

Field Testing of Conventional and High Velocity

Electric Hand Dryers

Statewide Emerging Technologies

Final Report



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Project Management

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Executive Summary

This study provides an energy savings comparison of five different types of hand dryers: standard manual, energy efficient manual, standard automatic, energy efficient automatic and high velocity automatic.

A standard automatic hand dryer and a high velocity hand dryer were installed in the men's and women's rooms, respectively, at the Customer Technology Application Center's main conference facility in Irwindale, California. Monitoring equipment was installed in these systems to track the average drying cycle.

Through this study, it was determined that individuals typically spent 17 seconds drying their hands with the standard automatic unit and 14 seconds using the high velocity unit. This means that a full 13 to 26 seconds of energy consumed by a standard manual unit is wasted due to the unit's fixed 30 to 40-second drying cycle.

To determine energy savings, an energy use profile was developed with data from two standard manual hand dryers located at a Taco Bell restaurant. One year's worth of monitoring data, captured at 15-minute intervals was segmented based on time of use and season, to determine true energy costs.

Table 1 compares the demand, drying cycle length, energy usage in kWh per 1,000 drying cycles and differential cost of each unit.

Dryer Model	Demand (kW) Connect Load	Length of Drying Cycle	Consumption (kWh per 1,000 Cycles)	Incremental Cost
Standard manual	2.2	30 - 40 sec (mfg data)		N/A
Energy efficient manual	1.5	30 - 40		N/A
Standard automatic	2.2	17 sec		\$26.80
Energy efficient automatic	1.5	Not Tested		N/A
High velocity automatic	1.5	14 sec		\$67.50

The study concluded that although the high velocity unit is most energy efficient, replacing the standard manual unit with a standard automatic unit provides the greatest energy savings at the lowest incremental cost.

Introduction

Public restrooms, such as those found in restaurants, airports, and rest-areas, typically provide cloth towels, paper towels or electric hand dryers for drying people's hands. Several studies have compared the various hand drying methods. The studies show that warm air hand drying units are the most effective in providing the greatest reduction in bacteria counts from pre-wash to post-dry.^{1,2} Hand dryers also have the lowest operating cost in comparison with paper towels and other methods. The average cost of hand dryers is less than \$0.50 per 1000 drying cycles compared to \$2.50/1000 drying cycles for paper.³

Electric hand dryers have been in the market for several decades. They are usually installed in public restrooms, and bathrooms in commercial and industrial buildings. There are five different types of hand dryers:

Standard manual dryers blow warm air over wet hands so that the water is evaporated. These units dryers typically contain a brushless motor which operates at between 120 and 240 volts, between 10 and 20 amps, from 1500 to 2000 watts, and in a 30- to 40-second drying cycle. Typically the unit draws 2.0 to 2.2 kW. The standard manual unit's drying cycle is fixed and is activated by the user pushing a button.

The standard automatic unit operates at the same voltage, amperage and wattage as its manual counterpart. The unit is controlled by an infrared sensor, however, to shut off automatically when a user is finished.

Energy efficient units exist in the marketplace, which reduce wattage to 1000 at 120 volts and 8 amps. They either operate with a fixed drying cycle or are sensor-driven to stop automatically.

As the name implies, a high velocity hand dryer works by blowing loose water droplets off hands with a high velocity air stream to dry them in 12 to 15 seconds. This unit draws only 1500 watts, instead of the usual 2000 to 2000 used by conventional manual units. One of the latest models, Xlerator™, produced by Excel Dryer, Inc., uses very little heat to dry the hands. The total connect load for this unit is only 1.5 kW.

Technical Approach

Field Monitoring

Since manually operated hand dryers have a preset drying cycle time, typically 30 to 40 seconds, the energy consumed for each drying cycle is easily calculated. For this reason, these energy calculations were not included in field testing. As for automatic hand dryers, the drying cycle depends on the user. The length of the drying cycle is a combination of how quickly the unit can remove hand moisture and the patience of the user. Most users dry their hands for roughly 15 to 20 seconds. To determine the average drying cycle, an automatic conventional hand dryer and a high velocity hand dryer were installed in the men's room and women's rooms of the Customer Technology Application Center (CTAC). The electric power drawn by each unit was measured at installation. Monitoring equipment was installed inside the units to track the duration of

each drying cycle. The hand dryers were monitored from October 1, 2002 to May 2, 2003.

The raw data showed that some drying cycles only lasted 2 – 3 seconds. After some investigation, it was noted that on occasion the hand dryers were activated by people walking too close to the unit. To eliminate this error, any cycles that were less than 5 seconds were considered bad data and eliminated from the data set. A total of 2126 data points were used in the averaging calculations. The results show that the average drying cycle for the conventional automatic hand dryer was 17 seconds, and for the high velocity hand dryer was 14 seconds.

Usage Profile

To determine the energy savings, the use profile of the hand dryer must be understood. In advance of this study, the energy usage of hand dryers installed at one Taco Bell restaurant were monitored for over a year. ⁴ There is one hand dryer in each restroom. These hand dryers are Model WA126002A manufactured by World Dryer and are push-button operated. They are rated at 120 Volts, 13 amps, 1.5 kW with 30 second drying cycle. A week of data was selected as typical weekly profiles for each season. The electrical consumption was also separated into the various time-of-use (TOU) periods, namely the summer on-peak, summer mid-peak, summer off-peak, winter mid-peak, and winter off-peak. They are presented in Tables 2 through 4. Determining time of use periods of electrical consumption is important to gain a true picture of market segment and usage. This information is valuable to calculate the benefit ratio for each equipment type.

