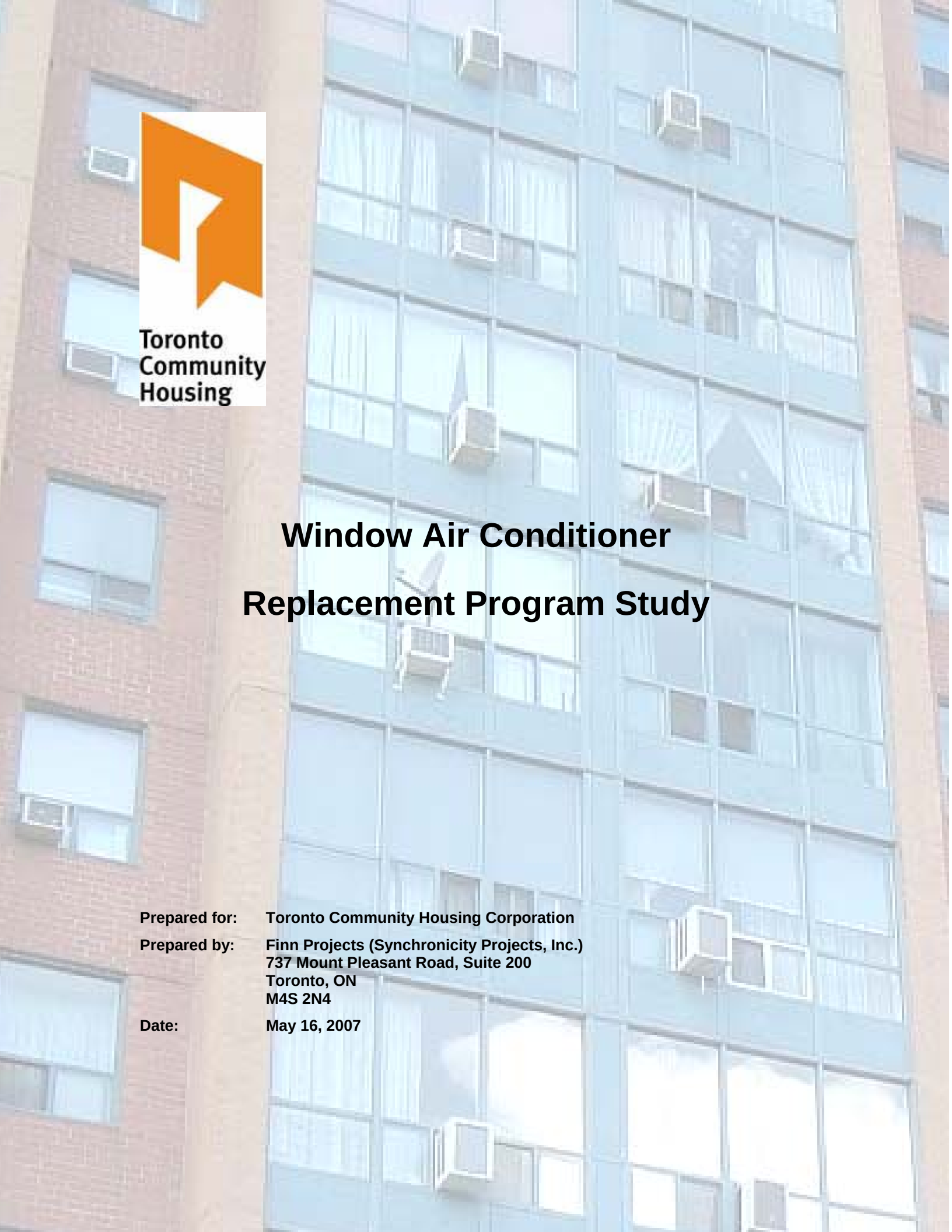

Toronto Community Housing

Window Air Conditioner

Replacement Program Study

Prepared for: Toronto Community Housing Corporation

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Executive Summary

Toronto Community Housing Corporation commissioned Finn Projects to:

- Assess TCHC's situation with respect to its inventory of Window Air-Conditioning units;
- Recommend replacement options based on the condition of the current units and energy savings;
- Research and nominate replacement makes and models in accordance with specific selection criteria;
- Develop a Preventive Maintenance program aimed at keeping operating costs to a minimum, extending the life of the units and satisfying tenants through high-level comfort conditions.

Most of the existing window air conditioners installed by the tenants in the TCHC developments are old and do not operate at optimum efficiency. The air conditioner controls are suspect, which results in increased operating hours, and the air conditioners have been inadequately maintained. Many of the units do not have clean filters and many of the condensers are covered in dirt. The units were also not installed properly which both adds to the energy consumption, due to infiltration, and produces a potential safety risk.

The most important finding in our study is the requirement for proper installation, maintenance and the removal of the window air conditioner units. In order to accomplish this, TCHC must take control of the current situation by mandating that the tenants either:

(a) rent ENERGY STAR® air conditioners through TCHC, which will ensure that the units will be properly installed, maintained and removed as needed; or

(b) purchase high efficiency portable air conditioners through TCHC, as they are easy to install, maintain and remove for the winter months.

As a first step, TCHC should not allow any additional window air conditioning units to be installed in any of its buildings. Tenants with existing window air conditioners should be instructed to remove them and rent or purchase a new unit as per the options detailed below.

We recommend that TCHC rent window air conditioners to the tenants based on a rental fee of $150 with the first year free for those who trade in their old air conditioning units. The estimated expenditures and revenues associated with renting window air conditioners to the tenants, over a six year period, is show below.

