ENERGY STAR Market & Industry Scoping Report
Vacuum Cleaners
November 2011

The U.S. Environmental Protection Agency (EPA) consistently looks for new opportunities to expand ENERGY STAR to new product categories that will deliver significant benefits to consumers and the environment in the form of energy and dollar savings plus greenhouse gas reductions. A key step in this evaluation is the development of a scoping report that provides a snapshot of the product market, energy use, and savings potential associated with an ENERGY STAR program for the scoped product type. EPA uses scoping findings to prioritize product specification development work. While scoping reports are drafted primarily for internal evaluation purposes, and are not intended to be exhaustive but rather a guidepost for the ENERGY STAR program, EPA makes the reports available with the interest of benefiting other efficiency programs evaluating similar opportunities. For more information about the ENERGY STAR specification development process, go to: www.energystar.gov/productdevelopment.

1. *Product & Technology Overview*

Vacuum cleaners are home appliances that are used to remove dirt and soil from carpets, floors, and furniture. Residential vacuums are generally designed for aesthetics, usability, and affordability while commercial vacuums are designed for durability and ease of maintenance. A commercial vacuum cleaner is intended for professional housekeeping purposes and for use by laymen, cleaning staff, or contracting cleaners, primarily in office, shop, hospitals and hotel environments for longer periods of time than household vacuum cleaners. Industrial vacuum cleaners designed for specialized applications. Handheld vacuums are excluded from the scope of this study, as are electronic sweepers without vacuum capability.

Table 1: Product Types

Product Type	Description	Details
Upright Vacuum	Self-contained unit with a motor, cleaning head, separation system, filtration system, and exhaust port built into a vertical standalone configuration.	The main cleaning head typically includes motor driven brush rolls and/or a beater bar to facilitate cleaning carpets.
Canister Vacuum	Consists of a cleaning head attached to a vacuum body by a long, extendable wand or tube. The body contains the motor, separation system, filtration system, and exhaust.	Has the suction power and filtration capability of an upright vacuum but allows for increased mobility. Some canister vacuums can be worn like a backpack. Also referred to as a cylinder or suction cleaner.
Stick Vacuum	Similar to an upright vacuum but with a compact, lightweight design for increased maneuverability.	Mainly used for smaller spaces. Typically less powerful than other types of vacuums.
Wet-Dry Vacuum	A canister-like body contains the motor, separation system and a long wand or tube that connects to the cleaning head.	Has the capability to take in wet debris, water, and large quantities of dirt without clogging. Typically does not have cleaning head attachments.

Product Type	Description	Details
Wide-area Vacuum	Similar to an upright vacuum but with a cleaning head that covers a much larger area.	Larger in size and intended for industrial cleaning. Typically has a self-propulsion system.
Steam Cleaner or Deep Cleaner	Available in upright, canister or industrial vacuum form factors. Cleans by spraying warm water and detergent on the cleaning surface before extracting the solution with suction.	The cleaning head typically includes a spraying system, an agitator or brush, and a suction intake.

Product Components and Features

- Motor: Most vacuum cleaner motors rely on carbon brushes to supply electrical power to a rotating armature. These brushes tend to wear down resulting in a finite life of the motor. A new generation of brushless motors drives a permanent magnet rotor without physical contact and has potential for extended life. Additionally, these motors can be smaller in size and can run at extremely high speeds (up to 100,000 rpm compared with approximately 30,000 rpm for carbon brush motors).[1]
- Separation System: The system by which the vacuum separates dirt and debris from the air. Types of separation systems include:
    - Bag: A vacuum bag is used to filter dirt out of a stream of air. The bag or filter is subsequently discarded along with the dirt.
    - Bagless: A removable container and reusable filter is used to trap dirt and debris. The container is then emptied and the filter cleaned for re-use. The majority of residential vacuums sold in the U.S. are bagless designs.
        - Water Filtration: Intake air is forced through a tank of water to dampen the dirt and debris, thus separating it from the air. The water is emptied after each use.
        - Cyclonic Separation: Intake air is spun at very high speeds in a separation chamber. Dust particles move outward while clean air exits from the inner part of the chamber. Some vacuums have multiple chambers to increase filtration efficiency.
- Filtration System: A system of one or more filters through which exhaust air passes to remove fine particulate matter that escapes the primary separation system. Some filters remove microscopic particulate matter and purify the exhaust air, which is an important feature for people who are sensitive to dust or other allergens. Filter types include:
    - HEPA[2] (High Efficiency Particulate Air) Filters meet stringent efficiency specifications. The U.S. Department of Energy (DOE) regulates HEPA filter standards and requires independent laboratory testing to validate filter performance in nuclear facility settings.

