

## Vacuum Cleaners: Recommendations for policy design

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### 1. Summary

The most important vacuum cleaners regarding energy consumption are canister and upright vacuum cleaners. The EuP Study estimates that over 45 million units are sold on the EU market annually and that the current annual energy consumption for vacuum cleaning is at around 120 Twh.

Input power of vacuum cleaners has more than doubled in the past fifty years. Today, most vacuum cleaners have input power ratings between 1500 and 2700 W. Yet there is no clear correlation between input power and cleaning efficiency.

Topten recommends several vacuum cleaners with input power ratings of 1200 W and lower and excellent cleaning efficiency. It is agreed by stakeholders that technology to reduce input power to 750 W will be available in the near future.

The Ecodesign Regulation is currently in preparation. It is recommended to introduce a power cap in two steps at 1000 W and at 750 W as well as minimal requirements for filtration efficiency and a limit for noise emissions.

Additionally, an Energy Label may be implemented to inform about energy efficiency, cleaning performance, noise and dust emissions.

The imposition of mandatory capping of input power ratings for mains powered vacuum cleaners in combination with the introduction of an Energy-Label will lead to significant energy savings: The EuP estimates that a cap of 750 W will result in overall energy-savings of 565 TWh.

### 2. Best available and average technology

There are two main types of vacuum cleaners:

- canister vacuum cleaners which have a passive nozzle and clean the floor by suction power only
- upright vacuum cleaners which clean the floor by a combination of agitating brushes in the nozzle and suction power.

The EuP study distinguishes between upright and canister vacuum cleaners for commercial and for domestic use. The main difference between commercial and domestic devices is the service life time which is up to three times higher for commercial devices.

Further technologies considered are cordless vacuum cleaners, which include handheld and robot models.

#### Definition of energy efficiency

There are several types of efficiencies that can be rated in a vacuum cleaner:

- efficiency of the motor: The conversion efficiency of electrical power into rotational mechanical power is very high, usually around 90%.
- maximum airflow efficiency: The conversion efficiency of electrical power into suction power is rather low, normally around 30%.
- cleaning performance /dust removal efficiency: The conversion efficiency of electrical power into dust removal.

The factors to be considered for evaluating vacuum cleaners are:

- cleaning performance (dust removal efficiency on carpet and hard floor, measured according to EN 60312)
- Wattage (rated input power)
- Energy consumption (energy consumed for cleaning 10m<sup>2</sup> according to EN 60312)
- Dust emissions (according to EN 60312)
- Noise emissions

According to Tipten, at present, several vacuum cleaners with a dust removal efficiency of 80% on carpet and 100% on hard floor are available having a rated input power of 1200 W. Nevertheless, many manufacturers still promote models with high input power (up to 2500W). Dust emission vary according to the filter system being used (filter bag, cyclonic filtration). While 0.04 mg/m<sup>3</sup> is already a good value, 0.0002 mg/m<sup>3</sup> are achieved according to product declaration (topten). Noise emissions below 80dB are easily achievable – 17 models recommended by Tipten already have lower noise emissions. Figure 1 shows the cleaning efficiency of Tipten-Rated vacuum cleaners. Clearly, there is no correlation between cleaning efficiency and input power.