To develop the energy usage profile, it is necessary to know the energy usage in each of the TOU periods. The number of drying cycles in each TOU period is equal to the total power consumption in each period divided by the energy consumption for one drying cycle.

Table 1
Typical Spring Load Profile for Hand Dryer, kWh

Time	05/09/98	05/10/98	05/11/98	05/12/98	05/13/98	05/14/98	05/15/98	Winter		
	Sat	Sun	Mon	Tue	Wed	Thur	Fri	Mid-Peak	Off-Peak	Total
0:00	0	0	0	0	0	0	0		0	0
0:15	0	0	0	0	0	0	0		0	0
0:30	0	0	0	0	0	0	0		0	0
0:45	0	0	0	0	0	0	0		0	0
1:00	0	0	0	0	0	0	0		0	0
1:15	0	0	0	0	0	0	0		0	0
1:30	0	0	0	0	0	0	0		0	0
1:45	0	0	0	0	0	0	0		0	0
2:00	0	0	0	0	0	0	0		0	0
2:15	0	0	0	0	0	0	0		0	0
2:30	0	0	0	0	0	0	0		0	0
2:45	0	0	0	0	0	0	0		0	0
3:00	0	0	0	0	0	0	0		0	0
3:15	0	0	0	0	0	0	0		0	0
3:30	0	0	0	0	0	0	0		0	0
3:45	0	0	0	0	0	0	0		0	0
4:00	0	0	0	0	0	0	0		0	0
4:15	0	0	0	0	0	0	0		0	0
4:30	0	0	0	0	0	0	0		0	0
4:45	0	0	0	0	0	0	0		0	0
5:00	0	0	0	0	0	0	0		0	0
5:15	0	0	0	0	0	0	0		0	0
5:30	0	0	0	0	0	0	0		0	0
5:45	0	0	0	0	0	0	0		0	0
6:00	0	0	0	0	0	0	0		0	0
6:15	0	0	0	0.068019	0	0	0		0.068019	0.068019
6:30	0	0	0.069654	0	0	0	0		0.069654	0.069654
6:45	0	0	0	0	0	0	0		0	0
7:00	0	0	0	0	0	0	0		0	0
7:15	0.068837	0	0	0	0	0	0		0.068837	0.068837
7:30	0	0	0	0	0	0	0.071616		0.071616	0.071616
7:45	0	0	0	0	0	0	0		0	0
8:00	0.067038	0	0	0	0	0.068183	0	0.068183	0.067038	0.135221
8:15	0	0	0	0	0	0	0.069654	0.069654	0	0.069654
8:30	0.066875	0	0	0.06851	0	0	0	0.06851	0.066875	0.135384
8:45	0	0	0.139145	0	0	0	0.20373	0.342875	0	0.342875
9:00	0.138	0	0.13473	0.068346	0.067856	0	0	0.270932	0.138	0.408932
9:15	0.070145	0	0.076194	0	0.139145	0	0	0.215339	0.070145	0.285484
9:30	0	0	0	0.071289	0	0	0	0.071289	0	0.071289
9:45	0	0.069818	0	0.067856	0.068183	0.212233	0.070799	0.419069	0.069818	0.488887
10:00	0	0.067529	0	0	0	0	0	0	0.067529	0.067529
10:15	0	0.074886	0	0	0.073088	0	0	0.073088	0.074886	0.147974
10:30	0	0	0.066875	0.069	0	0.068019	0.067692	0.271586	0	0.271586
10:45	0.069164	0.067692	0.066875	0	0.077993	0.141434	0.068837	0.355138	0.136856	0.491994
11:00	0	0	0.152389	0.136856	0.130806	0	0.138981	0.559032	0	0.559032
11:15	0	0	0.183782	0.073905	0.067856	0	0	0.325543	0	0.325543
11:30	0	0.068673	0	0	0.138164	0	0.326034	0.464198	0.068673	0.532871
11:45	0	0.076685	0.069654	0	0.068837	0	0	0.138491	0.076685	0.215176

