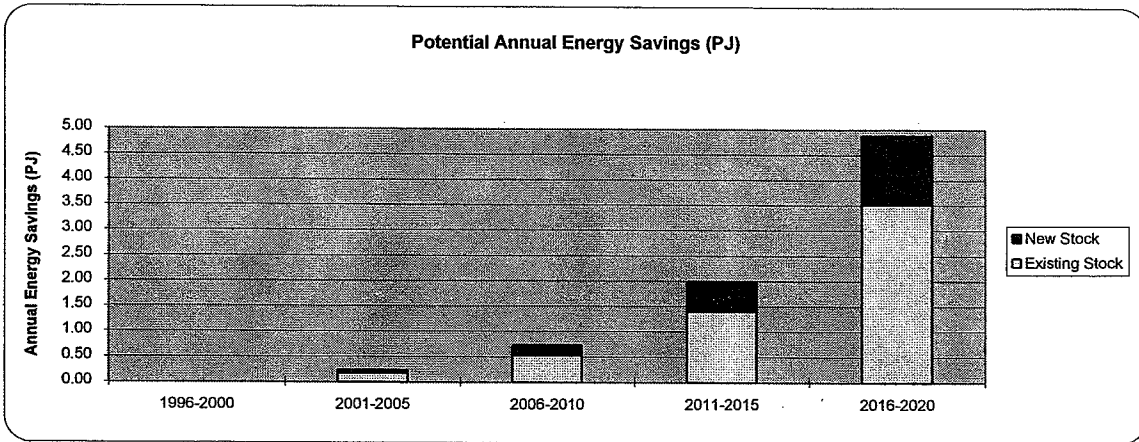
	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.0	0	0.0	0.0	0.0	0
2001-2005	0.1	0	0.0	0.0	0.1	0
2006-2010	0.2	0	0.1	0.1	0.3	0
2011-2015	0.4	1	0.2	0.3	0.6	1
2016-2020	1.0	2	0.4	0.7	1.4	2

\* Annual — Emissions reduced at the end of the period, tonnes/year

19. Environmental Benefits, N<sub>2</sub>O, tonnes

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.00	0.00	0.00	0.00	0.00	0.00
2001-2005	0.13	0.13	0.05	0.05	0.18	0.18
2006-2010	0.24	0.37	0.10	0.15	0.34	0.52
2011-2015	0.54	0.91	0.24	0.39	0.78	1.30
2016-2020	1.30	2.21	0.48	0.87	1.78	3.08

\* Annual — Emissions reduced at the end of the period, tonnes/year



## HOT-2000 Simulation Runs

**20. Simulation Results**

**Base Systems and Fuels:** Oil - Base system with AFUE of 71%, DHW energy factor of 0.53  
**New Fuels:** Oil - Retrofit with Advanced Oil System AFUE 85% and DHW energy factor of 0.75

**Energy consumption for the "typical" houses (kWh)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	89,519.2	100,866.2	79,366.9	117,833.0	58,171.4
	Upgrade	74,783.0	84,119.4	66,154.6	98,039.1	48,748.9
1946-1960	Base	80,993.8	88,669.8	54,169.6	80,056.0	40,748.9
	Upgrade	51,007.4	57,340.6	45,163.6	66,742.0	34,147.9
1961-1980	Base	53,702.8	60,004.7	47,224.0	70,043.7	35,556.0
	Upgrade	44,910.3	50,132.5	39,360.3	58,487.9	29,729.0
1981-1993	Base	36,390.7	40,380.6	31,883.2	47,232.5	23,870.9
	Upgrade	30,268.3	33,669.1	26,433.2	39,401.3	19,796.7
National Energy Code / new R-2000	Base	25,549.9	28,725.0	23,684.2	33,643.9	16,324.4
	Upgrade	22,400.3	24,269.6	20,615.8	29,773.6	14,098.9

**Floor Area** 155.00 sqm

**Energy consumption per unit floor area (kWh/m<sup>2</sup>)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	577.5	650.7	512.0	760.2	375.3
	Upgrade	482.5	542.7	426.8	632.5	314.5
1946-1960	Base	393.5	443.0	349.5	516.5	262.9
	Upgrade	329.1	369.9	291.4	430.6	220.3
1961-1980	Base	346.5	387.1	304.7	451.9	229.4
	Upgrade	289.7	323.4	253.9	377.3	191.8
1981-1993	Base	234.8	260.5	205.7	304.7	154.0
	Upgrade	195.3	217.2	170.5	254.2	127.7
National Energy Code / new R-2000	Base	164.8	185.3	152.8	217.1	105.3
	Upgrade	144.5	156.6	133.0	192.1	91.0

**Energy Savings per Unit Floor Area, kWh/m<sup>2</sup>**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		95.07	108.04	85.24	127.70	60.79
1946-1960		64.43	73.09	58.10	85.90	42.59
1961-1980		56.73	63.69	50.73	74.55	37.59
1981-1993		39.50	43.30	35.16	50.52	26.29
NEC / new R-2000		20.32	28.74	19.80	24.97	14.36

**Percentage reduction in space heat and DHW energy consumption per house, %**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		16.5%	16.6%	16.6%	16.8%	16.2%
1946-1960		16.4%	16.5%	16.6%	16.6%	16.2%
1961-1980		16.4%	16.5%	16.7%	16.5%	16.4%
1981-1993		16.8%	16.6%	17.1%	16.6%	17.1%
NEC / new R-2000		12.3%	15.5%	13.0%	11.5%	13.6%

## Detailed Calculations

**21. New Construction - Housing stock projections (Single, semi-detached and row) - VISION 1992-2020**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	7,961,544	617,289	1,396,232	3,285,382	1,462,551	1,200,090
2000	8,378,640	649,628	1,469,379	3,457,499	1,539,173	1,262,961
2005	8,897,720	689,874	1,560,411	3,671,701	1,634,529	1,341,205
2010	9,470,970	734,320	1,660,943	3,908,256	1,739,836	1,427,614
2015	10,073,990	781,075	1,766,896	4,157,096	1,850,612	1,518,511
2020	10,686,303	828,550	1,874,079	4,409,771	1,963,095	1,610,808

**22. New Construction - Housing stock projections (Single, semi-detached and row)**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	310,955	28,163	71,489	110,594	59,135	41,575
2000	417,096	37,776	95,891	148,344	79,320	55,766
2005	519,080	47,012	119,337	184,616	98,714	69,401
2010	573,250	51,918	131,791	203,882	109,016	76,644
2015	603,020	54,615	138,635	214,470	114,677	80,624
2020	612,313	55,456	140,771	217,775	116,444	81,866
<b>Total</b>	<b>3,035,714</b>	<b>274,940</b>	<b>697,913</b>	<b>1,079,681</b>	<b>577,305</b>	<b>405,875</b>

**23. Existing Housing Stock (Single) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,351,153	176,173	220,592	537,691	279,452	137,245
1946-1960	1,356,041	116,284	235,390	523,527	294,130	186,710
1961-1970	875,044	77,904	185,087	291,760	186,788	133,505
1971-1980	1,156,834	123,055	227,748	318,531	275,851	211,649
1981-1993	1,248,212	111,103	246,432	449,462	226,026	215,189
<b>Total</b>	<b>5,987,284</b>	<b>604,519</b>	<b>1,115,249</b>	<b>2,120,971</b>	<b>1,262,247</b>	<b>884,298</b>

**24. Existing Housing Stock (semi-detached and row) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	507,552	29,932	261,940	179,050	22,520	14,110
1946-1960	308,440	14,910	174,255	66,735	33,715	18,825
1961-1970	249,519	15,775	99,200	83,660	30,359	20,525
1971-1980	308,931	14,779	47,276	158,968	59,112	28,796
1981-1993	288,863	12,986	60,956	111,623	46,968	56,330
<b>Total</b>	<b>1,663,305</b>	<b>88,382</b>	<b>643,627</b>	<b>600,036</b>	<b>192,674</b>	<b>138,586</b>

## 25. Existing Housing Stock (Single, semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC	%age of total
Pre-1945	1,858,705	206,105	482,532	716,741	301,972	151,355	24.3%
1946-1960	1,664,481	131,194	409,645	590,262	327,845	205,535	21.8%
1961-1970	1,124,563	93,679	284,287	375,420	217,147	154,030	14.7%
1971-1980	1,465,765	137,834	275,024	477,499	334,963	240,445	19.2%
1981-1993	1,537,075	124,089	307,388	561,085	272,994	271,519	20.1%
<b>Total</b>	<b>7,650,589</b>	<b>692,901</b>	<b>1,758,876</b>	<b>2,721,007</b>	<b>1,454,921</b>	<b>1,022,884</b>	<b>100.0%</b>
%age of total		9.06%	22.99%	35.57%	19.02%	13.37%	
Single/Total		7.75%	17.54%	41.27%	18.37%	15.07%	

## 26. Existing Housing Average Floor Space (m2) (Single, semi-detached and row) - STAR-Housing

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	159	147	160	174	130	146
1946-1960	165	161	168	183	133	157
1961-1970	170	176	160	184	151	179
1971-1980	164	176	147	172	149	181
1981-1993	156	153	153	160	150	160

## 27. Existing housing stock potential energy savings (GWh) assuming 100% market penetration

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	28,187	2,889	8,342	10,612	5,004	1,340
1946-1960	17,796	1,365	5,033	6,266	3,759	1,373
1961-1970	12,368	1,064	3,316	4,003	2,811	1,174
1971-1980	13,475	1,376	2,578	4,155	3,726	1,640
1981-1993	9,147	748	2,031	3,153	2,072	1,144
<b>Total (GWh)</b>	<b>80,974</b>	<b>7,442</b>	<b>21,301</b>	<b>28,188</b>	<b>17,373</b>	<b>6,670</b>
<b>Total (PJ)</b>	<b>291.50</b>	<b>26.79</b>	<b>76.68</b>	<b>101.48</b>	<b>62.54</b>	<b>24.01</b>

## 28. Fuel Use Summary % (1993 - Statistics Canada)

	Electricity	Oil	Natural Gas	Wood	Propane
Atlantic	41.14	51.58	0.00	3.57	3.71
Quebec	65.00	22.90	8.60	3.50	0.00
Ontario	18.00	16.50	62.70	2.80	0.00
Prairies	17.24	15.41	67.09	0.26	0.00
BC	27.30	11.20	56.20	5.30	0.00
Canada	32.00	20.24	44.55	2.88	0.34