	Forest Air - 10.8 EER
Unit Cost	($4,448,000)
Interest	($859,567)
Maintanence	($4,800,000)
Energy Savings	$4,604,459
Rental Fees	$12,000,000
Total	$6,496,892

The environmental impact of this above measure is very substantial and would result in greenhouse gas reductions of 2,702 tonnes, which is equivalent to growing 69,275 tree seedlings for 10 years, or taking 585 passenger cars off the road.

As an alternative, we recommend that TCHC subsidize the cost of portable air conditioners for those tenants who do not wish to rent. We have assumed a cost to the tenant of $250 per unit. The following table shows the estimated expenditures and revenues over a six year period if the tenants were to purchase a portable air conditioner from TCHC:

	WA-1010M	ARC-12D
Unit Cost	($6,752,000)	($6,272,000)
Tenant Cost	$4,000,000	$4,000,000
Interest	($531,818)	($439,059)
Energy Savings	$3,418,677	$2,939,718
Total	$134,859	$228,659

1. Introduction

Room air conditioning units, essentially smaller versions of central air conditioners, are designed to provide in-suite space cooling. They are intended for cooling only small areas, usually one room, depending on its capacity. The units are electrically powered to remove heat and moisture from the living space to maintain comfortable conditions during hot, humid weather. Unlike a central air conditioner, no permanent ductwork is required, and all components are built into a single packaged unit that is mounted in a window opening, or in a sleeve through the wall. Three major categories of room air conditioners are available, the most common type are those intended for installation in window openings. The second type consists of units intended for through-the-wall installation, while the third category includes portable air conditioners, which are installed in a room and exhausted directly through a window or wall.

The basic cooling cycle begins with a fan, which circulates room air through the evaporator containing low-pressure refrigerant. Evaporation of the refrigerant cools the tubes and fins, extracting heat from the air and causes moisture in the air to condense on the evaporator's outer surface. The cooler, drier air is returned to the room and the gaseous refrigerant leaving the evaporator is drawn into the compressor, where mechanical compression raises its temperature and pressure. The hot, high-pressure refrigerant passes through the condenser, where it loses heat to outdoor air (which is blown over it with a second fan) and condenses. This high-pressure liquid refrigerant passes through a restriction and into the low-pressure side of the circuit, and the entire process is repeated.

The amount of cooling that the air conditioner must provide to maintain comfort conditions is called the cooling load. It is affected by the size of the room, the size and orientation of windows, insulation levels, number of occupants, appliances, lighting, climate, etc. Selecting an air conditioner with the proper cooling capacity is critical for providing a comfortable environment. An oversized unit may cycle on and off too frequently and not stay on long enough to properly dehumidify the room. An undersized unit, on he other hand, will not be able to handle the cooling load in very hot weather.

Window Air Conditioners

The following table[1] shows the basic cooling capacity required for a window air conditioner based on the total floor area being cooled:

TOTAL FLOOR AREA		BASIC COOLING CAPACITY
m^2	SQ. FT.	BTU/H*
9–14	100–150	5,000
14–23	150–250	6,000
23–28	250–300	6,500
28–33	300–350	7,250
33–38	350–400	8,000
38–41	400–450	8,750
41–46	450–500	9,650
46–51	500–550	10,500
51–65	550–700	12,500
65–93	700–1,000	15,000

[1] Based on rooms with two occupants and average windows, insulation and sun exposure. (Source: EnerGuide Room Air Conditioner Directory 2005)

Portable Air Conditioner

The compressor in a conventional window mounted air conditioner is on the exterior and can dissipate the heat built up from compressor directly through the outside. With portable air conditioners the entire unit is located inside the space being cooled and, as a result, require additional cooling capacity to effectively cool the same space. While the duct exhausts hot air from the room, the compressor and cooling coils generate extra heat which then has to be removed from the room by the unit. The following table shows the basic cooling capacity required for a portable air conditioner based on the total floor area being cooled:

TOTAL FLOOR AREA		BASIC COOLING CAPACITY
m^2	SQ. FT.	BTU/H
9-19	100-200	7,500
19-23	200-250	9,000
23-28	250-300	10,000
28-38	300-400	12,000

Energy Efficiency Ratio (EER)

The efficiency of an air conditioner is measured using the Energy Efficiency Ratio (EER). The EER essentially measures the cooling effect of the air conditioner for each unit of electrical energy that it consumes under steady-state operation. It is determined by dividing the unit's cooling output, in British thermal units per hour, by the electrical power input, in watts, at a specific temperature. The higher the EER, the more efficient the air conditioner will be.

The efficiency of room air conditioners varies widely, depending on the design. High-efficiency units generally incorporate efficient rotary compressors, large evaporators and condensers with louvered fins and internally rifled tubes, as well as efficient fans and a slinger ring to deposit water collected from the evaporator onto the hot condenser. Minimum efficiency units tend to use small conventional heat exchangers and standard compressors and fans

An ENERGY STAR® qualified window mounted room air conditioner with a cooling capacity under 20,000 BTU/h must have an EER rating of at least 10.7. ENERGY STAR® qualified room air conditioners use at least 10% less energy than conventional models. The following table[2] shows the energy efficiency ratio (EER) requirements for the various cooling capacities:

Btu/hr.	EER (Window-Mounted)	EER (Through-the-Wall)
< 6 000	>= 10.7	>= 9.9
6,000 to 7,999	>= 10.7	>= 9.9
8,000 to 13,999	>= 10.8	>= 9.4
14,000 to 19,999	>= 10.7	>= 9.4
>= 20,000	>= 9.4	>= 9.4

Portable air conditioners do not qualify for an ENERGY STAR® rating, because there is no test standard currently for portable units. The testing standards for window air conditioners would not apply because of the configuration of the portable unit when

[2] Source: Energuide Room Air Conditioner Directory 2005

installed is very different from window air conditioners. Although, portable air conditioners do not currently qualify for an ENERGY STAR® rating, many of them have very high efficiencies.

