



# EIA - Technology Forecast Updates – Residential and Commercial Building Technologies - Reference Case Second Edition (Revised)

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**Objective**

**The objective of this study is to develop baseline and projected performance/cost characteristics for residential and commercial end-use equipment.**

- 2003 and 2005 baselines, as well as today's (2007)
  - Review of literature, standards, installed base, contractor, and manufacturer information.
  - Provide a relative comparison and characterization of the cost/efficiency of a generic product.
- Forecast of technology improvements that are projected to be available through 2030
  - Review of trends in standards, product enhancements, Research and Development (R&D).
  - Projected impact of product improvements and enhancement to technology.

**The performance/cost characterization of end-use equipment developed in this study will assist EIA in projecting national primary energy consumption.**

## Methodology

**Input from industry, including government, R&D organizations, and manufacturers, was used to project product enhancements concerning equipment performance and cost attributes.**

- Varied sources ensure a balanced view of technology progress and the probable timing of commercial availability.
- Technology developments impact performance and cost forecasts.
- Technology forecasting involves many uncertainties.
- All cost forecasts are shown in real, 2007 dollars.

**Definition**

The following tables represent the current and projected efficiencies for residential and commercial building equipment ranging from the installed base in 2003 and 2005, to the highest efficiency equipment that is expected to be commercially available by 2030, assuming **incremental** adoption. Below are definitions for the terms used in characterizing the status of each technology.

- 2003/2005 Installed Base: the currently installed and “in use” equipment for that year. Represents the installed stock of equipment, does not represent sales.
- 2007 Current Standard: the minimum efficiency required by current standards, or typical where no standard exists.
- Typical: the average, or “typical” product being sold in the particular timeframe.
- ENERGY STAR ®: the minimum efficiency required to meet the ENERGY STAR ® criteria, where applicable.
- Mid-Level: middle tier high-efficiency product available in the particular timeframe.
- High: the product with the highest efficiency available in the particular timeframe.

## Performance/Cost Characteristics Residential Gas-Fired Water Heaters

## Residential Gas-Fired Water Heaters

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	Mid-Level	High <sup>1</sup>	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (gal)</b>	40	40	40	40	50	40	50	40	50	40	50
<b>Energy Factor</b>	0.55	0.59	0.61	0.64	0.86	0.62	0.86	0.63	0.86	0.63	0.86
<b>Average Life (yrs)</b>	9	9	9	9	15	9	15	9	15	9	15
<b>Retail Equip. Cost</b>	\$260-\$290	\$280-\$310	\$300-\$350	\$500-\$680	\$1500-\$2250	\$300-\$350	\$1500-\$2250	\$300-\$350	\$1250-\$1750	\$300-\$350	\$1250-\$1750
<b>Total Installed Cost</b>	\$370-\$400	\$390-\$500	\$410-\$550	\$650-\$850	\$2000-\$3000	\$410-\$550	\$2000-\$3000	\$410-\$550	\$1750-\$2500	\$410-\$550	\$1750-\$2500
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

<sup>1</sup> Assumption of equivalent EF made based on product research.

## Residential Gas-Fired Water Heaters

- The new federal standard which came into effect in January 2004 mandates an EF of 0.59 for a 40-gallon water heater. The equation for the federal standard is
$$EF=0.67-(0.0019*Gal).$$
- One of the most efficient gas water heaters currently available is the A.O. Smith Vertex™ Residential Power Vent Water Heater. The model is a stand alone water heating system. This water heater comes in sizes of 50 to 60-gallons. The thermal efficiency of the Vertex is 90%, however; the EF is not listed. Based on product research the assumption is made that a high efficient gas fired water heater has an EF equivalent of approximately 0.86.
- Generally, there are no storage gas water heaters between approximately 70 to 80 EF, which would fall in the “near-condensing” range of operation. Gas-fired water heaters are typically either condensing or non-condensing models.
- Total installed cost includes installation, replacement case only (which represents 80% of all water heater installations).



## Performance/Cost Characteristics Residential Electric Resistance Water Heaters

## Residential Electric Resistance Water Heaters

	2005	2007	2007		2010		2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (gal)</b>	50	50	50	50	50	50	50	50	50	50
<b>Energy Factor</b>	0.85	0.90	0.91	0.95	0.91	0.95	0.92	0.95	0.92	0.95
<b>Average Life (yrs)</b>	14	14	14	14	14	14	14	14	14	14
<b>Retail Equip. Cost</b>	\$200- \$250	\$250- \$300	\$290- \$350	\$320- \$400	\$250- \$300	\$320- \$400	\$250- \$300	\$320- \$400	\$250- \$300	\$320- \$400
<b>Total Installed Cost</b>	\$375- \$425	\$400- \$450	\$440- \$500	\$470- \$550	\$440- \$500	\$470- \$550	\$440- \$500	\$470- \$550	\$440- \$500	\$470- \$550
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

## Residential Electric Resistance Water Heaters

- The new federal minimum efficiency standard, which went into effect in January 2004, requires an EF of 0.90 for a 50-gallon electric resistance water heater. The equation for the federal standard is

$$EF=0.97-(0.00132*\text{volume}).$$

- There is no mid-level efficiency in this chart because there is very little difference between the typical efficiency and the high efficiency level.
- The 2007 highest efficiency electric resistance water heater is not likely to see any efficiency improvement due to thermal limits and diminishing returns on controlling heat loss.

## Performance/Cost Characteristics Residential Gas-Fired Water Heaters

## Residential Oil-Fired Water Heaters

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	Mid-Level	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (gal)</b>	30	30	30	30	30	30	30	30	30	30	30
<b>Energy Factor</b>	0.51	0.53	0.55	0.62	0.68	0.55	0.68	0.60	0.68	0.60	0.68
<b>Average Life (yrs)</b>	9	9	9	9	9	9	9	9	9	9	9
<b>Retail Equip. Cost</b>	\$800- \$1,000	\$850- \$1,050	\$900- \$1,100	\$1,350- \$1,650	\$1,700- \$2,100	\$900- \$1,100	\$1,700- \$2,100	\$1,150- \$1,450	\$1,700- \$2,100	\$1,150- \$1,450	\$1,700- \$2,100
<b>Total Installed Cost</b>	\$900- \$1,100	\$1,100- \$1,300	\$1,300- \$1,500	\$1,550- \$1,850	\$2,200- \$2,600	\$1,300- \$1,500	\$2,200- \$2,600	\$1,450- \$1,750	\$2,200- \$2,600	\$1,450- \$1,750	\$2,200- \$2,600
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

## Residential Oil-Fired Water Heaters

- The new federal standard which came into effect in January 2004 mandates an EF of 0.53 for a 30-gallon water heater. The equation for the federal standard is  $EF=0.59-(0.0019*\text{volume})$ .
- Bock Water Heaters, Inc. manufactures a very high efficient oil-fired water heater with an EF of 0.68, which uses a patented heat exchanger (turboflue) to achieve the higher efficiency levels.
- Oil-fired water heaters often have small tanks with larger input ratings, relative to natural gas and electric residential water heaters.

## Performance/Cost Characteristics Residential Heat Pump Water Heaters

## Residential Heat Pump Water Heaters

	2005	2007		2010		2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	50	50	50	50	50	50	50	50	50
Energy Factor	2.0	2.3	2.4	2.3	2.4	2.3	2.4	2.3	2.4
Average Life (yrs)	14	14	14	14	14	14	14	14	14
Retail Equip. Cost w/o Tank	\$1,200	\$1,200- \$1,500	\$1,500- \$1,800	\$1,200- \$1,500	\$1,500- \$1,800	\$1,000- \$1,200	\$1,500- \$1,800	\$1,000- \$1,200	\$1,500- \$1,800
Total Installed Cost w/o Tank	\$1,400	\$1,400- \$1,700	\$1,700- \$2,000	\$1,400- \$1,700	\$1,700- \$2,000	\$1,200- \$1,500	\$1,700- \$2,000	\$1,200- \$1,500	\$1,700- \$2,000
Annual Maintenance Cost	\$75	\$75	\$75	\$75	\$75	\$75	\$75	\$75	\$75

## Residential Heat Pump Water Heaters

- Since 1990, significant R&D efforts on heat pump water heater (HPWH) technology have focused on advances in efficiency and have reduced capacity to reduce cost. However, the high first cost still precludes a large market penetration.
- There are currently only a limited number of HPWH models. They are sold as both add-on systems and complete water heaters with storage tanks. Sales are estimated to be very limited.
- There is no mid-level efficiency in this chart because there is very little difference between the typical efficiency and the high efficiency level.
- The 2007 typical add-on product is based on the E-Tech R106K-5 model. ECR International manufacturers the Water Saver which is a drop-in HPWH and includes a tank.

## Performance/Cost Characteristics Residential Solar Water Heaters

## Residential Solar Water Heaters

	2005	2007	2010	2020	2030
	Installed Base	Typical	Typical	Typical	Typical
Typical Capacity (sq. ft)	40	40	40	40	40
Overall Efficiencies	50% of Water Heating Load	50% of Water Heating Load	50% of Water Heating Load	50% of Water Heating Load	50% of Water Heating Load
Solar Energy Factor	0.8-4.8	0.8-4.8	0.8-4.8	0.8-4.8	0.8-4.8
Average Life (yrs)	20	20	20	20	20
Retail Equip. Cost	\$3,000-\$4,000	\$3,000-\$4,000	\$2,500-\$3,500	\$2,500-\$3,500	\$2,000-\$3,000
Total Installed Cost <sup>1</sup>	\$5,000-\$6,000	\$5,000-\$6,000	\$4,500-\$5,500	\$4,000-\$5,000	\$3,500-\$4,500
Annual Maintenance Cost	Negligible	Negligible	Negligible	Negligible	Negligible

<sup>1</sup>These product costs are for an active, indirect or closed loop system; including tank and back-up system.

## Residential Solar Water Heaters

- Solar water heaters can be either active or passive. An active system uses an electric pump to circulate the heat-transfer fluid; a passive system has no pump. Most solar water heaters in the United States are the active type.
- Solar water heaters are also characterized as open loop (also called "direct") or closed loop (also called "indirect"). An open-loop system circulates household (potable) water through the collector. A closed-loop system uses a heat-transfer fluid (water or diluted antifreeze, for example) to collect heat and a heat exchanger to transfer the heat to household water.
- The typical annual efficiency (35-65%) of the Solar Water Heating (SWH) system (thermal output divided by solar input) will vary significantly depending on location.
- The typical collector area of 40 ft<sup>2</sup> is based on systems in the Southern and Western U.S. where the majority of SWH systems are installed. Colder areas such as Wisconsin would use 64 ft<sup>2</sup> collector and a secondary water/glycol heating loop.
- These installed costs are for systems in a Southern climate. An equivalent system installed in the Northeast would cost \$6,500-\$8,000 due to the requirements for freeze protection and additional collector area. Costs vary widely depending on collector quality and type of system.