## 29. Potential Energy Savings by Fuel Type - Existing Stock - assuming 100% market penetrations, PJ

	Electricity	Oil	Natural Gas	Wood	Propane	Total
Atlantic	0.00	13.82	0.00	0.00	0.00	13.82
Quebec	0.00	17.56	0.00	0.00	0.00	17.56
Ontario	0.00	16.74	0.00	0.00	0.00	16.74
Prairies	0.00	9.64	0.00	0.00	0.00	9.64
BC	0.00	2.69	0.00	0.00	0.00	2.69
Canada	0.00	60.45	0.00	0.00	0.00	60.45

## 30. Residential Energy Demand by Fuels (VISION 1992-2020)

	Electricity	Oil	Natural Gas	Wood	Other	Total
1996-2000	34.0%	12.0%	46.0%	3.0%	5.0%	100.0%
2001-2005	35.0%	11.0%	47.0%	3.0%	4.0%	100.0%
2006-2010	37.0%	10.0%	47.0%	3.0%	3.0%	100.0%
2011-2015	38.0%	9.0%	48.0%	3.0%	2.0%	100.0%
2016-2020	39.0%	9.0%	48.0%	3.0%	1.0%	100.0%

## 31. Electricity Production by Fuels (VISION - 1992-2020)

	Coal	Oil	Natural Gas	Hydro	Nuclear	Other
1996-2000	16.8%	2.6%	2.3%	62.0%	15.3%	1.1%
2001-2005	13.2%	2.1%	4.4%	60.1%	17.9%	2.2%
2006-2010	12.5%	1.7%	5.5%	61.1%	17.2%	2.0%
2011-2015	13.2%	1.0%	5.2%	59.7%	18.9%	1.9%
2016-2020	13.9%	0.3%	4.9%	58.4%	20.7%	1.7%
<b>Thermal efficiency</b>	<b>30.0%</b>	<b>33.0%</b>	<b>36.0%</b>	<b>48.0%</b>	<b>42.0%</b>	<b>33.0%</b>

## 32. Emission Conversion Factors (Environment Canada)

Combustion source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
Natural Gas	49.68	1.14	0.62
Wood	81.47	0.02	8.89
Fuel Oil	73.11	5.53	6.85
Coal	83.00	0.00	13.40
Propane	49.68	1.14	0.62

33. Electricity Generation Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	55.41	0.51	8.09
2001-2005	47.49	0.50	6.44
2006-2010	45.96	0.46	6.03
2011-2015	46.00	0.33	6.21
2016-2020	46.05	0.21	6.38

34. Environmental Emissions Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	8.77	0.66	0.82
2001-2005	8.04	0.61	0.75
2006-2010	7.31	0.55	0.69
2011-2015	6.58	0.50	0.62
2016-2020	6.58	0.50	0.62

Fuel switching

FALSE

35. Environmental Emissions Equivalence, after retrofit

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	8.77	0.66	0.82
2001-2005	8.04	0.61	0.75
2006-2010	7.31	0.55	0.69
2011-2015	6.58	0.50	0.62
2016-2020	6.58	0.50	0.62

36. Environmental Emissions Equivalence, net benefits

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	8.77	0.66	0.82
2001-2005	8.04	0.61	0.75
2006-2010	7.31	0.55	0.69
2011-2015	6.58	0.50	0.62
2016-2020	6.58	0.50	0.62

# Environmental Assessment of Advanced House Technologies

1. Technology  
2. Description

**Integrated Heating / Ventilating Appliance**

3. Assumptions

- 1 Anticipated that Natural Gas will be available in Greater Montreal and Quebec City area by the year 2000.
- 2 Steady state efficiency of 94% for space heat; DHW energy factor of 0.86
- 3 HRV Performance data: 0 C, 158 W, 84%; -25 C, 176 W, 72%

4. Type of fuel affected with the application of technology:

	Retrofit		New Construction		Legend:				
	Existing	New Fuel	Conventional	New Fuel					
Electricity	0	0	0	0	<table border="1" style="font-size: small;"> <tr><td>1</td><td>Yes</td></tr> <tr><td>0</td><td>No</td></tr> </table> Input data field	1	Yes	0	No
1	Yes								
0	No								
Natural Gas	1	1	1	1					
Oil	0	0	0	0					
Wood	0	0	0	0					
Propane	0	0	0	0					

5. Scope of Technology

		Legend:				
Atlantic	0	<table border="1" style="font-size: small;"> <tr><td>1</td><td>Yes</td></tr> <tr><td>0</td><td>No</td></tr> </table>	1	Yes	0	No
1	Yes					
0	No					
Quebec	1					
Ontario	1					
Prairie	1					
BC	1					

6. Energy Savings (kWh/m<sup>2</sup> of floor area)

	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	0.00	226.29	178.45	263.05	139.59
1946-1960	0.00	140.74	109.36	161.09	87.08
1961-1980	0.00	121.47	93.88	138.55	75.60
1981-1993	0.00	25.95	15.77	27.77	15.59
NEC / new R-2000	0.00	14.29	9.88	17.70	7.87

7. Applicable New Construction Stock Per Period Based on Fuels

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	185,814	0	8,247	93,012	53,215	31,340
2001-2005	231,247	0	10,263	115,754	66,226	39,003
2006-2010	255,379	0	11,334	127,834	73,138	43,074
2011-2015	268,642	0	11,923	134,473	76,936	45,311
2016-2020	272,782	0	12,106	136,545	78,121	46,009

8. Market Penetration by Period (New Construction) - Enter fraction of applicable stock using AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	1.0%	0.0%	0.0%	1.0%	1.0%	1.0%
2001-2005	7.7%	0.0%	0.5%	8.0%	8.0%	8.0%
2006-2010	14.5%	0.0%	3.0%	16.0%	15.0%	15.0%
2011-2015	19.3%	0.0%	4.5%	20.0%	20.0%	20.0%
2016-2020	24.2%	0.0%	6.0%	25.0%	25.0%	25.0%

Comments:

Penetration rates assume competition with other advanced gas technologies.

9. Number of Related Retrofits/year

134,000

10. Applicable Existing Stock Based on Fuels

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	778,546	0	41,498	449,397	202,590	85,062
1946-1960	740,783	0	35,229	370,094	219,948	115,511
1961-1970	492,084	0	24,449	235,388	145,682	86,565
1971-1980	682,898	0	23,652	299,392	224,724	135,130
1981-1993	713,979	0	26,435	351,800	183,149	152,594
<b>Total</b>	<b>3,408,289</b>	<b>0</b>	<b>151,263</b>	<b>1,706,071</b>	<b>976,094</b>	<b>574,861</b>

11. Market Penetration by Period (Existing) - Enter fraction of related retrofits using AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.9%	0.0%	0.0%	0.9%	0.9%	0.9%
2001-2005	6.9%	0.0%	0.5%	7.2%	7.2%	7.2%
2006-2010	13.0%	0.0%	2.7%	13.5%	13.5%	13.5%
2011-2015	17.5%	0.0%	4.1%	18.0%	18.0%	18.0%
2016-2020	21.9%	0.0%	5.4%	22.5%	22.5%	22.5%

Comments:

There are 134,000 retrofits of gas systems every year. Replacement rate is reduced due to ventilation distribution system and also due to competing gas technologies.

12. Market Penetration by Period (New Construction) - Net fraction of all new housing using AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.4%	0.0%	0.0%	0.6%	0.7%	0.6%
2001-2005	3.4%	0.0%	0.0%	5.0%	5.4%	4.5%
2006-2010	6.4%	0.0%	0.3%	9.4%	10.1%	8.4%
2011-2015	8.6%	0.0%	0.4%	12.5%	13.4%	11.2%
2016-2020	10.8%	0.0%	0.5%	15.7%	16.8%	14.1%

## 13. Market Penetration by Period (Existing) - Net fraction of existing stock retrofitted with AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%
2001-2005	0.6%	0.0%	0.0%	0.9%	0.9%	0.8%
2006-2010	1.1%	0.0%	0.0%	1.7%	1.8%	1.5%
2011-2015	1.5%	0.0%	0.1%	2.2%	2.4%	2.0%
2016-2020	1.9%	0.0%	0.1%	2.8%	3.0%	2.5%

## 14. Summary of Market Penetration Scenario

Effects of above scenario on new housing up to 2020	Number of Installations	175,552	from 1994 to 2020
	Number of New Houses	3,035,714	
	Percentage of New Stock by 2020	5.8%	
Effects of above scenario on existing housing up to 2020	Number of Installations	401,351	up to 1993
	Number of Existing Houses	7,650,589	
	Percentage of Existing Stock by 2020	5.2%	

## Summary of Results

## 15. Summary of market penetration by the year 2020

Technology effects on housing stock by 2020	Number of Installations	576,903
	Number of Houses	10,686,303
	Percentage of stock	5.4%

## 16. Energy Savings Benefits for the Advanced House Technology with Above Market Penetrations, PJ

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.38	0.38	0.01	0.01	0.39	0.39
2001-2005	3.03	3.41	0.12	0.13	3.15	3.54
2006-2010	5.72	9.13	0.25	0.38	5.97	9.51
2011-2015	7.64	16.77	0.35	0.72	7.99	17.50
2016-2020	9.56	26.34	0.44	1.16	10.00	27.50

\* Annual — Energy saved at the end of the period, PJ/year

## 17. Environmental Benefits, Carbon Dioxide Emissions, kilotons

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	8.6	9	0.3	0	8.9	9
2001-2005	70.7	79	2.8	3	73.5	82
2006-2010	133.7	213	5.7	9	139.4	222
2011-2015	182.3	395	8.2	17	190.5	412
2016-2020	228.0	623	10.5	27	238.5	651

