Subject **Focus on Energy Evaluation**

Dehumidifiers Deemed Savings Review for Targeted Home Performance with ENERGY STAR

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The Targeted Home Performance with ENERGY STAR (THP) program manager reported in evaluation interviews that the program is considering adding ENERGY STAR replacement dehumidifiers as a new approved energy conservation measure. This is based on anecdotal information from the field that several of THP participant homes have old, inefficient dehumidifiers in their basements. The program design is to replace dehumidifier for eligible homeowners with program funds when the following criteria are met:

- Existing unit is functional and necessary for moisture control
- Existing dehumidifier is not ENERGY STAR.

This memorandum presents the results of a deemed savings review conducted for dehumidifiers by evaluators. The purpose of the deemed savings review is to estimate the increased deemed energy savings that could be attributable to these appliances being included in the program.

The study found that dehumidifiers are more than twice as common in Wisconsin than in the US as a whole. The study's analysis estimates the deemed energy savings for replacement ENERGY STAR dehumidifiers at 90 kWh/year and 0.098 kW/unit. This is the evaluation team's best estimate of what the might achieve before any program-specific data is available. In addition, the study found that the dehumidification load in Wisconsin peaks fairly strongly in the summer.

Overview of Dehumidifiers

The 2005 Residential Energy Consumption Survey[i] found that dehumidifiers were used in 28.2 percent of all households in the East North Central States. The East North Central States includes Wisconsin, Illinois, Indiana, Michigan, and Ohio. Nationwide, the share of households

with dehumidifiers was only 11.7 percent. In Wisconsin's region, dehumidifiers are used primarily in basements in the summer months.

Average annual usage

Table 1 below summarizes the annual usage of dehumidifiers based on several studies and sources. Unfortunately, none of the studies is based on metered data. The studies rely on power measurements and assumptions regarding usage to derive the annual energy consumption values.

Table 1. Dehumidifier Annual Usage Data[ii]

Study/Source	Annual Energy Use (kWh)	Power Use (Watts)	Operating Hours /Year
LBNL (1992)[iii]	Average: 400 Range: 200–1000	NA	NA
ADL (1998)[iv]	Average: 972	Average: 600	1620
LBNL (2005)[v]	Range: 500–4650	Range: 520–710	1620, 4320
Energy Center of Wisconsin (2005)[vi]	Average: 600 Range: ±300 (WI only)	Average: 350 Range: ± 250	NA
Central Maine Power Co. (2006)[vii]	Average: 540 (Maine only)	NA	NA
ENERGY STAR Fact Sheet (from website, 2006)[viii]	ENERGY STAR: 2161 Non-ENERGY STAR: 2378	ENERGY STAR: 1334 Non-ENERGY STAR: 1368	1620
ENERGY STAR Calculator (from website, 2006)[ix]	ENERGY STAR: 937–2061 Non-ENERGY STAR: 1022–2616	ENERGY STAR: 329–723 , Non-ENERGY STAR: 358– 918	2851

The Department of Energy (DOE)[2] reports that during rulemaking the Association of Home Appliances Manufacturers (AHAM) commented that it is not aware of any data related to the typical annual hours of operation for dehumidifiers. In consultation with manufacturers and others familiar with the product, AHAM and some of the sources identified in Table 1 provided estimates of typical dehumidifier usage in monthly and annual operating hours. Table 2 summarizes the monthly usage data.

Table 2. Dehumidifier Monthly Usage (Hours of Operation)

Source	Jan–Mar	Apr	May	June	July	Aug	Sept	Oct	Nov–Dec	Annual
AHAM Low	0	0	70	210	245	245	70	35	0	875
AHAM Mid	0	14	86	231	288	288	130	58	0	1095
AHAM High	0	37	110	256	329	329	183	73	0	1315
ADL*	0	0	180	360	360	360	180	180	0	1620
ENERGY STAR#	0	0	475	475	475	475	475	475	0	2851[1]
LBNL-High†	1080	360	360	360	360	360	360	360	720	4320

* Based on peak dehumidification period of three months (at 360 hours/month) with half the usage (180 hours/month) during the remaining three months.
#Based on six-month operation with 0.66 duty cycle.
†Monthly operation equal to ADL peak dehumidification period.