## Performance/Cost Characteristics Residential Instantaneous Water Heaters

## Residential Instantaneous Water Heaters (Natural Gas)

	2005	2007		2010		2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	175	175	175	175	175	175	175	175	175
<b>Energy Factor</b>	0.69	0.80	0.85	0.80	0.85	0.80	0.85	0.80	0.86
<b>Average Life (yrs)</b>	20	20	20	20	20	20	20	20	20
<b>Retail Equip. Cost</b>	\$530-\$650	\$650-\$790	\$950-\$1,250	\$650-\$790	\$950-\$1,250	\$650-\$790	\$950-\$1,250	\$650-\$790	\$950-\$1,250
<b>Total Installed Cost</b>	\$940-\$1,060	\$1,080-\$1,220	\$1,300-\$1,650	\$1,080-\$1,220	\$1,300-\$1,650	\$1,080-\$1,220	\$1,300-\$1,650	\$1,080-\$1,220	\$1,300-\$1,650
<b>Annual Maintenance Cost</b>	\$25-\$30	\$25-\$30	\$25-\$30	\$25-\$30	\$25-\$30	\$25-\$30	\$25-\$30	\$25-\$30	\$25-\$30

Note: Data represents natural gas fired water heaters.

## Residential Instantaneous Water Heaters (Natural Gas)

- Most instantaneous hot water heaters sold on the market in 2007 have an efficiency of 0.80 EF or above.
- The highest efficiency models currently available on the market have an EF of 0.85.
- There is no mid-level efficiency because there is little difference between the typical efficiency and the high efficiency level.
- Many of the major water heater manufacturers now offer an instantaneous model.
- There is at least one electric (whole house) instantaneous water heater (four chamber model) available on the market. This product is priced around \$700-\$750.
- The maintenance cost for the water heater includes cleaning the water inlet filter and the heat exchanger of mineral deposits and replacing the water valve approximately once every five years.

## Residential Gas-Fired Furnaces

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	75	75	75	75	75	75	75	75	75	75	75
<b>AFUE (%)</b>	78.0	78.0	80.0	90.0	96.0	80.0	96.0	81.0	96.0	82.0	96.0
<b>Electric Consumption (kWh/yr)</b>	780	780	780	500	275	500	275	500	275	500	275
<b>Average Life (yrs)</b>	15	15	15	15	20	15	20	15	20	15	20
<b>Retail Equip. Cost</b>	\$900-\$1000	\$900-\$1000	\$900-\$1100	\$1400-\$1500	\$2200-\$2400	\$900-\$1100	\$1700-\$1900	\$900-\$1100	\$1700-\$1900	\$900-\$1100	\$1700-\$1900
<b>Total Installed Cost</b>	\$1700-\$1800	\$1700-\$1800	\$1700-\$1900	\$2400-\$2500	\$3200-\$3400	\$1700-\$1900	\$2700-\$2900	\$1700-\$1900	\$2700-\$2900	\$1700-\$1900	\$2700-\$2900
<b>Annual Maintenance Cost</b>	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50

## Residential Gas-Fired Furnaces

- Current NAECA Standard for gas-fired, forced-air furnaces is 78% AFUE.
- The criteria for an ENERGY STAR® qualified gas-fired furnace is 90% AFUE.
- The majority of furnaces on the market have an 80% AFUE. The highest efficiency models currently available on the market have an efficiency of 96.0%.
- The high efficiency furnaces available are condensing furnaces, which use an additional heat exchanger to extract additional energy from the flue gases, and higher end models have variable speed blowers.
- Non-condensing AFUE levels will top out at 82% to 83%; above this level, potential for exhaust gas condensation increases. This condensation can be corrosive, leading to failures of the vent system in furnaces not designed to handle condensation.
- High-efficiency condensing furnaces typically have stainless-steel (corrosion resistant from flue-gas condensate) heat exchangers, and low NO<sub>x</sub> emissions, flexible installation, direct vent, and sealed combustion.
- Recently, the Gas Appliance Manufacturers Association has begun to designate “electrically efficient” furnaces, which have reduced electrical consumption, some as low as 100 to 150 kWh/yr (Gas Appliance Manufacturer’s Consumers’ Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment, (GAMA Directory)).

## Performance/Cost Characteristics Residential Oil-Fired Furnaces

## Residential Oil-Fired Furnaces

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/hr)	105	105	105	105	105	105	105	105	105	105	105
AFUE (%)	80	78	81	83	95	81	95	81	95	81	95
Annual Electric Use (kWh/yr)	900	950	850	800	650	800	610	800	610	800	610
Average Life (yrs)	18	18	18	18	18	18	18	18	18	18	18
Retail Equip. Cost	\$1800- \$1900	\$1750- \$1850	\$1850- \$2150	\$2150- \$2350	\$4300- \$5300	\$1850- \$2150	\$4300- \$5300	\$1850- \$2150	\$4300- \$5300	\$1850- \$2150	\$4300- \$5300
Total Installed Cost	\$2300- \$2400	\$2250- \$2350	\$2350- \$2650	\$2650- \$2850	\$4,800- \$5,800	\$2350- \$2650	\$4800- \$5800	\$2350- \$2650	\$4800- \$5800	\$2350- \$2650	\$4800- \$5800
Annual Maintenance Cost	\$100	\$100	\$100	\$100	\$100	\$100	\$100	\$100	\$100	\$100	\$100

## Residential Oil-Fired Furnaces

- Current NAECA Standard for oil fired, forced air furnaces is 78% AFUE.
- The ENERGY STAR® criteria for oil-fired furnaces is 83% AFUE.
- Many of the oil-fired furnaces on the market have an 80% to 81% AFUE. A manufacturer advertises a condensing oil-fired furnace with a 95% AFUE. This unit is listed on ENERGY STAR's® qualified product list, but is not listed in the most recent version of the GAMA directory, available at the time of this presentation, of certified efficiency ratings. For this reason, the typical annual electric use is not available and is estimated.
  - The highest efficiency listed in the GAMA directory is 86% AFUE.

## Performance/Cost Characteristics Residential Hydronic Heating System (Boilers)

## Residential Hydronic Heating System (Boilers)

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/hr)	100	100	100	100	100	100	100	100	100	100	100
AFUE (%)	78	80	81	85	95	82	95	83	95	85	95
Average Life (yrs)	21	21	21	21	30	21	30	21	30	21	30
Retail Equip. Cost	\$1400-\$1500	\$1400-\$1500	\$1500-\$1600	\$1600-\$1800	\$2700-\$3000	\$1500-\$1600	\$2700-\$3000	\$1500-\$1600	\$2700-\$3000	\$1500-\$1600	\$2700-\$3000
Total Installed Cost	\$2900-\$3000	\$2900-\$3000	\$3000-\$3100	\$3600-\$3800	\$4700-\$5000	\$3000-\$3100	\$4700-\$5000	\$3000-\$3100	\$4700-\$5000	\$3000-\$3100	\$4700-\$5000
Annual Maintenance Cost	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50	\$50

## Residential Hydronic Heating System (Boilers)

- The NAECA standard for hot-water residential boilers is 80% AFUE.
- The ENERGY STAR ® Standard for boilers is 85% AFUE.
- Very few high efficiency condensing boilers exist. In the future, higher efficiency boilers may involve modulating burners, power venting, and electronic ignition.
- The market for boilers is primarily retrofit. Shipments have decreased 9% in the last five years. In 2006, hydronic systems represented about 9% of heating systems across the U.S. These systems are most popular in the New England states.



## Performance/Cost Characteristics Residential Room A/C

## Residential Room A/C

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
<b>EER</b>	8.7	9.8	10.0	10.8	12.0	10.2	12.0	10.4	12.0	10.6	12.0
<b>Average Life (yrs)</b>	10	10	10	10	10	10	10	10	10	10	10
<b>Retail Equip. Cost</b>	\$175-\$225	\$200-\$275	\$225-\$300	\$250-\$325	\$775-\$925	\$225-\$300	\$775-\$925	\$225-\$300	\$775-\$925	\$225-\$300	\$775-\$925
<b>Total Installed Cost</b>	\$200-\$250	\$250-\$310	\$290-\$420	\$370-\$450	\$875-\$1025	\$290-\$420	\$875-\$1025	\$290-\$420	\$875-\$1025	\$290-\$420	\$875-\$1025
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

## Residential Room A/C

- Federal efficiency standards require common-sized room air conditioners to have an EER of 9.8. These standards took effect in October 2000. The ENERGY STAR ® criteria effective October 2000 requires an EER of 10.8.
- One of the highest efficiency models is from Friedrich Air Conditioning Company with an EER of 12.0.
- Installation costs vary depending on whether the unit is purchased retail or through a distributor. Many retail stores offer free installation.
- Efficiency improvements are attained by:
  - Higher efficiency compressor and fan motors
  - Increased heat transfer area in evaporator and condenser

## Performance/Cost Characteristics Residential Central A/C

## Residential Central A/C

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/hr)	42	42	42	42	42	42	42	42	42	42	42
SEER	10.2	13.0	13.0	14.0	21.0	13.0	23.0	14.0	23.0	15.0	23.0
Average Life (yrs)	14	14	14	14	14	14	14	14	14	14	14
Retail Equip. Cost	\$1,300- \$1,500	\$1,500- \$1,800	\$1,500- \$1,800	\$1,800- \$2,000	\$3,750- \$4,250	\$1,500- \$1,800	\$3,750- \$4,250	\$1,800- \$2,000	\$3,750- \$4,250	\$1,800- \$2,000	\$3,750- \$4,250
Total Installed Cost	\$2,500- \$2,700	\$2,700- \$3,000	\$2,700- \$3,000	\$3,000- \$3,200	\$5,750- \$6,250	\$2,700- \$3,000	\$5,750- \$6,250	\$3,000- \$3,200	\$5,750- \$6,250	\$3,000- \$3,200	\$5,750- \$6,250
Annual Maintenance Cost	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120

## Residential Central A/C

- Current NAECA minimum SEER is 13.0 Btu/Watt-hr. This federal minimum efficiency standard became effective January 2006. The ENERGY STAR ® criteria is 14 SEER.
- There are a large number of mid-high efficiency units (16 SEER) available on the market and range from \$2,300-\$2,700 retail price.
- The high efficiency units currently available (greater than 19 SEER) use an evaporator ECM fan motor and have modulating capacity.
  - Higher efficiency levels (greater than 21 SEER) can be expected with the use of electronic valves, variable-speed scroll compressor systems, and condenser ECM fan motors.

## Performance/Cost Characteristics Residential Air Source Heat Pumps

## Residential Air Source Heat Pumps

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High <sup>1</sup>	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	36	36	36	36	36	36	36	36	36	36	36
<b>HSPF (Heating)</b>	6.8	7.7	7.7	8.2	10.6	7.7	10.7	7.9	10.8	7.9	10.9
<b>SEER (Cooling)</b>	10	13	13	14	17	13	18	13	19	13	20
<b>Average Life (yrs)</b>	14	14	14	14	14	14	14	14	14	14	14
<b>Retail Equip. Cost</b>	\$2,600- \$2,900	\$2,700- \$3,300	\$2,700- \$3,300	\$3,150- \$3,850	\$4,500- \$5,500	\$2,700- \$3,300	\$4,700- \$5,700	\$2,700- \$3,300	\$4,700- \$5,700	\$2,700- \$3,300	\$4,700- \$5,700
<b>Total Installed Cost</b>	\$3,500- \$4,300	\$3,800- \$4,900	\$3,800- \$4,900	\$3850- \$5,550	\$6,500- \$7,500	\$3,800- \$4,900	\$6,700- \$7,700	\$3,800- \$4,900	\$6,700- \$7,700	\$3,800- \$4,900	\$6,700- \$7,700
<b>Annual Maintenance Cost</b>	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120	\$120

<sup>1</sup> Represents highest HSPF on the market. Products with 19 SEER and <10.6 HSPF are available. See notes page.