[1] "Work on Preparatory Studies for Eco-Design Requirements of EuPs (II) Lot 17 Vacuum Cleaners Final Report to the European Commission," AEA Group, February 2009.
[2] DOE-STD-3020-97: Specification for HEPA Filters Used by DOE Contractors, U.S. Department of Energy, January 1997.

    - ULPA (Ultra Low Penetration Air) Filters meet an efficiency standard required for ultra sterile environments, such as pharmaceutical laboratories.
    - Allergenic Filters specifically target allergens such as pet dander and pollen, but do not meet HEPA or ULPA specifications

- Cleaning Head: The part of the vacuum that is in direct contact with the surface to be cleaned. The cleaning head style varies based on the vacuum's primary function. For carpeted surfaces, adjustable brushes, beater bars, and small turbines may be used to loosen dirt or debris. Wet-Dry vacuums usually have a large open cleaning head to allow large volumes of debris or water to be ingested quickly.
- Power Source:
    - Mains Powered: A vacuum cleaner that is connected to a mains voltage electrical supply during its operation.
    - Cordless: A vacuum cleaner with integrated electrical supply (usually low voltage DC) that uses rechargeable battery storage of electricity during its operation. Handheld vacuum cleaners are usually cordless. Larger battery operated vacuums may be introduced to the market in coming years as battery technology improves.

      NOTE: Some hand-held and stick combination vacuum cleaner products qualify for the ENERGY STAR label under the Version 1.1 Battery Charging Systems Specification.[3]
    - Hybrid: Hybrid canister models that use either mains or battery power during operation have recently been introduced in the European market.[4]
- Clean Carpet Sensor: Some vacuum cleaners have an indicator light that activates once the machine senses the carpet is clean.

2. *Market Assessment*

U.S. Retail Sales: Residential

Retail sales of vacuum and steam cleaners in the US totaled more than 26 million units in 2010. Upright designs continue to dominate the market, while stick vacuum cleaners have maintained a small yet steady share.

Residential steam cleaners have recently gained market share with sales growth driven largely by the growing popularity of steam mop configurations. In 2010, the industry saw an increasing number of multi-function products as more suppliers introduced units that combined steam with vacuum and sweeper functions.

[3] www.energystar.gov/batterychargers
[4] http://www.miele.co.uk/vacuum-cleaners/s6/hybrids4812-380/

Table 2: U.S. Retail Sales of Vacuums – 2010[5]

Product Type	Retail Dollar Sales (millions)	Market Share by Retail Dollar Sales	Retail Unit Sales (millions)	Market Share by Retail Unit Sales
Upright	$2,040	78%	19.3	69%
Canister[6]	~$200	8%	~2	7%
Stick	$140	5%	3.5	12%
Steam	$240	9%	3.3	12%
Total	**$2,620**		**28.1**	

Table 3: U.S. Retail Unit Sales of Vacuums – 2006-2010[7]

Product Type	2006	2007	2008	2009	2010	2006-10 CAGR
Upright	19.7	19.6	18.8	18.6	19.3	-0.5%
Stick	3.6	3.5	3.5	3.4	3.5	-0.7%
Steam	1.4	1.4	1.5	2.8	3.3	23.0%
Total	**24.7**	**24.5**	**23.8**	**24.8**	**26.1**	**1.4%**

U.S. Retail Pricing: Residential

According to several sources, price point is not necessarily tied to energy efficiency or performance. One manufacturer noted that efficiency can be improved without an increase in price to the consumer. Below are the typical price ranges for various types of residential and commercial vacuums.