\* Annual — Emissions reduced at the end of the period, kilotons/year

18. Environmental Benefits, Methane CH<sub>4</sub>, tonnes

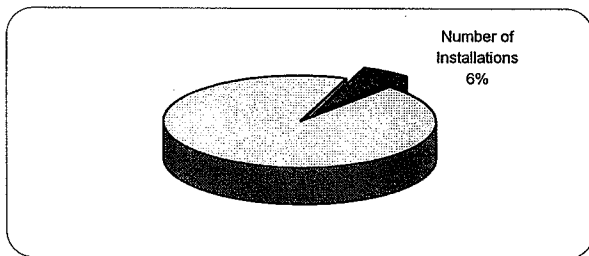
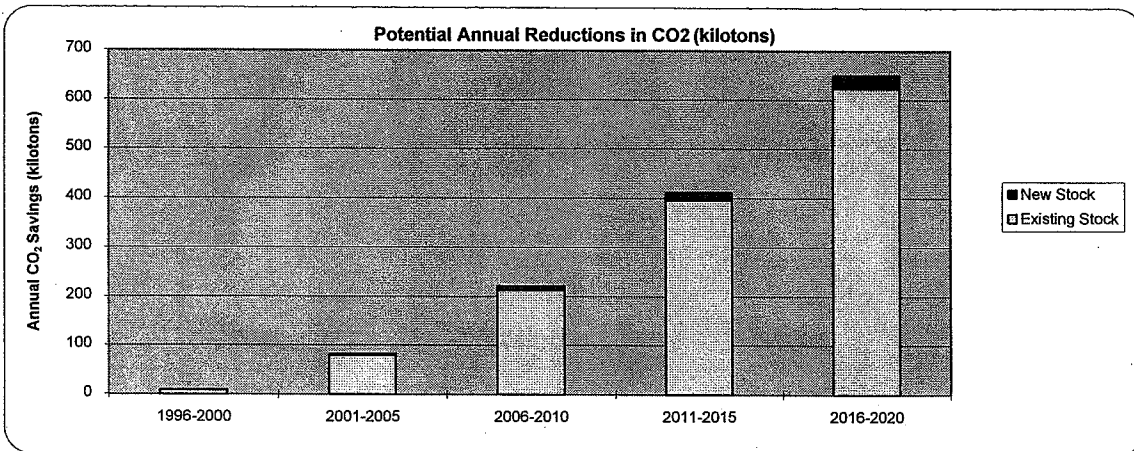
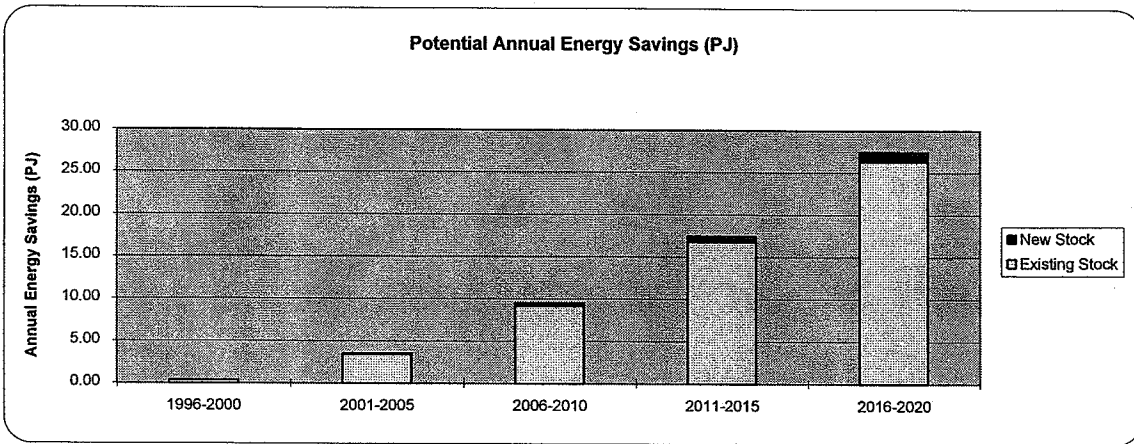
	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.2	0	0.0	0.0	0.2	0
2001-2005	1.6	2	0.1	0.1	1.7	2
2006-2010	3.1	5	0.1	0.2	3.2	5
2011-2015	4.2	9	0.2	0.4	4.4	9
2016-2020	5.2	14	0.2	0.6	5.5	15

\* Annual — Emissions reduced at the end of the period, tonnes/year

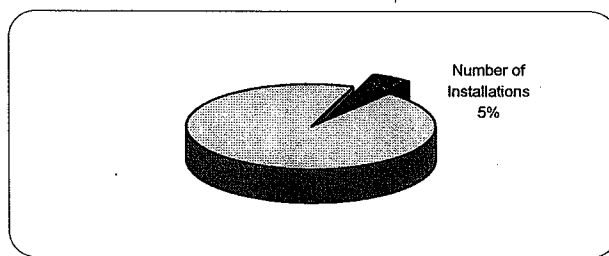
19. Environmental Benefits, N<sub>2</sub>O, tonnes

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.11	0.11	0.00	0.00	0.11	0.11
2001-2005	0.88	0.99	0.03	0.04	0.92	1.03
2006-2010	1.67	2.66	0.07	0.11	1.74	2.77
2011-2015	2.27	4.93	0.10	0.21	2.38	5.15
2016-2020	2.85	7.78	0.13	0.34	2.98	8.12

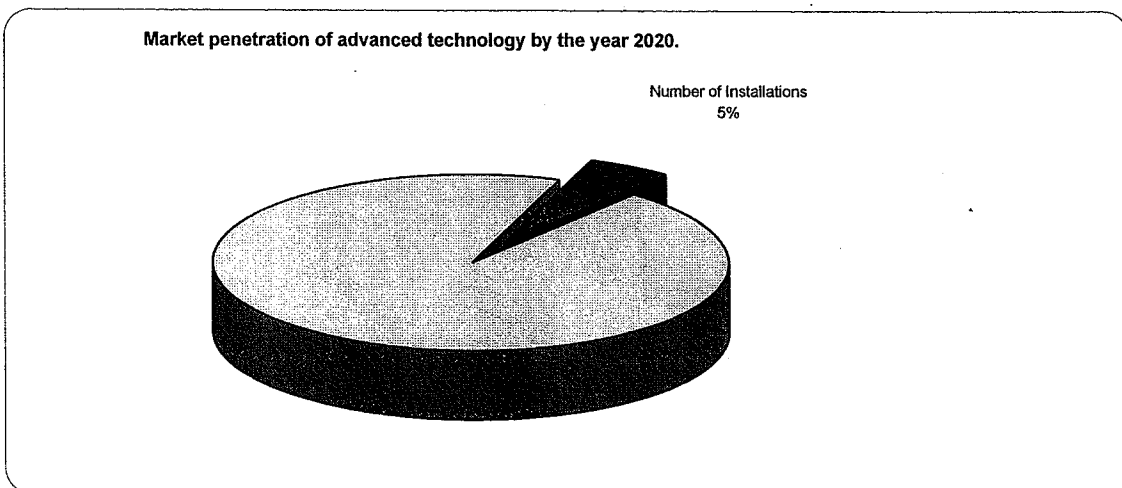
\* Annual — Emissions reduced at the end of the period, tonnes/year



Market penetration in new housing stock built during 1994-2020 by the year 2020.



Market penetration in existing housing stock built up to 1993 by the year 2020.





## HOT-2000 Simulation Runs

### 20. Simulation Results

**Base Systems and Fuels:** In the retrofit - natural gas forced-air systems, and natural gas DHW system  
 In new construction - spark ignition conventional gas furnace (78% ss eff.)

**New Fuels:** Natural gas

#### Energy consumption for the "typical" houses (kWh)

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base		114,042.4	89,744.3	134,317.7	67,207.0
	Upgrade		78,967.0	62,084.7	93,545.2	45,570.5
1946-1960	Base		76,419.9	60,020.4	88,868.9	45,814.3
	Upgrade		54,605.9	43,069.2	63,899.8	32,316.7
1961-1980	Base		66,899.0	52,389.1	77,850.9	40,104.1
	Upgrade		48,069.5	37,837.3	56,385.7	28,386.2
1981-1993	Base		37,114.3	28,688.0	43,335.7	21,893.8
	Upgrade		33,092.5	26,224.4	39,031.4	19,476.7
National Energy Code / new R-2000	Base		29,652.1	24,437.5	35,458.9	15,560.3
	Upgrade		27,436.4	22,905.8	32,714.9	15,340.3

Floor Area 155.00 sqm

#### Energy consumption per unit floor area (kWh/m<sup>2</sup>)

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	-	735.8	579.0	866.6	433.6
	Upgrade	-	509.5	400.5	603.5	294.0
1946-1960	Base	-	493.0	387.2	573.3	295.6
	Upgrade	-	352.3	277.9	412.3	208.5
1961-1980	Base	-	431.6	338.0	502.3	258.7
	Upgrade	-	310.1	244.1	363.8	183.1
1981-1993	Base	-	239.4	185.0	279.6	141.3
	Upgrade	-	213.5	169.2	251.8	125.7
National Energy Code / new R-2000	Base	-	191.3	157.7	228.8	106.8
	Upgrade	-	177.0	147.8	211.1	99.0

#### Energy Savings per Unit Floor Area, kWh/m<sup>2</sup>

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		-	226.29	178.45	263.05	139.59
1946-1960		-	140.74	109.36	161.09	87.08
1961-1980		-	121.47	93.88	138.55	75.60
1981-1993		-	25.95	15.77	27.77	15.59
NEC / new R-2000		-	14.29	9.88	17.70	7.87

#### Percentage reduction in space heat and DHW energy consumption per house, %

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		#DIV/0!	30.8%	30.8%	30.4%	32.2%
1946-1960		#DIV/0!	28.5%	28.2%	28.1%	29.5%
1961-1980		#DIV/0!	28.1%	27.8%	27.6%	29.2%
1981-1993		#DIV/0!	10.8%	8.5%	9.9%	11.0%
NEC / new R-2000		#DIV/0!	7.5%	6.3%	7.7%	7.4%

## Detailed Calculations

### 21. New Construction - Housing stock projections (Single, semi-detached and row) - VISION 1992-2020

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	7,961,544	617,289	1,396,232	3,285,382	1,462,551	1,200,090
2000	8,378,640	649,628	1,469,379	3,457,499	1,539,173	1,262,961
2005	8,897,720	689,874	1,560,411	3,671,701	1,634,529	1,341,205
2010	9,470,970	734,320	1,660,943	3,908,256	1,739,836	1,427,614
2015	10,073,990	781,075	1,766,696	4,157,096	1,850,612	1,518,511
2020	10,686,303	828,550	1,874,079	4,409,771	1,963,095	1,610,808

### 22. New Construction - Housing stock projections (Single, semi-detached and row)

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	310,955	28,163	71,489	110,594	59,135	41,575
2000	417,096	37,776	95,891	148,344	79,320	55,766
2005	519,080	47,012	119,337	184,616	98,714	69,401
2010	573,250	51,918	131,791	203,882	109,016	76,644
2015	603,020	54,615	138,635	214,470	114,677	80,624
2020	612,313	55,456	140,771	217,775	116,444	81,866
<b>Total</b>	<b>3,035,714</b>	<b>274,940</b>	<b>697,913</b>	<b>1,079,681</b>	<b>577,305</b>	<b>405,875</b>

### 23. Existing Housing Stock (Single) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,351,153	176,173	220,592	537,691	279,452	137,245
1946-1960	1,356,041	116,284	235,390	523,527	294,130	186,710
1961-1970	875,044	77,904	185,087	291,760	186,788	133,505
1971-1980	1,156,834	123,055	227,748	318,531	275,851	211,649
1981-1993	1,248,212	111,103	246,432	449,462	226,026	215,189
<b>Total</b>	<b>5,987,284</b>	<b>604,519</b>	<b>1,115,249</b>	<b>2,120,971</b>	<b>1,262,247</b>	<b>884,298</b>