## Residential Air Source Heat Pumps

- The NAECA minimum HSPF is 7.7 and the minimum SEER is 13. These standards became effective January 2006.
- Heat pumps are generally sized to meet the cooling load of the house. When the heating load exceeds heat pump heating capacity, resistance heat is used to compensate.
  - However, when the heating capacity exceeds the heating load, the heat pump starts and stops more frequently, causing wear and tear on the components and an overall loss of efficiency.
- High efficiency cooling does not necessarily lead to high efficiency heating. The range of SEER/HSPF combinations is very broad. Many high efficiency heating units have low SEER and vice-versa. The heat pump model that has the highest HSPF at 10.6 has a SEER of 17.0 at a capacity of approximately 3 tons. One company has an energy efficient residential heat pump with a SEER of 19.0 and a HSPF of 9.5 at a capacity of 3 tons.

## Performance/Cost Characteristics Residential Ground Source Heat Pumps

## Residential Ground Source Heat Pumps

	2005	2007			2010		2020		2030	
	Installed Base	Typical	ENERGY STAR® <sup>1</sup>	High	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/hr)	36	36	36	36	36	36	36	36	36	36
Heating (COP)	3.4	3.4	3.3	5.0	3.5	5.0	3.8	5.0	3.8	5.0
Cooling (EER)	13.8	16.0	14.1	30.0	16.0	30.0	18.0	30.0	18.0	30.0
Average Life (yrs.)	15	15	15	20	15	20	15	20	15	20
Retail Equip. Cost	\$4,050-\$4,950	\$4,050-\$4,950	\$4,000-\$4,500	\$6,000-\$7,000	\$4,050-\$4,950	\$6,000-\$7,000	\$4,050-\$4,950	\$6,000-\$7,000	\$4,050-\$4,950	\$6,000-\$7,000
Total Installed Cost	\$8,550-\$9,450	\$8,550-\$9,450	\$8,000-\$9,000	\$13,500-\$18,000	\$8,550-\$9,450	\$12,000-\$15,000	\$8,550-\$9,450	\$12,000-\$15,000	\$8,550-\$9,450	\$12,000-\$15,000
Annual Maintenance Cost	\$70	\$70	\$70	\$70	\$70	\$70	\$70	\$70	\$70	\$70

<sup>1</sup> Represents ENERGY STAR® criteria for closed loop geothermal heat pumps.

## Residential Ground Source Heat Pumps

- There are currently 18 ground source heat pump manufacturers in the U.S.
- A high heating COP does not coincide with a high cooling EER. The highest efficiency GSHP is the Envision by WaterFurnace International, Inc. The Envision has a 30 EER and 5.0 COP.
- The ENERGY STAR® criteria for a ground source heat pump is
  - Open Loop:  $\geq 3.6$  COP;  $\geq 16.2$  EER
  - Closed Loop:  $\geq 3.3$  COP;  $\geq 14.1$  EER
  - Direct Expansion:  $\geq 3.5$  COP;  $\geq 15$  EER.
- The most common ground source heat pump is a closed-loop system in which water or an anti-freeze solution is circulated through plastic pipes buried underground. Open-loop systems that employ groundwater, or surface water such as a pond or lake, are used in some parts of the country, but water supply and water quality issues impose limitations on such applications.
- Installation cost is for a closed-loop system and includes necessary accessories. Accessories include auxiliary pump, thermostat, and pump kit which adds approximately \$1,500 to the installation cost.



## Performance/Cost Characteristics Residential Gas Heat Pumps

## Residential Gas Heat Pumps

	2005	2007	2010	2020	2030
	Installed Base	Typical	Typical	Typical	Typical
Typical Capacity (kBtu/hr)	60	60	60	60	60
Heating (GCOP)	1.1	1.4	1.4	1.4	1.4
Cooling (GCOP)	0.67	0.67	0.67	0.67	0.67
Annual Electric Use (kWh/yr)	200	200	200	200	200
Average Life (yrs)	15	15	15	15	15
Retail Equipment Cost	\$3500-\$4500	\$6500-\$7500	\$6500-\$7500	\$6500-\$7500	\$6500-\$7500
Total Installed Cost	\$5500-\$6500	\$8500-\$9500	\$8500-\$9500	\$8500-\$9500	\$8500-\$9500
Annual Maintenance Cost	\$150	\$150	\$150	\$150	\$150

## Residential Gas Heat Pumps

- Residential Gas Heat Pumps are not currently covered by NAECA. There is essentially one type of product on the market, hence no mid-level efficiency and/or high efficiency level.
- The data represents absorption heat pumps. In 2000, York pulled the gas engine-driven heat pump (Triathlon) out of the market and to our knowledge, currently has no plans of reintroducing the product line.
- The absorption heat pump is a gas-fired, ammonia-water absorption cycle, combined with a high-efficiency low-pressure boiler integrated into one outdoor unit.
- The absorption gas heater-chiller unit manufactured by Robur/Servel is the only gas cooling equipment commercially available for the residential market.
- Gas-fired cooling equipment currently comprises less than 1% of the residential air-conditioning/heat pump market.

## Performance/Cost Characteristics Residential Refrigerator/Freezer

Residential Refrigerator/Freezer (Typical Volume 20.6 ft<sup>3</sup>)

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High	Typical	High
<b>Energy Consumption (kWh/yr)</b>	840	510	475	434	417	475	417	460	417	430	417
<b>Average Life (yrs)</b>	14	14	14	14	18	14	18	14	18	14	18
<b>Retail Equip. Cost</b>	\$400- \$500	\$450- \$550	\$550- \$750	\$750- \$850	\$1,000- \$1,200	\$550- \$750	\$1,000- \$1,200	\$550- \$750	\$1,000- \$1,200	\$550- \$750	\$1,000- \$1,200
<b>Total Installed Cost</b>	\$450- \$550	\$500- \$600	\$600- \$800	\$800- \$900	\$1,050- \$1,150	\$600- \$800	\$1,050- \$1,150	\$600- \$800	\$1,050- \$1,150	\$600- \$800	\$1,050- \$1,150
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

**Residential Refrigerator/Freezer (Typical Volume 20.6 ft<sup>3</sup>)**

- Current NAECA Standard (in effect since 2001) for a typical 20.6 ft<sup>3</sup> top-mount refrigerator/freezer is 510 kWh/yr.
- The typical refrigerator/freezer sold currently (2007) consumes approximately 475 kWh/yr.
- The best available refrigerator/freezer with a total volume over 21 ft<sup>3</sup> is a 21.6 ft<sup>3</sup> model and uses 417 kWh/yr.

## Performance/Cost Characteristics Residential Cooktops and Ovens (Gas)

## Residential Cooktops (Gas)

	2005	2007		2010		2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	9-12	9-12	9-12	9-12	9-12	9-12	9-12	9-12	9-12
<b>Cooking Efficiency (%)</b>	38.0%	39.9%	42.0%	39.9%	42.0%	39.9%	42.0%	39.9%	42.0%
<b>Average Life (yrs)</b>	18	18	18	18	18	18	18	18	18
<b>Retail Equip. Cost</b>	\$225-\$300	\$250-\$350	\$375-\$450	\$250-\$350	\$375-\$450	\$250-\$350	\$375-\$450	\$250-\$350	\$375-\$450
<b>Total Installed Cost</b>	\$275-\$350	\$300-\$400	\$425-\$500	\$300-\$400	\$425-\$500	\$300-\$400	\$425-\$500	\$300-\$400	\$425-\$500
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

## Performance/Cost Characteristics Residential Cooktops and Ovens (Gas)

## Residential Ovens (Gas)

	2005	2007			2010		2020		2030	
	Installed Base	Typical	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (inch)</b>	30	30	30	30	30	30	30	30	30	30
<b>Cooking Efficiency (%)</b>	5.9%	5.9%	6.5%	9.4%	5.9%	9.4%	5.9%	9.4%	5.9%	9.4%
<b>Average Life (yrs)</b>	18	18	18	18	18	18	18	18	18	18
<b>Retail Equip. Cost</b>	\$500-\$600	\$500-\$600	\$600-\$700	\$950-\$1,150	\$500-\$600	\$950-\$1,150	\$500-\$600	\$950-\$1,150	\$500-\$600	\$950-\$1,150
<b>Total Installed Cost</b>	\$550-\$650	\$550-\$650	\$650-\$750	\$1,000-\$1,200	\$550-\$650	\$1,000-\$1,200	\$550-\$650	\$1,000-\$1,200	\$550-\$650	\$1,000-\$1,200
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

## Residential Cooktops and Ovens (Gas)

- In 1990, gas cooktops and ovens with electric connections were no longer allowed to have a constantly burning pilot light. Thus, gas cooktops and ovens with an electrical supply must have electronic ignition systems.
- Efficiency levels vary little for cooktops on the market. However, efficiency levels do vary for gas ovens. Higher efficiency ovens are self-cleaning and include forced convection and improved seals.

## Performance/Cost Characteristics Residential Clothes Washers

## Residential Clothes Washers

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High	Typical	High
Typical Capacity (ft <sup>3</sup> )	3.0	3.0	3.0	2.8	2.5	3.0	2.5	3.0	2.5	3.0	2.5
Modified Energy Factor (ft <sup>3</sup> /kWh per cycle)	0.95	1.26	1.50	1.72	2.79	1.50	2.79	1.50	2.79	1.50	2.79
Average Life (yrs)	12	12	12	12	14	12	14	12	14	12	14
Water Consumption (gallons per cycle)	39	30	30	30	18	30	18	30	18	30	18
Hot Water Energy (kWh per cycle)	1.4	0.8	0.8	0.4	0.4	0.8	0.4	0.8	0.4	0.8	0.4
Machine Energy (kWh per cycle)	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.1
Dryer Energy (kWh per cycle)	1.4	1.0	1.0	0.7	0.7	1.0	0.7	1.0	0.7	1.0	0.7
Retail Equip. Cost	\$320-\$400	\$360-\$440	\$600-\$730	\$660-\$800	\$850	\$600-\$730	\$900	\$600-\$730	\$900	\$600-\$730	\$900
Total Installed Cost	\$420-\$500	\$460-\$540	\$700-\$840	\$750-\$900	\$950	\$700-\$840	\$1,000	\$700-\$840	\$1,000	\$700-\$840	\$1,000

Note: The typical capacity is smaller for higher efficiency models.



## Residential Clothes Washers

- The current NAECA standard for clothes washers is a modified energy factor (MEF) of 1.26. The ENERGY STAR® criteria is 1.72 MEF.
- High efficiency models historically have been horizontal axis washers. ENERGY STAR® (high efficiency) models represent about 30% of clothes washer sales in the United States.
- The higher efficiency models have smaller volumes than other products. The highest efficiency clothes washer has an MEF of 2.79 and a capacity of 2.5 cu.ft. The highest MEF for a 3.0 cu.ft. model is around 1.6-1.8.
- The annual maintenance cost for residential clothes washer is negligible.
- Clothes washer test procedures were revised in 1997 to account for dryer energy.
  - The Department of Energy amended the existing test procedure and adopted a new procedure that must be used since the new energy conservation standards for clothes washers became effective in January 2004.
  - Both the amended and new test procedure report the clothes washer efficiency in terms of the new descriptor Modified Energy Factor (MEF)
  - The test procedure is based on 392 cycles per year.