Table 4: Product Price Ranges

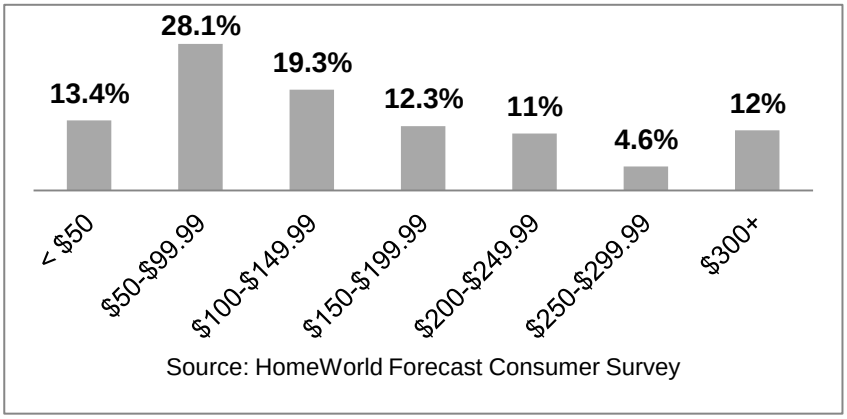
Product Type	Residential Price*	Commercial Price
Upright	$50 - $1000	$100 - $1000
Canister	$50 - $1300	$300 - $1600
Stick	$30 - $300	N/A
Wet/Dry	$50 - $700	$50 - $1400
Wide-area	N/A	$1000 - $3000
Steam	$100 - $400	$200 - $3500

**Note: The upper end of the cost range for residential vacuums represents units sold door-to-door and via specialty retailers.*

In the last several years, retail product assortments have shifted toward lower price segments. The results of the HomeWorld Forecast 2011's annual survey of consumers below indicate how much money consumers expect to pay for upright and stick vacuum cleaners.

[5] Upright, stick, and steam 2010 sales data are from the "Housewares Census 2011," HomeWorld Business, January 2011.
[6] Canister sales data was last collected for the year 2006 and reported in the "Housewares Census 2007," HomeWorld Business, January 2007. In the above table, rough estimates for 2010 canister sales are provided assuming nearly 0% sales growth.
[7] Ibid. Canister models not included. Data are unavailable for all years.

Figure 1: U.S. Upright Vacuum Consumer Purchase Price Expectation[8]



Source: HomeWorld Forecast Consumer Survey

U.S. Market Penetration: Residential

In 2009, the NPD Group conducted an online consumer survey of a U.S. representative sample of nearly 2,000 users of electric floor care products. Nearly 90% of respondents owned some type of electric floor care product.[9] Upright configurations accounted for the majority of vacuums owned (69%) by respondents, followed by workshop vacuums and handhelds. Owners of vacuums told the NPD Group that when purchasing their next vacuum they will consider suctioning power, product durability, ease of use, and ease of mobility.

The NPD Group also found that the average household owns two vacuum cleaners in total. This multiple ownership scenario is also common in Europe with certain types of vacuum cleaners being used for special areas or tasks within the household. For example, there could be an upright vacuum cleaner for the downstairs level, a smaller canister or suction vacuum for the upstairs level, a cleaner for use in the garage and a hand-held for quick cleaning indoors[10].

According to industry sources, consumers purchase a new vacuum approximately every 4-5 years. Sales trends in Europe also indicate that the working life of the products have declined from 8 years to around 4 years though it is not clear how the lifespan is affected with many households having multiple units.[11]

U.S. Stock of Vacuum Cleaners

The stock of U.S. vacuum cleaners is estimated based on household data, annual sales, and assumptions about ownership levels established in the preceding sections.

