CAUGHT ON THE RISE:
A STUDY OF THE ECONOMIC & ENERGY WASTE CREATED BY ESCALATORS

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ABSTRACT

Millions of Americans utilize escalators everyday for quick access between floors of multistory buildings. With thousands of escalators running constantly, retailers spend millions in energy costs to keep them operating. These facts extend the question: how much energy goes to waste when escalators are not in use? For this case study, our team analyzed the cost of a constantly running escalator in a local mall and sought to quantify energy and dollars wasted when the escalator was not in use. We found that, over our observation period, mall patrons utilized the escalator less than half of the time—approximately 38.3% of observed time. Our data projected gross energy and economic waste for this escalator over an annual period in comparison to its actual use with over 17,500 kWh and $1000 per year going to waste.

1. INTRODUCTION

With an estimated 30,000 escalators running nationally, escalators provide an everyday convenience and move more people annually than airplanes. (1) However, this convenience comes at a cost.

Escalators, located largely in retail centers and airports, typically run everyday of the week, throughout business hours. Regardless of their use, energy is constantly expended to run the motors powering these machines. Constantly running escalators also produce heat, contributing to the cooling load that must be managed by HVAC systems.

Our team organized this case study as a 5-week assignment in an environmental control systems class in the Department of Architecture at the University of Oregon. Determined to do a study related to energy use, efficiency, and conservation, we had observed that escalators frequently were unoccupied for periods of time in airports, large hotels, and shopping malls.

From these facts and observations, we sought to answer: what does escalator operation (or lack of) ultimately cost businesses?

To conduct this study, our team obtained security clearance at the Valley River Center (VRC) shopping mall in Eugene, Oregon. We chose an escalator at the center of the facility, instead of in a department store, due to its wider access to mall patrons. See Fig. 1 below for more details on escalator specifications and installation. The observed escalator provides access to and from a mezzanine level featuring a Department of Motor Vehicles branch, a hair salon, a restaurant, and a seasonally utilized retail space.

This study explored how often the mall escalators at the VRC were utilized. Observations and calculations were made to determine the percentage of energy wasted daily.

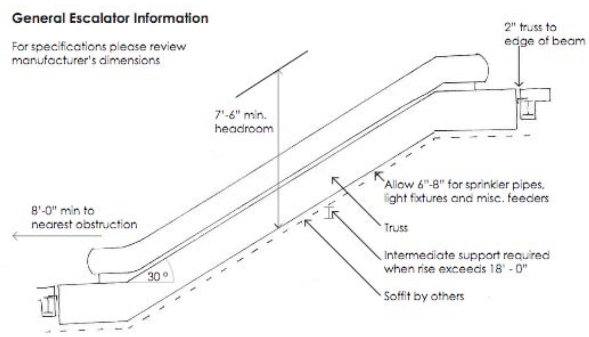

Fig. 1: A typical escalator

2. HYPOTHESIS

The case study followed the approach outlined in the Agents of Change Project where we established a hypothesis, developed an appropriate methodology, and analyzed the data. The hypothesis framed for this study was:

"Constantly running escalators will not be occupied during 50% of observed business hours."

For the purpose of this study, "escalator occupation" was defined as anytime a patron had their feet on the moving steps of the escalator. This included instances of standing, walking and running in the opposite direction of the escalator's movement.

3. METHODOLOGY

Data was collected, by observation, from an inconspicuous location with clear views of the mezzanine escalator. Stopwatches recorded the amount of time mall patrons occupied the escalator for both the ascending and descending escalator.

Recording was initiated and halted on the hour, reflecting the gross amount of use during a one-hour time period. Recording periods took place over several days and various times throughout the week in order to provide a comprehensive set of data.

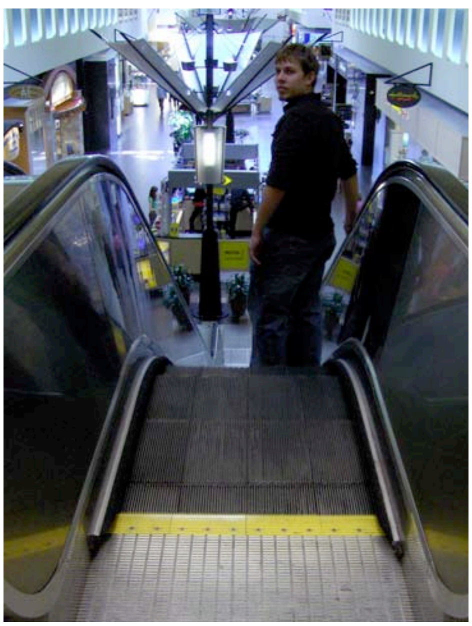

Fig. 3: Team member on descending escalator

4. DATA AND ANALYSIS

4.1 Escalator Occupancy

The following charts summarize the data collected with stopwatches during the six, one-hour observation periods throughout the week. Data collection began on Thursday, 8 March 2007 at 4:15 PM and finished Sunday, 11 March 2007 at 5:47 PM.