2. TCHC's Situation

The majority of TCHC's buildings do not have central air conditioners and as such many of the occupants have installed their own individual window air conditioners.

The existing air conditioners consume significant amounts energy and, for the most part they are not ENERGY STAR® rated. At the majority of buildings TCHC pays the air conditioning costs as the units are not submetered. The tenants are not aware of their air conditioning impacts on hydro costs, nor are they aware of how to reduce these impacts.

In the buildings we inspected we found that most of the existing air conditioners are old and do not operate at optimum efficiency. We believe that the majority of air conditioner controls are suspect, which could result in increased operating hours. For the most part air conditioners were inadequately maintained, many of the units did not have clean filters and the condensers were covered in dirt.

For the most part, the air conditioners inspected were not properly installed, which has two impacts:

- The air conditioners are not properly sealed around the edges resulting in energy loss; and
- There is a safety issue as the air conditioners could potentially fall out of the windows.

A majority of the air conditioners are not removed during the winter, which results in significant heat loss, both through the air conditioner and through the gaps around the opening.

Here are some statistics on the window air conditioner population:

Approximate number of TCHC buildings with window conditioners	400+
Approximate number of window air conditioners in use	16,000
Approximate age of the window air conditioners	5 to 10 years

A replacement program, complemented by a comprehensive Window Air Conditioner Preventive Maintenance program, is now needed for the following reasons:

1. Many of window air conditioners are rapidly reaching the end of their useful life expectancy.
2. Most units are in a less than optimal state of operation due to lack of regular maintenance and age. As a result these units consume a significant amount of energy.
3. Many units are not properly installed, posing a serious safety risk.

The Window Air Conditioner Replacement and Preventative Maintenance Programs in this report have been designed to deliver these benefits:

1. The best possible comfort conditions for TCHC's tenants.
2. The most cost effective (operating plus capital) solution resulting from:
    - High energy efficiency;
    - Low planned maintenance requirements;
    - High reliability;
    - Low first cost.
3. Readily-available parts and service.
4. Easy maintenance; high serviceability.
5. An effective Preventative Maintenance program.
6. The lowest possible impact on the environment.

Disposal of the existing window air conditioner units represent a huge mass of physical and chemical material that requires a coordinated plan. The first consideration is the handling of the refrigerants in the units – typically R22, and possibly R11 and R12. As these are ozone-depleting chemicals, there are strict environmental laws and guidelines specifying procedures for the capture, containment, handling, storage and documentation of these CFCs. There are licensed, reputable refrigeration sales and service companies that are available to take on all aspects of refrigerant management.

The metal from old air-conditioning units is routinely reclaimed in the GTA by scrap dealers who pay for each window air conditioner on a per-kilogram basis, after legal evacuation and disposal of refrigerants.

We recommend hiring a contractor to manage the removal and disposal of the old air conditioners to TCHC's specification.

Finally, we have included a Preventative Maintenance program in **Appendix A and B**, based on a review of best operating practices. We believe that following the maintenance procedures and schedule will optimize the life and functionality of both the new units and the existing units not traded in by the residents.

3. Methodology

To accomplish this study, Finn Projects approached the problem through these steps:

1. Through physical audits specifically for this study, as well as building audits preformed in the past, we developed an inventory of the window air conditioners in use.
2. We divided the TCHC buildings into several smaller groups (33 in all) based on a variety of criteria (building structure, size, occupancy types, etc). These were the same groups that Finn Projects identified in developing TCHC's Utility and Energy Management Plan.
3. The inventory was then extrapolated to encompass all TCHC buildings based on the results of the buildings within each group.
4. We determined the total consumption and cost to TCHC due to the operation of the window air conditioners based on our findings. For our infiltration calculations we assumed that the units had a 1/16" gap around the unit and that 50% of the air conditioners are left in during the winter months. We also assumed that approximately 90% of the units are heating with gas and 10% are heated with electricity. We have used current market rates of $0.10 per kWh of electricity and $0.40 per m^3 of gas
5. We searched the market for replacement alternatives that balanced our ideal replacement criteria against capital constraints and the physical constraints of the buildings.
6. We obtained budgetary installed prices for each alternative from reputable manufacturers and distributors.

4. Window Air Conditioner Building Audits

In order to objectively determine the current condition and state of the installed window air conditioners, Finn Projects collected data on approximately 20 units in each of the audited buildings. The two buildings audited specifically for this study were 40 Teesdale Place and Lerette Manor.

Our standardized data collection forms for this study included two sets of input fields in addition to general building descriptors:

- Nameplate data for each window air conditioner audited in the building, including make, model, cooling capacity and electrical input;
- 10 condition evaluation fields that allowed us to objectively summarize the state of each individual unit.

While we did not gain access to all apartments with window air conditioners in the buildings, we collected sufficient data to assess the physical characteristics and condition of the window air conditioners typically found within the buildings. We also recorded the total number of visible window air conditioners for each building.

During the site visits to 40 Teesdale and Lerette Manor, the following conditions with regards to the window AC units were noted:

- Installation Condition:
  - Gaps around window AC unit.
  - Poorly installed, not sealed properly.
  - Sheets, towels, etc stuffed around unit.
  - Some units appear to be left in year round.
  - Some units were dripping condensate inside the room.