Field Testing of Conventional and High Velocity Hand Dryers



Table 1 (Continue)
Typical Spring Load Profile for Hand Dryer, kWh

Time	05/09/98	05/10/98	05/11/98	05/12/98	05/13/98	05/14/98	05/15/98
	Sat	Sun	Mon	Tue	Wed	Thur	Fri
12:00	0	0.132441	0.066875	0.066384	0.136856	0	0
12:15	0.072107	0.138491	0.133422	0	0	0.134403	0
12:30	0.068673	0	0.13424	0.270768	0.139962	0.337479	0
12:45	0	0.069491	0	0	0	0.077666	0.069491
13:00	0.21583	0.069491	0.138491	0.066384	0.066384	0	0.066057
13:15	0	0	0	0.143069	0.07505	0.067692	0
13:30	0.491667	0	0.067856	0	0	0.137183	0.068837
13:45	0.212396	0	0	0.129661	0.272403	0	0.139145
14:00	0.219263	0	0.215666	0.012263	0	0.068673	0.078647
14:15	0	0.07227	0	0.196209	0	0.007521	0
14:30	0.220408	0.070472	0	0.068183	0	0.061642	0.211742
14:45	0.131787	0	0	0	0	0	0
15:00	0	0	0.077993	0	0.066548	0.069164	0
15:15	0	0	0	0.069654	0	0	0
15:30	0.07178	0	0	0.069327	0.06851	0.070635	0.140126
15:45	0	0.213214	0.142251	0	0	0.156967	0
16:00	0	0	0.068837	0	0	0.139472	0
16:15	0	0	0	0.069327	0	0.142905	0
16:30	0	0	0	0	0	0	0
16:45	0	0	0	0	0	0	0
17:00	0.070472	0	0	0	0	0	0
17:15	0	0	0	0	0	0.140943	0
17:30	0.06851	0	0	0	0.138	0	0.069164
17:45	0	0	0.073742	0	0	0	0
18:00	0	0	0	0.070308	0	0	0
18:15	0.042185	0	0.069164	0.068346	0.202586	0	0
18:30	0.028777	0	0	0	0	0.069654	0.135711
18:45	0	0	0	0.070308	0	0	0
19:00	0	0	0	0.068019	0	0	0
19:15	0.066384	0	0	0	0.069654	0.132604	0
19:30	0	0	0	0	0.066384	0	0
19:45	0	0	0	0	0.609229	0	0
20:00	0	0	0	0	0	0	0.074396
20:15	0	0	0.066057	0	0.035318	0	0.133586
20:30	0.068346	0	0	0	0.098595	0	0.142578
20:45	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0.137019
21:15	0	0	0	0.06851	0	0	0
21:30	0	0.068019	0	0	0	0	0
21:45	0	0	0	0	0	0	0
22:00	0	0	0.001308	0	0	0	0
22:15	0	0	0.068837	0	0	0	0
22:30	0	0	0.068673	0	0	0	0
22:45	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0
23:15	0	0	0	0	0	0	0
23:30	0	0	0	0	0	0	0
23:45	0	0	0	0	0	0	0
Total	2.528642	1.25917	2.352708	2.130501	2.877403	2.304473	2.483841

Winter		
Mid-Peak	Off-Peak	Total
0.270114	0.132441	0.402555
0.267825	0.210598	0.478423
0.882449	0.068673	0.951123
0.147157	0.069491	0.216647
0.337316	0.28532	0.622636
0.285811	0	0.285811
0.273875	0.491667	0.765542
0.541209	0.212396	0.753606
0.375249	0.219263	0.594513
0.20373	0.07227	0.276
0.341567	0.29088	0.632447
0	0.131787	0.131787
0.213704	0	0.213704
0.069654	0	0.069654
0.348598	0.07178	0.420378
0.299219	0.213214	0.512432
0.208308	0	0.208308
0.212233	0	0.212233
0	0	0
0	0	0
0	0.070472	0.070472
0.140943	0	0.140943
0.207164	0.06851	0.275673
0.073742	0	0.073742
0.070308	0	0.070308
0.340095	0.042185	0.38228
0.205365	0.028777	0.234143
0.070308	0	0.070308
0.068019	0	0.068019
0.202259	0.066384	0.268643
0.066384	0	0.066384
0.609229	0	0.609229
0.074396	0	0.074396
0.23496	0	0.23496
0.241173	0.068346	0.30952
0	0	0
	0.137019	0.137019
	0.06851	0.06851
	0.068019	0.068019
	0	0
	0.001308	0.001308
	0.068837	0.068837
	0.068673	0.068673
	0	0
	0	0
	0	0
	0	0
11.59529	4.341448	15.93674

Field Testing of Conventional and High Velocity Hand Dryers



Table 2
Typical Summer Load Profile for Hand Dryer, kWh

Time	08/07/98	08/08/98	08/09/98	08/10/98	08/11/98	08/12/98	08/13/98	Summer			
	Fri	Sat	Sun	Mon	Tue	Wed	Thur	On-Peak	Mid-Peak	Off-Peak	Total
0:00	0	0	0	0	0	0	0			0	0
0:15	0	0	0	0	0	0	0			0	0
0:30	0	0	0	0	0	0	0			0	0
0:45	0	0	0	0	0	0	0			0	0
1:00	0	0	0	0	0	0	0			0	0
1:15	0	0	0	0	0	0	0			0	0
1:30	0	0	0	0	0	0	0			0	0
1:45	0	0	0	0	0	0	0			0	0
2:00	0	0	0	0	0	0	0			0	0
2:15	0	0	0	0	0	0	0			0	0
2:30	0	0	0	0	0	0	0			0	0
2:45	0	0	0	0	0	0	0			0	0
3:00	0	0	0	0	0	0	0			0	0
3:15	0	0	0	0	0	0	0			0	0
3:30	0	0	0	0	0	0	0			0	0
3:45	0	0	0	0	0	0	0			0	0
4:00	0	0	0	0	0	0	0			0	0
4:15	0	0	0	0	0	0	0			0	0
4:30	0	0	0	0	0	0	0			0	0
4:45	0	0	0	0	0	0	0			0	0
5:00	0	0	0	0	0	0	0			0	0
5:15	0	0	0	0	0	0	0			0	0
5:30	0	0	0	0	0	0	0			0	0
5:45	0	0	0	0	0	0	0			0	0
6:00	0	0	0	0	0	0	0			0	0
6:15	0	0	0	0	0	0	0			0	0
6:30	0.073578	0	0	0	0	0	0			0.073578	0.073578
6:45	0	0	0	0	0	0	0.06622			0.06622	0.06622
7:00	0	0	0	0	0	0	0			0	0
7:15	0.118706	0.069491	0	0	0	0	0			0.188197	0.188197
7:30	0.088621	0	0	0.067365	0	0	0.068019			0.224005	0.224005
7:45	0.067529	0	0	0	0	0	0			0.067529	0.067529
8:00	0	0	0	0.135384	0	0	0			0.135384	0.135384
8:15	0	0.065566	0	0	0	0.067365	0			0.067365	0.132932
8:30	0	0.131623	0.074069	0.067529	0	0.071453	0			0.138981	0.344674
8:45	0	0	0	0.06622	0	0	0			0.06622	0.06622
9:00	0	0	0	0	0	0	0			0	0
9:15	0	0	0	0	0	0.068183	0			0.068183	0.068183
9:30	0	0.063931	0	0	0	0	0			0.063931	0.063931
9:45	0.066875	0.064585	0	0.064258	0.136202	0.129171	0.063931			0.460437	0.525022
10:00	0	0	0.065566	0.064258	0	0.066711	0.064912			0.195882	0.261448
10:15	0	0	0.133259	0	0	0.125574	0.06295			0.188524	0.321783
10:30	0	0.001472	0.071616	0	0	0.063277	0.195064			0.258342	0.331429
10:45	0.073742	0.062133	0	0.129007	0	0	0.064749			0.267498	0.329631
11:00	0	0.063441	0	0	0.318839	0	0			0.318839	0.38228
11:15	0.06622	0	0.063277	0	0.130152	0	0.185744			0.382117	0.445394
11:30	0.136529	0	0	0	0	0	0			0.136529	0.136529
11:45	0	0.278944	0	0.204221	0.071943	0.134567	0.019948			0.430678	0.709622