## Performance/Cost Characteristics Residential Dishwashers (Standard)

## Residential Dishwashers (Standard)

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Low	ENERGY STAR ® <sup>1</sup>	High	Typical	High	Typical	High	Typical	High
Typical Annual Use (kWh/yr)	720	465	360	340	190	360	190	353	190	353	190
Efficiency (cycle/kWh)	0.42	0.46	0.62	0.65	1.1	0.62	1.1	0.63	1.1	0.63	1.1
Annual Hot Water Energy Use (kwh/yr)	286	261	194	185	100	194	100	191	100	191	100
Average Life (yrs)	12	12	12	12	12	12	12	12	12	12	12
Retail Equip. Cost	\$550	\$600-\$700	\$625-\$725	\$650-\$750	\$900	\$625-\$725	\$900	\$625-\$725	\$900	\$625-\$725	\$900
Total Installed Cost	\$650	\$700-\$800	\$725-\$825	\$750-\$850	\$1200	\$725-\$825	\$1200	\$725-\$825	\$1200	\$725-\$825	\$1200
Annual Maintenance Cost	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

<sup>1</sup> Energy Star levels are for standard dishwashers

## Residential Dishwashers (Standard)

- The NAECA standard for dishwashers is 0.46 EF. The high efficiency models use less water (approximately 20 liters per wash).
- The ENERGY STAR® standard requires an EF of 0.65 for standard dishwashers. A standard dishwasher is  $\geq 8$  place settings + six serving pieces and a compact dishwasher is  $< 8$  place settings + six serving pieces.
- ENERGY STAR® dishwashers represent about 90% of the market. The typical model represents a model just below ENERGY STAR® to provide a different data point. However, ENERGY STAR® would be more "typical" in today's market.
- While the most efficient dishwasher at 1.1 EF with a retail price of \$900 is available, is has a very small market share, typical high efficiency units sold have an EF of 0.71.
- Dishwasher EF is based on the U.S. DOE test procedure. This procedure is based on total energy use - including motor, dryer, booster heater (if present), and for hot water required from the water heater. The previous U.S. DOE test procedure was based on a usage estimate of 322 cycles per year, but as of September 2003 a new test procedure of 215 cycles per year was implemented.

## Performance/Cost Characteristics Commercial Chillers

## Centrifugal Chillers

	2003	2007	2007			2010		2020		2030	
	Installed Base	ASHRAE 90.1-2004	Typical	Mid	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (tons)</b>	350	350	350	350	350	350	350	350	350	350	350
<b>Efficiency (kW/ton)<sup>1</sup></b>	0.75	0.58	0.60	0.51	0.48	0.55	0.48	0.50	0.48	0.50	0.48
<b>Efficiency (COP)<sup>1</sup></b>	4.7	6.1	5.9	6.9	7.3	6.4	7.3	7.0	7.3	7.0	7.3
<b>Average Life (yrs)</b>	23	23	23	23	23	23	23	23	23	23	23
<b>Retail Equip. Cost (\$/ton)</b>	\$180-\$380	\$200-\$400	\$300-\$400	\$350-\$450	\$400-\$500	\$300-\$400	\$400-\$500	\$300-\$400	\$400-\$500	\$300-\$400	\$400-\$500
<b>Total Installed Cost (\$/ton)</b>	\$250-\$450	\$375-\$475	\$390-\$490	\$440-\$540	\$470-\$570	\$390-\$490	\$470-\$570	\$390-\$490	\$470-\$570	\$390-\$490	\$470-\$570
<b>Annual Maintenance Cost (\$/ton)</b>	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30	\$15-\$30

<sup>1</sup> This represents the COP and kW/ton based on full-load efficiency.

## Centrifugal Chillers

- No Federal standards exist for centrifugal chillers.
- ASHRAE 90.1-2004 is not mandatory, but many chillers meet this standard level.
- As of January, 2004, 18 states had adopted as mandatory the more stringent code of 0.58 kW/ton and a COP of 6.10 in ASHRAE 90.1-2004.
- The Federal Energy Management Program (FEMP) recommends a full-load efficiency of 0.56 or less kW/ton.
- Future increases in efficiency will include the following modifications to the standard centrifugal chiller:
  - Greater heat exchanger surface area and enhanced tube configurations (counterflow)
  - Optimized fluid flow velocities
  - High efficiency electric motors
  - Improved turbomachinery design, resulting in higher compressor efficiency
  - Better piping and valving, including electronic expansion valves
  - Evaporative condenser for the heat rejection equipment
- Installed costs vary widely depending on equipment needed for installation (e.g. crane) and size of system. This is a mature market with centrifugal chillers representing 75% of commercial chiller sales larger than 200 tons.

## Performance/Cost Characteristics Commercial Chillers

## Gas-Fired Chillers (Water Cooled)

	2003	2007		2010		2020		2030	
	Absorption Installed Base	Absorp- tion	Engine- Driven	Absorp- tion	Engine- Driven	Absorp- tion	Engine- Driven	Absorp- tion	Engine- Driven
Typical Capacity (tons)	150-1,500	150-1,500	350	150-1,500	350	150-1,500	350	150-1,500	350
Efficiency (kW/ton)	3.5	3.5	2.1	2.9	2.1	2.9	2.1	2.9	2.1
COP	1.0	1.0	1.7	1.2	1.7	1.2	1.7	1.2	1.7
Average Life (yrs)	23	23	20	23	20	23	20	23	20
Retail Equip. Cost (\$/ton)	\$500- \$650	\$500- \$650	\$600- \$700	\$500- \$650	\$600- \$700	\$500- \$650	\$600- \$700	\$500- \$650	\$600- \$700
Total Installed Cost (\$/ton)	\$650- \$750	\$650- \$750	\$800- \$900	\$650- \$750	\$800- \$900	\$650- \$750	\$800- \$900	\$650- \$750	\$800- \$900
Annual Maintenance Cost (\$/ton)	\$12-\$25	\$12-\$25	\$12-\$25	\$12-\$25	\$12-\$25	\$12-\$25	\$12-\$25	\$12-\$25	\$12-\$25

## Gas-Fired Chillers (Water Cooled)

- The gas-fired chillers in the tables are water cooled. Air cooled gas-fired chillers do exist but have lower COPs at 1.1-1.4, and are smaller (50-250 ton capacity range).
- Current retail costs were obtained from manufacturers. The absorption chiller retail costs are for a range of double-effect sizes.
- There are three types of absorption chillers: single effect (retrofit market), double effect (mainly new construction and hospitals), and triple effect (under development). These systems vary in the number of heat exchanger stages. The double effect system is 50 to 60 percent more efficient than the single effect chiller. The triple effect system has demonstrated COPs around 1.4.

## Performance/Cost Characteristics Commercial Chillers

## Reciprocating Chillers

	2003	2007		2010		2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (tons)</b>	100-200	100-200	100-200	100-200	100-200	100-200	100-200	100-200	100-200
<b>Efficiency (kW/ton)</b>	1.5	1.3	1.0	1.3	1.0	1.26	0.97	1.26	0.93
<b>COP</b>	2.3	2.7	3.5	2.7	3.5	2.8	3.6	2.8	3.8
<b>Average Life (yrs)</b>	23	23	23	23	23	23	23	23	23
<b>Retail Equip. Cost (\$/ton)</b>	\$300-\$330	\$400-\$430	\$450-\$500	\$400-\$430	\$450-\$500	\$350-\$400	\$400-\$430	\$350-\$400	\$400-\$430
<b>Total Installed Cost (\$/ton)</b>	\$390-\$420	\$490-\$520	\$540-\$590	\$490-\$520	\$540-\$590	\$440-\$490	\$490-\$520	\$440-\$490	\$490-\$520
<b>Annual Maintenance Cost (\$/ton)</b>	\$25-\$40	\$25-\$40	\$25-\$40	\$25-\$40	\$25-\$40	\$25-\$40	\$25-\$40	\$25-\$40	\$25-\$40



## Reciprocating Chillers

- No Federal standards exist for air cooled chillers, ASHRAE 90.1-2004 is not mandatory, but many chillers meet this standard level (2.8 COP).
- FEMP recommends a full load efficiency of 1.23 kW/ton or less for reciprocating chillers in the 30-150 ton range.
- Reciprocating chillers use pistons and cylinders for compression and are most cost effective at small loads. They account for the bulk of the market under 200 tons of refrigeration capacity.
- Reciprocating chillers can be used in either air-cooled or water cooled applications. Reciprocating chillers shown in the data are air-cooled. Air-cooled chillers are less efficient than the water-cooled models.
- Reciprocating chiller higher efficiencies are achieved through the use of multiple compressors for stepwise capacity control, and improved heat-exchangers.

## Performance/Cost Characteristics Commercial Chillers

## Screw Chillers

	2003	2007		2010		2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (tons)</b>	100-300	100-300	100-300	100-300	100-300	100-300	100-300	100-300	100-300
<b>Efficiency (kW/ton)</b>	1.5	1.3	1.2	1.3	1.2	1.2	0.97	1.2	0.90
<b>COP</b>	2.3	2.7	2.9	2.7	2.9	2.9	3.6	2.9	3.9
<b>Average Life (yrs)</b>	23	23	23	23	23	23	23	23	23
<b>Retail Equip. Cost (\$/ton)</b>	\$300- \$330	\$400- \$430	\$450- \$500	\$400- \$430	\$450- \$500	\$350- \$400	\$400- \$430	\$350- \$400	\$400- \$430
<b>Total Installed Cost (\$/ton)</b>	\$390- \$420	\$490- \$520	\$540- \$590	\$490- \$520	\$540- \$590	\$440- \$490	\$490- \$520	\$440- \$490	\$490- \$520
<b>Annual Maintenance Cost (\$/ton)</b>	\$10- \$50	\$10- \$50	\$10- \$50	\$10- \$50	\$10- \$50	\$10- \$50	\$10- \$50	\$10- \$50	\$10- \$50

## Screw Chillers

- No Federal standards exist for air cooled chillers, ASHRAE 90.1-2004 is not mandatory, but many chillers meet this standard level (2.8 COP).
- Screw chillers use two intermeshing screws to trap and compress pockets of gas and are most cost effective at smaller loads.
- Screw chillers can be used in either air-cooled or water cooled applications. The data shown is for air-cooled, with water cooled applications having higher efficiencies.
- Screw chiller higher efficiencies are achieved through the use of multiple compressors for stepwise capacity control, and improved heat-exchangers.