- Room temperature:
  - Generally the indoor air temperature was between 72°F - 76°F (although in Lerette Manor, the indoor air temperature was slightly higher because the AC units, which had been off overnight, were just turned on).
- Operating Conditions:
  - Some AC units run all day, even when people are not home.
  - Most said that they only run the units when needed, and many at Lerette Manor said that they turn them off at night.
  - Even with the AC running, there were open doors and windows in other areas of the apartment (and in some cases, right beside the unit).
  - In most cases the AC units running were set to the coldest setting and highest fan speed.
  - Often the units were combined with fans in order to try and cool the entire apartment down. Mostly the units were mounted in the living room area.

- Filter condition:
  - Almost all needed cleaning.
  - Many filters were significantly clogged.
  - The filter in many units were not easily accessible (face plate screwed or taped on, etc).

- Age of units:
  - Many of the units were 10 yrs old or more, inefficient and in poor condition. There were also some newer units, especially in Lerette Manor.
  - Multiple AC units at Lerette Manor (a seniors building) were rented for the year - these models were at least 10 yrs old and had low EER's.

The following table shows the approximate number of units, the cooling capacity and EER for the two buildings based on our site visits.

Location	# of Units	# of AC units	AC use %	Average EER	Cooling Capacity (BTU/h)
Lerette Manor	178	119	66.9%	8.1	8,300
40 Teesdale	278	42	15.1%	7.1	7,100
Totals	456	161	35.3%	7.6	7,700

Approximately 8.6% of the units audited for the window air conditioner study were found to have multiple air conditioners installed.

In addition to the window air conditioner site audits, information gathered from 54 previous TCHC site audits was used to help approximate the number and size of window air conditioners in each of those buildings. The combined results from the all site visits are shown in the table below.

Location	# of Units	# of AC units	AC use %	Average EER	Cooling Capacity (BTU/h)
Windows AC Audits	456	161	35.3%	7.6	7,700
Previous Site Audits	10,927	3,636	33.3%	7.0	7,000
Average Total	11,383	3,797	33.4%	7.0	7,030

Based on the sample audits, approximately 33.4% of apartments in TCHC buildings have window air conditioners. This would translate into a total of approximately 16,000 window air conditioners currently in use in all of the TCHC buildings. We have assumed that the current inventory of window air conditioners would have similar specifications to those found in the two window air conditioner audits, for which we took detailed notes of the specifications and quantity of units in use. In the previous audits only estimates of the specifications and quantity were made based on a limited number of units and a physical count from outside the building.

Extrapolating our findings and analysis to the TCHC portfolio is summarized in the table below, which shows the probable average properties of the current inventory of window air conditioners in the buildings:

# of AC units	Average EER	Cooling Capacity (BTU/h)
16,000	7.0	7,030

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5. Replacement Options

The next step in the process was to evaluate various replacement options. The options we considered were:

1. Replace the window air conditioners with new, higher efficiency units.
2. Replace the window air conditioners with portable air conditioners.
3. Install a central air conditioning system in select buildings.

5.1 Window Air Conditioners

Replacing the current air conditioner units with new, high efficiency units was considered due to their high efficiency and lower cost. New window air conditioners come in a variety of cooling capacities, they are widely available and they can have high EER's.

The new units would provide energy savings due to the increased efficiency, however, they still lend themselves to the same problems observed during the window air conditioner audits. These include:

- The units are difficult to remove for the winter and replace again in the summer, and as a result many of the units are left in place year round, which leads to considerable heat losses through the units during the winter months. The heat losses can, however, be reduced by installing an insulated sleeve on the units during the winter.
- The space between the window and the air conditioner is difficult to seal properly, which results in considerable cooling losses during the summer months and further heating losses during the winter, if left in place.
- The window air conditioners also represent a safety concern if not properly installed, due to their weight and hanging position.
- Window air conditioners are very difficult relocate to other rooms, resulting in either multiple units being installed, or the unit being over worked in an effort to cool the entire apartment.
- Due to their semi-permanent installation, some window air conditioners are difficult to adequately maintain.

A comprehensive program must be implemented in order to minimize the problems above. The program must include:

- Maintenance of the unit
- Installation on the unit at the beginning of the season
- Removal and storage of the unit at the end of the season

Energy Savings:

The cooling capacity required to cool an apartment is dependent on the size of space being cooled. For most apartments, an 8,000 BTU/h cooling capacity would be adequate. The following ENERGY STAR® window air conditioner model was selected:

- Forest Air - 8,200 BTU/h cooling capacity and an EER of 10.8

The following table shows the potential energy savings for replacing the current window air conditioners with new ENERGY STAR® window air conditioners.

	Existing	Proposed (Forest Air)
Total # units	16,000	16,000
Cooling Capacity (BTU/hr)	7,030	8,200
EER	7.0	10.8
Hrs of Operation (per season)	650	650
Electrical Consumption (kWh):		
-per unit	650	494
-total	10,404,707	7,896,296
Operational Electricity Cost:		
-per unit	$65	$49
-total	$1,040,471	$710,667
Infiltration Cost:		
-elec	$82,595	
-gas	$355,011	
Total Cost	$1,478,077	$710,667
Cost Savings		
-total		$767,410
-percentage		51.92%
GHG Emissions Savings		
-total (tonnes)		2,702

TCHC could potentially reduce its air conditioning costs by 51.92% (or $767,410) by switching to ENERGY STAR® window air conditioners.

In addition to energy savings there would also be a substantial greenhouse gas emissions reduction. A reduction of 2,702 tonnes of GHG is equivalent to growing 69,275 tree seedlings for 10 years, or taking 585 passenger cars off the road.