Table 3
Typical Fall Load Profile for Hand Dryer, kWh

Time	11/05/97	11/06/97	11/07/97	11/08/97	11/09/97	11/10/97	11/11/97	Winter		
	wed	Thur	Fri	Sat	Sun	Mon	Tue	Mid-Peak	Off-Peak	Total
0:00	0	0	0	0	0	0	0		0	0
0:15	0	0	0	0	0	0	0		0	0
0:30	0	0	0	0	0	0	0		0	0
0:45	0.076521	0	0	0	0	0	0		0.076521	0.076521
1:00	0	0	0	0	0	0	0		0	0
1:15	0	0	0	0	0	0	0		0	0
1:30	0	0	0	0	0	0	0		0	0
1:45	0	0	0	0	0	0	0		0	0
2:00	0	0	0	0	0	0	0		0	0
2:15	0	0	0	0	0	0	0		0	0
2:30	0	0	0	0	0	0	0		0	0
2:45	0	0	0	0	0	0	0		0	0
3:00	0	0	0	0	0	0	0		0	0
3:15	0	0	0	0	0	0	0		0	0
3:30	0	0	0	0	0	0	0		0	0
3:45	0	0	0	0	0	0	0		0	0
4:00	0	0	0	0	0	0	0		0	0
4:15	0	0	0	0	0	0	0		0	0
4:30	0	0	0	0	0	0	0		0	0
4:45	0	0	0	0	0	0	0		0	0
5:00	0	0	0	0	0	0	0		0	0
5:15	0	0	0	0	0	0	0		0	0
5:30	0	0	0	0	0	0	0		0	0
5:45	0	0	0	0	0	0	0		0	0
6:00	0	0	0	0	0	0	0		0	0
6:15	0	0	0	0	0	0	0		0	0
6:30	0	0	0	0	0	0	0		0	0
6:45	0.002453	0	0	0	0	0	0		0.002453	0.002453
7:00	0.066057	0	0.074723	0	0	0	0		0.14078	0.14078
7:15	0	0	0.068837	0	0	0	0		0.068837	0.068837
7:30	0	0	0	0	0	0	0		0	0
7:45	0	0	0	0	0	0.144868	0		0.144868	0.144868
8:00	0	0	0	0	0	0	0	0	0	0
8:15	0	0	0	0	0	0	0	0	0	0
8:30	0	0	0	0	0	0	0.069491	0.069491	0	0.069491
8:45	0	0	0	0	0	0	0	0	0	0
9:00	0	0	0	0	0	0	0	0	0	0
9:15	0	0	0	0	0	0	0	0	0	0
9:30	0	0.070145	0	0	0	0	0	0.070145	0	0.070145
9:45	0	0	0	0.135057	0	0	0	0	0.135057	0.135057
10:00	0	0.067692	0	0	0	0.069	0.141434	0.278126	0	0.278126
10:15	0.070472	0	0.069818	0	0	0.069654	0	0.209943	0	0.209943
10:30	0	0.068346	0	0	0	0	0.068346	0.136692	0	0.136692
10:45	0	0.009156	0	0	0	0	0	0.009156	0	0.009156
11:00	0	0.126064	0	0.072924	0	0	0	0.126064	0.072924	0.198988
11:15	0.066548	0	0.072924	0	0	0	0.068346	0.207818	0	0.207818
11:30	0.069164	0	0	0.072434	0	0.140616	0	0.20978	0.072434	0.282214
11:45	0.138	0	0	0.135711	0	0.136856	0.135221	0.410077	0.135711	0.545788