## Performance/Cost Characteristics Commercial Chillers

## Scroll Chillers

	2003	2007	2010	2020	2030
	Installed Base	Typical	Typical	Typical	Typical
Typical Capacity (tons)	20-60	20-60	20-60	20-60	20-60
Efficiency EER (Full Load)	9.0	10.0	10.2	10.5	10.5
COP	2.6	3.0	3.0	3.1	3.1
Average Life (yrs)	23	23	23	23	23
Retail Equip. Cost (\$/ton)	\$260-\$320	\$260-\$320	\$260-\$320	\$260-\$320	\$260-\$320
Total Installed Cost (\$/ton)	\$400-\$470	\$400-\$470	\$400-\$470	\$400-\$470	\$400-\$470
Annual Maintenance Cost (\$/ton)	\$35-\$50	\$35-\$50	\$35-\$50	\$35-\$50	\$35-\$50

## Scroll Chillers

- No Federal standards exist for air cooled chillers, ASHRAE 90.1-2004 is not mandatory, but many chillers meet this standard level (2.8 COP).
- Scroll chillers use two intermeshing scroll shaped surfaces to trap and compress pockets of gas and are most cost effective at smaller loads.
- Scroll chiller higher efficiencies are achieved through the use of multiple compressors for stepwise capacity control, and improved heat-exchangers.

## Performance/Cost Characteristics Commercial Rooftop Units

## Commercial Rooftop Units (A/C Only)

	2003	2007			2010		2020		2030	
	Installed Base	Typical	Mid	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	90	90	90	90	90	90	90	90	90	90
<b>Efficiency (EER)</b>	9.2	10.1	11.2	12.0	11.2	12.0	11.2	12.0	11.2	12.0
<b>Average Life (yrs)</b>	15	15	15	15	15	15	15	15	15	15
<b>Retail Equip. Cost</b>	\$3,000- \$4,000	\$3,800- \$4,800	\$4,500- \$5,500	\$5,500- \$6,500	\$4,500- \$5,500	\$5,500- \$6,500	\$4,500- \$5,500	\$5,500- \$6,500	\$4,500- \$5,500	\$5,500- \$6,500
<b>Total Installed Cost</b>	\$4,500- \$6,000	\$5,300- \$6,500	\$6,000- \$7,000	\$7,000- \$8,300	\$6,000- \$7,000	\$7,000- \$8,300	\$6,000- \$7,000	\$7,000- \$8,300	\$6,000- \$7,000	\$7,000- \$8,300
<b>Annual Maintenance Cost</b>	\$150- \$200	\$150- \$200	\$150- \$200	\$150- \$200	\$150- \$200	\$150- \$200	\$150- \$200	\$150- \$200	\$150- \$200	\$150- \$200

## Commercial Rooftop Units (A/C Only)

- EPACT 2005 requires an EER of 11.2 for air-cooled equipment with electric resistance heat or no heating.
- EPACT 2005 requires an EER of 11.0 for air-cooled equipment with all other heating-system types that are integrated into the unitary equipment for air cooled units manufactured on and after January 1<sup>st</sup>, 2010.
- The Department adopted the ASHRAE standard 90.1-1999 for water-cooled A/Cs, effective October 29, 2003.
- The efficiency of the 2007 high efficiency units is achieved through the use of multiple compressors for stepwise capacity control and enhanced heat exchanger surfaces.
- Approximately 200,000 air-source A/Cs with a capacity between 65 kBtu/h and 135 kBtu/h were sold in 2006.

## Performance/Cost Characteristics Commercial Heat Pumps (Rooftop)

## Commercial Rooftop Heat Pumps

	2003	2007		2010		2020		2025	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	90	90	90	90	90	90	90	90	90
<b>EER</b>	9.3	10.3	11.7	11.0	12.0	11.0	12.0	11.0	12.0
<b>COP (Heating)</b>	3.1	3.2	3.4	3.3	3.4	3.3	3.4	3.3	3.4
<b>Average Life (yrs)</b>	15	15	15	15	15	15	15	15	15
<b>Retail Equip. Cost</b>	\$3,500- \$4,500	\$4,000- \$5,000	\$5,500- \$6,500	\$5,000- \$6,000	\$5,500- \$6,500	\$5,000- \$6,000	\$5,500- \$6,500	\$5,000- \$6,000	\$5,500- \$6,500
<b>Total Installed Cost</b>	\$5,000- \$6,500	\$6,000- \$7,100	\$7,900- \$9,500	\$6,500- \$7,300	\$7,900- \$9,500	\$6,500- \$7,300	\$7,900- \$9,500	\$6,500- \$7,300	\$7,900- \$9,500
<b>Annual Maintenance Cost</b>	\$100- \$150	\$100- \$150	\$100- \$150	\$100- \$150	\$100- \$150	\$100- \$150	\$100- \$150	\$100- \$150	\$100- \$150



## Commercial Rooftop Heat Pumps

- EPACT 2005 requires an EER of 11.0 and a COP of 3.3 for small, air-cooled heat pumps with electric resistance heat or no heating.
- EPACT 2005 requires an EER of 10.8 and a COP of 3.3 for small, air-cooled heat pumps with all other heating-system types that are integrated into the unitary equipment for air cooled units manufactured on and after January 1<sup>st</sup>, 2010.
- The Department adopted the ASHRAE standard 90.1-1999 for water-cooled A/Cs, effective October 29, 2003.
- Installed costs vary widely depending on size of building and unit for retrofit applications.

## Performance/Cost Characteristics Commercial Ground Source Heat Pumps

## Commercial Ground Source Heat Pumps

	2003	2007		2010		2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	80-100	80-100	80-100	80-100	80-100	80-100	80-100	80-100	80-100
<b>Heating COP</b>	3.4	3.5	4.9	3.5	4.9	4.0	4.9	4.0	4.9
<b>Cooling EER</b>	13.8	14	27.8	14	27.8	14	27.8	14	27.8
<b>Average Life (yrs)</b>	20	20	20	20	20	20	20	20	20
<b>Retail Equip. Cost</b>	\$7,000-\$8,000	\$7,000-\$8,000	\$10,000-\$12,000	\$7,000-\$8,000	\$10,000-\$12,000	\$7,000-\$8,000	\$10,000-\$12,000	\$7,000-\$8,000	\$10,000-\$12,000
<b>Total Installed Cost</b>	\$14,000-\$15,000	\$14,000-\$15,000	\$17,000-\$20,000	\$14,000-\$15,000	\$17,000-\$20,000	\$14,000-\$15,000	\$17,000-\$19,000	\$14,000-\$15,000	\$17,000-\$19,000
<b>Annual Maintenance Cost (¢/ft<sup>2</sup>/year)</b>	\$12-15	\$12-15	\$12-15	\$12-15	\$12-15	\$12-15	\$12-15	\$12-15	\$12-15

## Commercial Ground Source Heat Pumps

- The most common ground-source heat pump is a closed-loop system in which water or an anti-freeze solution is circulated through plastic pipes buried underground. Open-loop systems that employ groundwater, or surface water such as a pond or lake, are used in some parts of the country, but water supply and water quality issues impose limitations on such applications.
- Useful life is based on the expected life of the compressor. Replacement cost would be less than installed cost, since the ground loop is already in place and would have a useful life much longer than the compressor. A closed-loop system can last up to 50 years.

## Performance/Cost Characteristics Commercial Natural Gas-Fired Rooftop A/C

## Commercial Natural Gas-Fired Engine-Driven Rooftop A/C

	2003	2007		2010		2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High	Typical	High
Typical Capacity (tons)	25	25	25	25	25	25	25	25	25
COP	0.70	0.70	1.0	0.70	1.0	0.70	1.1	0.70	1.1
Average Life (yrs)	30	30	30	30	30	30	30	30	30
Retail Equip. Cost (\$/ton)	\$775-\$835	\$775-\$835	\$1,000-\$1,700	\$775-\$835	\$1,000-\$1,700	\$775-\$835	\$1,000-\$1,700	\$775-\$835	\$1,000-\$1,700
Total Installed Cost (\$/ton)	\$1,200-\$1,300	\$1,200-\$1,300	\$1,800-\$2,400	\$1,200-\$1,300	\$1,800-\$2,400	\$1,200-\$1,300	\$1,800-\$2,400	\$1,200-\$1,300	\$1,800-\$2,400
Annual Maintenance Cost (\$/ton)	\$55	\$55	\$55	\$55	\$55	\$55	\$55	\$55	\$55

## Commercial Natural Gas-Fired Engine-Driven Rooftop A/C

- There are currently no federal requirements on gas-fired engine-driven rooftop A/C.
- Annual sales of the Engine-Driven Rooftop A/C are estimated at less than 5,000 units per year.
- Tecogen is one of the leading manufacturers in natural gas fired engine driven rooftop units.

## Performance/Cost Characteristics Commercial Gas Furnaces

## Commercial Gas-Fired Furnaces

	2003	2007	2007	2007	2010		2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)<sup>1</sup></b>	400	400	400	400	400	400	400	400	400	400
<b>Thermal Efficiency (%)</b>	76	80	80	82	80	82	81	90	82	91
<b>Average Life (yrs)</b>	18	20	20	20	20	20	20	20	20	20
<b>Retail Equip. Cost</b>	\$1,900	\$2,000-\$2,400	\$2,000-\$2,400	\$2,200-\$2,650	\$2,000-\$2,400	\$2,200-\$2,650	\$2,000-\$2,400	\$3,150-\$3,800	\$2,000-\$2,400	\$3,150-\$3,800
<b>Total Installed Cost</b>	\$2,900	\$3,000-\$3,500	\$3,000-\$3,500	\$3,150-\$3,900	\$3,000-\$3,500	\$3,150-\$3,900	\$3,000-\$3,500	\$4,050-\$4,950	\$3,000-\$3,500	\$4,050-\$4,950
<b>Annual Maintenance Cost</b>	\$300	\$300	\$300	\$300	\$300	\$300	\$300	\$300	\$300	\$300

## Commercial Gas-Fired Furnaces

- EPACT standard for a gas-fired furnace is 80% thermal efficiency at maximum rated capacity.
- Approximately 10% of the 3,519,000 gas-fired furnaces shipped in 2004 were for commercial applications.
- The maintenance cost is based on two cleanings per year.

## Performance/Cost Characteristics Commercial Oil-Fired Furnaces

## Commercial Oil-Fired Furnaces

	2003	2007	2010	2020	2030
	Installed Base	Typical	Typical	Typical	Typical
Typical Capacity (kBtu/hr)	400	400	400	400	400
Thermal Efficiency (%)	81	81	81	81	81
Average Life (yrs)	20	20	20	20	20
Retail Equip. Cost	\$2,000-\$2,500	\$2,000-\$2,500	\$2,000-\$2,500	\$2,000-\$2,500	\$2,000-\$2,500
Total Installed Cost	\$3,000-\$3,500	\$3,000-\$3,500	\$3,000-\$3,500	\$3,000-\$3,500	\$3,000-\$3,500
Annual Maintenance Cost	\$300	\$300	\$300	\$300	\$300

Note: 2007 typical case is equivalent to the 2007 current standard.



## Commercial Oil-Fired Furnaces

- Commercial warm air oil-fired furnaces with a capacity of 225,000 Btu/hr or more must meet a thermal efficiency standard of 81%. The new federal standards adopt the ASHRAE Standard 90.1-1999, which requires a thermal efficiency of 81%. The ASHRAE standard also mandates a jacket loss of 0.75%.
- The maintenance cost is based on two cleanings per year.