Because of the wide variation in estimated annual operating hours, it was decided to compare the various estimates with Wisconsin weather data on humidity from National Oceanic and Atmospheric Administration (NOAA)[x]. NOAA calculates an index from the outdoor humidity records, akin to heating and cooling degree days, referred to as the average latent cooling (drying) load (ALCL). It provides a measure of the raw energy necessary to reduce outside air humidity levels to indoor levels of 60 percent relative humidity at 75°F during the cooling season. While this index cannot be directly related to average dehumidifier operating hours due to complications from varying infiltration rates, internal moisture gains and contributions by air conditioning systems, it can provide a measure of seasonal demand. Table 3 summarizes the data available for Wisconsin.

Table 3. Average Latent Cooling (Drying) Load (BTU/cfm)

	Eau Claire	Green Bay	La Crosse	Madison	Milwaukee	WI Average
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	7	6	14	7	11	9
May	377	404	712	458	419	474
June	1667	1675	2876	1989	1905	2022.4
July	4475	4484	6680	5134	5366	5227.8
August	3587	4279	6051	4526	5366	4761.8
September	1085	1243	1871	1436	1820	1491
October	40	43	62	55	69	53.8
November	0	0	0	0	1	0.2
December	0	0	0	0	0	0

[1] This savings number is from the EERE LCC calculator spreadsheet for dehumidifiers. The URL is http://www1.eere.energy.gov/buildings/appliance_standards/residential/dehumidifiers.html. It provides a variety of usage scenarios.

Upon comparison (illustrated in Figure 1), it was observed that the dehumidification load in Wisconsin peaks more strongly in the summer that the estimated operating hours in Table 2 would indicate. To develop an estimate of operating hours for Wisconsin, we calculated the average of the peak, monthly operating hours of all the estimates (343 hours/month) and adjusted it monthly based on the Wisconsin average ALCL. The results of this calculation are shown in Table 4. From Table 4, daily operating hours for the peak month would be over 11 hours/day.