### 24. Existing Housing Stock (semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	507,552	29,932	261,940	179,050	22,520	14,110
1946-1960	308,440	14,910	174,255	66,735	33,715	18,825
1961-1970	249,519	15,775	99,200	83,660	30,359	20,525
1971-1980	308,931	14,779	47,276	158,968	59,112	28,796
1981-1993	288,863	12,986	60,956	111,623	46,968	56,330
<b>Total</b>	<b>1,663,305</b>	<b>88,382</b>	<b>643,627</b>	<b>600,036</b>	<b>192,674</b>	<b>138,586</b>

25. Existing Housing Stock (Single, semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC	%age of total
Pre-1945	1,858,705	206,105	482,532	716,741	301,972	151,355	24.3%
1946-1960	1,664,481	131,194	409,645	590,262	327,845	205,535	21.8%
1961-1970	1,124,563	93,679	284,287	375,420	217,147	154,030	14.7%
1971-1980	1,465,765	137,834	275,024	477,499	334,963	240,445	19.2%
1981-1993	1,537,075	124,089	307,388	561,085	272,994	271,519	20.1%
<b>Total</b>	<b>7,650,589</b>	<b>692,901</b>	<b>1,758,876</b>	<b>2,721,007</b>	<b>1,454,921</b>	<b>1,022,884</b>	<b>100.0%</b>
%age of total		9.06%	22.99%	35.57%	19.02%	13.37%	
Single/Total		7.75%	17.54%	41.27%	18.37%	15.07%	

26. Existing Housing Average Floor Space (m2) (Single, semi-detached and row) - STAR-Housing

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	159	147	160	174	130	146
1946-1960	165	161	168	183	133	157
1961-1970	170	176	160	184	151	179
1971-1980	164	176	147	172	149	181
1981-1993	156	153	153	160	150	160

27. Existing housing stock potential energy savings (GWh) assuming 100% market penetration

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	53,072	0	17,471	22,217	10,308	3,076
1946-1960	31,343	0	9,691	11,794	7,049	2,808
1961-1970	21,591	0	6,385	7,534	5,272	2,400
1971-1980	22,828	0	4,917	7,688	6,925	3,297
1981-1993	4,448	0	1,217	1,414	1,139	679
<b>Total (GWh)</b>	<b>133,282</b>	<b>0</b>	<b>39,682</b>	<b>50,646</b>	<b>30,694</b>	<b>12,260</b>
<b>Total (PJ)</b>	<b>479.81</b>	<b>0.00</b>	<b>142.85</b>	<b>182.32</b>	<b>110.50</b>	<b>44.14</b>

28. Fuel Use Summary % (1993 - Statistics Canada)

	Electricity	Oil	Natural Gas	Wood	Propane
Atlantic	41.14	51.58	0.00	3.57	3.71
Quebec	65.00	22.90	8.60	3.50	0.00
Ontario	18.00	16.50	62.70	2.80	0.00
Prairies	17.24	15.41	67.09	0.26	0.00
BC	27.30	11.20	56.20	5.30	0.00
Canada	32.00	20.24	44.55	2.88	0.34

29. Potential Energy Savings by Fuel Type - Existing Stock - assuming 100% market penetrations, PJ

	Electricity	Oil	Natural Gas	Wood	Propane	Total
Atlantic	0.00	0.00	0.00	0.00	0.00	0.00
Quebec	0.00	0.00	12.29	0.00	0.00	12.29
Ontario	0.00	0.00	114.32	0.00	0.00	114.32
Prairies	0.00	0.00	74.13	0.00	0.00	74.13
BC	0.00	0.00	24.80	0.00	0.00	24.80
Canada	0.00	0.00	225.54	0.00	0.00	225.54

30. Residential Energy Demand by Fuels (VISION 1992-2020)

	Electricity	Oil	Natural Gas	Wood	Other	Total
1996-2000	34.0%	12.0%	46.0%	3.0%	5.0%	100.0%
2001-2005	35.0%	11.0%	47.0%	3.0%	4.0%	100.0%
2006-2010	37.0%	10.0%	47.0%	3.0%	3.0%	100.0%
2011-2015	38.0%	9.0%	48.0%	3.0%	2.0%	100.0%
2016-2020	39.0%	9.0%	48.0%	3.0%	1.0%	100.0%

31. Electricity Production by Fuels (VISION - 1992-2020)

	Coal	Oil	Natural Gas	Hydro	Nuclear	Other
1996-2000	16.8%	2.6%	2.3%	62.0%	15.3%	1.1%
2001-2005	13.2%	2.1%	4.4%	60.1%	17.9%	2.2%
2006-2010	12.5%	1.7%	5.5%	61.1%	17.2%	2.0%
2011-2015	13.2%	1.0%	5.2%	59.7%	18.9%	1.9%
2016-2020	13.9%	0.3%	4.9%	58.4%	20.7%	1.7%
<b>Thermal efficiency</b>	<b>30.0%</b>	<b>33.0%</b>	<b>36.0%</b>	<b>48.0%</b>	<b>42.0%</b>	<b>33.0%</b>

32. Emission Conversion Factors (Environment Canada)

Combustion source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
Natural Gas	49.68	1.14	0.62
Wood	81.47	0.02	8.89
Fuel Oil	73.11	5.53	6.85
Coal	83.00	0.00	13.40
Propane	49.68	1.14	0.62

## 33. Electricity Generation Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	55.41	0.51	8.09
2001-2005	47.49	0.50	6.44
2006-2010	45.96	0.46	6.03
2011-2015	46.00	0.33	6.21
2016-2020	46.05	0.21	6.38

## 34. Environmental Emissions Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	22.85	0.52	0.29
2001-2005	23.35	0.54	0.29
2006-2010	23.35	0.54	0.29
2011-2015	23.85	0.55	0.30
2016-2020	23.85	0.55	0.30

Fuel switching

FALSE

## 35. Environmental Emissions Equivalence, after retrofit

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	22.85	0.52	0.29
2001-2005	23.35	0.54	0.29
2006-2010	23.35	0.54	0.29
2011-2015	23.85	0.55	0.30
2016-2020	23.85	0.55	0.30

## 36. Environmental Emissions Equivalence, net benefits

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	22.85	0.52	0.29
2001-2005	23.35	0.54	0.29
2006-2010	23.35	0.54	0.29
2011-2015	23.85	0.55	0.30
2016-2020	23.85	0.55	0.30

# Environmental Assessment of Advanced House Technologies

**1. Technology** High Efficiency Fans / Motors (ECM)  
**2. Description**  
**3. Assumptions**  
 1 Applied to forced air systems. 45.8% of heating systems are forced air systems in existing housing.  
 2 The conventional furnace motor power demand is 465 W. The ECM motor has a power demand of 165 W.  
 3 Assumed that furnace fan is operating when required with heating or cooling loads.

**4. Type of fuel affected with the application of technology:**

	Retrofit		New Construction		Legend:
	Existing	New Fuel	Conventional	New Fuel	
Electricity	1	1	1	1	1 Yes 0 No Input data field
Natural Gas	1	1	1	1	
Oil	1	1	1	1	
Wood	0	0	0	0	
Propane	0	0	0	0	

**5. Scope of Technology**

Atlantic	1
Quebec	1
Ontario	1
Prairie	1
BC	1

**Legend:**

1	Yes
0	No

**6. Energy Savings (kWh/m<sup>2</sup> of floor area)**

	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	5.43	5.43	5.43	5.43	5.43
1946-1960	5.43	5.43	5.43	5.43	5.43
1961-1980	5.43	5.43	5.43	5.43	5.43
1981-1993	5.43	5.43	5.43	5.43	5.43
NEC / new R-2000	5.43	5.43	5.43	5.43	5.43

**7. Applicable New Construction Stock Per Period Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	403,678	35,026	92,535	144,191	79,117	52,810
2001-2005	502,382	43,590	115,160	179,447	98,462	65,723
2006-2010	554,809	48,139	127,178	198,173	108,737	72,581
2011-2015	583,621	50,639	133,783	208,465	114,384	76,351
2016-2020	592,615	51,419	135,844	211,677	116,147	77,527

**8. Market Penetration by Period (New Construction) - Enter fraction of applicable stock using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
2001-2005	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
2006-2010	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
2011-2015	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
2016-2020	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%

**Comments:** As ventilation requirements take effect adoption will accelerate.

**9. Number of Related Retrofits/year** 268,000

**10. Applicable Existing Stock Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,797,952	191,102	465,643	696,672	301,201	143,333
1946-1960	1,612,336	121,644	395,307	573,735	327,008	194,642
1961-1970	1,088,564	86,860	274,337	364,908	216,593	145,866
1971-1980	1,419,138	127,801	265,398	464,129	334,108	227,701
1981-1993	1,486,486	115,056	296,629	545,375	272,297	257,128
Total	7,404,477	642,464	1,697,315	2,644,819	1,451,208	968,671

**11. Market Penetration by Period (Existing) - Enter fraction of related retrofits using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
2001-2005	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
2006-2010	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
2011-2015	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
2016-2020	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%

**Comments:** There are 134,000 furnace replacements plus assumed equal number of fan replacements.

**12. Market Penetration by Period (New Construction) - Net fraction of all new housing using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	2.9%	2.8%	2.9%	2.9%	3.0%	2.8%
2001-2005	9.7%	9.3%	9.7%	9.7%	10.0%	9.5%
2006-2010	24.2%	23.2%	24.1%	24.3%	24.9%	23.7%
2011-2015	48.4%	46.4%	48.3%	48.6%	49.9%	47.4%
2016-2020	77.4%	74.2%	77.2%	77.8%	79.8%	75.8%

## 13. Market Penetration by Period (Existing) - Net fraction of existing stock retrofitted with AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
2001-2005	1.2%	1.2%	1.2%	1.2%	1.3%	1.2%
2006-2010	2.6%	2.5%	2.6%	2.6%	2.7%	2.6%
2011-2015	6.1%	5.9%	6.1%	6.2%	6.3%	6.0%
2016-2020	10.5%	10.1%	10.5%	10.6%	10.8%	10.3%

## 14. Summary of Market Penetration Scenario

Effects of above scenario on new housing up to 2020	Number of Installations	975,982	from 1994 to 2020
	Number of New Houses	3,035,714	
	Percentage of New Stock by 2020	32.2%	
Effects of above scenario on existing housing up to 2020	Number of Installations	1,608,000	up to 1993
	Number of Existing Houses	7,650,589	
	Percentage of Existing Stock by 2020	21.0%	