[8] Ibid.
[9] Electric floor care products refers to all vacuums, as well as electric bare-floor cleaners/steam mops, carpet sweepers, deep carpet cleaner/extractors, and other types of electric floor care products.
[10] "Work on Preparatory Studies for Eco-Design Requirements of EuPs(II) Lot 17 Vacuum Cleaners Final Report to the European Commission," AEA Group, February 2009.
[11] Ibid.

Table 5: U.S Household Stock of Electric Floor Cleaners

U.S. Households in 2009	113.43
Electric Floor Cleaner Household Penetration	90%
Average Product per Household	2
Total Estimated Stock 2009 (Millions)	205
Total Unit Sales 2004-2010 (Millions)[12]	220
% of Households Owning Upright in 2009	69%
Estimated Upright and Stick Vacuum Cleaner Stock (Millions)	140
Estimated Lifetime of Electric Floor Cleaner	5-8 years

Product Trends: Residential

Upright vacuum cleaners in the U.S. are typically rated by the amount of amperage drawn from the electrical outlet which flows through them. This rating is often used in marketing claims to indicate how "powerful" a vacuum cleaner is and thus persuade consumers that it will it have better cleaning performance than a lower power model. In the 1990s, most vacuum cleaners were rated at 8A until an "amp" marketing war ensued. Now, the majority of upright vacuums in the U.S. have 12A ratings, the maximum permitted for UL approval.

Many brands feature amperage rating prominently on product packaging and associate it with cleaning performance prompting consumers to pick models that have the highest amperage rating. Wattage ratings are more frequently used in European markets and are commonly provided for canister vacuums in the U.S instead of amperage ratings. At this time, energy efficiency is not explicitly rewarded in the U.S. marketplace.

While vacuum cleaners in Europe tend to use less power on average, the market has seen similar trends in power increases. A UK Consumer Testing organization revealed that power ratings of vacuum cleaners have increased over the last 40 years with a 1960 report indicating that tested products had an average wattage of 400 W, with a range of 150 to 950 W. Information from retail catalogs in the table below confirms the trend.[13]

Table 6: Approximate Input Power Range of Vacuum Cleaners

Product Type	Input Power Range 2003	Input Power Range 2008
Bagged upright cleaners	1300 W to 1800 W	1150 W to 2000 W
Bagless upright cleaners	1450 W to 1700 W	1700 W to 2000 W
Bagged cylinders (canisters)	1100 W to 1800 W	1200 W to 2500 W
Bagless cylinders (canisters)	1400 W to 2000 W	1400 W to 2700 W

U.S. Market Data: Commercial

Approximately 575,000 commercial vacuums were sold in the US in 2008, with a projected annual growth rate of 2 to 5%. The majority of commercial sales are through retail distribution channels, though the Internet is the fastest-growing sales channel.

[12] Estimate includes sales of upright, canister, stick, hand-held, and steam vacuum cleaners.

[13] Ibid.

3. *Energy Efficiency Assessment*

Available Test Procedures

- IEC/EN 60312-1 Ed 1.0 *Vacuum cleaners for household use - Part 1: Dry vacuum cleaners - Methods for Measuring the Performance*. This procedure includes an energy consumption test to measure energy and cleaning performance on different surfaces and with different types of soiling. This standard is not intended for battery-operated vacuum cleaners.

  According to industry sources, the European Committee for Electrotechnical Standardization (CENELEC) developed an amendment to EN/IEC 60312 to define "energy efficiency" as energy consumption necessary to reach a reference level of dust pick up on carpet and hard floor and "filtration performance" as "fractional filtration efficiency," taking into account the dust entering and emitted by the vacuum cleaner. The result will be shown as percentage of retained dust.

- ASTM F2756 – 09 *Standard Test Method for Determining Energy Consumption of Vacuum Cleaner.* This procedure provides an indication of the amount of energy usage of the vacuum cleaner while operating over a specified cleaning area at a specified stoke speed and total number of cleaning strokes. This method applies to household and commercial upright, canister, stick, and wet/dry vacuum cleaners.