## Performance/Cost Characteristics Commercial Electric Boilers

## Commercial Electric Boilers

	2003	2007	2010	2020	2030
	Installed Base	Typical	Typical	Typical	Typical
Typical Capacity (kW)	165	165	165	165	165
Efficiency (%)	98	98	98	98	98
Average Life (yrs)	21	21	21	21	21
Retail Equip. Cost	\$3,700-\$6,000	\$3,700-\$6,000	\$3,700-\$6,000	\$3,700-\$6,000	\$3,700-\$6,000
Total Installed Cost	\$7,500-\$11,000	\$7,500-\$11,000	\$7,500-\$11,000	\$7,500-\$11,000	\$7,500-\$11,000
Annual Maintenance Cost	\$60-\$120	\$60-\$120	\$60-\$120	\$60-\$120	\$60-\$120

## Commercial Electric Boilers

- There are currently no Federal standards associated with electric boilers.
- The costs shown are for one 165kW unit. This sized unit would be necessary to meet approximately a 500,000 Btu/hr load.
- Lifetime is determined mainly by water quality, which may well require filters, softeners, de-alkizers and chemical feeders. Annual maintenance in a typical application would include draining the unit for removal of any accumulated scale or sludge build-up.
- With a small market (in the hundreds of units/year), electric boiler costs remain high compared to common fossil fuel boilers.

## Performance/Cost Characteristics Commercial Gas-Fired Boilers

## Commercial Gas-Fired Boilers

	2003	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	Mid	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)<sup>1</sup></b>	440	440	440	440	440	440	440	440	440	440	440
<b>Combustion Efficiency (%)</b>	76	80	80	85	96	80	96	82	96	82	96
<b>Average Life (yrs)</b>	25	25	25	25	25	25	25	25	25	25	25
<b>Retail Equip. Cost</b>	\$4,500	\$4,500-\$5,000	\$4,500-\$5,000	\$6,000-\$6,500	\$11,500-\$12,500	\$4,500-\$5,000	\$11,500-\$12,500	\$4,500-\$5,000	\$11,500-\$12,500	\$4,500-\$5,000	\$11,500-\$12,500
<b>Total Installed Cost</b>	\$6,675-\$7,725	\$7,400-\$7,600	\$7,400-\$7,600	\$9,000-\$10,000	\$16,000-\$17,000	\$7,400-\$7,600	\$16,000-\$17,000	\$7,400-\$7,600	\$16,000-\$17,000	\$7,400-\$7,600	\$16,000-\$17,000
<b>Annual Maintenance Cost</b>	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190	\$165-\$190

## Commercial Gas-Fired Boilers

- The current requirement for gas-fired boilers is a minimum combustion efficiency of 80% at the maximum rated capacity.
- The higher efficiency units typically include electronic ignition, power burners, and improved heat exchangers.

## Performance/Cost Characteristics Commercial Oil-Fired Boilers

## Commercial Oil-Fired Boilers

	2003	2007	2007	2007	2010		2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
<b>Combustion Efficiency (%)</b>	79	83	83	89	83	89	83	89	83	89
<b>Average Life (yrs)</b>	20	20	20	20	20	20	20	20	20	20
<b>Retail Equip. Cost</b>	\$11,000-\$12,000	\$11,500-\$12,500	\$11,500-\$12,500	\$14,000-\$16,000	\$11,500-\$12,500	\$14,000-\$16,000	\$11,500-\$12,500	\$14,000-\$16,000	\$11,500-\$12,500	\$14,000-\$16,000
<b>Total Installed Cost</b>	\$15,000-\$16,000	\$15,500-\$16,500	\$15,500-\$16,500	\$19,000-\$20,000	\$15,500-\$16,500	\$19,000-\$20,000	\$15,500-\$16,500	\$19,000-\$20,000	\$15,500-\$16,500	\$19,000-\$20,000
<b>Annual Maintenance Cost</b>	\$102-\$144	\$102-\$144	\$102-\$144	\$102-\$144	\$102-\$144	\$102-\$144	\$102-\$144	\$102-\$144	\$102-\$144	\$102-\$144

## Commercial Oil-Fired Boilers

- The Energy Policy Act of 1992 sets standards for commercial HVAC equipment and commercial water heaters. Since January 1994, oil-fired boilers with a capacity over 300,000 Btu/hr have been required to meet a minimum combustion efficiency of 83%.
- The higher efficiency units typically include all oil boilers that have improved heat exchangers.

## Performance/Cost Characteristics Commercial Gas Water Heaters

## Commercial Gas Water Heaters

	2003	2007	2007		2010		2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	100	100	100	100	100	100	100	100	100	100
Typical Input Capacity (kBtu/hr)	200	200	200	200	200	200	200	200	200	200
Thermal Efficiency (%)	77	80	80	94	80	94	80	94	80	94
Average Life (yrs)	12	12	12	12	12	12	12	12	12	12
Retail Equip. Cost	\$1,500	\$2,000-\$4,000	\$2,000-\$4,000	\$4,500-\$5,000	\$2,000-\$4,000	\$4,500-\$5,000	\$2,000-\$4,000	\$4,500-\$5,000	\$2,000-\$4,000	\$4,500-\$5,000
Total Installed Cost	\$2,000	\$2,500-\$4,500	\$2,500-\$4,500	\$5,000-\$5,500	\$2,500-\$4,500	\$5,000-\$5,500	\$2,500-\$4,500	\$5,000-\$5,500	\$2,500-\$4,500	\$5,000-\$5,500
Annual Maintenance Cost	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200



## Performance/Cost Characteristics Commercial Electric Resistance Water Heaters

## Commercial Electric Resistance Water Heaters

	2003	2007	2007	2010	2020	2030
	Installed Base	Current Standard	Typical	Typical	Typical	Typical
Typical Capacity (gal)	120	120	120	120	120	120
Typical Capacity (kW)	45	45	45	45	45	45
Thermal Efficiency (%)	97	98	98	98	98	98
Average Life (yrs)	14	14	14	14	14	14
Retail Equip. Cost	\$2,000	\$2,400-\$3,000	\$2,400-\$3,000	\$2,400-\$3,000	\$2,400-\$3,000	\$2,400-\$3,000
Total Installed Cost	\$2,500	\$3,000-\$3,500	\$3,000-\$3,500	\$3,000-\$3,500	\$3,000-\$3,500	\$3,000-\$3,500
Annual Maintenance Cost	\$50	\$50	\$50	\$50	\$50	\$50

## Commercial Gas and Electric Resistance Water Heaters

- The new federal standards adopted the ASHRAE 90.1-1999 standard, which requires a minimum thermal efficiency of 80% for gas water heaters. The EPACT standard will remain in effect for electric water heaters.
- The best available gas water heater technologies are condensing units which are currently available in 100 gallon or 130 gallon size tanks.
- Maintenance for water heaters consists of sediment and scale removal once or twice per year. Estimated cost for a gas water heater would be \$100 per year for one cleaning performed by a plumber.

## Performance/Cost Characteristics Commercial Oil Water Heaters

## Commercial Oil Water Heaters

	2003	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	Mid	High	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	70	70	70	70	70	70	70	70	70	70	70
Typical Input Capacity (kBtu/hr)	300	300	300	300	300	300	300	300	300	300	300
Thermal Efficiency (%)	78	78	80	82	84	80	84	80	84	80	84
Average Life (yrs)	12	12	12	15	20	12	20	12	20	12	20
Retail Equip. Cost	\$4,100	\$4,100	\$4,200	\$4,300	\$4,400	\$4,200	\$4,400	\$4,200	\$4,400	\$4,200	\$4,400
Total Installed Cost	\$4,600	\$4,600	\$4,700	\$4,800	\$4,900	\$4,700	\$4,900	\$4,700	\$4,900	\$4,700	\$4,900
Annual Maintenance Cost	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200	\$100-\$200

## Commercial Oil Water Heaters

- Maintenance for commercial oil water heaters consists of sediment and scale removal once or twice per year.

## Performance/Cost Characteristics Commercial Booster Water Heaters

## Commercial Gas Booster Water Heaters

	2003	2007	2007		2010		2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (gal)</b>	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10
<b>Thermal Efficiency (%)</b>	79	80	80	90	82	95	82	95	82	95
<b>Average Life (yrs)</b>	3-8	3-8	3-8	3-8	3-8	3-8	3-8	3-8	3-8	3-8
<b>Retail Equip. Cost</b>	\$3,800- \$5,500	\$3,800- \$5,500	\$3,800- \$5,500	\$7,000- \$9,000	\$3,800- \$5,500	\$7,000- \$9,000	\$3,800- \$5,500	\$7,000- \$9,000	\$3,800- \$5,500	\$7,000- \$9,000
<b>Total Installed Cost</b>	\$4,100- \$5,800	\$4,100- \$5,800	\$4,100- \$5,800	\$7,300- \$9,300	\$4,100- \$5,800	\$7,300- \$9,300	\$4,100- \$5,800	\$7,300- \$9,300	\$4,100- \$5,800	\$7,300- \$9,300
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

## Performance/Cost Characteristics Commercial Booster Water Heaters

## Commercial Electric Booster Water Heaters

	2003	2007	2010	2020	2030
	Installed Base	Typical	Typical	Typical	Typical
Typical Capacity (gal)	6-10	6-10	6-10	6-10	6-10
Thermal Efficiency (%)	98	98	98	98	98
Average Life (yrs)	3-8	3-8	3-8	3-8	3-8
Retail Equip. Cost	\$1,150-\$1,550	\$1,150-\$1,550	\$1,150-\$1,550	\$1,150-\$1,550	\$1,150-\$1,550
Total Installed Cost	\$1,350-\$1,750	\$1,350-\$1,750	\$1,350-\$1,750	\$1,350-\$1,750	\$1,350-\$1,750
Annual Maintenance Cost	Negligible	Negligible	Negligible	Negligible	Negligible

## Commercial Booster Water Heaters

- Booster water heaters are used for high water temperature applications, which typically include commercial dishwashers, laundromats, hospitals, and car washes where water temperatures must reach greater than 180 degrees Fahrenheit.
- Booster water heaters typically have short lifetimes because of high usage and extreme temperatures.
- Typical sales are small due to the limited number of applications.

## Performance/Cost Characteristics Commercial Instantaneous Water Heaters

## Commercial Gas-Fired Instantaneous Water Heaters

	2003	2007	2007		2010		2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	Typical	High
<b>Typical Capacity (kBtu/hr)</b>	180-230	180-230	180-230	180-230	180-230	180-230	180-230	180-230	180-230	180-230
<b>Thermal Efficiency (%)</b>	76	80	84	85	84	85	84	90	84	90
<b>Average Life (yrs)</b>	20	20	20	20	20	20	20	20	20	20
<b>Retail Equip. Cost</b>	\$460-\$700	\$800-\$1,000	\$1,250-\$1,300	\$1,350-\$1,450	\$1,250-\$1,300	\$1,350-\$1,450	\$1,250-\$1,300	\$1,350-\$1,450	\$1,250-\$1,300	\$1,350-\$1,450
<b>Total Installed Cost</b>	\$620-\$850	\$950-\$1,250	\$1,500-\$1,800	\$1,600-\$2,000	\$1,500-\$1,800	\$1,600-\$2,000	\$1,500-\$1,800	\$1,600-\$2,000	\$900-\$1,250	\$1,600-\$2,000
<b>Annual Maintenance Cost</b>	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible



## Commercial Instantaneous Water Heaters

- EPCA standards for gas-fired instantaneous water heaters, require a thermal efficiency of 80%. The new federal efficiency standards, which became effective in 2003, adopted the ASHRAE Standard 90.1-1999.
- GAMA currently lists commercial gas instantaneous water heaters may have greater than 200,000 Btu's per hour input and may deliver 180°F water.
- Smaller point-of-use electric instantaneous water heaters for hand washing applications are in the \$150-\$250 price range. These typically have a storage capacity of 2-7 gallons.