Figure 1. Dehumidification Demand

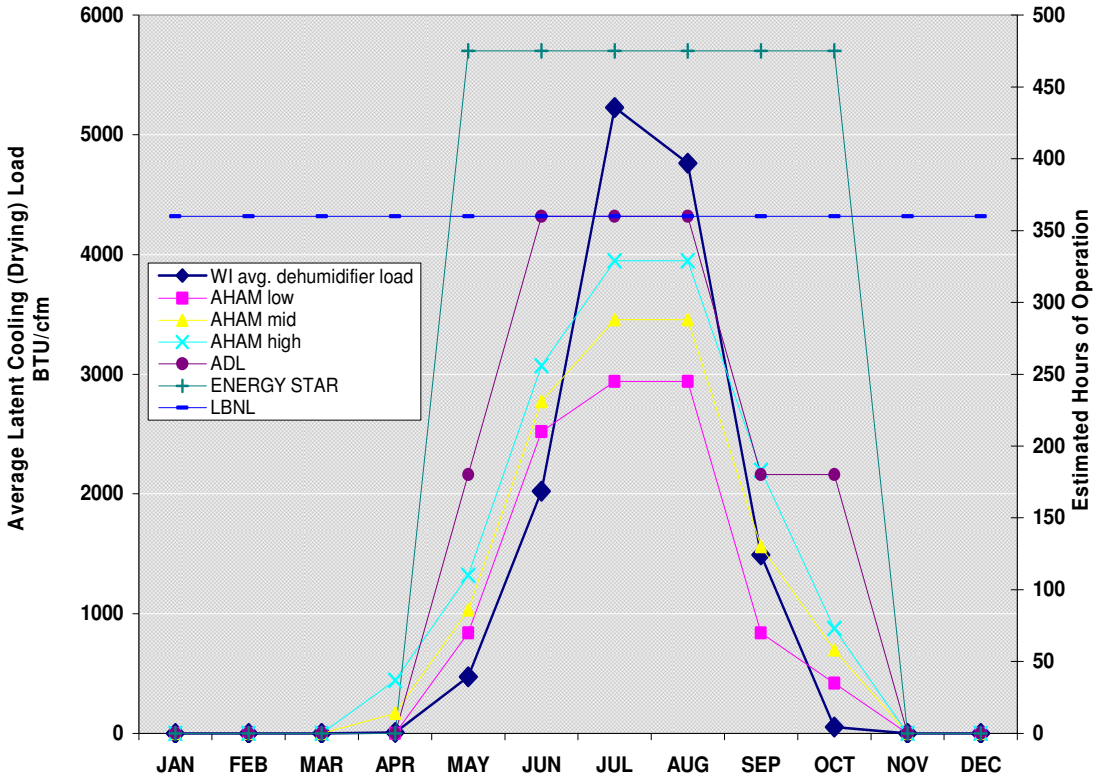

Table 4. Wisconsin Estimated Dehumidifier Operating Hours

	Wisconsin Average ALCL	% of Monthly Maximum Load	Climate-weighted Operating hours
January	0	0.0%	0
February	0	0.0%	0
March	0	0.0%	0
April	9	0.2%	1
May	474	9.1%	31
June	2022.4	38.7%	133
July	5227.8	100.0%	343
August	4761.8	91.1%	312
September	1491	28.5%	98
October	53.8	1.0%	4

	Wisconsin Average ALCL	% of Monthly Maximum Load	Climate-weighted Operating hours
November	0.2	0.0%	0
December	0	0.0%	0
Annual			**921**

This result falls within the range of the other estimates and agrees well with the findings of RECS 2005 that dehumidifiers are used an average 4.9 months a year in the East North Central region.

Average annual energy consumption

DOE based the annual energy consumption of a dehumidifier on the following equation:

DEH ENERGY = CAP ×(0.473/24) × Hours /Eff

where:

DEH *ENERGY* = Dehumidifier annual energy consumption (kWh/year),
CAP = Dehumidifier capacity (pints/day)
0.473 = Conversion factor for liters in a pint
24 = Number of hours in a day
Hours = Annual operating hours
Eff = Dehumidifier efficiency (liters/kWh).

DOE and ENERGY STAR consider six product classes of dehumidifiers based on their capacity. DOE based the market shares for each of these six product classes on data provided by AHAM[xi]

Table 5. Product Classes and Market Share of Dehumidifiers

	Product Class (pints/day)					
Year	**≤25.00**	**25.01–35.00**	**35.01–45.00**	**45.01–54.00**	**54.01–74.99**	**≥75.00**
2003	13.4%	21.3%	23.2%	21.8%	19.3%	1.0%
2005	10.0%	23.0%	23.4%	20.3%	22.3%	1.0%
2005	6.4%	25.7%	23.0%	20.5%	23.3%	1.0%
Average	**10.0%**	**23.4%**	**23.2%**	**20.9%**	**21.6%**	**1.0%**

Using DOE's equation and weighting each class by its market share, we obtain the results shown in Table 6 through Table 9 for the average annual energy consumption and demand savings of conventional and ENERGY STAR dehumidifiers.

Table 6. Average Annual Dehumidifier Energy Consumption: Conventional

Capacity Class	Average Capacity (L/day)	Annual Operating Hours	*Conventional* Unit Energy Factor[xii] (L/KWh)	Annual Energy Consumption (kWh/yr)	Market Share	Weighted Annual Energy Consumption (kWh/unit/year)
1–25 pints/day	9.5	921	1.10	330	10%	33
25–35 pints/day	14.2	921	1.20	456	23.4%	107
35–45 pints/day	18.9	921	1.20	605	23.2%	140
45–54 pints/day	23.4	921	1.23	730	20.9%	153
54–75 pints/day	30.5	921	1.55	755	21.6%	163
75–185 pints/day	61.5	921	1.90	1242	1.0%	12
					100%	**608**

Table 7. Average Annual Dehumidifier Energy Consumption: ENERGY STAR

Capacity Class	Average Capacity (L/day)	Annual Operating Hours	*ENERGY STAR* Unit Energy Factor[12] (L/KWh)	Annual Energy Consumption (kWh/yr)	Market Share	Weighted Annual Energy Consumption (kWh/unit/year)
1–25 pints/day	9.5	921	1.2	303	10%	30
25–35 pints/day	14.2	921	1.4	389	23.4%	91
35–45 pints/day	18.9	921	1.5	484	23.2%	112
45–54 pints/day	23.4	921	1.6	562	20.9%	117
54–75 pints/day	30.5	921	1.6	732	21.6%	158
75–185 pints/day	61.5	921	2.5	944	1.0%	9
					100%	**518**