- ASTM F608–07 *Standard Test Method for Evaluation of Carpet Embedded Dirt Removal Effectiveness of Household/Commercial Vacuum Cleaners*. This procedure measures relative carpet dirt removal effectiveness and applies to residential and commercial upright, canister, and combination vacuum cleaners. This standard differs from IEC 60312-1 in that it measures cleaning on four different types of carpet rather than a single type.

- ASTM F2608 – 07 *Standard Test Method for Determining the Change in Room Air Particulate Counts as a Result of the Vacuum Cleaning Process.* In this test method, the amount of particulate generated into the air by operating a vacuum cleaner over a specific floor covering that is contaminated with dust will be determined. Particles from the motor, floor covering, and the test dust will all be measured. A standardized test chamber, equipment, floor covering material, and dust particulate are used in this test method.

- CRI TM 112 *Standard Test Method for Evaluation of Solid Particulate Removal Effectiveness Using X-Ray Fluorescence Techniques.* This procedure describes X-ray fluorescence techniques for measuring the percentage of soil compounds removed from a test carpet.

- CRI TM 115: *Standard Laboratory Test Practice for Determining the Power Use Effectiveness of Residential and Commercial Vacuum Cleaners.* This procedure evaluates soil removal performance versus power consumption to determine Power Use Effectiveness (PUE). A high PUE indicates removal of more soil with less power consumption.

- Consumers Union uses a deep cleaning carpet test similar to the ASTM standard. Vacuums with brushes, wide power heads, and large mass tend to do well in deep cleaning carpet tests.

Product Usage Patterns: Residential

Product usage may be dependent upon the size of a dwelling, the amount and type of soil to be removed, the type of surface being cleaned, the effectiveness of the vacuum, the hygienic standards of the user, and the time available for cleaning. When asked about the relationship between cleaning performance and energy use, and whether vacuums with better performance are used for shorter durations, one stakeholder indicated that vacuum cleaner users commonly develop a conditioned usage pattern that is independent of the effectiveness of the vacuum and that usage is not typically decreased as a result of markedly increased cleaning performance.

Many manufacturers conduct field testing to measure typical vacuum usage patterns, with reported average weekly usage time ranging from 20-60 minutes. Consensus on the average usage time for U.S. households has not been established. The preparatory studies for EU Eco-Design requirements suggest an average of one hour of cleaning per week in residential applications, with a 'light' pattern of 15 minutes per week, and a 'heavy' pattern of four hours per week. *For purposes of this study an average residential usage of 40 hours per year is assumed.*

Some residential vacuums offer user controlled operating modes which may affect power consumption. Other products may automatically adjust power consumption depending on the surface being cleaned. There is limited data available regarding user behavior with respect to various product settings.

Product Usage Patterns: Commercial

Commercial vacuums are generally used by professional cleaning companies or professional cleaning staff, and operate for a greater number of hours than products in residential environments. Industry sources suggest typical usage from 60 to 2,028 hours per year. *For purposes of this study, an average commercial usage of 700 hours per year is assumed.*

Product Lifetime

The typical service lifetime for residential vacuum cleaners has been reported to be in a range of 4-10 years. The preparatory studies for EU Eco-Design requirements suggest that 8 years best approximates residential vacuum lifetime and stakeholder input seems to indicate that lifetime in the U.S. may be lower. *For purposes of this study, an average residential product lifetime of 7 years is assumed.*

According to industry representatives, the typical lifespan of a commercial vacuum is only 2-3 years due to more frequent usage. *For purposes of this study, an average commercial product lifetime of 2.5 years is assumed.*

4. *Energy and Cost Savings Potential*

Historically, vacuum cleaners have employed centrifugal fans to create suction power in a manner that leads to relatively inefficient energy conversion. According to the EU Eco-Design preparatory study, maximum efficiency can be as low as 15% and has seldom been greater than 50%. When the leaks and inefficiencies of the vacuum cleaner and its connecting tubes and filters are taken in to account, the overall energy conversion capability can be anything between 10% and 33%. This energy conversion efficiency has no relationship with cleaning efficiency or ability to pick up dirt where absolute levels of suction, airflow and suction power are more critical.