Rental Option:

During the site audits, some of the tenants in Loretta Manor (a seniors' building), rented their window air conditioner for the summer. This price included installation and removal of the unit. The units installed, however, are old and inefficient. The price charged for an 8,000 BTU window air conditioner is approximately $250 per season.

Providing the tenants with an opportunity to trade in their existing units and rent a unit from TCHC would assure that the units are being properly installed, being properly maintained and that they are not being left in during the winter months.

The following table shows the expenditure and revenue over a six year period, if TCHC were charge to a rental fee of charge $150 per unit, per season.

	Forest Air - 10.8 EER
Unit Cost	($4,448,000)
Interest	($859,567)
Maintanence	($4,800,000)
Energy Savings	$4,604,459
Rental Fees	$12,000,000
Total	$6,496,892

The expenses in the above table include the cost of the units, interest, their operating costs and a maintenance cost. The interest rate was calculated at 6%, amortized over six years. A maintenance cost of $50 per unit per season, has been estimated, which includes installation of the unit at the beginning of the cooling season, removal of the unit at the end of the season, and storage and maintenance of the units.

The revenue in the above table is generated from the $150 rental fee charged each season, excluding the first year's rental fee. This would be waived in exchange for the tenant's old window air conditioner.

We have also allowed $15 per unit for delivery and $25 per unit for proper disposal of the old units being replaced. Both of these costs have been incorporated into the unit price.

5.2 Portable Air Conditioners

Portable air conditioners provide an effective option for replacing the window air conditioners. While the units are more expensive, they do have several advantages over window air conditioners:

- They do not present the same safety concerns as window air conditioners with respect to falling from windows.
- The window exhaust hose kit is easy to install and can provide a good seal, minimizing the infiltration.
- The portable units are easily moved from one room to another and are easily stored for the winter months.

Portable air conditioners require additional cooling capacity to effectively cool the same space because the entire unit is located inside the space being cooled, not

outside. While the duct exhausts hot air from the room, the compressor and cooling coils generate extra heat which then has to be removed from the air by the unit.

Energy Savings:

The cooling capacity required to cool an apartment is dependent on the size of space being cooled. For most apartments, a 10,000 BTU/h cooling capacity would be adequate, however, for larger areas a 12,000 BTU/h unit may be required. Two portable air conditioner models with different cooling capacities were selected, however these models should be used only as an indicator as to what portable air conditioners are available:

- Model WA-1010M, manufactured by Sunpentown has a cooling capacity of 10,000 BTU/h, an EER of 11.45 and can cool up to 300 sq.ft.
- The alternative model ARC-12D, manufactured by Whynter, has a 12,000 BTU/h cooling capacity, an EER of 12.63 and can cool up to 400 sq.ft.

The portable units generally have life expectancy of approximately 7-10 years, depending on the usage and how well the units are maintained.

The following table shows the potential energy savings for replacing the current window air conditioners with new portable air conditioners.

		Portable AC	
	Existing	WA-1010M	ARC-12D
Total # units	16,000	16,000	16,000
Cooling Capacity (BTU/hr)	7,030	10,000	12,000
EER	7.0	11.45	12.63
Hrs of Operation (per season)	650	650	650
Electrical Consumption (kWh):			
-per unit	650	568	618
-total	10,404,707	9,082,969	9,881,235
Operational Electricity Cost:			
-per unit	$65	$57	$62
-total	$1,040,471	$908,297	$988,124
Infiltration Cost:			
-elec	$82,595		
-gas	$355,011		
Total Cost	$1,478,077	$908,297	$988,124
Cost Savings			
-total		$569,780	$489,953
-percentage		38.5%	33.1%
GHG Emissions Savings			
-total (tonnes)		2,341	2,098

TCHC could potentially reduce its air conditioning costs by 33.1% to 38.5% (or $489,953 to $569,780, respectively, depending on the models selected) by switching to portable air conditioners.

In addition to energy savings there would also be a substantial greenhouse gas emissions reduction. A reduction of between 2,341 and 2,098 tonnes of GHG is

equivalent to growing 53,803 to 60,025 tree seedlings for 10 years, or taking between 454 and 507 passenger cars off the road.

Rental Option:

Providing the tenants with an opportunity to trade in their existing units and rent a unit from TCHC would assure that the units are being properly installed and being properly maintained.

The cost of each portable air conditioner was based on the budget prices provided directly from both Sunpentown and Whynter. We have also allowed $25 per unit to account for the cost of shipping the units to Toronto (which is in line with the costs estimated from the manufacturer) and $25 per unit for proper disposal of the old units being replaced. The price obtained from the manufacturers is based on an order size of 1,000 units. The unit cost would decrease for larger quantities.

The following table shows the expenditure and revenue over a six year period, if TCHC were charge to a rental fee of charge $150 per unit, per season.

	WA-1010M	ARC-12D
Unit Cost	($6,752,000)	($6,272,000)
Interest	($1,304,810)	($1,212,051)
Maintanence	($4,800,000)	($4,800,000)
Energy Savings	$3,418,677	$2,939,718
Rental Fees	$12,000,000	$12,000,000
Total	$2,561,867	$2,655,667

The expenses in the above table include the cost of the units, interest, their operating costs and a maintenance cost. The interest rate was calculated at 6%, amortized over six years. The maintenance cost of $50 per unit, per season, includes installation of the unit at the beginning of the cooling season, removal of the unit at the end of the season, and storage and maintenance of the units.

The revenue in the above table is generated from the $150 rental fee charged each season, excluding the first year's rental fee. This would be waived in exchange for the tenant's old window air conditioner.