Table 8. Average Annual Dehumidifier Demand: Conventional

Capacity Class	Average Capacity (L/day)	*Conventional* Unit Energy Factor (L/KWh)	Power Consumption kW	Market Share	Weighted Power Consumption, kW
1–25 pints/day	9.5	1.10	0.358	10%	0.036
25–35 pints/day	14.2	1.20	0.495	23.40%	0.116
35–45 pints/day	18.9	1.20	0.657	23.20%	0.152
45–54 pints/day	23.4	1.23	0.793	20.90%	0.166
54–75 pints/day	30.5	1.55	0.820	21.60%	0.177
75–185 pints/day	61.5	1.90	1.348	1.00%	0.013
				100%	0.660

Table 9. Average Annual Dehumidifier Demand: ENERGY STAR

Capacity Class	Average Capacity (L/day)	*ENERGY STAR* Unit Energy Factor (L/KWh)	Power Consumption kW	Market Share	Weighted Power Consumption, kW
1–25 pints/day	9.5	1.2	0.328	10%	0.033
25–35 pints/day	14.2	1.4	0.422	23.40%	0.099
35–45 pints/day	18.9	1.5	0.526	23.20%	0.122
45–54 pints/day	23.4	1.6	0.610	20.90%	0.127
54–75 pints/day	30.5	1.6	0.794	21.60%	0.172
75–185 pints/day	61.5	2.5	1.025	1.00%	0.010
				100%	0.563

The difference between the conventional and ENERGY STAR results, **90 kWh/yr and 0.098 kW/unit**, provides the evaluation team's best estimate of deemed energy and demand savings for replacement ENERGY STAR dehumidifiers for the program without specific program data. We realize that this estimate may be conservative. We recommend that the program implementer collect a large enough sample of nameplate power consumption and capacity data from the old units that are replaced to develop a more accurate baseline[2].

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[i] Energy Information Administration, *2005 Residential Energy Consumption Survey*, September 2008.

[ii] U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment*, November 2007.

[iii] A. Meier, L. Rainer, S. Greenberg, "Miscellaneous Electrical Energy Use in Homes," *Energy*, Vol. 17, No. 5: pp. 509–518, 1992.

[iv] R. Zogg and D. Alberino, *Electricity Consumption by Small End Uses in Residential Buildings: Final Report*, Report to the Office of Building Equipment, U.S. Department of Energy, 1998.

[v] M. McWhinney, A. Fanara, R. Clark, C. Hershberg, R. Schmeltz, J. Roberson, "ENERGY STAR Product Specification Development Framework: Using Data and Analysis to Make Program Decisions," *Energy Policy*, 33 (2005): pp. 1613–1625, 2005.

[vi] Energy Center of Wisconsin. *Energy Efficiency and Customer-sited Renewable Energy: Achievable Potential in Wisconsin 2006–2015. Volume II: Technical Appendix,* ECW Report Number 236-2, November 2005.

[vii] Personal Communication. John Davoulis, Central Maine Power Company. Telephone call with Lawrence Berkeley National Laboratory, March 1, 2006.

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[2] Nearly all dehumidifiers have some form of humidistat. If used, it would not operate continuously. If the only control is a full bucket, it still will not operate continuously since most households do not monitor their buckets continuously.

[viii] U.S. Environmental Protection Agency and U.S. Department of Energy, ENERGY STAR. *Qualified Appliance Savings Fact Sheets, Inputs*, 2006. <http://www.energystar.gov/ia/partners/manuf_res/SavingFactSheets_backup_calcs.pdf> Accessed March 8, 2006.

[ix] U.S. Environmental Protection Agency and U.S. Department of Energy, ENERGY STAR. *Savings Calculator – Dehumidifiers (Assumptions)*, 2006.

[x] U.S. Department of Commerce, National Climatic Data Center*, Engineering Weather Data Products*, December 1999.

[xi] Association of Home Appliance Manufacturers. *AHAM Data on Dehumidifiers for Efficiency Standards Rulemaking*, Letter to Building Technologies Program, U.S. Department of Energy, August 23, 2006.

[xii] U.S. Environmental Protection Agency and U.S. Department of Energy, ENERGY STAR. *Savings Calculator – Dehumidifiers (Assumptions)*, 2008.