## Performance/Cost Characteristics Office Equipment

## Office Equipment

	PC's / Monitors			Laser Printers		Facsimile		Copiers	
Capacity (hrs/day)	Non E-Star		E-Star	Non E-Star	E-Star	Non E-Star	E-Star	Non E-Star	E-Star
		PC: 9.5	Mon: 9.5	4.0	6.2	5.2	23.5	0.5	12.6
Energy Efficiency Criteria	<u>Standby (Off Mode):</u> ≤2.0W <u>Sleep Mode:</u> ≤4.0W <u>Idle State:</u> ≤50.0 – 95.0W			After 5 to 60 minutes, enter sleep mode where energy consumption is less than 1 - 2W, depending on product characteristics.		After 5 minutes, enter sleep mode where energy consumption is less than 2 W.		After 30 to 60 minutes, enter sleep mode.	
Added Price (ENERGY STAR® vs. Standard)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Average Life (yrs)	4	4	4	5	5	5	5	6	6
Energy Use (kWh/year)	524	406	406	696	392	321	205	1,317	1,174

## Office Equipment

- Commercial computers currently uses approximately 3% of all commercial sector energy use.
- In 2007, ENERGY STAR has/will adopt new specifications for office and imaging equipment.
  - Computers in effect on July 20, 2007.
  - Imaging equipment became effective on April 1, 2007 (copiers, printers, and fax machines) .
- The new specifications also set additional requirements. For example, if an imaging product is sold with an external power adapter, cordless handset, or digital front-end, the accessories must meet current ENERGY STAR External Power Supply (EPS), Telephony, or Computer specifications.

# Appendix A Data Sources

September 2007

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1801 K Street, NW, Suite 500  
Washington, D.C. 20006  
(202) 973-2400

[www.navigantconsulting.com](http://www.navigantconsulting.com)

Data Sources Residential Gas-Fired Water Heaters

### Residential Gas-Fired Water Heaters

	2005	2007	2007			2010		2020		2030	
	Installed Base	Current Standard	Typical	Mid-Level	High	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	GAMA/ Distributors					NCI					
Energy Factor	GAMA	Federal Standard	GAMA/ Distributors								
Average Life (yrs)	EERE: DOE Appliance Standards Framework										
Retail Equip. Cost	Distributors										
Total Installed Cost	Distributors/ RS Means 2007										
Annual Maintenance Cost	NCI										

Data Sources Residential Electric Resistance Water Heaters

## Residential Electric Resistance Water Heaters

	2005	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	GAMA/ Distributors				NCI			
Energy Factor	GAMA	Federal Standard	GAMA/ Distributors					
Average Life (yrs)	EERE: DOE Appliance Standards Framework							
Retail Equip. Cost	Distributors							
Total Installed Cost	Distributors/ RS Means 2007							
Annual Maintenance Cost	NCI							

Data Sources Residential Electric Resistance Water Heaters

### Residential Oil-Fired Water Heaters

	2005	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	GAMA/ Distributors				NCI			
Energy Factor	GAMA	Federal Standard	GAMA/ Distributors					
Average Life (yrs)	EERE: DOE Appliance Standards Framework							
Retail Equip. Cost	Distributors							
Total Installed Cost	Distributors/ RS Means 2007							
Annual Maintenance Cost	NCI							

Data Sources Residential Heat Pump Water Heaters

### Residential Heat Pump Water Heaters

	2005	2007		2010-2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	GAMA/Product Literature						
Energy Factor	GAMA/Product Literature			NCI			
Average Life (yrs)	ACEEE						
Retail Equip. Cost w/o Tank	RS Means 2007/ ACEEE						
Total Installed Cost w/o Tank							
Annual Maintenance Cost	Product Literature						



Data Sources Residential Solar Water Heaters

### Residential Solar Water Heaters

	2005	2007	2010	2020	2030
	Installed Base	Typical	Typical	Typical	Typical
Typical Capacity (ft <sup>2</sup> )	Distributors		NCI		
Overall Efficiencies					
Solar Energy Factor					
Average Life (yrs)	ENERGY STAR ®				
Retail Equip. Cost	Distributors				
Total Installed Cost	RS Means 2007				
Annual Maintenance Cost					

Data Sources Residential Electric Resistance Water Heaters

### Residential Instantaneous Water Heaters

	2005	2007		2010-2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	Distributors			NCI			
Energy Factor	Distributors						
Average Life (yrs)	ENERGY STAR®						
Retail Equip. Cost	Distributors/ RS Means 2007						
Total Installed Cost	DEER						
Annual Maintenance Cost	NCI						

Data Sources Residential Gas-Fired Furnaces

### Residential Gas-Fired Furnaces

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR ®	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	GAMA					NCI			
AFUE (%)	GAMA	Federal Standard	GAMA	ENERGY STAR ®	GAMA				
Annual Electric Use (kWh/yr)	GAMA								
Average Life (yrs)	Appliance Magazine 2005								
Retail Equip. Cost	EERE: Technical Analysis for Residential Furnaces and Boilers/ Distributors								
Total Installed Cost									
Annual Maintenance Cost									

Data Sources Residential Oil-Fired Furnaces

### Residential Oil-Fired Furnaces

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR ®	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	GAMA					NCI			
AFUE (%)	GAMA	Federal Standard	GAMA	ENERGY STAR ®	GAMA				
Annual Electric Use (kWh/yr)	GAMA								
Average Life (yrs)	Appliance Magazine 2005								
Retail Equip. Cost	EERE: Technical Analysis for Residential Furnaces and Boilers/ Distributors								
Total Installed Cost									
Annual Maintenance Cost									

Data Sources Residential Hydronic Heating System

### Residential Hydronic Heating System

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	Grainger					NCI			
AFUE (%)	GAMA	Federal Standard	GAMA	ENERGY STAR®	GAMA				
Average Life (yrs)	Appliance Magazine 2005								
Retail Equip. Cost	EERE: Technical Analysis for Residential Furnaces and Boilers/ Distributors								
Total Installed Cost									
Annual Maintenance Cost									

Data Sources Residential Room A/C

### Residential Room A/C

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	Retail Appliance Stores	Federal Standard	U.S. Census	ENERGY STAR®	Retail Appliance Stores	NCI			
EER									
Average Life (yrs)	Appliance Magazine 2005								
Retail Equip. Cost	Retail Appliance Stores								
Total Installed Cost	Retail Appliance Stores								
Annual Maintenance Cost	NCI								

Data Sources Residential Central A/C

### Residential Central A/C

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	Distributors	Federal Standard	Distributors	ENERGY STAR®	Distributors	NCI			
SEER									
Average Life (yrs)	Appliance Magazine 2005								
Retail Equip. Cost	Distributors								
Total Installed Cost	Distributors								
Annual Maintenance Cost	NCI								

Data Sources Residential Air Source Heat Pumps

### Residential Air Source Heat Pumps

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	Distributors/ Product Literature					NCI			
HSPF (Heating)	ARI	Federal Standard	Distributors	ENERGY STAR®	Distributors				
SEER (Cooling)									
Average Life (yrs)	EERE: Website Fact Sheets								
Retail Equip. Cost	Distributors/ RS Means 2007/ NCI								
Total Installed Cost									
Annual Maintenance Cost	NCI								



Data Sources Residential Ground Source Heat Pumps

## Residential Ground Source Heat Pumps

	2005	2007			2010-2020		2030	
	Installed Base	Typical	ENERGY STAR®	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	Distributors		ENERGY STAR®	Distributors	NCI			
Heating (COP)								
Cooling (EER)								
Average Life (yrs)	EERE: Website Fact Sheets							
Retail Equip. Cost	Distributors/NCI							
Total Installed Cost								
Annual Maintenance Cost (¢/ft <sup>2</sup> /year)	NCI							

Data Sources Residential Gas Heat Pumps

### Residential Gas Heat Pumps

	2005	2007		2010-2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	NCI/ Product Literature			NCI			
Heating (COP)							
Cooling (EER)							
Average Life (yrs)							
Retail Equip. Cost							
Total Installed Cost							
Annual Maintenance Cost (¢/ft <sup>2</sup> /year)	NCI						

Data Sources Residential Refrigerator/Freezer

### Residential Refrigerator/Freezer

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High
<b>Energy Consumption (kWh/yr)</b>	Retail Appliance Stores	Federal Standard	Retail Appliance Stores	ENERGY STAR®	Retail Appliance Stores	NCI			
<b>Average Life (yrs)</b>	Appliance Magazine 2005								
<b>Retail Equip. Cost</b>	Retail Appliance Stores/ EERE: Draft Technical Analysis for Refrigerators								
<b>Total Installed Cost</b>	Retail Appliance Stores/RS Means 2007								
<b>Annual Maintenance Cost</b>	NCI								

Data Sources Residential Cooktops and Ovens (Gas)

### Residential Cooktops (Gas)

	2005	2007		2010-2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High
Typical Capacity (Btr/hr)	Retail Appliance Stores/Product Literature			NCI			
Energy Factor	Retail Appliance Stores/Product Literature						
Average Life (yrs)	Appliance Magazine 2005						
Retail Equip. Cost	EERE: Technical Analysis for Rulemaking Framework for Dishwashers/ Cooktops/ Ovens/ Retail Appliance Stores						
Total Installed Cost	EERE: Technical Analysis for Rulemaking Framework for Dishwashers/ Cooktops/ Ovens/ Retail Appliance Stores						
Annual Maintenance Cost	NCI/RS Means 2007						

Data Sources Residential Cooktops and Ovens (Gas)

### Residential Ovens (Gas)

	2005	2007		2010-2020		2030	
	Installed Base	Typical	High	Typical	High	Typical	High
Typical Capacity (in)	Retail Appliance Stores/Product Literature			NCI			
Energy Factor	Retail Appliance Stores/Product Literature						
Average Life (yrs)	Appliance Magazine 2005						
Retail Equip. Cost	EERE: Technical Analysis for Rulemaking Framework for Dishwashers/ Cooktops/ Ovens/ Retail Appliance Stores						
Total Installed Cost	EERE: Technical Analysis for Rulemaking Framework for Dishwashers/ Cooktops/ Ovens/ Retail Appliance Stores						
Annual Maintenance Cost	NCI/RS Means 2007						

Data Sources Residential Clothes Washers

### Residential Clothes Washers

	2005	2007	2007		2010-2020		2030		
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High
Typical Capacity (ft <sup>3</sup> )	Retail Appliance Stores	Federal Standard	Retail Appliance Stores	ENERGY STAR®	Retail Appliance Stores	NCI			
Modified Energy Factor (ft <sup>3</sup> /kWh per cycle)									
Average Life (yrs)	Appliance Magazine 2005/ EERE: 2006 Buildings Energy Databook								
Water Consumption (gallons per cycle)	EERE: Clothes Washers Technical Support Document/ Retail Appliance Stores								
Hot Water Energy (kWh per cycle)									
Machine Energy (kWh per cycle)									
Dryer Energy (kWh per cycle)									
Retail Equip. Cost	Retail Appliance Stores/ Product Literature								
Total Installed Cost	RS Means 2007								