## Summary of Results

## 15. Summary of market penetration by the year 2020

Technology effects on housing stock by 2020	Number of Installations	2,583,982
	Number of Houses	10,686,303
	Percentage of stock	24.2%

## 16. Energy Savings Benefits for the Advanced House Technology with Above Market Penetrations, PJ

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.13	0.13	0.04	0.04	0.16	0.16
2001-2005	0.30	0.42	0.15	0.19	0.45	0.61
2006-2010	0.64	1.06	0.42	0.61	1.06	1.67
2011-2015	1.48	2.54	0.89	1.50	2.37	4.04
2016-2020	2.54	5.08	1.44	2.94	3.99	8.03

\* Annual — Energy saved at the end of the period, PJ/year

## 17. Environmental Benefits, Carbon Dioxide Emissions, kilotons

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	6.4	6	1.9	2	8.3	8
2001-2005	14.2	21	7.3	9	21.6	30
2006-2010	30.3	51	20.1	29	50.4	80
2011-2015	71.0	122	42.5	72	113.6	194
2016-2020	123.0	245	69.8	142	192.8	387

\* Annual — Emissions reduced at the end of the period, kilotons/year

18. Environmental Benefits, Methane CH<sub>4</sub>, tonnes

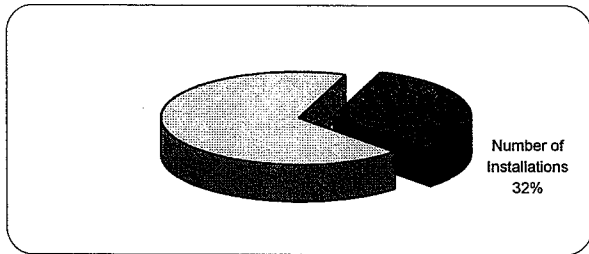
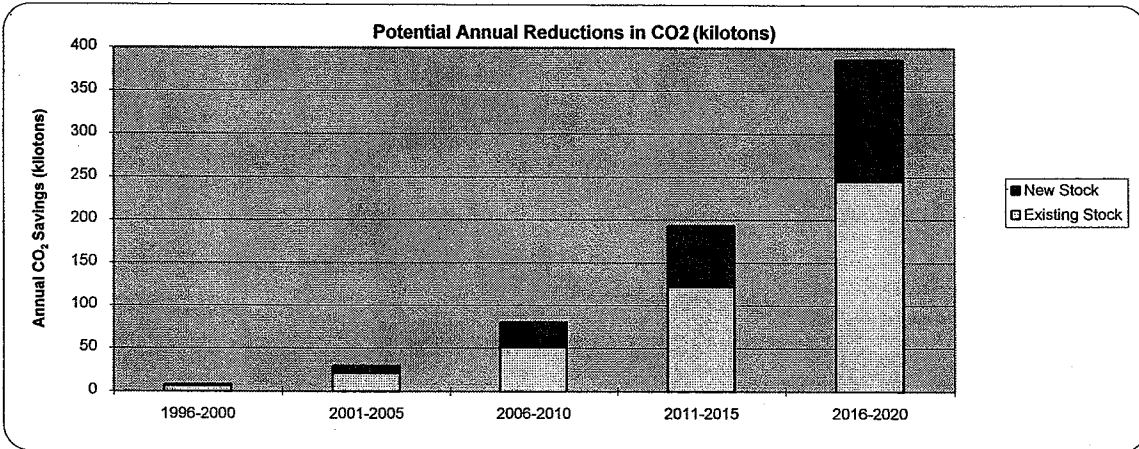
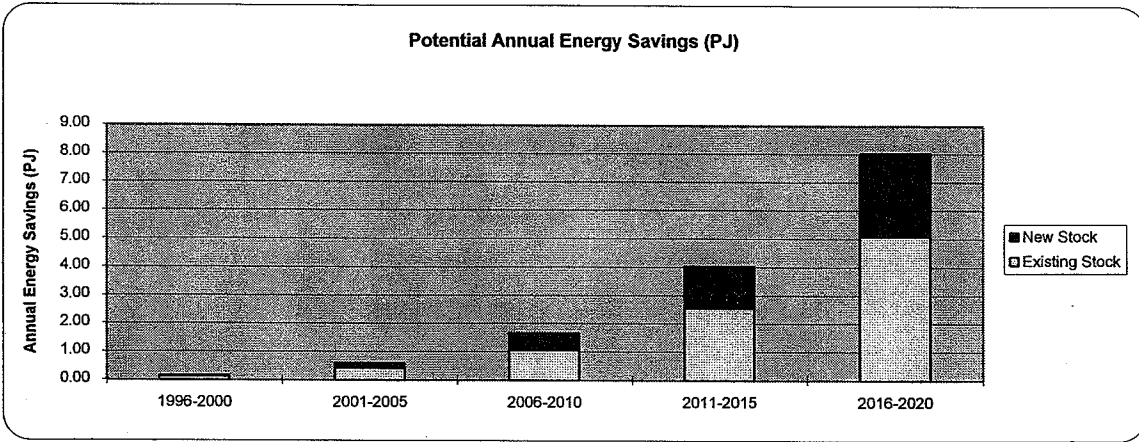
	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.2	0	0.1	0.1	0.2	0
2001-2005	0.4	1	0.2	0.3	0.6	1
2006-2010	0.8	1	0.5	0.8	1.3	2
2011-2015	1.7	3	1.0	1.8	2.8	5
2016-2020	2.9	6	1.7	3.5	4.6	9

\* Annual — Emissions reduced at the end of the period, tonnes/year

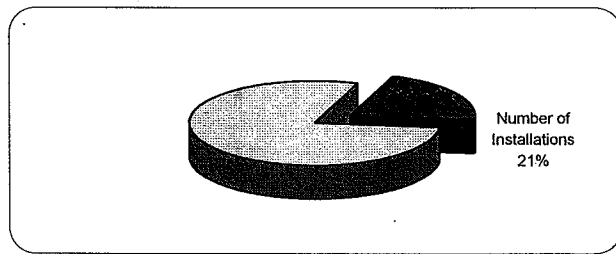
19. Environmental Benefits, N<sub>2</sub>O, tonnes

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.49	0.49	0.14	0.14	0.63	0.63
2001-2005	0.98	1.47	0.50	0.65	1.48	2.11
2006-2010	2.04	3.51	1.35	2.00	3.39	5.51
2011-2015	4.85	8.36	2.91	4.91	7.76	13.27
2016-2020	8.65	17.01	4.72	9.63	13.38	26.64

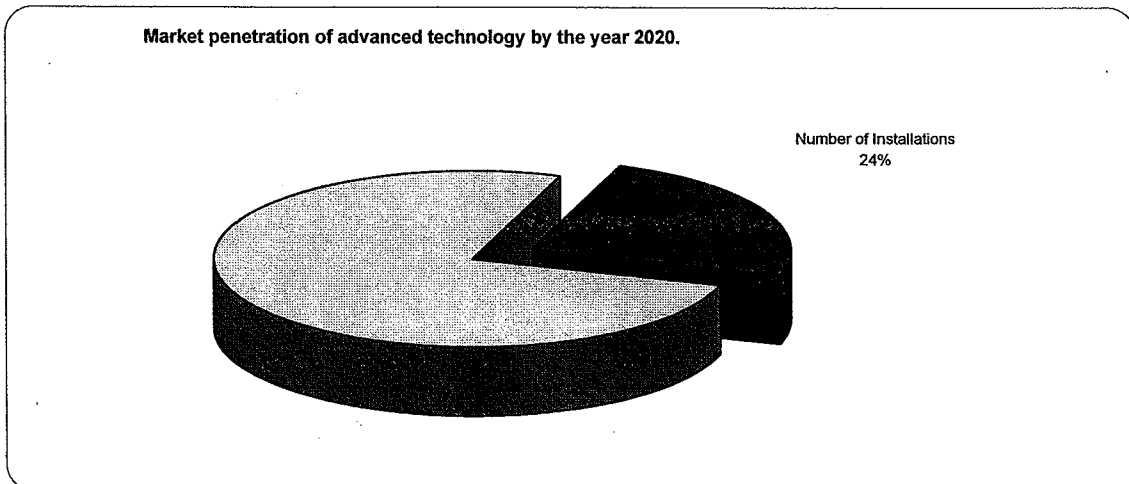
\* Annual — Emissions reduced at the end of the period, tonnes/year



Market penetration in new housing stock built during 1994-2020 by the year 2020.



Market penetration in existing housing stock built up to 1993 by the year 2020.



## HOT-2000 Simulation Runs

**20. Simulation Results**

**Base Systems and Fuels:**

Intermittent operation of furnace fan. Power demand is 465 W.  
Forced air systems

**New Fuels:**

Intermittent operation. Power demand is 165 W.

**Energy consumption for the "typical" fans (kWh)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	1,476.2	1,476.2	1,476.2	1,476.2	1,476.2
	Upgrade	634.7	634.7	634.7	634.7	634.7
1946-1960	Base	1,476.2	1,476.2	1,476.2	1,476.2	1,476.2
	Upgrade	634.7	634.7	634.7	634.7	634.7
1961-1980	Base	1,476.2	1,476.2	1,476.2	1,476.2	1,476.2
	Upgrade	634.7	634.7	634.7	634.7	634.7
1981-1993	Base	1,476.2	1,476.2	1,476.2	1,476.2	1,476.2
	Upgrade	634.7	634.7	634.7	634.7	634.7
National Energy Code / new R-2000	Base	1,476.2	1,476.2	1,476.2	1,476.2	1,476.2
	Upgrade	634.7	634.7	634.7	634.7	634.7

**Floor Area**

165.00 sqm

**Fan Energy consumption per unit floor area (kWh/m<sup>2</sup>)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	9.5	9.5	9.5	9.5	9.5
	Upgrade	4.1	4.1	4.1	4.1	4.1
1946-1960	Base	9.5	9.5	9.5	9.5	9.5
	Upgrade	4.1	4.1	4.1	4.1	4.1
1961-1980	Base	9.5	9.5	9.5	9.5	9.5
	Upgrade	4.1	4.1	4.1	4.1	4.1
1981-1993	Base	9.5	9.5	9.5	9.5	9.5
	Upgrade	4.1	4.1	4.1	4.1	4.1
National Energy Code / new R-2000	Base	9.5	9.5	9.5	9.5	9.5
	Upgrade	4.1	4.1	4.1	4.1	4.1

**Fan Energy Savings per Unit Floor Area, kWh/m<sup>2</sup>**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		5.43	5.43	5.43	5.43	5.43
1946-1960		5.43	5.43	5.43	5.43	5.43
1961-1980		5.43	5.43	5.43	5.43	5.43
1981-1993		5.43	5.43	5.43	5.43	5.43
NEC / new R-2000		5.43	5.43	5.43	5.43	5.43