Field Testing of Conventional and High Velocity Hand Dryers



Table 2 (Continue)
Typical Summer Load Profile for Hand Dryer, kWh

Time	08/07/98	08/08/98	08/09/98	08/10/98	08/11/98	08/12/98	08/13/98	Summer			
	Fri	Sat	Sun	Mon	Tue	Wed	Thur	On-Peak	Mid-Peak	Off-Peak	Total
12:00	0.199316	0.065076	0	0.069327	0.259159	0.062623	0.307394	0.897819		0.065076	0.962895
12:15	0.067202	0.065239	0.126718	0	0.504584	0	0	0.571785		0.191958	0.763743
12:30	0.065566	0.051178	0	0	0.007031	0	0	0.072597		0.051178	0.123775
12:45	0	0.080446	0	0.188851	0	0	0	0.188851		0.080446	0.269297
13:00	0.066875	0.128844	0.064422	0	0.125901	0	0.125901	0.318676		0.193266	0.511942
13:15	0.066711	0.196536	0.07178	0.127209	0.131623	0	0	0.325543		0.268316	0.593859
13:30	0.129171	0	0.056247	0.063931	0.129498	0.061152	0	0.383752		0.056247	0.439998
13:45	0	0.196699	0.006704	0.134076	0.063277	0.180839	0	0.378193		0.203403	0.581596
14:00	0.062296	0	0.125901	0.133749	0.064585	0	0	0.260631		0.125901	0.386531
14:15	0.202095	0.119524	0	0	0	0	0	0.202095		0.119524	0.321619
14:30	0.12819	0.209126	0.067038	0.068019	0.064422	0	0	0.260631		0.276164	0.536795
14:45	0.065076	0	0.062787	0	0	0	0	0.065076		0.062787	0.127863
15:00	0	0	0	0	0.061315	0	0	0.061315		0	0.061315
15:15	0	0	0.125901	0.061806	0	0	0.127045	0.188851		0.125901	0.314752
15:30	0.068346	0.142742	0	0.127372	0	0	0	0.195718		0.142742	0.33846
15:45	0	0	0	0	0	0.12165	0	0.12165		0	0.12165
16:00	0	0.067365	0.06851	0	0	0	0	0		0.135875	0.135875
16:15	0	0	0	0	0.127045	0	0	0.127045		0	0.127045
16:30	0.066384	0.067038	0.199479	0	0	0	0	0.066384		0.266517	0.332901
16:45	0	0.127863	0	0	0.252128	0.064585	0	0.316714		0.127863	0.444577
17:00	0.067856	0	0	0	0.198825	0	0	0.266681		0	0.266681
17:15	0	0	0.065076	0	0	0	0	0		0.065076	0.065076
17:30	0	0	0	0	0	0	0	0		0	0
17:45	0	0	0.068673	0	0.074723	0.132932	0.051014	0.258669		0.068673	0.327342
18:00	0	0	0.065239	0.067529	0	0	0.012917		0.080446	0.065239	0.145685
18:15	0.067365	0	0	0	0	0	0		0.067365	0	0.067365
18:30	0	0	0	0	0.10301	0	0.064585		0.167595	0	0.167595
18:45	0.07505	0.129825	0	0	0.220081	0.065239	0		0.36037	0.129825	0.490195
19:00	0	0	0	0.12819	0.129498	0	0.161218		0.418906	0	0.418906
19:15	0	0	0	0.258669	0.064095	0	0.03172		0.354484	0	0.354484
19:30	0.068346	0	0	0.064912	0.064749	0	0.072761		0.270768	0	0.270768
19:45	0	0.128517	0.06246	0	0	0	0.064585		0.064585	0.190977	0.255562
20:00	0	0.027142	0.064422	0	0	0	0.064095		0.064095	0.091564	0.155659
20:15	0	0.099249	0	0	0	0	0		0	0.099249	0.099249
20:30	0.070799	0	0	0	0	0.132441	0		0.20324	0	0.20324
20:45	0	0	0	0	0	0	0		0	0	0
21:00	0	0.073905	0	0.065893	0.066548	0.204384	0.131787		0.468612	0.073905	0.542518
21:15	0.067038	0	0.064258	0	0	0	0		0.067038	0.064258	0.131296
21:30	0	0.400266	0	0	0	0	0		0	0.400266	0.400266
21:45	0	0	0	0	0	0	0.065893		0.065893	0	0.065893
22:00	0	0	0	0	0	0	0		0	0	0
22:15	0	0	0	0	0	0	0		0	0	0
22:30	0	0	0	0	0	0	0		0	0	0
22:45	0	0	0	0	0	0	0		0	0	0
23:00	0	0	0	0	0	0	0.066875			0.066875	0.066875
23:15	0	0	0	0	0	0	0			0	0
23:30	0	0	0	0	0	0	0.067038			0.067038	0.067038
23:45	0	0	0	0	0	0	0			0	0
Total	2.29548	3.177766	1.773401	2.357777	3.369233	1.752145	2.206369	5.528676	5.768377	5.635119	16.93217