Data from outside this time period would be relevant to this study, but it was not feasible to observe for the entirety of the VRC's business hours.

TABLE 1: MINUTES OF ESCALATOR OCCUPANCY

Date	Time Period	Up (min.)	Down (min.)
Thursday (3/8)	4:15-5:15 PM	13:29	12:05
Friday (3/9)	12:00-1:00 PM	24:44	28:21
Friday (3/9)	1:00-2:00 PM	26:53	28:17
Saturday (3/10)	3:30-3:40 PM	31:27	32:15
Sunday (3/11)	3:10-4:10 PM	25:48	25:04
Sunday (3/11)	4:47-5:47 PM	13:04	13:42

To compare with the hypothesis, individual time measurements for both the ascending and descending escalators were converted from minutes into percentages of an hour.

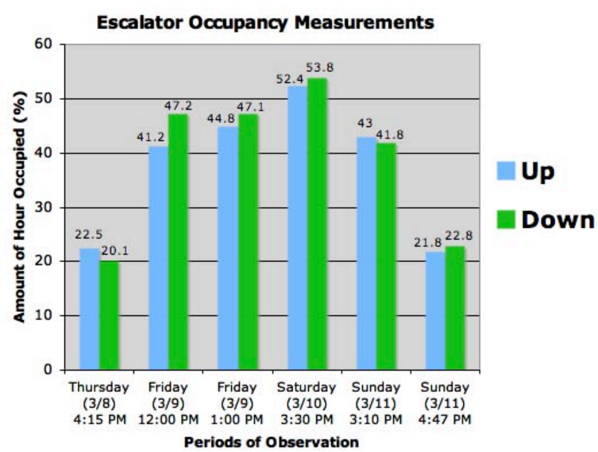

Fig. 2: Graph of occupancy percentages from observation

The data shows that patrons utilized the escalator more than 50% of the time during only one observed hour period. To calculate an average occupancy figure (AOF), we took the total minutes of occupancy from each side of the escalator and used the following calculations:

Down escalator:
139.73 minutes/60 minutes = 2.33 hr/6 hr = 38.8%

Up escalator:
135.42 minutes/60 minutes = 2.26 hr/6 hr = 37.7%

Average of both: **38.3%**

This figure met our hypothesis: the escalator was in use, overall, less than 50% of observed hours.

4.2 Escalator Motor Energy Use

The calculations for the annual energy use of the escalator required the motor size to indicate energy output. Since the precise motor size was not available, dimensions were projected into a specification chart in Mechanical and Electrical Equipment for Buildings (MEEB) to determine the probable motor size. (3)

TABLE 2: ESCALATOR SPECIFICATIONS

Step Width	32"
Rise	14'
Motor	5 HP

Horsepower-watt conversion:
5 HP x 0.746 kW = **3.73 kW**

To find the cost of energy output, the following energy prices for commercial use were taken from the Eugene Water & Electric Board (EWEB), at the time of the study. (2)

TABLE 3: LOCAL ENERGY PRICES

Monthly Service Charge	$28.25
Demand Charge	$5.00/kW
Energy Charge	$0.04479/kWh

Demand charge for motor:
3.73 kW x $5.00/kW = **$18.65**

Energy charge per hour for motor:
3.73 kW x 1 hr x $0.04779 = **$0.178**

The cost per hour for the motor would be $0.178 with a monthly demand charge of $18.65.

4.3 Cooling Load Energy Use

To get a more accurate estimate of the actual energy use of the escalator, it was necessary to calculate the cooling load that the escalator added to the VRC HVAC system.

Available figures project that for every watt used, approximately 3.41 BTUs are added to the cooling load. (4)

Escalator cooling load:
3730 W x 3.41 BTU = **12,719.3 BTU**

By these figures, 12,719.3 BTU were added to the total cooling load due to the escalators constant use. For the energy utilized to meet this cooling load, the BTUs were converted back into kilowatts.

Cooling energy cost:
12719.3 btu/3.41 BTU = 3730 W = **3.73 kW**

Demand charge for cooling:
3.73 kW x $5.00/kW = **$18.65**

Energy charge per hour for cooling:
3.73 kW x 1 hr x $0.04779 = **$0.178**

Figures project an additional 3.73 kW of demand on the system, resulting in an additional hourly charge of $0.178.