Purchase Option:

As an alternative, TCHC could give its tenants an opportunity to trade in their existing window air conditioners for new portable units. For this exchange we recommend that TCHC subsidizes a portion of the new unit's cost. For the purpose of this study we have estimated that the tenants would be able to purchase the new units at an assumed cost of $250.

The following table shows the expenditure and revenue over a six year period, based on TCHC subsidizing of the costs of the units, with the tenants paying $250 per unit:

	WA-1010M	ARC-12D
Unit Cost	($6,752,000)	($6,272,000)
Tenant Cost	$4,000,000	$4,000,000
Interest	($531,818)	($439,059)
Energy Savings	$3,418,677	$2,939,718
Total	$134,859	$228,659

The above interest was calculated using a 6% interest rate, amortized over six years.

To replace the approximately 16,000 window air conditioners currently in use, the estimated total cost to TCHC would be between $2,272,000 and $2,752,000 (depending on the models selected).

5.3 Central Air Conditioners

For buildings with fancoil systems in place, an alternative to window air conditioners or portable air conditioners would be to install a central air conditioning system. The installation of a chiller and cooling tower would provide air conditioning to the entire building, eliminating the need for window or portable air conditioners.

Based on our findings, approximately 33.4% of the units in a building would have window air conditioners installed. With a central system installed there would be an increase in the operating costs for the building, since 100% of the building and the entire space in each apartment would now be air conditioned. For an apartment building with 100 units, the estimated operating costs would be as follows:

Annual Operating Costs - 100 Unit Building	
Central System	$13,816
Window Air Conditioners	$3,081
Variance	$10,734

The additional capital cost required to install a central cooling system would be approximately $200,000. This does not include any costs associated for structural upgrades of the building or annual maintenance costs.

For a new building under construction with approximately 100 units, we have assumed that approximately 1/3 of the tenants would install window air conditioners. The extra operating costs associated with a central air conditioning system would, therefore, be approximately $10,734 per year. The capital costs, however, for a new building under construction would be significantly less, estimated at approximately $160,000.

6. Recommendations

Based on our study, it is clear that any recommendation made must include the proper installation of the window air conditioner at the beginning of the cooling season, the proper maintenance of the units and the removal of the units at the end of the cooling season.

To accomplish this, TCHC must take control of the current situation by mandating that the tenants must either rent window air conditioners through TCHC, which will ensure that the units will be properly installed, maintained and removed as needed; or purchase approved portable air conditioner. If the tenants do not want to rent, then they could purchase a portable air conditioner from TCHC because it is easy to install, maintain and remove for the winter months.

We recommend that TCHC implement the following policies:

1. TCHC should not allow any additional window air conditioning units to be installed in any of its buildings. Tenants with existing window air conditioners should be instructed to remove them and rent or purchase a new unit as per the options detailed below.
2. We recommend that TCHC rent ENERGY STAR® window air conditioners to the tenants based on a rental fee of $150 with the first year free for those who trade in their old air conditioning units. The expenditure and revenue associated with renting window air conditioners to the tenants, over a six year period, is show below.

	Forest Air - 10.8 EER
Unit Cost	($4,448,000)
Interest	($859,567)
Maintanence	($4,800,000)
Energy Savings	$4,604,459
Rental Fees	$12,000,000
Total	$6,496,892

This recommendation would result in a reduction of 2,702 tonnes of GHG, which is equivalent to growing 69,275 tree seedlings for 10 years, or taking 585 passenger cars off the road.

3. As an alternative, we recommend that TCHC subsidize the cost of approved portable air conditioners for those tenants who do not wish to rent. We have assumed a cost to the tenant of $250 per unit. The following table shows the expenditure and revenue over a six year period if the tenants were to purchase a portable air conditioner from TCHC:

	WA-1010M	ARC-12D
Unit Cost	($6,752,000)	($6,272,000)
Tenant Cost	$4,000,000	$4,000,000
Interest	($531,818)	($439,059)
Energy Savings	$3,418,677	$2,939,718
Total	$134,859	$228,659

7. Disposal of Old Window AC Units

We recommend TCHC engages a licensed, reputable refrigeration service company for the disposal of the old air conditioners, which would provide complete and auditable documentation showing proper and legal treatment of the refrigerants and metal parts.

- TCHC should be provided with CFC evacuation certificates for each unit indicating apartment number and serial number of unit. Proper documentation of units disposed after CFC removal should include name of disposal company, Ministry license number of disposal company, serial number of units disposed and weigh tickets or receipt showing quantity of units disposed
- TCHC should ensure that the old units are taken out of service, recycled and the CFC's disposed off properly. Old machines should not be refurbished due to their inefficiency and high energy consumption. Doing so would simply pass high energy consumption down the line and not accomplish the global objective of reducing energy consumption.

8. Air Conditioner Maintenance

We have included a Preventive Maintenance program based on a review of best operating practices. We believe that following the procedures and schedule will optimize the life and functionality of both the portable air conditioners and existing window units (should tenants decide to rent a window air conditioner from TCHC). The Preventive Maintenance Program for window air conditioners is detailed in **Appendix A**; and in **Appendix B** for portable air conditioners.