Data Sources Residential Dishwashers

### Residential Dishwashers

	2005	2007	2007			2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR ®	High	Typical	High	Typical	High
Typical Annual Use (kWh/yr)	Product Literature	Federal Standard	Retail Appliance Stores	ENERGY STAR ®	Retail Appliance Stores	NCI			
Cooking Efficiency (%)									
Annual Hot Water Energy Use (kwh/yr)	NCI								
Average Life (yrs)	Appliance Magazine 2005								
Retail Equip. Cost	EERE: Technical Analysis for Rulemaking Framework for Dishwashers/ Cooktops/ Ovens/ Retail Appliance Stores								
Total Installed Cost									
Annual Maintenance Cost	NCI								

Data Sources Commercial Chillers

### Commercial Centrifugal Chillers

	2003	2007	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	ENERGY STAR®	High	Typical	High	Typical	High
Typical Capacity (tons)	US Census		NCI			NCI			
Efficiency (kW/ton)	DEER/ Product Literature								
Efficiency (COP)									
Average Life (yrs)	ASHRAE: 2003 ASHRAE Handbook – HVAC Applications								
Retail Equip. Cost (\$/ton)	DEER/ Distributors								
Total Installed Cost (\$/ton)									
Annual Maintenance Cost (\$/ton)	NCI								



### Commercial Gas-Fired Chillers (Water Cooled)

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Absorption	Engine-Driven	Typical	High	Typical	High
Typical Capacity (tons)	BSRIA				NCI			
Efficiency (kW/ton)	NCI/ Distributors							
COP	NCI/ Distributors							
Average Life (yrs)	ASHRAE: 2003 ASHRAE Handbook – HVAC Applications							
Retail Equip. Cost (\$/ton)	Distributors/ RS Means 2007/NCI/ DEER							
Total Installed Cost (\$/ton)	Distributors/ RS Means 2007/NCI/ DEER							
Annual Maintenance Cost (\$/ton)	Distributors/ RS Means 2007/NCI/ DEER							

Data Sources Commercial Chillers

### Commercial Reciprocating Chillers

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (tons)	BSRIA/DEER				NCI			
Efficiency (kW/ton)	ASHRAE: Standard	DEER/ Product Literature						
COP								
Average Life (yrs)	ASHRAE: 2003 ASHRAE Handbook – HVAC Applications/DEER							
Retail Equip. Cost (\$/ton)	Distributors/ RS Means 2007/NCI/DEER							
Total Installed Cost (\$/ton)								
Annual Maintenance Cost (\$/ton)								

Data Sources Commercial Chillers

### Commercial Screw Chillers

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (tons)	NCI				NCI			
Efficiency (kW/ton)	NCI	DEER/ Product Literature						
COP								
Average Life (yrs)	EERE: FEMP							
Retail Equip. Cost (\$/ton)	Distributors/ DEER/ RS Means 2007/NCI							
Total Installed Cost (\$/ton)								
Annual Maintenance Cost (\$/ton)								

Data Sources Commercial Chillers

### Commercial Scroll Chillers

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (tons)	NCI				NCI			
Efficiency (kW/ton)	NCI	DEER/ Product Literature						
COP								
Average Life (yrs)	EERE: FEMP							
Retail Equip. Cost (\$/ton)	Distributors/DEER/RS Means 2007/NCI							
Total Installed Cost (\$/ton)								
Annual Maintenance Cost (\$/ton)								

Data Sources Commercial Rooftop Units

**Commercial Rooftop Units (A/C Only)**

	2003	2007	2007		2010-2020		2030		
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	
Typical Capacity (kBtu/hr)	ARI				NCI				
EER	ASHRAE: Standard	Distributors/NCI		DEER					
Average Life (yrs)	ASHRAE: 2003 ASHRAE Handbook – HVAC Applications								
Retail Equip. Cost	NCI/ LBNL: Commercial Unitary Air Conditioning and Heat Pumps		Distributors/NCI/DEER						
Total Installed Cost									
Annual Maintenance Cost									

Data Sources Commercial Heat Pumps (Rooftop)

### Commercial Rooftop Heat Pumps

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/hr)	ARI				NCI			
EER	ASHRAE: Standard	Distributors	DEER/NCI					
COP	NCI/ EERE: Website Fact Sheets							
Average Life (yrs)	ASHRAE: 2003 ASHRAE Handbook							
Retail Equip. Cost	Distributors/ RS Means 2007/ NCI/ DEER							
Total Installed Cost								
Annual Maintenance Cost								

Data Sources Residential Ground Source Heat Pumps

### Commercial Ground Source Heat Pumps

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	GHPC				NCI			
Heating (COP)	IGSPHA/ GHPC							
Cooling (EER)								
Average Life (yrs)	GHPC							
Retail Equip. Cost	NCI	Distributors/ NCI						
Total Installed Cost								
Annual Maintenance Cost ( $\text{\$/ft}^2/\text{year}$ )	GHPC							

Data Sources Commercial Natural Gas-Fired Rooftop A/C

### Commercial Natural Gas-Fired Engine-Driven Rooftop A/C

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (tons)	BSRIA/ Distributors				NCI			
Efficiency	NCI/ Distributors							
Average Life (yrs)	BSRIA							
Retail Equip. Cost (\$/ton)	NCI/ Distributors							
Total Installed Cost (\$/ton)								
Annual Maintenance Cost (\$/ton)								



Data Sources Commercial Gas Furnaces

### Commercial Gas-Fired Furnaces

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (Btu/hr)	MMTSS		GAMA		NCI			
AFUE	ASHRAE: Standard							
Average Life (yrs)	ASHRAE: 2003 ASHRAE Handbook							
Retail Equip. Cost	RS Means 2007/ NCI/ Distributors							
Total Installed Cost								
Annual Maintenance Cost								

### Commercial Oil-Fired Furnaces

	2003	2007	2010	2020	2030
	Installed Base	Current Standard	Typical	Typical	Typical
Typical Capacity (Btu/hr)	NCI/ Distributors/ GAMA		NCI		
Thermal Efficiency (%)	ASHRAE: Standard	GAMA			
Average Life (yrs)	ASHRAE: 2003 ASHRAE Handbook				
Retail Equip. Cost	RS Means 2007/ Distributors				
Total Installed Cost					
Annual Maintenance Cost	NCI/ Distributors				

### Commercial Electric Boilers

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (kW)	BSRIA				NCI			
Efficiency	NCI/ Distributors							
Average Life (yrs)	BSRIA							
Retail Equip. Cost	RS Means 2007/ NCI							
Total Installed Cost								
Annual Maintenance Cost	NCI/ RS Means 2007							

Data Sources Commercial Gas-Fired Boilers

### Commercial Gas-Fired Boilers

	2003		2007		2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High		
<b>Typical Capacity (kBtu/hr)</b>	MMTSS/BSRIA/ NCI				NCI					
<b>Combustion Efficiency (%)</b>	ASHRAE: Standard									
<b>Average Life (yrs)</b>	BSRIA/Appliance Magazine 2005									
<b>Retail Equip. Cost</b>	CEC/ RS Means 2007	DEER/ NCI/ Distributors								
<b>Total Installed Cost</b>										
<b>Annual Maintenance Cost</b>	NCI									

Data Sources Commercial Oil-Fired Boilers

### Commercial Oil-Fired Boilers

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/hr)	NCI/ BSRIA				NCI			
Combustion Efficiency (%)	ASHRAE: Standard							
Average Life (yrs)	BSRIA/NCI							
Retail Equip. Cost	Distributors/ RS Means 2007/ NCI							
Total Installed Cost								
Annual Maintenance Cost	NCI							

Data Sources Commercial Gas Water Heaters

### Commercial Gas Water Heaters

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	Distributors/ MMTSS/ GAMA				NCI			
Typical Input Capacity (Btu/hr)	MMTS/GAMA							
Thermal Efficiency (%)	EERE: Website Fact Sheets/ GAMA/ CEC ASHRAE: Standard	GAMA						
Average Life (yrs)	BSRIA/ Appliance Magazine 2005							
Retail Equip. Cost	Grainger/Distributors/CEC/NCI							
Total Installed Cost								
Annual Maintenance Cost	NCI							

Data Sources Commercial Electric Resistance Water Heaters

### Commercial Electric Resistance Water Heaters

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	NCI/ Product Literature				NCI			
Typical Capacity (kW)	Product Literature							
Thermal Efficiency (%)	Product Literature/ <b>ASHRAE</b> : Standard							
Average Life (yrs)	Appliance Magazine 2005/ BSIRA							
Retail Equip. Cost	Distributors/ NCI/ Grainger							
Total Installed Cost								
Annual Maintenance Cost	NCI							

Data Sources Commercial Electric Resistance Water Heaters

### Commercial Oil-fired Water Heaters

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	NCI/ GAMA				NCI			
Thermal Efficiency (%)	NCI/ Appliance Magazine 2005							
Average Life (yrs)	Appliance Magazine 2005/ BSRIA							
Retail Equip. Cost	Distributors/ NCI							
Total Installed Cost								
Annual Maintenance Cost	NCI							



Data Sources Commercial Gas Booster Water Heaters

### Commercial Gas Booster Water Heaters

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	NCI/ Distributors				NCI			
Thermal Efficiency	Product Literature							
Average Life (yrs)	Product Literature/ Distributors							
Retail Equip. Cost	Distributors/ NCI							
Total Installed Cost								
Annual Maintenance Cost								

Data Sources Commercial Electric Booster Water Heaters

### Commercial Electric Booster Water Heaters

	2003	2007	2007		2010-2020		2030	
	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (gal)	NCI/ Distributors				NCI			
Thermal Efficiency	Product Literature/ Distributors							
Average Life (yrs)								
Retail Equip. Cost								
Total Installed Cost	Distributors/ NCI							
Annual Maintenance Cost								

Data Sources Commercial Instantaneous Water Heaters

### Commercial Gas-fired Instantaneous Water Heaters

	2003		2007	2007		2010-2020		2030	
	Installed Base		Current Standard	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/hr)	BSRIA/ Market Disposition/ GAMA					NCI			
Thermal Efficiency	GAMA	ASHRAE: Standard	GAMA						
Average Life (yrs)	EERE: Website Fact Sheets	EERE: Website Fact Sheets/ EERE: Water Heating Rule							
Retail Equip. Cost	Distributors/ Grainger/ NCI								
Total Installed Cost									
Annual Maintenance Cost	CEC/ NCI/ Distributors								

# Office Equipment

	PC's & Monitors		Laser Printers		Facsimile		Copiers	
	Non ENERGY STAR®	ENERGY STAR®	Non ENERGY STAR®	ENERGY STAR®	Non ENERGY STAR®	ENERGY STAR®	Non ENERGY STAR®	ENERGY STAR®
Capacity (hrs/day)	ENERGY STAR®							
Energy Efficiency Criteria								
Added Price (ENERGY STAR® vs. Standard)								
Average Life (yrs)								
Energy Use (kWh/year)								

## Appendix B References

September 2007

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