**Percentage reduction in fan energy consumption per house, %**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945		57.0%	57.0%	57.0%	57.0%	57.0%
1946-1960		57.0%	57.0%	57.0%	57.0%	57.0%
1961-1980		57.0%	57.0%	57.0%	57.0%	57.0%
1981-1993		57.0%	57.0%	57.0%	57.0%	57.0%
NEC / new R-2000		57.0%	57.0%	57.0%	57.0%	57.0%

## Detailed Calculations

**21. New Construction - Housing stock projections (Single, semi-detached and row) - VISION 1992-2020**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	7,961,544	617,289	1,396,232	3,285,382	1,462,551	1,200,090
2000	8,378,640	649,628	1,469,379	3,457,499	1,539,173	1,262,961
2005	8,897,720	689,874	1,560,411	3,671,701	1,634,529	1,341,205
2010	9,470,970	734,320	1,660,943	3,908,256	1,739,836	1,427,614
2015	10,073,990	781,075	1,766,696	4,157,096	1,850,612	1,518,511
2020	10,686,303	828,550	1,874,079	4,409,771	1,963,095	1,610,808

**22. New Construction - Housing stock projections (Single, semi-detached and row)**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	310,955	28,163	71,489	110,594	59,135	41,575
2000	417,096	37,776	95,891	148,344	79,320	55,766
2005	519,080	47,012	119,337	184,616	98,714	69,401
2010	573,250	51,918	131,791	203,882	109,016	76,644
2015	603,020	54,615	138,635	214,470	114,677	80,624
2020	612,313	55,456	140,771	217,775	116,444	81,866
<b>Total</b>	<b>3,035,714</b>	<b>274,940</b>	<b>697,913</b>	<b>1,079,681</b>	<b>577,305</b>	<b>405,875</b>

**23. Existing Housing Stock (Single) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,351,153	176,173	220,592	537,691	279,452	137,245
1946-1960	1,356,041	116,284	235,390	523,527	294,130	186,710
1961-1970	875,044	77,904	185,087	291,760	186,788	133,505
1971-1980	1,156,834	123,055	227,748	318,531	275,851	211,649
1981-1993	1,248,212	111,103	246,432	449,462	226,026	215,189
<b>Total</b>	<b>5,987,284</b>	<b>604,519</b>	<b>1,115,249</b>	<b>2,120,971</b>	<b>1,262,247</b>	<b>884,298</b>

**24. Existing Housing Stock (semi-detached and row) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	507,552	29,932	261,940	179,050	22,520	14,110
1946-1960	308,440	14,910	174,255	66,735	33,715	18,825
1961-1970	249,519	15,775	99,200	83,660	30,359	20,525
1971-1980	308,931	14,779	47,276	158,968	59,112	28,796
1981-1993	288,863	12,986	60,956	111,623	46,968	56,330
<b>Total</b>	<b>1,663,305</b>	<b>88,382</b>	<b>643,627</b>	<b>600,036</b>	<b>192,674</b>	<b>138,586</b>

## 25. Existing Housing Stock (Single, semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC	%age of total
Pre-1945	1,858,705	206,105	482,532	716,741	301,972	151,355	24.3%
1946-1960	1,664,481	131,194	409,645	590,262	327,845	205,535	21.8%
1961-1970	1,124,563	93,679	284,287	375,420	217,147	154,030	14.7%
1971-1980	1,465,765	137,834	275,024	477,499	334,953	240,445	19.2%
1981-1993	1,537,075	124,089	307,388	561,085	272,994	271,519	20.1%
<b>Total</b>	<b>7,650,589</b>	<b>692,901</b>	<b>1,758,876</b>	<b>2,721,007</b>	<b>1,454,921</b>	<b>1,022,884</b>	<b>100.0%</b>
%age of total		9.06%	22.99%	35.57%	19.02%	13.37%	
Single/Total		7.75%	17.54%	41.27%	18.37%	15.07%	

## 26. Existing Housing Average Floor Space (m2) (Single, semi-detached and row) - STAR-Housing

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	159	147	160	174	130	146
1946-1960	165	161	168	183	133	157
1961-1970	170	176	160	184	151	179
1971-1980	164	176	147	172	149	181
1981-1993	156	153	153	160	150	160

## 27. Existing housing stock potential energy savings (GWh) assuming 100% market penetration

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,592	165	419	676	213	120
1946-1960	1,487	115	374	585	238	175
1961-1970	1,037	90	246	374	178	150
1971-1980	1,304	132	220	445	271	237
1981-1993	1,303	103	255	487	223	236
<b>Total (GWh)</b>	<b>6,724</b>	<b>604</b>	<b>1,514</b>	<b>2,567</b>	<b>1,122</b>	<b>917</b>
<b>Total (PJ)</b>	<b>24.21</b>	<b>2.17</b>	<b>5.45</b>	<b>9.24</b>	<b>4.04</b>	<b>3.30</b>

## 28. Fuel Use Summary % (1993 - Statistics Canada)

	Electricity	Oil	Natural Gas	Wood	Propane
Atlantic	41.14	51.58	0.00	3.57	3.71
Quebec	65.00	22.90	8.60	3.50	0.00
Ontario	18.00	16.50	62.70	2.80	0.00
Prairies	17.24	15.41	67.09	0.26	0.00
BC	27.30	11.20	56.20	5.30	0.00
Canada	32.00	20.24	44.55	2.88	0.34

## 29. Potential Energy Savings by Fuel Type - Existing Stock - assuming 100% market penetrations, PJ

	Electricity	Oil	Natural Gas	Wood	Propane	Total
Atlantic	0.89	1.12	0.00	0.00	0.00	2.02
Quebec	3.54	1.25	0.47	0.00	0.00	5.26
Ontario	1.66	1.52	5.79	0.00	0.00	8.98
Prairies	0.70	0.62	2.71	0.00	0.00	4.03
BC	0.90	0.37	1.86	0.00	0.00	3.13
Canada	7.70	4.89	10.83	0.00	0.00	23.41

## 30. Residential Energy Demand by Fuels (VISION 1992-2020)

	Electricity	Oil	Natural Gas	Wood	Other	Total
1996-2000	34.0%	12.0%	46.0%	3.0%	5.0%	100.0%
2001-2005	35.0%	11.0%	47.0%	3.0%	4.0%	100.0%
2006-2010	37.0%	10.0%	47.0%	3.0%	3.0%	100.0%
2011-2015	38.0%	9.0%	48.0%	3.0%	2.0%	100.0%
2016-2020	39.0%	9.0%	48.0%	3.0%	1.0%	100.0%

## 31. Electricity Production by Fuels (VISION - 1992-2020)

	Coal	Oil	Natural Gas	Hydro	Nuclear	Other
1996-2000	16.8%	2.6%	2.3%	62.0%	15.3%	1.1%
2001-2005	13.2%	2.1%	4.4%	60.1%	17.9%	2.2%
2006-2010	12.5%	1.7%	5.5%	61.1%	17.2%	2.0%
2011-2015	13.2%	1.0%	5.2%	59.7%	18.9%	1.9%
2016-2020	13.9%	0.3%	4.9%	58.4%	20.7%	1.7%
<b>Thermal efficiency</b>	<b>30.0%</b>	<b>33.0%</b>	<b>36.0%</b>	<b>48.0%</b>	<b>42.0%</b>	<b>33.0%</b>

## 32. Emission Conversion Factors (Environment Canada)

Combustion source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
Natural Gas	49.68	1.14	0.62
Wood	81.47	0.02	8.89
Fuel Oil	73.11	5.53	6.85
Coal	83.00	0.00	13.40
Propane	49.68	1.14	0.62



## 33. Electricity Generation Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	55.41	0.51	8.09
2001-2005	47.49	0.50	6.44
2006-2010	45.96	0.46	6.03
2011-2015	46.00	0.33	6.21
2016-2020	46.05	0.21	6.38

## 34. Environmental Emissions Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	50.47	1.36	3.86
2001-2005	48.01	1.32	3.30
2006-2010	47.66	1.26	3.21
2011-2015	47.91	1.17	3.27
2016-2020	48.39	1.13	3.40

Fuel switching

0

## 35. Environmental Emissions Equivalence, after retrofit

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	50.47	1.36	3.86
2001-2005	48.01	1.32	3.30
2006-2010	47.66	1.26	3.21
2011-2015	47.91	1.17	3.27
2016-2020	48.39	1.13	3.40

## 36. Environmental Emissions Equivalence, net benefits

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	50.47	1.36	3.86
2001-2005	48.01	1.32	3.30
2006-2010	47.66	1.26	3.21
2011-2015	47.91	1.17	3.27
2016-2020	48.39	1.13	3.40

# Environmental Assessment of Advanced House Technologies

**1. Technology**  
**2. Description**

High Efficiency Fans / Motors (AC)

**3. Assumptions**

- 1 Applied to HRVs. No HRV related retrofits in housing stock built prior to 1980.
- 2 The conventional furnace motor power demand is 150 W. The AC motor has a power demand of 139 W.
- 3 Assumed that HRV fan is operating when required with heating and cooling appliance year around.

**4. Type of fuel affected with the application of technology:**

	Retrofit		New Construction		Legend:				
	Existing	New Fuel	Conventional	New Fuel					
Electricity	1	1	1	1	<table border="1"> <tr> <td>1</td> <td>Yes</td> </tr> <tr> <td>0</td> <td>No</td> </tr> </table> Input data field	1	Yes	0	No
1	Yes								
0	No								
Natural Gas	1	1	1	1					
Oil	1	1	1	1					
Wood	0	0	0	0					
Propane	0	0	0	0					

**5. Scope of Technology**

	Legend:
Atlantic	1
Quebec	1
Ontario	1
Prairie	1
BC	1

	Legend:
1	Yes
0	No

**6. Energy Savings (kWh/m<sup>2</sup> of floor area)**

	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	0.00	0.00	0.00	0.00	0.00
1946-1960	0.00	0.00	0.00	0.00	0.00
1961-1980	0.00	0.00	0.00	0.00	0.00
1981-1993	0.61	0.61	0.61	0.61	0.61
NEC / new R-2000	0.61	0.61	0.61	0.61	0.61

**7. Applicable New Construction Stock Per Period Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	403,678	35,026	92,535	144,191	79,117	52,810
2001-2005	502,382	43,590	115,160	179,447	98,462	65,723
2006-2010	554,809	48,139	127,178	198,173	108,737	72,581
2011-2015	583,621	50,639	133,783	208,465	114,384	76,351
2016-2020	592,615	51,419	135,844	211,677	116,147	77,527

**8. Market Penetration by Period (New Construction) - Enter fraction of applicable stock using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	1.1%	1.2%	0.6%	1.2%	1.2%	1.2%
2001-2005	3.4%	4.0%	1.5%	4.0%	4.0%	4.0%
2006-2010	8.4%	10.0%	3.0%	10.0%	10.0%	10.0%
2011-2015	16.8%	20.0%	6.0%	20.0%	20.0%	20.0%
2016-2020	34.3%	40.0%	15.0%	40.0%	40.0%	40.0%

**Comments:**

As ventilation requirements take effect, adoption of high efficiency AC motors for HRVs will accelerate. Assumes 60% of new houses will have HRVs.