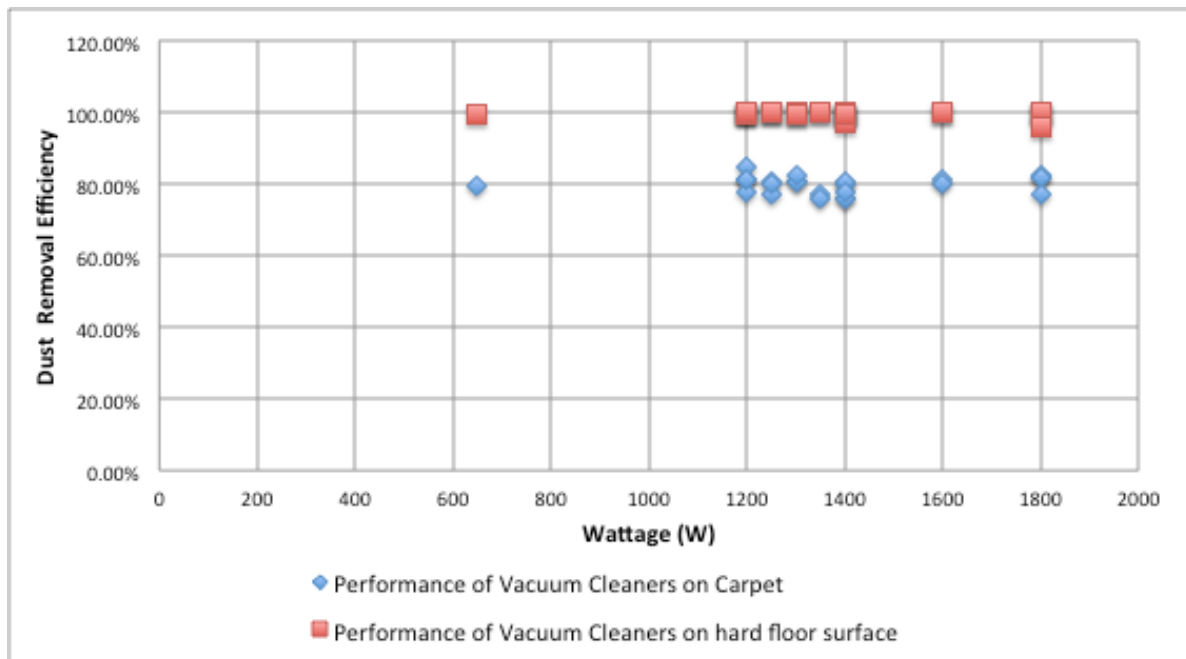


Figure 1: Dust removal efficiency and input power of vacuum cleaners recommended by Tipten.

### Factors for improvement

The study identified the following factors to improve energy efficiency in canister and upright vacuum cleaners. These improvements are considered to be achievable and cost-effective (reducing the combined costs of purchasing and operating the product):

- maximising fan efficiency
- improving airways design
- improving sealing
- minimising energy loss from filters
- improving nozzle design

An energy-optimized vacuum cleaner would have an input power requirement of around 750 W according to the EuP Study. Power requirement could be reduced to around 400 W if motorized brushes were used in canister vacuum cleaners as well, however this technology may create additional costs and is not yet available.

Emission of particles can be controlled by HEPA (high efficiency particulate air) filters, either used as filter bags or as an additional filter in a cyclonic system vacuum cleaner. Further improvement may be achievable by better fitting filter bags and self-sealing bags to reduce dust emission when bags are changed.

Improvement of cordless and robot vacuum cleaners are mainly dependent on charging efficiency and on prolonging battery life.

### 3. Market situation in Europe

According to the EuP preparatory study on vacuum cleaners 46 million vacuum cleaners have been sold in the EU in 2005. Between 2000 and 2005 there has been a major increase in the sales of vacuum cleaners (see figure 2). Surveys on a national level indicate that vacuum cleaner ownership varies between 0.67 and 0.95 per household. In some countries, it is common to have more than one vacuum cleaner per household. This multiple ownership is likely to increase.

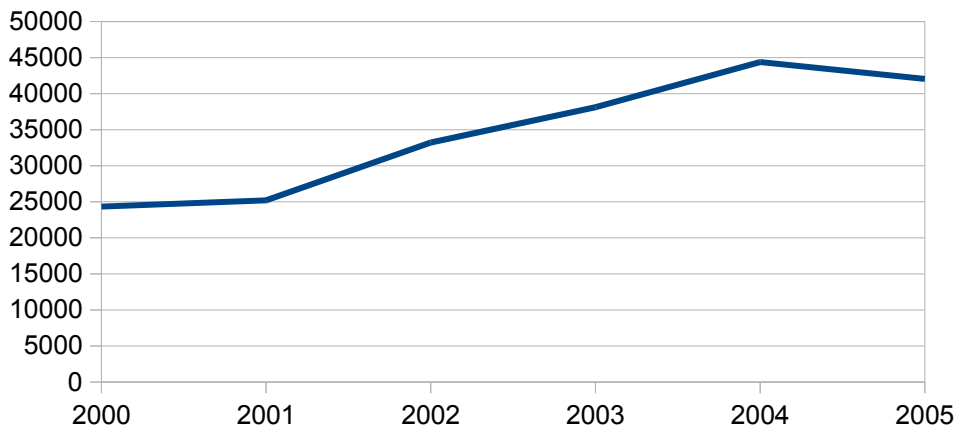


Figure 2: Apparent Consumption of Domestic Vacuum Cleaners in the EU 15

Table 1 shows estimates for stock and annual sales in the EU. Canister vacuum cleaners are predominant in both domestic and commercial use. Upright vacuum cleaners have a share of 15%. With 2 million sold units per year, cordless devices including robot models are a technology that should also be considered in the regulation process.