Table 3 (Continue)
Typical Fall Load Profile for Hand Dryer, kWh

Time	11/05/97	11/06/97	11/07/97	11/08/97	11/09/97	11/10/97	11/11/97	Winter		
	wed	Thur	Fri	Sat	Sun	Mon	Tue	Mid-Peak	Off-Peak	Total
12:00	0	0	0.066548	0.069491	0.077666	0.135875	0	0.202422	0.147157	0.349579
12:15	0.192775	0.064585	0.203403	0.134567	0	0.076358	0.142578	0.6797	0.134567	0.814267
12:30	0.007358	0.06622	0.135057	0	0	0.13751	0	0.346145	0	0.346145
12:45	0.136529	0.067692	0.140453	0.069654	0	0	0.068837	0.41351	0.069654	0.483164
13:00	0	0.13146	0	0	0.139308	0.209943	0.134567	0.47597	0.139308	0.615278
13:15	0.067365	0	0.066057	0.113311	0.139472	0.135711	0.067856	0.336989	0.252782	0.589771
13:30	0	0	0.204221	0.235451	0	0.205202	0	0.409423	0.235451	0.644873
13:45	0.07178	0	0.130642	0	0.067856	0	0.140126	0.342548	0.067856	0.410404
14:00	0.067365	0.198498	0.131296	0	0.072761	0	0.136529	0.533688	0.072761	0.606449
14:15	0	0.201932	0	0.067692	0	0.069981	0	0.271913	0.067692	0.339605
14:30	0.066384	0	0	0.070472	0	0	0.135711	0.202095	0.070472	0.272567
14:45	0.066384	0.133586	0.067692	0.13424	0	0.06851	0.136856	0.473027	0.13424	0.607266
15:00	0	0	0	0	0.071453	0.068019	0.14078	0.208799	0.071453	0.280252
15:15	0	0	0.138818	0.067529	0	0	0.067692	0.20651	0.067529	0.274038
15:30	0.069981	0	0	0.208635	0	0	0.096142	0.166124	0.208635	0.374759
15:45	0.070472	0.140289	0.068019	0	0.070308	0.068019	0.039896	0.386695	0.070308	0.457003
16:00	0	0.13424	0	0	0	0.071616	0.219754	0.42561	0	0.42561
16:15	0.068837	0.065893	0.076358	0.068019	0.069	0.070472	0	0.28156	0.137019	0.418579
16:30	0.023872	0.136038	0	0	0.277636	0	0	0.15991	0.277636	0.437546
16:45	0.113474	0	0	0	0	0	0	0.113474	0	0.113474
17:00	0	0	0	0.064912	0.073251	0	0	0	0.138164	0.138164
17:15	0	0.067529	0	0.073088	0.076194	0.077175	0	0.144704	0.149282	0.293986
17:30	0.067692	0.071453	0.136856	0	0.139635	0.074396	0.139308	0.489705	0.139635	0.62934
17:45	0	0	0	0.206183	0	0	0	0	0.206183	0.206183
18:00	0	0.20373	0	0	0	0	0.145522	0.349252	0	0.349252
18:15	0	0	0.132441	0	0	0	0	0.132441	0	0.132441
18:30	0	0.402065	0	0	0	0	0.066875	0.468939	0	0.468939
18:45	0	0	0	0	0	0	0.066057	0.066057	0	0.066057
19:00	0.070308	0	0	0	0.139145	0	0	0.070308	0.139145	0.209453
19:15	0.132932	0	0	0	0.073415	0	0	0.132932	0.073415	0.206346
19:30	0	0	0.069327	0.130806	0.133913	0	0	0.069327	0.264718	0.334046
19:45	0	0	0	0	0.000327	0.000818	0.069	0.069818	0.000327	0.070145
20:00	0	0	0	0.069981	0.066711	0.135548	0	0.135548	0.136692	0.27224
20:15	0	0	0	0	0	0.068183	0.135221	0.203403	0	0.203403
20:30	0	0	0	0	0	0.28205	0	0.28205	0	0.28205
20:45	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0.069327	0	0.207164	0	0	0	0.276491	0.276491
21:15	0	0	0.134403	0	0	0	0	0	0.134403	0.134403
21:30	0.066875	0	0	0	0.069	0	0	0	0.135875	0.135875
21:45	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0.071453	0	0	0.071453	0.071453
22:15	0	0	0	0	0	0	0	0	0	0
22:30	0	0	0	0	0	0.070799	0	0	0.070799	0.070799
22:45	0.074232	0	0	0	0.067856	0.072107	0	0	0.214195	0.214195
23:00	0	0	0	0	0	0	0	0	0	0
23:15	0	0	0	0	0	0	0	0	0	0
23:30	0	0	0	0	0	0	0	0	0	0
23:45	0	0	0	0	0	0	0	0	0	0
Total	1.923828	2.426613	2.25722	2.200156	2.03207	2.730737	2.632142	10.97789	5.224879	16.20277