This section assesses the available options for energy efficiency improvements and summarizes the technical analysis and findings of the Eco-Design study[14]. All improvements would be capable of being introduced within the design life cycle of the product which is typically three years; information available suggests many efficiency improvements would be achievable at a relatively low cost.

Input Power

Though manufacturers have historically promoted the amperage of the vacuum motor as an indication of the vacuum's cleaning ability, there is minimal correlation between power and cleaning performance. There is a lower limit below which no cleaning performance would occur at all, then a small band of rapid improvement, followed by a wider band of small or negligible improvement. Beyond this point, no discernable improvement can be seen.[15] Stakeholders have also indicated that filtration or dust removal performance is almost independent of power. Cleaning head design, brush mechanisms, a sealed system, and other overall design are often more important factors for cleaning performance than input power.

Suction Power

The suction motor takes electrical power from the power source and converts it into mechanical power in the form of suction with air flow. There is more correlation between suction power and cleaning performance than input power alone, particularly when comparing canister models only using suction power for cleaning. Though, it is important to note that the design of the actual nozzle may be a more influential factor.

Suction power is measured in airwatts based on suction with air flow at the unit itself.[16] The suction is typically measured with the air flow being restricted by a two inch opening. The maximum suction power divided by the input power at the same point determines the maximum airflow efficiency (energy conversion efficiency) of the vacuum cleaner. This value, which is not related to cleaning efficiency, is normally quite low, rarely above 50% and often around 30%, indicating that input power is converted mostly to heat. This heat is primarily the result of resistance in the copper windings on the motor armature and field as current flows through them. Air flow travels through both the suction fans and the motor to cool the system.

The airwatts rating does not necessarily reflect the actual air flow in the complete system in normal use. In addition to the resistance within the power unit, there is resistance caused by air turbulence in the hose and tubing, restriction where the cleaning nozzle contacts the floor, as well as increased resistance within the filtering system as the unit fills with dirt. The sealed suction rating (no air flow) is typically about four times higher and indicates the maximum suction that can be produced by a motor.

The largest potential for energy savings is in the improvement in the efficiency of the motor/fan (vacuum generator). For current vacuum cleaners, energy losses are between 60% and 75%. The energy losses are manifested as heat via the exhaust air. With application of best available

[14] "Work on Preparatory Studies for Eco-Design Requirements of EuPs (II) Lot 17 Vacuum Cleaners Final Report to the European Commission," AEA Group, February 2009.
[15] "Work on Preparatory Studies for Eco-Design Requirements of EuPs(II) Lot 17 Vacuum Cleaners Final Report to the European Commission," AEA Group, February 2009.
[16] The airwatt is derived from English units. ASTM International defines the airwatt as 0.117354 * F * S, where F is the rate of air flow in cu-ft/min and S is the pressure in inches of water. This makes one airwatt equal to 0.9983 watts.

technology, a target energy loss of 45% is achievable through improvements in design to the fan case and fan blades.

Airflow

The air flow is proportional to the amount of suction produced by the motor and inversely proportional to the total resistance to air flow within the complete system. In order to remove soil away from the cleaning head and into the receptacle, airflow needs to meet a certain threshold, typically 18 ft^3 per minute. Improvements can also be made to the design of vacuum cleaner airways. Currently the energy losses due to the airways are at best 5% and at worst 10%. Best available technology suggests that energy loss of around 5% is the achievable target.

Nozzle Design and Agitation

Nozzle design is a critical area for ensuring most efficient cleaning effectiveness. Suction power requirements (as measured at the nozzle) can be as low as 50 airwatts where an agitator is present. Current energy losses exhibited are at best around 15% and at worst around 25%. With efficient nozzle design, a target energy loss of 10% is achievable.

Leakage between the vacuum generator and nozzle can lead to energy losses. Current energy losses are at best around 10% and at worst around 20%. Losses due to leakage could be reduced to a target energy loss of about 5%.