	% share Canister:Upright	Stock (units)	Annual Sales (units)
Canister domestic	85%	273,595,932	36,543,200
Canister commercial	85%	8,840,000	1,105,000
Upright domestic	15%	48,281,635	6,448,800
Upright commercial	15%	1,560,000	195,000
Battery/cordless	n/a	10,000,000	2,000,000
<b>TOTALS</b>		<b>342,277,567</b>	<b>46,292,000</b>

Table 1: 2005 Stock and Sales Estimates from Stock Modelling (EuP "vacuum cleaners")

Service lifetime of vacuum cleaners is assumed 8 years in the EuP. However, consumer behaviour differs and market data suggests that many consumers buy new models earlier.

As illustrated in figure 2, the trend in the last 30 years has been to develop vacuum cleaners

with high input power. High input power is marketed by the manufacturers as an indicator for high cleaning performance. However, this correlation could not be found by the authors of the EuP. On the other hand, development of low input power vacuum cleaners is also progressing. Cordless vacuum cleaners may soon offer the same performance as mains powered models while using less energy.

#### 4. Energy consumption and saving potentials

A market survey conducted by the EuP Study showed that in 2008, input power ranged from 1200 to 2700 Watt for canister vacuum cleaners and from 1150 to 2000 for upright models.

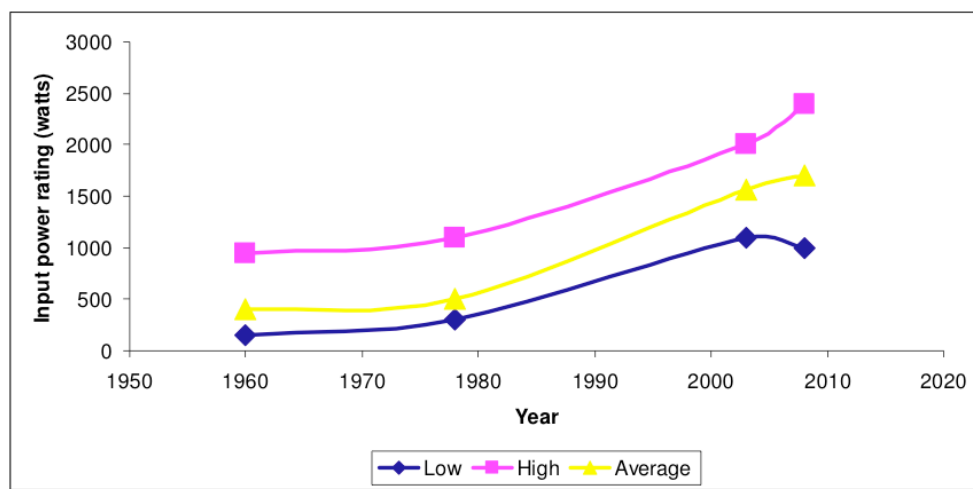


Figure 3: *Input power of vacuum cleaners has more than doubled in the last 50 years (EuP “Vacuum Cleaners”)*

The environmental impact assessment conducted by the EuP Study showed that the environmental impact is dominated by the “In use” phase energy cost. The summary of environmental impacts as estimated in the EuP Study is shown in table 2. The assessment was based on the base cases as shown in table 3.

The EuP Study assumes that the average household spends 70 minutes/week vacuum cleaning. The time and frequency a vacuum cleaner is used depends on personal preferences. The EuP Study stressed that there is no evidence that a higher cleaning performance would lead to a changed cleaning behaviour. Therefore, the most important factor to reduce environmental impact of vacuum cleaners is to reduce input power.