**9. Number of Related Retrofits/year**

20,000

**10. Applicable Existing Stock Based on Fuels**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,797,952	191,102	465,643	696,672	301,201	143,333
1946-1960	1,612,336	121,644	395,307	573,735	327,008	194,642
1961-1970	1,088,564	86,860	274,337	364,908	216,593	145,866
1971-1980	1,419,138	127,801	265,398	464,129	334,108	227,701
1981-1993	1,486,486	115,056	296,629	545,375	272,297	257,128
Total	7,404,477	642,464	1,697,315	2,644,819	1,451,208	968,671

**11. Market Penetration by Period (Existing) - Enter fraction of related retrofits using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
2001-2005	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
2006-2010	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
2011-2015	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
2016-2020	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%

**Comments:**

There are 20,000 HRV retrofits every year. Assumed that a portion of these houses would use this technology.

**12. Market Penetration by Period (New Construction) - Net fraction of all new housing using AT during each period.**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	1.0%	1.1%	0.6%	1.2%	1.2%	1.1%
2001-2005	3.3%	3.7%	1.4%	3.9%	4.0%	3.8%
2006-2010	8.1%	9.3%	2.9%	9.7%	10.0%	9.5%
2011-2015	16.3%	18.5%	5.8%	19.4%	19.9%	18.9%
2016-2020	33.2%	37.1%	14.5%	38.9%	39.9%	37.9%

## 13. Market Penetration by Period (Existing) - Net fraction of existing stock retrofitted with AT during each period.

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1996-2000	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
2001-2005	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
2006-2010	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
2011-2015	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
2016-2020	0.7%	0.6%	0.7%	0.7%	0.7%	0.6%

## 14. Summary of Market Penetration Scenario

Effects of above scenario on new housing up to 2020	Number of Installations	372,361	from 1994 to 2020
	Number of New Houses	3,035,714	
	Percentage of New Stock by 2020	12.3%	
Effects of above scenario on existing housing up to 2020	Number of Installations	125,000	up to 1993
	Number of Existing Houses	7,650,589	
	Percentage of Existing Stock by 2020	1.6%	

## Summary of Results

## 15. Summary of market penetration by the year 2020

Technology effects on housing stock by 2020	Number of Installations	497,361
	Number of Houses	10,686,303
	Percentage of stock	4.7%

## 16. Energy Savings Benefits for the Advanced House Technology with Above Market Penetrations, PJ

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.00	0.00	0.00	0.00	0.00	0.00
2001-2005	0.00	0.00	0.01	0.01	0.01	0.01
2006-2010	0.00	0.00	0.02	0.02	0.02	0.03
2011-2015	0.00	0.01	0.03	0.06	0.04	0.06
2016-2020	0.00	0.01	0.07	0.13	0.07	0.13

\* Annual — Energy saved at the end of the period, PJ/year

## 17. Environmental Benefits, Carbon Dioxide Emissions, kilotons

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.0	0	0.1	0	0.1	0
2001-2005	0.0	0	0.3	0	0.3	0
2006-2010	0.1	0	0.8	1	0.8	1
2011-2015	0.1	0	1.6	3	1.7	3
2016-2020	0.2	0	3.4	6	3.5	6

\* Annual — Emissions reduced at the end of the period, kilotons/year

18. Environmental Benefits, Methane CH<sub>4</sub>, tonnes

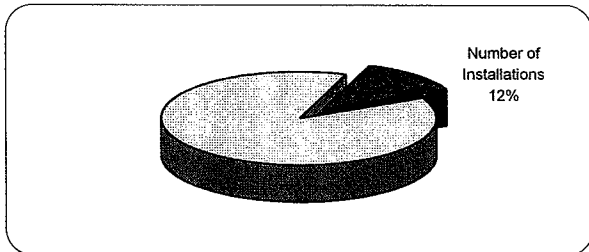
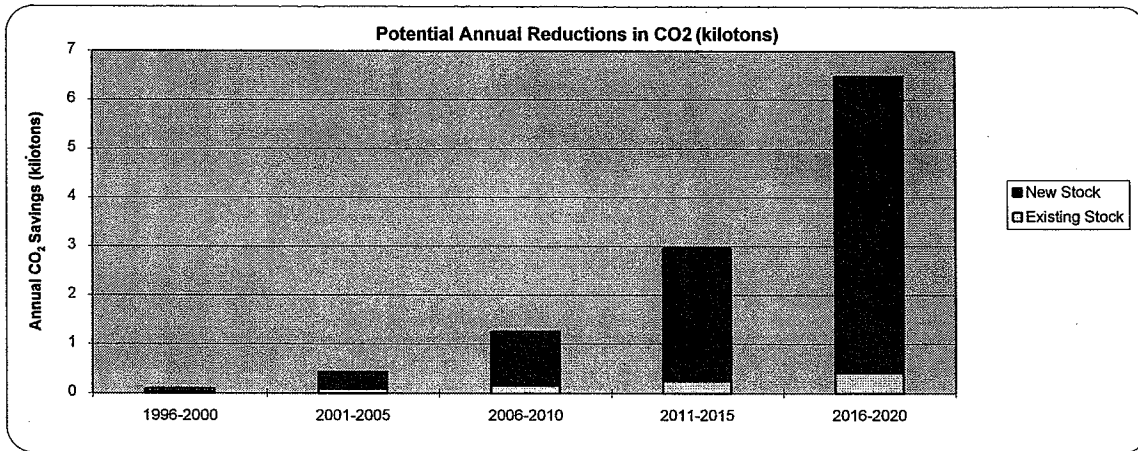
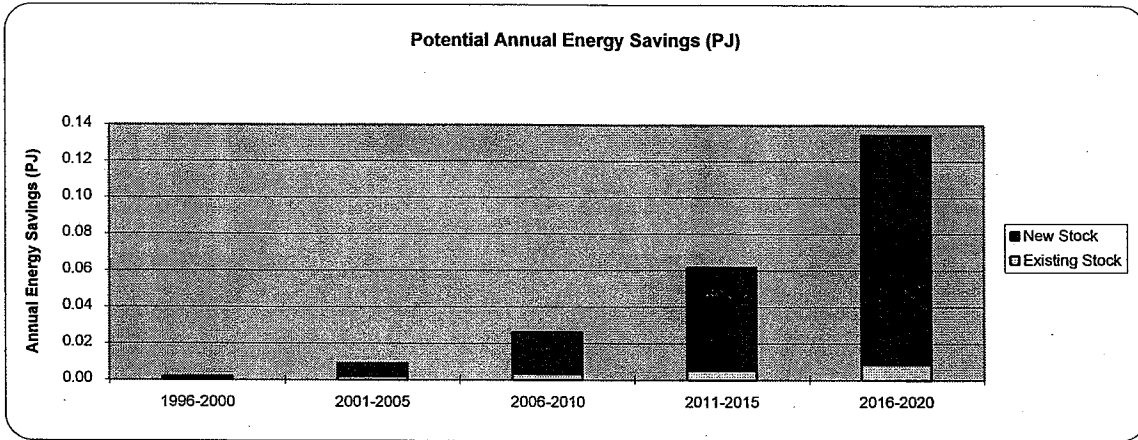
	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.0	0	0.0	0.0	0.0	0
2001-2005	0.0	0	0.0	0.0	0.0	0
2006-2010	0.0	0	0.0	0.0	0.0	0
2011-2015	0.0	0	0.0	0.1	0.0	0
2016-2020	0.0	0	0.1	0.2	0.1	0

\* Annual — Emissions reduced at the end of the period, tonnes/year

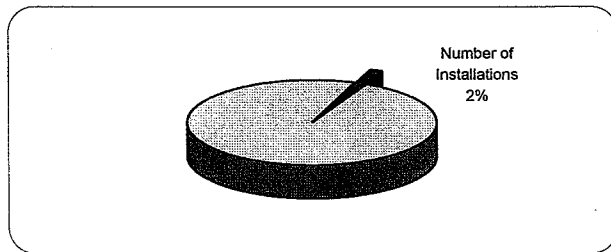
19. Environmental Benefits, N<sub>2</sub>O, tonnes

	Existing Stock		New Stock		All Housing	
	Increment/Period	Annual *	Increment/Period	Annual *	Increment/Period	Annual *
1996-2000	0.00	0.00	0.01	0.01	0.01	0.01
2001-2005	0.00	0.01	0.02	0.03	0.02	0.03
2006-2010	0.00	0.01	0.05	0.08	0.06	0.09
2011-2015	0.01	0.02	0.11	0.19	0.12	0.20
2016-2020	0.01	0.03	0.23	0.41	0.24	0.44

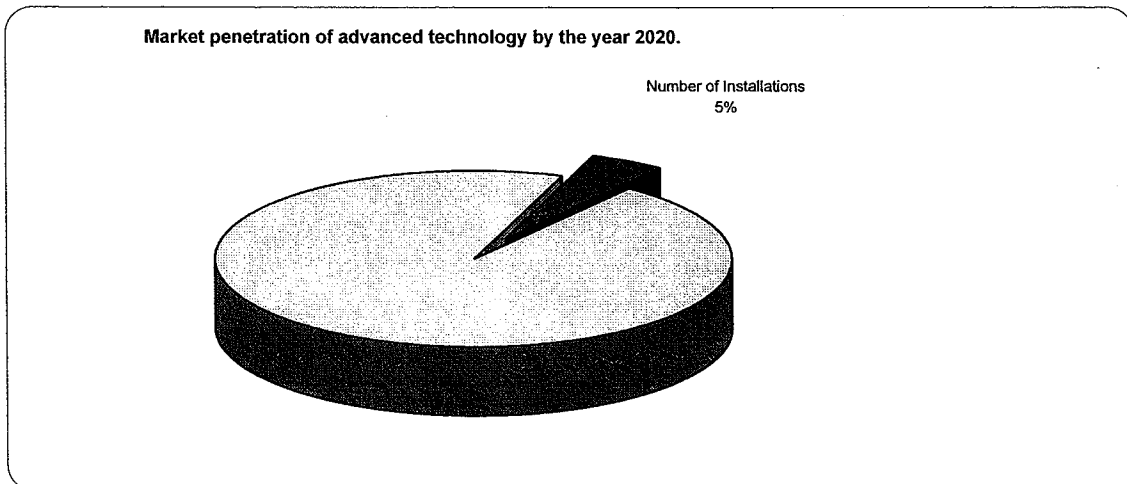
\* Annual — Emissions reduced at the end of the period, tonnes/year



Market penetration in new housing stock built during 1994-2020 by the year 2020.