Field Testing of Conventional and High Velocity Hand Dryers



Table 4
Typical Winter Load Profile for Hand Dryer, kWh

Time	02/04/98	02/05/98	02/06/98	02/07/98	02/08/98	02/09/98	02/10/98	Winter		
	Wed	Thur	Fri	Sat	Sun	Mon	Tue	Mid-Peak	Off-Peak	Total
0:00	0	0	0	0	0	0	0		0	0
0:15	0	0	0	0	0	0	0		0	0
0:30	0	0	0	0	0	0	0		0	0
0:45	0	0	0	0	0	0	0		0	0
1:00	0	0	0	0	0	0	0		0	0
1:15	0	0	0	0	0	0	0		0	0
1:30	0	0	0	0	0	0	0		0	0
1:45	0	0	0	0.071943	0	0	0		0.071943	0.071943
2:00	0	0	0	0	0	0	0		0	0
2:15	0	0	0	0	0	0	0		0	0
2:30	0	0	0	0	0	0	0		0	0
2:45	0	0	0	0	0	0	0		0	0
3:00	0	0	0	0	0	0	0		0	0
3:15	0	0	0	0	0	0	0		0	0
3:30	0	0	0	0	0	0	0		0	0
3:45	0	0	0	0	0	0	0		0	0
4:00	0	0	0	0	0	0	0		0	0
4:15	0	0	0	0	0	0	0		0	0
4:30	0	0	0	0	0	0	0		0	0
4:45	0	0	0	0	0	0	0		0	0
5:00	0	0	0	0	0	0	0		0	0
5:15	0	0	0	0	0	0	0		0	0
5:30	0	0	0	0	0	0	0		0	0
5:45	0	0	0	0	0	0	0		0	0
6:00	0	0	0	0	0	0	0		0	0
6:15	0	0	0	0	0	0	0		0	0
6:30	0	0	0	0	0	0	0		0	0
6:45	0	0	0	0	0	0	0		0	0
7:00	0	0	0	0	0	0	0		0	0
7:15	0	0	0	0	0	0	0		0	0
7:30	0	0	0	0	0	0	0		0	0
7:45	0	0	0	0	0	0	0		0	0
8:00	0	0.070308	0	0	0	0	0	0.070308	0	0.070308
8:15	0	0.069654	0	0	0	0	0	0.069654	0	0.069654
8:30	0	0	0	0	0	0	0	0	0	0
8:45	0	0	0	0	0	0	0	0	0	0
9:00	0	0	0	0	0	0	0	0	0	0
9:15	0	0	0	0	0	0	0.068346	0.068346	0	0.068346
9:30	0	0	0	0	0	0.069327	0	0.069327	0	0.069327
9:45	0	0	0.07227	0	0	0.076521	0	0.148792	0	0.148792
10:00	0.071289	0.06851	0	0	0	0.070308	0	0.210107	0	0.210107
10:15	0	0.069981	0	0	0	0.069	0	0.138981	0	0.138981
10:30	0.146176	0.07178	0	0	0	0	0	0.217955	0	0.217955
10:45	0.069981	0.069654	0	0	0	0	0	0.139635	0	0.139635
11:00	0	0.070308	0	0	0	0	0.074396	0.144704	0	0.144704
11:15	0	0.069818	0	0.071289	0	0.069164	0	0.138981	0.071289	0.210271
11:30	0.068673	0	0	0.212723	0	0.076358	0.067038	0.212069	0.212723	0.424792
11:45	0	0	0.069818	0	0	0.179368	0	0.249185	0	0.249185

Field Testing of Conventional and High Velocity Hand Dryers



Table 4 (Continue)
Typical Winter Load Profile for Hand Dryer, kWh

Time	02/04/98	02/05/98	02/06/98	02/07/98	02/08/98	02/09/98	02/10/98	Winter		
	Wed	Thur	Fri	Sat	Sun	Mon	Tue	Mid-Peak	Off-Peak	Total
12:00	0.211252	0	0	0	0.000327	0.0345	0.068673	0.314425	0.000327	0.314752
12:15	0	0.136856	0	0.068673	0.069654	0.078484	0	0.215339	0.138327	0.353666
12:30	0.069491	0.007521	0.148628	0.070472	0	0.070145	0	0.295785	0.070472	0.366257
12:45	0.150263	0.133259	0.069491	0	0.069654	0	0	0.353012	0.069654	0.422667
13:00	0.068673	0.072597	0.071289	0.155005	0.069327	0.072761	0.13751	0.42283	0.224332	0.647162
13:15	0.07554	0.072107	0.069327	0.209616	0	0.070145	0.066548	0.353666	0.209616	0.563283
13:30	0	0	0.074069	0.139308	0.071289	0.069654	0	0.143723	0.210598	0.354321
13:45	0.144868	0.069491	0.071943	0.192775	0	0.142578	0.132114	0.560994	0.192775	0.753769
14:00	0.069654	0	0.075213	0.089602	0	0.205365	0.003761	0.353994	0.089602	0.443596
14:15	0.068183	0	0	0.224659	0.28205	0.069327	0.067529	0.205038	0.506709	0.711748
14:30	0	0	0.069491	0.141434	0	0	0	0.069491	0.141434	0.210925
14:45	0	0	0	0	0.071126	0.077339	0.068183	0.145522	0.071126	0.216647
15:00	0.071289	0.137019	0	0.358408	0	0	0.073088	0.281396	0.358408	0.639804
15:15	0.141434	0.138491	0	0	0.008012	0.299546	0	0.57947	0.008012	0.587482
15:30	0	0	0	0	0.134076	0.221716	0.20324	0.424956	0.134076	0.559032
15:45	0.140126	0.068183	0	0	0.072761	0.069164	0	0.277472	0.072761	0.350233
16:00	0	0	0	0.071126	0	0	0.064095	0.064095	0.071126	0.135221
16:15	0	0	0	0	0.295621	0	0.217955	0.217955	0.295621	0.513577
16:30	0	0.137673	0.068837	0.009156	0.139472	0.139472	0.143069	0.489051	0.148628	0.637679
16:45	0	0.206183	0.069491	0.061806	0.013081	0.068183	0	0.343856	0.074886	0.418742
17:00	0	0.138	0	0	0.069654	0	0.138981	0.276982	0.069654	0.346636
17:15	0.071453	0.069	0	0	0.068673	0	0	0.140453	0.068673	0.209126
17:30	0	0	0	0	0	0	0.136856	0.136856	0	0.136856
17:45	0.070962	0	0	0	0	0.138818	0	0.20978	0	0.20978
18:00	0	0	0	0	0	0.070145	0	0.070145	0	0.070145
18:15	0	0	0	0	0	0	0.079301	0.079301	0	0.079301
18:30	0.284012	0.066057	0.070308	0.069327	0	0.203567	0.063441	0.687385	0.069327	0.756712
18:45	0	0	0	0	0	0	0	0	0	0
19:00	0	0.068673	0	0.06851	0.13473	0	0.272894	0.341567	0.20324	0.544807
19:15	0.21583	0	0	0	0	0.069491	0	0.28532	0	0.28532
19:30	0	0.288918	0	0	0	0.070145	0	0.359062	0	0.359062
19:45	0	0	0.215503	0	0	0.073415	0.067529	0.356446	0	0.356446
20:00	0.069981	0.017822	0.14405	0	0.206673	0	0	0.231853	0.206673	0.438527
20:15	0.068837	0.051014	0.142088	0	0	0	0	0.261939	0	0.261939
20:30	0	0	0.00654	0	0	0	0	0.00654	0	0.00654
20:45	0	0	0.206346	0	0	0	0	0.206346	0	0.206346
21:00	0	0	0	0	0	0	0		0	0
21:15	0	0	0	0	0.071289	0	0		0.071289	0.071289
21:30	0	0	0	0	0	0	0		0	0
21:45	0	0	0	0	0	0	0		0	0
22:00	0	0	0.079465	0	0	0	0		0.079465	0.079465
22:15	0	0	0	0	0	0	0		0	0
22:30	0	0	0	0	0	0	0		0	0
22:45	0	0	0.070799	0	0	0	0		0.070799	0.070799
23:00	0	0	0	0.069327	0	0	0		0.069327	0.069327
23:15	0	0	0	0	0	0	0		0	0
23:30	0	0	0	0	0	0	0		0	0
23:45	0	0	0	0	0	0	0		0	0
Total	2.347966	2.438876	1.864965	2.355161	1.84747	2.924003	2.214544	11.64009	4.352894	15.99299