Main life cycle indicators	unit	Canister Domestic	Canister Commercial	Upright Domestic	Upright Commercial	Battery Cordless	TOTAL
Total Energy (GER)	PJ	315.92	21.28	55.30	3.73	7.52	<b>403.74</b>
of which, electricity	TWh	26.32	1.85	4.64	0.33	0.56	<b>33.69</b>
Water (process)*	mln.m3	28.88	2.03	5.08	0.36	0.76	<b>37.11</b>
Waste, non-haz./ landfill*	kton	803.35	64.69	118.94	6.30	23.06	<b>1016.33</b>
Waste, hazardous/ incinerated*	kton	71.80	2.96	11.91	0.51	2.92	<b>90.10</b>
<b>Emissions (Air)</b>							
Greenhouse Gases in GWP100	mt CO2eq.	14.28	0.95	2.50	0.17	0.35	<b>18.25</b>
Acidifying agents (AP)	kt SO2eq.	82.39	5.75	14.19	0.95	1.85	<b>105.13</b>
Volatile Org. Compounds (VOC)	kt	0.23	0.01	0.04	0.00	0.01	<b>0.30</b>
Persistent Org. Pollutants (POP)	g i-Teq.	3.39	0.22	0.62	0.04	0.27	<b>4.54</b>
Heavy Metals (HM)	ton Ni eq.	11.07	0.59	1.91	0.09	0.39	<b>14.06</b>
PAHs	ton Ni eq.	2.34	0.12	0.37	0.02	0.07	<b>2.92</b>
Particulate Matter (PM, dust)	kt	30.18	1.21	5.39	0.21	1.23	<b>38.22</b>
<b>Emissions (Water)</b>							
Heavy Metals (HM)	ton Hg/20	4.96	0.33	0.82	0.04	0.16	<b>6.31</b>
Eutrophication (EP)	kt PO4	0.35	0.02	0.06	0.00	0.01	<b>0.44</b>

\*=caution: low accuracy for production phase

Table 2: Environmental Impact of EU-Stock 2005 during its lifetime (Final Report EuP (II) Lot 17 Vacuum Cleaners, AEA 2009)

	Domestic Canister	Commercial Canister	Domestic Upright	Commercial Upright	Battery / Cordless
Lifetime (years)	8	8	8	8	5
Electricity consumption per hour (kWh)	1.5	1.1	1.5	1.1	0.024
No. of hours per year in use	62.5	187.5	62.5	187.5	832
Standby electricity consumption per hour (kWh)	0	0	0	0	0.00082
No. of hours per year at standby	0	0	0	0	7891

Table 3: Use Phase Inputs by Base Cases (EuP)

The imposition of mandatory capping of input power ratings for mains powered vacuum cleaners in combination with the introduction of an energy-label will lead to significant energy savings: The EuP estimates that a cap of 750 W will result in overall energy-savings of 565 TWh.

Details to these processes are described in chapter 5.

## 5. Political instruments and initiatives

### Current status of regulation process

There is currently no EU legislation specifically dealing with the energy consumption of vacuum cleaners. The voluntary EU Ecolabel dating from 2003 is now expired. The Commission Regulation implementing Eco-Design Directive 2009/125/EC and Energy Labelling Directive 2010/30/EU with regard to Vacuum Cleaners is in preparation. The preparatory study has been completed in February 2009. The Consultation Forum took place in June 2010. The Commission has released a Working Document on a possible Commission Regulation in June 2010 (see references) which was commented by NGO's (see references). Two working documents proposing regulations regarding eco design requirements and energy-Label measures have been proposed by CECED in December 2010 (see references).

### Eco-Design of EuP

In the following section, the proposals of different stakeholders are presented.

Recommendations of EuP-Commission:

The EuP study has identified energy consumption in the use phase as most significant environmental aspect to be addressed by the Eco-Design Regulation. As a further aspect, noise emissions are considered, but it is recommended to include it only in the Energy-Label declaration.

The EuP study suggested the following power capping procedure:

	2011	2014
Uprights without integral hose and cleaning tools	750 watts	500 watts
Canister cleaners and uprights with integral hose and tools	1100 watts	750 watts
Commercial Vacuum cleaners with single motor	1200 watts	1000 watts
Commercial Vacuum cleaners with dual motor	1500 watts	1250 watts

Recommendations of EC Working Document:

The EC Working Document does not make any proposal on how to implement a power cap. Regarding the different categories, it is suggested that the same regulation should apply to upright and canister, commercial and domestic devices, since differentiation may be difficult. Battery-operated models in similar size as mains models should be included in the regulation.

Noise: a limit of 76dBA is suggested.