Vacuum cleaners can have either have an active nozzle (with an agitator) or a passive nozzle (without an agitator) with latter being more common in canister configurations. Agitator or brush design has more effect on carpet cleaning performance than any other factor and is normally driven by the same motor driving the fan. Typical speeds of around 3000 RPM produce the best cleaning effect through vibration and as well as brushing action. At low powers, an active nozzle is superior to a passive nozzle at cleaning carpets.

Dirt Receptacle and Filtration

Usually the more effective a filter media is at stopping and trapping the dirt, the more energy it absorbs from the airflow. The most effective way to reduce airflow loss is to increase the overall area of the filter. Cyclones also absorb energy, in order to create centrifugal velocities and forces. Multiple cyclones in series can absorb as much energy as a heavy duty barrier filter. The use of multiple second stage cyclones in parallel has led to a reduction in energy absorbed but may allow more dust to pass through thus requiring the subsequent use of barrier filters in addition to the cyclones.

For current filters (HEPA 12), the energy losses due to the filtration process are at best 15% and at worst around 20%. The best available technology position with regard to filtration would suggest an achievable target energy loss of 10%. This would require larger area filters thereby requiring increased amounts of filtration materials.

Estimated Savings Potential

The design improvements discussed in this section indicate there is opportunity for significant gains in vacuum efficiency, though the gains from a collection of design options may not necessarily be additive. Currently, total overall energy losses are at best 75% and at worst as high as 89%. Through greater emphasis on energy efficiency in the design process, the data currently available suggests that an overall target energy loss of 60% could be achieved.

For purposes of this report, savings potential was estimated with motor amperage as a proxy for efficiency improvements, which equates to an assumption that equivalent cleaning performance can be achieved with a less powerful motor. The baseline is based on a 12A rated vacuum and savings on direct substitution of vacuums rated at 10A (16% efficiency improvement) and 8A (33% efficiency improvement). These improvements are roughly equivalent to the power caps suggested by the European Union.

Estimated per-unit annual savings for residential vacuums are on the order of 10-19 kWh/year, which would offer lifetime savings of $7-15 over an assumed 7-year lifetime. However, there is a more significant saving opportunity on a national basis due to the size of the market. Considering there are approximately 28 million vacuums sold in the U.S. each year, the national energy savings opportunity would be on the order of 67,000-135,000 MWh per year if 25% of products sold were replaced with energy efficient models. This reduction in energy use would reduce CO_2 emissions by approximately 103 -208 million lbs (assuming a conversion of 1.54 lbs CO_2 per kWh).

Due to their more frequent operation, it is estimated that vacuums used in commercial settings could provide significantly greater unit savings ($46-91 over a 2.5 year lifetime of the product) than residential vacuums. However, since the overall market for commercial vacuums is substantially smaller (annual shipments estimated to be 575 thousand in 2008) than the residential market, the national savings opportunity is also somewhat smaller. For commercial applications, assuming 25% of vacuums sold were replaced with energy efficiency models, the national energy savings would be the order of 24,000 to 48,000 MWh per year, a reduction in energy would reduce CO_2 emissions by approximately 37 - 74 million lbs.

Split-incentive Challenges for Commercial Markets

In the residential market, savings achieved by efficient household vacuum cleaners are passed directly on to the user. This is not the case for commercial market vacuums. The owner of a commercial building pays for the electricity required to run the vacuums for their cleaning service whereas the cleaning service would be responsible for purchasing an efficient product. It is possible that the cleaning service could highlight the energy savings from efficient vacuum use as an incentive for their customers.

5. *Key Market Players*

Industry Associations

The Carpet and Rug Institute (CRI)[17] is a nonprofit trade organization representing the manufacturers of more than 95 percent of carpet made in the US, as well as their suppliers and service providers. CRI has developed a vacuum cleaner certification program that promotes effective cleaning and superior vacuum operation. To qualify, vacuums must be tested by CRI or a CRI-certified test lab.

The CRI “Green Label” program controls indoor air quality by stipulating that a vacuum must not release more than 100 micrograms of dust particles per cubic meter of air. There are currently 180 models that meet CRI Green Label requirements.