Field Testing of Conventional and High Velocity Hand Dryers



There are eighteen (18) weeks within SCE's summer rate. It starts from the first Sunday of June and ends the first Sunday of October. The rest of the year (34.14 weeks) are under the winter TOU rate.

To obtain the total electric consumption during each of the summer TOU periods, the summer weekly energy consumption in each TOU period is multiplied by 18 weeks. Similarly, by multiplying the average weekly seasonal energy consumption in the winter TOU period by 34.14 weeks, the total electric consumption for the winter TOU periods is received. Since the data collected is for two restrooms, the results were divided by two. Table 5 summarizes the result for one single hand dryer in Taco Bell -- a typical fast food restaurant.

Table 5

Electric Demand & Consumption of a Hand Dryer in a Fast Food Restaurant

TOU Period	Summer			Winter		Annual
	On-Peak	Mid-Peak	Off-Peak	Mid-Peak	Off-Peak	
kWh	50	52	51	195	79	426
Percent	11.7%	12.2%	11.9%	45.7%	18.6%	100.0%
kW	1.009	0.517	0.801	1.218	0.983	1.218
Percent	82.8%	42.5%	65.7%	100.0%	80.7%	100.0%

Demand Reduction and Energy Savings

The reduction in electric demand and energy savings vary depending upon the type of hand dryers that are going to be replaced. The most energy intense hand dryers are the conventional, manual operated units. High velocity units are the lowest energy consumers. Table 6 summarizes electric demand and consumption per 1,000 drying cycles for 5 different types of hand dryers ranging from standard manual through to high velocity. By using this information, one can calculate the number drying cycles in a fast food restaurant by dividing the total energy consumption by the kWh/1,000 cycle. For Taco Bell, the average hand dryer provides 34,080 drying cycles per year (426 kWh/12.5 kWh/1,000 cycles). Table 7 shows the reduction of electric demand and consumption when one model is replaced with a more efficient model.

Table 6

Electric Demand & Consumption of Typical Hand Dryers

Type	kW	Drying Cycle, sec.	kWh/1,000 Drying Cycles
Standard Manual	2.2	30	18.33
Energy Efficient Manual	1.5	30	12.50
Standard Automatic	2.2	17	10.39
Energy Efficient Automatic	1.5	17	7.08
High Velocity Automatic	1.5	14	5.83

**Table 7
Demand & Consumption Savings of Hand Dryer Replacements**

From	To	kW	kWh/1,000 Cycles
Standard Manual	Standard Automatic	0.00	7.94
Standard Manual	High Velocity Automatic	0.70	12.50
Standard Automatic	Energy Efficient Automatic	0.70	3.31
Standard Automatic	High Velocity Automatic	0.70	4.56

The demand reduction and energy savings profile is proportional to the usage profile as shown in Table 5.

Incremental Cost and Useful Life

The incremental cost for a typical automatic hand dryer in place of a manually operated dryer is about \$26.80. As for the high velocity automatic hand dryer, the incremental cost over the conventional automatic dryer is \$67.50. According to Excel Dryer, Inc., one of the major manufacturers, the average service life of a hand dryer is about 10 years.

Conclusions and Recommendations

The field monitoring data show that the average hand drying cycle varies between 14 to 17 seconds. It is far shorter than the manual preset drying cycle of 30 seconds. By installing an automatic hand dryer instead of a manual operated hand dryer, it will pay back in about one year. If a high velocity hand dryer is installed, the pay back occurs in approximately 1.6 years. However, the high velocity hand dryer will provide the greatest savings over the service life of the dryer. For retrofit applications, the study supports replacement of a standard manual hand drying system with a standard automatic to save approximately 8 kW per 1,000 cycles.

References

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