Filtration performance: a minimum requirement of 98% of 0.2 – 4 micron particles removed is suggested.

Recommendations of NGOs:

The NGO's comments on the working document also suggest that eco-design requirements

are developed not only for energy but also for noise and filtration performance. It is recommended that for cordless devices and robot models regulations are developed as well, especially regarding standby mode.

The following procedure is proposed for power capping:

	2013	2015
All models	1000 watts	750 watts

Further, the definition of a minimum requirement for the performance of the main nozzle is suggested.

Recommendations of CECED:

CECED proposed in their document the following capping:

	In 2 years after entry into force of regulation	In 5 years after entry into force of regulation
All models	243 kWh/y /1600 watts	91 kWh/y / 1200 watts

Noise: No suggestions are made for eco-design requirements on noise.

Filtration efficiency: CECED agrees with the minimum requirement of 98% of 0.2 – 4 micron particles removed to be applied 5 years after entry into force of regulation.

### **Energy label**

Stakeholders agree that the energy-label is only additional to the eco-Design requirements and cannot replace power capping.

The EuP Study suggests an energy label in which energy consumption and cleaning efficiency appear separately. This method will ensure that models with high energy input will be rated with a low energy efficiency class even if their dust removal performance is outstanding.

CECED has proposed a Draft Energy Label Measure with the following aspects:

- energy efficiency class (based on annual energy consumption)
- separate performance classes of the dust removal on a carpet and on hard floor with crevice
- filtration efficiency
- average annual energy consumption
- airborne acoustical noise emissions expressed as sound power level

The layout of the energy-label is shown in figure 4.

The proposal is equal to the energy-label proposed by the EC Working Document in most points. Differing proposals are given for filtration efficiency and noise, where CECED suggests to present values instead of classifications.

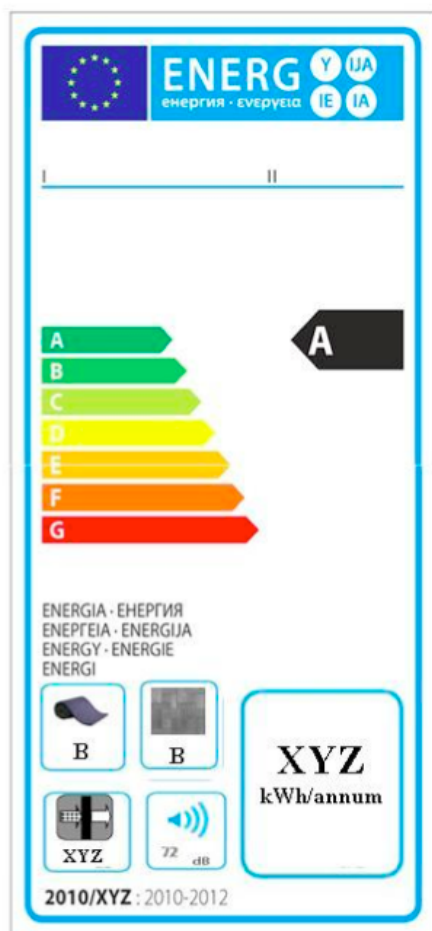


Figure 4: Layout of energy label as proposed by CECED

CECED proposes energy efficiency classes based on annual energy consumption shown in table 4.

energy efficiency class	Annual Energy Consumption	
	min	max
	kWh/yr	kWh/yr
A (most efficient)	0	34
B	>34	56
C	>56	91
D	>91	130
E	>130	178
F	>178	243
G (least efficient)	>243	$\infty$

Table 4: Energy efficiency class according to CECED Draft Regulation

Recommendations of NGO's:

NGO's agree on the scaling of the efficiency classes. It is suggested that in the course of phasing out classes D and F, additional classes A+ and A++ might be added.

### **Test Standards and Calculation of energy efficiency**

Test standards for the measurement of the different aspects of the energy-label are in development by CENELEC. Existing test standards in Europe are the EN/IEC 60312 which is relevant for testing the performance, product life, and energy use, EN 60335 relevant to safety and the measurement of input power and EN 60704-1-2 for the measurement of noise level.

The calculation of energy efficiency as proposed by CECED is based on the average power consumption during the test on carpet and on hard floor with crevice, cleaning a specific area. It takes into account the number of double strokes required to reach the reference level of dust removal and the width of the head of the vacuum cleaner.