Appendix A - Installation, Operation & Preventive Maintenance for Window Air Conditioners

Installation:

At the start of each cooling season:

- Follow the manufacturer's instructions included with the unit.
- Make sure the unit is installed securely. Support the A/C unit from underneath or firmly fasten it from inside with angles. Metal brackets, mounting rails, etc. may be used for a safe installation.
- Supporting metal brackets, interior angles, etc. should be structurally fastened to the building envelope and are to be strong enough for the size and weight of the A/C unit.
- Objects utilized to adjust the position (for example, shims) of the A/C unit must have an independent source of fastening or attachment.
- Secure leveling objects in order to prevent movement and shifting due to vibration from the A/C unit and wind and weather conditions.
- Install the A/C so that it remains in place when the window is opened and or affix it so that the window cannot be opened accidentally.
- Tilt the unit slightly to provide water drainage; however, do not over tilt.
- Ensure there is a proper seal between the air conditioner's metal casing and the window frame.
- Check and verify the unit is operating correctly and properly cooling.
- Ensure there are no refrigerant leaks.
- Ensure there are no obstructions in front of the unit to prevent good airflow.
- DO NOT USE loose objects, such as wood blocking, to support the levelling of an A/C unit.
- DO NOT USE bricks, telephone books, gypsum board or cans for levelling under the A/C unit.
- DO NOT BLOCK fire escape windows or any other exit with an A/C unit.
- DO NOT PLACE anything (TV antennae, satellite dishes, plants, etc.) on top of an A/C unit.

Operation & Best Practices:

The energy consumption and cost of operating an efficient window air conditioner may be minimized by taking the simple steps listed below:

- Set the air conditioner's thermostat as high as is comfortably possible in the summer. A setting of 25.5°C is recommended. The less difference between the indoor and outdoor temperatures, the lower the overall cooling bill will be.
- If the space is going to be unoccupied for more than four hours, the thermostat should be turned up to achieve a temperature of about 28°C. If it will be unoccupied for more that 24 hours, it should be shut off.
- Don't let heat build up all day and then, in an effort to cool quickly, switch your air conditioner to its maximum setting. It's far more efficient to start the unit earlier in the day, letting the

room cool gradually. A timer or programmable thermostat enables your air conditioner to cool and dehumidify slowly and efficiently.

- Don't set your thermostat at a colder setting than normal when you turn on your air conditioner. It will not cool your home any faster and could result in excessive cooling and, therefore, unnecessary expense.
- Set the fan speed on high, except on very humid days. When humidity is high, set the fan speed on low for more comfort. The low speed on humid days will cool your home better and will remove more moisture from the air because of slower air movement through the cooling equipment.
- Set the fan to operate continuously when you need air movement to maintain comfortable conditions.
- Use the "fan-only" mode (if available) in the evening and early morning to draw cooler outside air into the residence.
- Consider using an interior fan in conjunction with the window air conditioner to spread the cooled air more effectively through the residence without greatly increasing electricity use.
- Keeping the filter clean can lower the air conditioner's energy consumption by 5% to 15%.
- Reduce the amount of heat generated inside by inefficient appliances, lights, etc.
- Make sure that all windows and balcony doors are adequately sealed so that there are no leaks.
- Reduce solar radiation with window coverings.

Monthly Maintenance:

- Check the air conditioner’s air filter once a month and clean or replace filters as necessary. A dirty air filter reduces airflow and operating efficiency and, in some cases, can damage a room air conditioner.
- Occasionally pass a stiff wire through the unit's drain channels. Clogged drain channels prevent a unit from reducing humidity, and the resulting excess moisture may damage walls or flooring.

Seasonal Removal:

At the end of each cooling season:

- Complete a final check on the unit’s operation and note any problems so that it can be repaired over the winter.
- Ensure there are no refrigerant leaks.
- Remove the unit from the window and clean before storing.
- Cover and seal the window opening used for the air conditioner to prevent air leaks.
- Store the air conditioner in a protected cardboard container to prevent damage in shipping and storage.
- Store the air conditioner in a dry place over the winter.

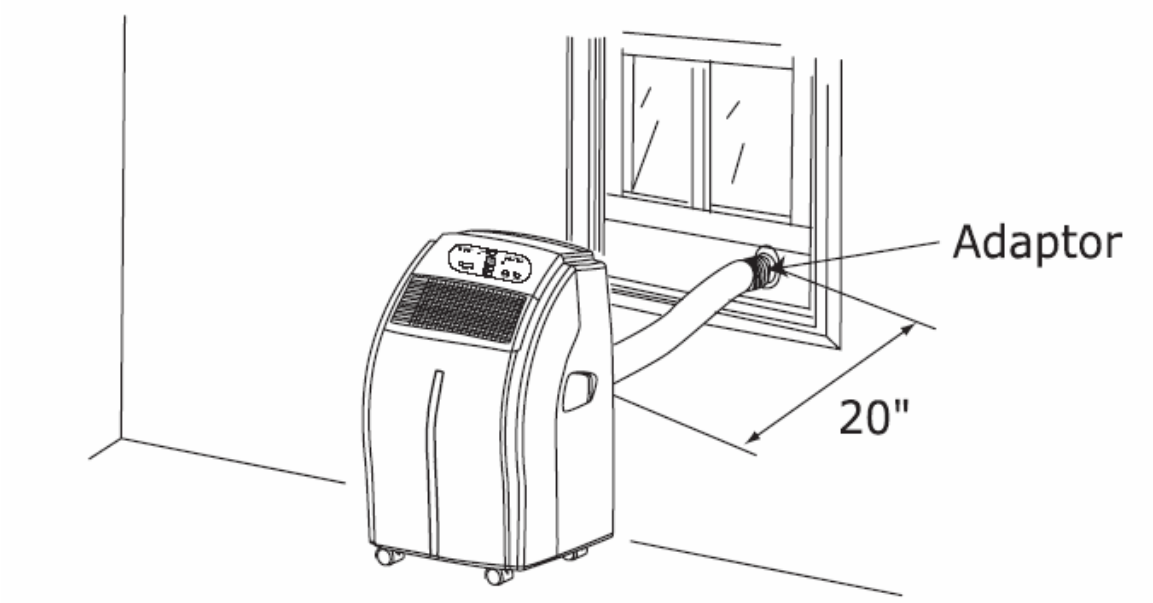
Appendix B - Installation, Operation & Preventive Maintenance for Portable Air Conditioners

The following sections are generic and should be used only as a guideline. The user should refer to the manufacturer's supplied manual for the procedures that are specific to the equipment purchased.