4.4 Annual Energy Use

To calculate the annual energy use, the above energy expenditures and costs were projected over the total mall business hours for a year. (5)

TABLE 4: WEEKLY MALL HOURS

Days	Hours	Total
Mon-Sat	10 AM - 9 PM	66 hrs
Sun	11 AM - 6 PM	7 hrs
	Total	73 hrs

Mall hours per week:
Mon – Sat: 10AM – 9 PM: 11 hrs x 6 = **66 hrs**
Sun – 11AM – 6PM: **7 hrs**
Hours open per week = **73 hrs**

Energy charge for week:
73 hrs x [$0.178 (motor) + $0.178 (cooling)] = **$25.988 per week**

Weeks per year:
365.25 days / (7 days/week) = 52.18 weeks per year

Annual Energy Use:
(3.73 kWh (motor) +3.73 kWh (cooling)) x 73 hours x 52.18 weeks = **28416.1844 kWh**

Demand charge per week:
$18.65 (escalator) + $18.65 (cooling) = **$37.30 per week**

The annual energy cost was found by applying the weekly energy charge ($25.988), the monthly service charge ($28.25) and the demand charge ($37.30).

Annual Energy Cost:
($25.988 x 52.18) + 12($28.25 + $37.30) = **$2142.654**

4.5 Energy/Cost Effectiveness

To calculate the cost effectiveness per hour, the occupancy percentage was calculated with the hourly energy charge.

Money utilized per hour:
$0.178 x .383 = **$0.068**

Money not utilized per hour:
$0.178 - $0.068 = **$0.11**

For the cost effectiveness per year, the average occupancy figure (AOF) was applied to the total annual cost of energy.

Money utilized annually:
$2142.654 x .383 = **$820.636**

Money not utilized annually:
$2142.654 - $820.636 = **$1322.018**

For the energy effectiveness per year, the AOF was applied to the annual energy use.

Energy utilized annually:
28416.1844 kWh x .383 = **10883.39863 kWh**

Energy not utilized annually:
28416.1844 kWh - 10883.39863 kWh = **17532.78577 kWh**

5. CONCLUSIONS

Using these hours, we calculated that it costs the mall $25.988/week to operate the escalator based upon both the motor and cooler output. This cost with demand charges over a year come to a total of $2142.65/year and 28416.18 kWh/year to operate the escalator.

We applied the AOF calculated from our data (38.3%) to calculate the amount of resources appropriately utilized when people were using the escalator. The following is a breakdown of the annual energy use between times when the escalator is occupied and the times it has zero-occupancy.

TABLE 5: ENERGY EFFECTIVENESS FIGURES

	Utilized	Not Utilized
Money	$820.64	$1322.02
Energy	10883.398 kWh	17532.786 kWh

These results show that over the period of a year, over half of the energy and money expended on running the escalator, between the motor and the cooling load, is wasted.

There were some disparities in the usage of the ascending and descending escalators with one possible cause being that people were coming upstairs and remained upstairs beyond the scope of our observation interval. On the mezzanine level there was a café, DMV and hair salon, where visits may very well exceed our one-hour observation interval.

Just beyond the escalators, a new movie theater had just opened during the four days we recorded data meaning that we may have had more traffic than usual.

Our projection of unoccupied time is based on six hours over four days. We adjusted for different times of the day and different times of the week to observe different loads of traffic. However, this is still a very small time frame. It would be of great benefit to be able to observe over a much larger period of time.

Because we couldn't obtain values directly from the Valley River Center, we have projected values from MEEB and the U.S. Department of Energy to size our escalator unit and calculate the energy used for cooling. The demand charge has been based off of the capacity of the motor, 3.73kW, as the demand of the whole mall cannot be taken into account.

Despite disparity, there were losses throughout the observation periods. With both the energy and economic losses, the results infer that the VRC would benefit from energy saving devices such as an intermittent escalator. Popular in Europe, intermittent escalators only operate when they detect human occupancy. (1) Such a device would help mitigate annual energy wastes. Other strategies for savings in the long term include restructuring the mall to limit the need for the escalator or removing it entirely in favor of stairs. Due to their limited accessibility to the alternately able, escalators, such as the one at VRC, are accompanied by elevators for ease of access to second floors. A device for aesthetics as much as convenience, our team questions the necessity in the face of gross energy losses.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

(1) Slaughter, Louise M. United States. Cong. House. Energy Efficiency Act Amendment. 108th Cong., 2nd sess. HR 4995. 22 July 2004. 25 Feb. 2008 <http://thomas.loc.gov/home/gpoxmlc108/h4995_ih.xml>. *(Escalator Statistics)*

(2) "Energy Rates." Eugene Water & Electric Board. May 2007. 10 Mar. 2007 <http://www.eweb.org/news/projects/rates/index.htm>. *(Electricity Rates for Eugene)*

(3) Kwok, Alison G., Benjamin Stein, John S. Reynolds, and Walter T. Grondzik. Mechanical and Electrical Equipment for Buildings, Hoboken: Wiley, 2005. 1472. *(Escalator Motor Specifications)*

(4) Kwok, Alison G., and Walter T. Grondzik. The Green Studio Handbook. Architectural P, 2006. 183.

(5) Valley River Center. 2008. 10 Mar. 2007 <http://www.valleyrivercenter.com/>