In the present draft regulation document (2010/12/17) some formulae are not clearly readable. Furthermore, tolerances for the verification procedure seem to be too high or are missing at all.

## **6. Recommendations regarding policy design**

Energy consumption of vacuum cleaners has doubled in the last 50 years without any effect on cleaning performance. The proposed ecodesign measurements are an important step to alter the preposterous drive to higher input power ratings. Marketing has to change from promoting high input power to promoting high cleaning performance.

To achieve a significant power saving, the implementation of a power cap is absolutely necessary. People are used to clean for one h per week and they will keep this routine even with more efficient vacuum cleaners. Therefore, only with a power cap energy saving can be achieved. A power cap of 1000 W by 2013 and of 750 W by 2015 should be implemented. Industry is expected to cope easily with the power cap requirements, as efficiency has decreased since the 1970's. In today's models, efficiency measured as the ratio between suction power and input power is lower than 25%.

The energy label should only be additional to power capping. The label should inform consumers primarily about annual energy consumption. Further information may be provided with letters about cleaning efficiency, filtration efficiency and noise level

The eco-design regulation should also include robot and handheld cordless devices, as their share in the market is expected to increase.

The saving potential of vacuum cleaners is estimated at 550 TWh. This reduction can be reached if power cap and energy-label are implemented. The European commission should move forward to put the regulations into force as soon as possible. Due to population growth, overall energy consumption by vacuum cleaning is still expected to rise. To alter the trend, more incentives for energy efficiency as well as a change of cleaning habits are needed.

## 7. References and Links

### References

AEA Energy & Environment: Work on Preparatory Studies for Eco-Design Requirements of EuPs (II) Lot 17 Vacuum Cleaners TREN/D3/390-2006 Final Report, February 2009

[http://ec.europa.eu/energy/efficiency/studies/doc/ecodesign/eup\\_lot17\\_final\\_report\\_issue\\_1.pdf](http://ec.europa.eu/energy/efficiency/studies/doc/ecodesign/eup_lot17_final_report_issue_1.pdf)

EC Working Document on the Eco-Design and Energy Labelling of Vacuum Cleaners (June 2010) [http://www.eceee.org/Eco\\_design/products/vacuum\\_cleaners/WD\\_CF25June2010](http://www.eceee.org/Eco_design/products/vacuum_cleaners/WD_CF25June2010)

NGO Comments on the EC Working Document on the Eco-Design and Energy Labelling of Vacuum Cleaners (June 2010)

[http://www.eceee.org/Eco\\_design/products/vacuum\\_cleaners/ecos\\_comments\\_april2010\\_VC](http://www.eceee.org/Eco_design/products/vacuum_cleaners/ecos_comments_april2010_VC)

Working document of CECED regarding Energy Label Measure:

[http://www.eup-network.de/fileadmin/user\\_upload/Produktgruppen/Lots/Working\\_Documents/Lot\\_17/2010-12-17\\_Draft\\_Energy\\_Label\\_Measure\\_CECED\\_EUCelaning.pdf](http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Working_Documents/Lot_17/2010-12-17_Draft_Energy_Label_Measure_CECED_EUCelaning.pdf)

### Regulations

EN 60312 Vacuum cleaners for household use - Methods of measuring the performance (IEC 60312:2007)

EN 60704-1-2 Household and similar electrical appliances - Test code for the determination of airborne acoustical noise - Part 2-1: Particular requirements for vacuum cleaners (IEC 60704-2-1:2000)

### Links

Most efficient products of Europe: [www.topten.eu](http://www.topten.eu)

Information on the 'eco-design of EuP' process: [www.coolproducts.eu](http://www.coolproducts.eu)

eceee (European Council for an Energy Efficient Economy)

- overview on the eco-design of EuP status:

[http://www.eceee.org/Eco\\_design/products/?sort=status](http://www.eceee.org/Eco_design/products/?sort=status)

- information on vacuum cleaners

[http://www.eceee.org/Eco\\_design/products/vacuum\\_cleaners/](http://www.eceee.org/Eco_design/products/vacuum_cleaners/)

SELINA, Standby and Off mode Energy Losses in New Appliances measured in shops:

<http://www.selina-project.eu/index.cfm>

NGO Network on EuP

<http://env-ngo.eup-network.de/>

European committee on standardization

<http://www.cen.eu/cen/pages/default.aspx>