Installation:

Portable air conditioners are easily moved once installed, either from one room to another, or removed completely at the end of the cooling season. In order for the portable air conditioners to function properly, the unit must be vented to the outside. The easiest way to accomplish this is through the window.

To properly vent the portable air conditioner, connect one end of the exhaust hose to the unit and the other end to the foam insert for the window, which should be supplied with the unit. Install the foam strips into the window opening as shown in the figure below.



The foam strips can be expanded or cut depending on the model selected, in order to fit the window opening properly. Window kits can be used on either horizontal or vertical sliding windows.

Ensure that the foam forms an airtight seal with the window. An airtight seal will also prevent insects from entering the unit through the air conditioner opening.

Operation:

The operation of portable air conditioners is fairly straight forward. In order to operate a portable air conditioner, the mode, temperature and fan speed need to be set. The units can generally either be in an auto mode or in a cooling mode. In the auto mode, the temperature is preset to 24°C and the fan speed is set according to the ambient air temperature.

The preset temperature can be also selected by the user as detailed in the Best Practices section below. When the set temperature is reached the unit will operate in fan mode only. In order to conserve energy, the compressor will not turn back on until the temperature in the room has deviated from the set point temperature by a set number of degrees, determined by the model. The fan's speed can be varied, except in auto mode, which will automatically set the fan speed.

Some models also have a timer setting, which allows the unit to operate only for a specified period of time, e.g. from 1 to 12 hours. The timer does not have to be used and the unit can run in the continuous mode.

The direction of the air flow can also be controlled using the horizontal and vertical louvers located on the machine.

Portable air conditioner units use self-evaporating technology, which uses and recycles moisture collected during cooling to produce cool air. Additional moisture that is removed from the air will be collected in a container in the unit, which will have to be emptied periodically. Once the container in the unit is full, the compressor will turn off and the unit will only operate in the fan mode. Emptying procedures vary between models; however, most involve using a flat container or dish to remove the excess water through a drain hole in the back of the machine.

Best Practices:

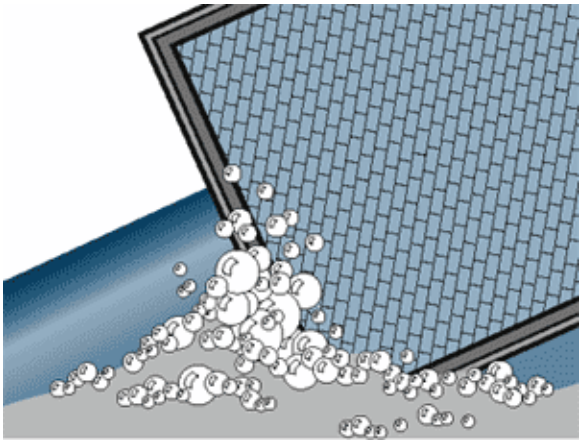
The energy consumption and cost of operating an efficient portable air conditioner may be minimized by taking the simple steps listed below:

- Select the highest possible thermostat setting that would result in an acceptable comfort level. A temperature of 25.5°C is usually recommended.
- Don't let heat build up all day and then, in an effort to cool quickly, switch your air conditioner to its maximum setting. It is actually far more efficient to start the unit earlier in the day, letting the room cool gradually.
- If the space is going to be unoccupied for more than four hours, the thermostat should be turned up to achieve a temperature of about 28°C. If it will be unoccupied for more that 24 hours, it should be shut off.
- Apartments should be closed up tight during hot days. Close all doors leading to your air-conditioned space as much as possible to keep cool air in. Draw curtains and blinds to limit the amount of heat gain through the windows.
- Use continuous air conditioner fan operation only when the resulting air movement is required to maintain comfortable conditions in the room.
- Do not block the air conditioner vents with drapes or furniture.
- Shut closet doors to avoid cooling unused space.
- Turn off lights and appliances when they aren't needed because they generate heat.
- The compressor will start approximately three minutes after the unit is turned on (which helps extend the life of the compressor). Once the machine is turned off, wait at least three minutes before turning the unit back on.

Maintenance:

- Keep the condenser clean and free of debris.
- Clean condensate drain holes or tubes that become blocked.
- If the unit's performance seems to have deteriorated, have it serviced. A small loss of refrigerant can cause a significant drop in efficiency.

- Clean the air filters on a regular basis and at least once each season. A dirty air filter reduces airflow and, in some cases, this could cause damage to the air conditioner. Cleaning procedures vary between models, but generally involve removing the filter frame, vacuuming or tapping it lightly to remove excess dirt and the rinsing the filters under running water (no hotter than 40°C). Dry the filter thoroughly before putting the filter back on the unit. Note that activated charcoal filters should not be wetted and should be removed from the frame before rinsing the other filters.



- Check the owner's manual about the correct maintenance schedule for the unit. Some models may require additional attention.

Seasonal Removal:

At the end of the cooling season, the portable air conditioner should be removed and stored properly. Before storage, the following steps should be taken:

- Unplug the unit.
- Drain the condenser water completely.
- Clean or change the filter.
- Clean the outside of the machine with a soft, damp cloth only.
- Run in fan mode (with the cooling switched off) for a couple of hours on a warm day, so that the unit dries out completely.

The air conditioner should then be stored in the original container until needed again.