Dust Containment:

- Bronze: ≤ 100 µg/m^3
- Silver: ≤ 100 µg /m^3

[17] http://www.carpet-rug.org/

- Gold: ≤ 35 µg/m^3

The CRI "Seal of Approval" program combines the indoor air quality protection of the Green Label program with enhanced cleaning standards for soil removal and carpet fiber retention. There are currently 88 models that meet CRI Seal of Approval requirements.

Soil Removal:

- Bronze: 40 – 49% Soil Removal
- Silver: 50 – 54% Soil Removal
- Gold: ≥ 55% Soil Removal

Carpet Fiber Retention: The carpet fiber retention test visually rates a change in the texture appearance by applying six cleaning cycles to residential cut pile carpet and eleven cleaning cycles to commercial cut pile carpet. The vacuum must not affect the texture of commercial cut pile carpet more than one step change based on one year of normal vacuum use.

The Association of Home Appliance Manufacturers (AHAM)[18] is a trade association of home appliance manufacturers. AHAM performs market research and supplies business data to its members. AHAM supports the ASTM test procedures but does not currently offer a certification program for vacuums.

Product Manufacturers

Table 7: Vacuum Cleaner Manufacturers

Residential Brands/Manufacturers	Commercial Brands/Manufacturers
• Aerus LLC • Bissell Inc. (Bissell) • BSH Home Appliance Corp (Bosch) • Cleartrak • Dyson Ltd • Electrolux Home Care (Eureka, RIDGID, Craftsman, goClean, DirtHound) • Emerson Tool Company • Euro-Pro • Hoover • Kenmore • Lindhaus • Miele Inc • Oreck • Panasonic • Royal Appliance Mfg. • Shop-Vac • Tacony (Riccar, Simplicity, Tacony Vac Pros) • Ultracare	• Clarke • DeWalt • Electrolux Home Care (Sanitaire) • Hoover • Karcher Floor Care • Koblenz (Koblenz Electrica) • Mastercraft Industries • Minuteman International Inc • NaceCare Solutions • Nilfisk-Advance (Kent Euroclean) • NSS Enterprises Inc. • Nobles • Pacific Floor Care • PacVac • Panasonic • ProTeam • Royal Appliance Mfg. • Rubbermaid Commercial Products • Shop-Vac • Tacony (CFR Corp, Powr-Flite, Tornado, Truvox International) • Tennant • Thoro-Matic

[18] http://www.aham.org/

Residential Brands/Manufacturers	Commercial Brands/Manufacturers
	• Windsor Industries

6. *International Activity*

European Union Energy Label

There is currently no European Union legislation specifically dealing with the energy consumption of vacuum cleaners. Under Directive 2010/30/EU, a preparatory study has been undertaken with proposals that include an energy label for vacuum cleaners based on energy consumption and cleaning performance with possible minimum limits set for noise and dust re-emissions. The label would apply to "normal" vacuum cleaners intended for domestic use and similar cleaning likely making no distinction between canister, stick, and upright configurations. The label excludes wet, hand-held battery operated, industrial, and central vacuum cleaners as well as sweeper appliances that do not use a vacuum for dust pick up.

Table 8: European Union Proposed Caps for Input Power Rating of Vacuum Cleaners

	2011	2014
Uprights without integral hose and tools	750 W	500 W
Canister Cleaners and Uprights with integral hose and tools	1100 W	750 W
Commercial Vacuums with single motors	1200 W	1000 W
Commercial Vacuums with dual motors	1500 W	1250 W

Energy Saving Trust

Energy Saving Trust Recommended is a UK voluntary product certification and labeling scheme covering over 30 products that has recently finalized criteria for vacuum cleaners. In order to receive certification, both upright and canister vacuums must have input power of ≤1200 W while meeting minimum cleaning hard floor and carpet performance measured at full load using EN 60312. The model must comply with minimum safety standards and 500 hours of usage, as demonstrated by test data, or a 5 year guarantee offered to consumers.