Market penetration in existing housing stock built up to 1993 by the year 2020.



## HOT-2000 Simulation Runs

**20. Simulation Results**

**Base Systems and Fuels:**

Intermittant operation of HRV. Power demand is 156 W.

**New Fuels:**

Forced air systems

Intermittant operation. Power demand is 139 W.

**Energy consumption for the "typical" fans (kWh)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base					
	Upgrade					
1946-1960	Base					
	Upgrade					
1961-1980	Base					
	Upgrade					
1981-1993	Base	766.5	766.5	766.5	766.5	766.5
	Upgrade	672.4	672.4	672.4	672.4	672.4
National Energy Code / new R-2000	Base	766.5	766.5	766.5	766.5	766.5
	Upgrade	672.4	672.4	672.4	672.4	672.4

**Floor Area**

155.00 sqm

**Fan Energy consumption per unit floor area (kWh/m<sup>2</sup>)**

Vintage		Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	Base	-	-	-	-	-
	Upgrade	-	-	-	-	-
1946-1960	Base	-	-	-	-	-
	Upgrade	-	-	-	-	-
1961-1980	Base	-	-	-	-	-
	Upgrade	-	-	-	-	-
1981-1993	Base	4.9	4.9	4.9	4.9	4.9
	Upgrade	4.3	4.3	4.3	4.3	4.3
National Energy Code / new R-2000	Base	4.9	4.9	4.9	4.9	4.9
	Upgrade	4.3	4.3	4.3	4.3	4.3

**Fan Energy Savings per Unit Floor Area, kWh/m<sup>2</sup>**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	-	-	-	-	-	-
1946-1960	-	-	-	-	-	-
1961-1980	-	-	-	-	-	-
1981-1993	0.61	0.61	0.61	0.61	0.61	0.61
NEC / new R-2000	0.61	0.61	0.61	0.61	0.61	0.61

**Percentage reduction in fan energy consumption per house, %**

	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1946-1960	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1961-1980	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1981-1993	12.3%	12.3%	12.3%	12.3%	12.3%	12.3%
NEC / new R-2000	12.3%	12.3%	12.3%	12.3%	12.3%	12.3%

## Detailed Calculations

**21. New Construction - Housing stock projections (Single, semi-detached and row) - VISION 1992-2020**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	7,961,544	617,289	1,396,232	3,285,382	1,462,551	1,200,090
2000	8,378,640	649,628	1,469,379	3,457,499	1,539,173	1,262,961
2005	8,897,720	689,874	1,560,411	3,671,701	1,634,529	1,341,205
2010	9,470,970	734,320	1,660,943	3,908,256	1,739,836	1,427,614
2015	10,073,990	781,075	1,766,696	4,157,096	1,850,612	1,518,511
2020	10,686,303	828,550	1,874,079	4,409,771	1,963,095	1,610,808

**22. New Construction - Housing stock projections (Single, semi-detached and row)**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
1995	310,955	28,163	71,489	110,594	59,135	41,575
2000	417,096	37,776	95,891	148,344	79,320	55,766
2005	519,080	47,012	119,337	184,616	98,714	69,401
2010	573,250	51,918	131,791	203,882	109,016	76,644
2015	603,020	54,615	138,635	214,470	114,677	80,624
2020	612,313	55,456	140,771	217,775	116,444	81,866
<b>Total</b>	<b>3,035,714</b>	<b>274,940</b>	<b>697,913</b>	<b>1,079,681</b>	<b>577,305</b>	<b>405,875</b>

**23. Existing Housing Stock (Single) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	1,351,153	176,173	220,592	537,691	279,452	137,245
1946-1960	1,356,041	116,284	235,390	523,527	294,130	186,710
1961-1970	875,044	77,904	185,087	291,760	186,788	133,505
1971-1980	1,156,834	123,055	227,748	318,531	275,851	211,649
1981-1993	1,248,212	111,103	246,432	449,462	226,026	215,189
<b>Total</b>	<b>5,987,284</b>	<b>604,519</b>	<b>1,115,249</b>	<b>2,120,971</b>	<b>1,262,247</b>	<b>884,298</b>

**24. Existing Housing Stock (semi-detached and row) - CMHC, Statistics Canada**

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	507,552	29,932	261,940	179,050	22,520	14,110
1946-1960	308,440	14,910	174,255	66,735	33,715	18,825
1961-1970	249,519	15,775	99,200	83,660	30,359	20,525
1971-1980	308,931	14,779	47,276	158,966	59,112	28,796
1981-1993	288,863	12,986	60,956	111,623	46,968	56,330
<b>Total</b>	<b>1,663,305</b>	<b>88,382</b>	<b>643,627</b>	<b>600,036</b>	<b>192,674</b>	<b>138,586</b>

## 25. Existing Housing Stock (Single, semi-detached and row) - CMHC, Statistics Canada

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC	%age of total
Pre-1945	1,858,705	206,105	482,532	716,741	301,972	151,355	24.3%
1946-1960	1,664,481	131,194	409,645	590,262	327,845	205,535	21.8%
1961-1970	1,124,583	93,679	284,287	375,420	217,147	154,030	14.7%
1971-1980	1,465,765	137,834	275,024	477,499	334,963	240,445	19.2%
1981-1993	1,537,075	124,089	307,388	561,085	272,994	271,519	20.1%
Total	7,650,589	692,901	1,758,876	2,721,007	1,454,921	1,022,884	100.0%
%age of total		9.06%	22.99%	35.57%	19.02%	13.37%	
Single/Total		7.75%	17.54%	41.27%	18.37%	15.07%	

## 26. Existing Housing Average Floor Space (m2) (Single, semi-detached and row) - STAR-Housing

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	159	147	160	174	130	146
1946-1960	165	161	168	183	133	157
1961-1970	170	176	160	184	151	179
1971-1980	164	176	147	172	149	181
1981-1993	156	153	153	160	150	160

## 27. Existing housing stock potential energy savings (GWh) assuming 100% market penetration

Year	Canada	Atlantic	Quebec	Ontario	Prairie	BC
Pre-1945	0	0	0	0	0	0
1946-1960	0	0	0	0	0	0
1961-1970	0	0	0	0	0	0
1971-1980	0	0	0	0	0	0
1981-1993	146	11	28	54	25	26
Total (GWh)	146	11	28	54	25	26
Total (PJ)	0.52	0.04	0.10	0.20	0.09	0.10

## 28. Fuel Use Summary % (1993 - Statistics Canada)

	Electricity	Oil	Natural Gas	Wood	Propane
Atlantic	41.14	51.58	0.00	3.57	3.71
Quebec	65.00	22.90	8.60	3.50	0.00
Ontario	18.00	16.50	62.70	2.80	0.00
Prairies	17.24	15.41	67.09	0.26	0.00
BC	27.30	11.20	56.20	5.30	0.00
Canada	32.00	20.24	44.55	2.88	0.34

## 29. Potential Energy Savings by Fuel Type - Existing Stock - assuming 100% market penetrations, PJ

	Electricity	Oil	Natural Gas	Wood	Propane	Total
Atlantic	0.02	0.02	0.00	0.00	0.00	0.04
Quebec	0.07	0.02	0.01	0.00	0.00	0.10
Ontario	0.04	0.03	0.12	0.00	0.00	0.19
Prairies	0.02	0.01	0.06	0.00	0.00	0.09
BC	0.03	0.01	0.05	0.00	0.00	0.09
Canada	0.16	0.10	0.25	0.00	0.00	0.51

## 30. Residential Energy Demand by Fuels (VISION 1992-2020)

	Electricity	Oil	Natural Gas	Wood	Other	Total
1996-2000	34.0%	12.0%	46.0%	3.0%	5.0%	100.0%
2001-2005	35.0%	11.0%	47.0%	3.0%	4.0%	100.0%
2006-2010	37.0%	10.0%	47.0%	3.0%	3.0%	100.0%
2011-2015	38.0%	9.0%	48.0%	3.0%	2.0%	100.0%
2016-2020	39.0%	9.0%	48.0%	3.0%	1.0%	100.0%

## 31. Electricity Production by Fuels (VISION - 1992-2020)

	Coal	Oil	Natural Gas	Hydro	Nuclear	Other
1996-2000	16.8%	2.6%	2.3%	62.0%	15.3%	1.1%
2001-2005	13.2%	2.1%	4.4%	60.1%	17.9%	2.2%
2006-2010	12.5%	1.7%	5.5%	61.1%	17.2%	2.0%
2011-2015	13.2%	1.0%	5.2%	59.7%	18.9%	1.9%
2016-2020	13.9%	0.3%	4.9%	58.4%	20.7%	1.7%
Thermal efficiency	30.0%	33.0%	36.0%	48.0%	42.0%	33.0%

## 32. Emission Conversion Factors (Environment Canada)

Combustion source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
Natural Gas	49.68	1.14	0.62
Wood	81.47	0.02	8.89
Fuel Oil	73.11	5.53	6.85
Coal	83.00	0.00	13.40
Propane	49.68	1.14	0.62

## 33. Electricity Generation Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	55.41	0.51	8.09
2001-2005	47.49	0.50	6.44
2006-2010	45.96	0.46	6.03
2011-2015	46.00	0.33	6.21
2016-2020	46.05	0.21	6.38

## 34. Environmental Emissions Equivalence

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	50.47	1.36	3.86
2001-2005	48.01	1.32	3.30
2006-2010	47.66	1.26	3.21
2011-2015	47.91	1.17	3.27
2016-2020	48.39	1.13	3.40

Fuel switching

0

## 35. Environmental Emissions Equivalence, after retrofit

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	50.47	1.36	3.86
2001-2005	48.01	1.32	3.30
2006-2010	47.66	1.26	3.21
2011-2015	47.91	1.17	3.27
2016-2020	48.39	1.13	3.40

## 36. Environmental Emissions Equivalence, net benefits

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
	kilotons/PJ	tonnes/PJ	tonnes/PJ
1996-2000	50.47	1.36	3.86
2001-2005	48.01	1.32	3.30
2006-2010	47.66	1.26	3.21
2011-2015	47.91	1.17	3.27
2016-2020	48.39	1.13	3.40