

# **An Evaluation of Three Types of Gas Station Canopy Lighting**

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# Introduction

- A brightness war has broken out between gas stations throughout America
- There has been a steady increase in the illuminances produced by under-canopy lighting
  - Today illuminances commonly exceed 1000 lx (100 fc)
- Further, the luminaires used are commonly designed with a drop lens and visible light source
  - Increased level of complaints from nearby residents and drivers about glare and light trespass

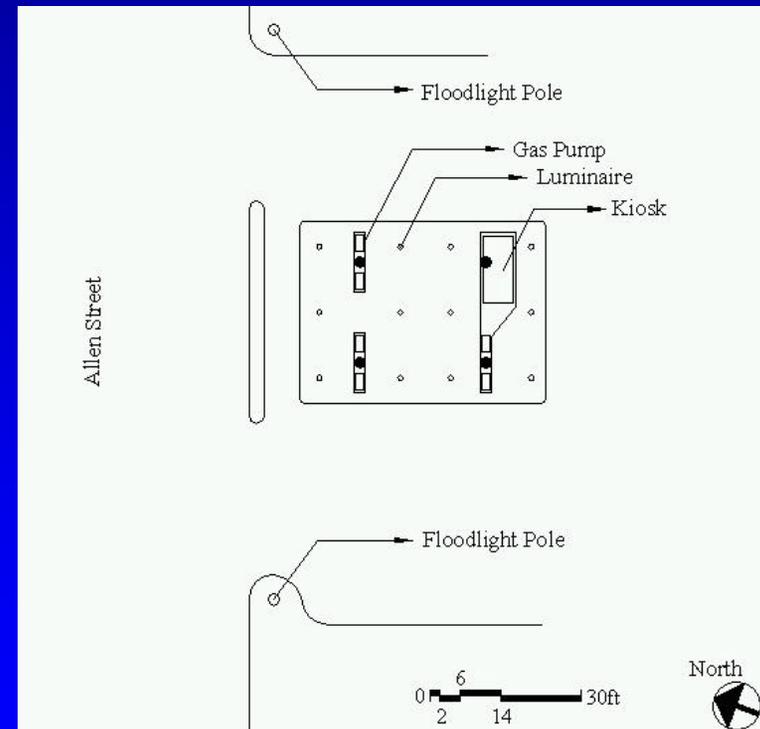


# Study Objectives

- The objective of this evaluation was to quantify the effects of the three types of canopy lighting luminaires on:
  - Photometric conditions related to visibility, visual discomfort, and light trespass
  - Energy efficiency of the installation
  - Tendency of drivers approaching the gas station to turn into it
  - Patrons' opinions regarding task visibility for filling the vehicle with gas, plus an overall impression of visual comfort
  - Opinions of a panel of community leaders regarding visual amenity
  - Gasoline sales

# Method – Evaluation Site

- Sunoco gas station at 1390 Allen Street, Springfield, MA



# Method - Lighting

- Three different canopy lighting installations were evaluated
  - Original (non-cutoff)
  - First retrofit (full-cutoff)
  - Second retrofit (cutoff)

# Method - Lighting

- *Original* lighting
  - Twelve (12) LSI Petroleum Super Scottsdale recessed luminaires arranged in a 4 x 3 regular array
  - Each luminaire contained one 320W vertically-burning, pulse-start metal halide lamp
  - The lamp projects down into the glass refractor (**non-cutoff**)



# Method - Lighting

- *First retrofit lighting*
  - Twelve (12) Ruud Lighting Constellation luminaires recessed into the canopy with a flat, clear-glass lens
  - Each luminaire contained one 320W vertically-burning, pulse-start metal halide lamp recessed into luminaire
  - Luminaires conform to the IESNA **full-cutoff** classification



# Method - Lighting

- *Second retrofit* lighting
  - Twelve (12) Ruud Lighting Constellation luminaires (same as first retrofit)
  - Flat lens was replaced by a prismatic glass, drop-lens option that extends 2.5 in. below the canopy
  - Conforms to the IESNA **cutoff** classification

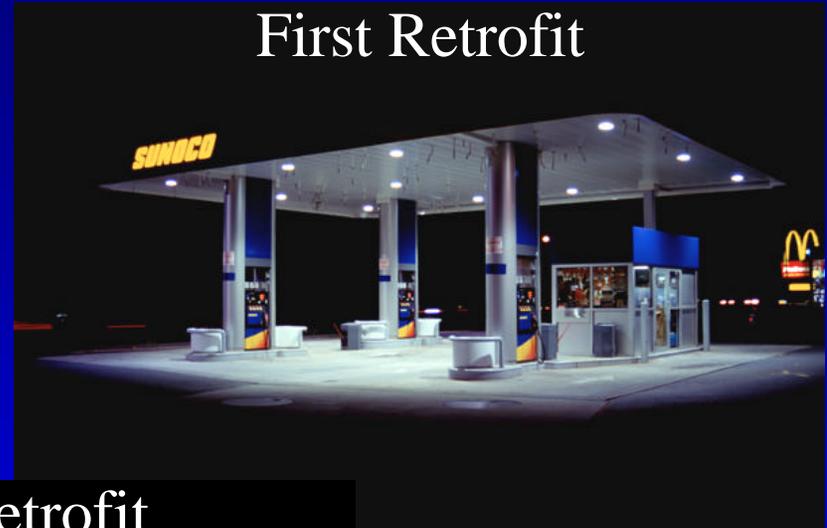


# Method – Lighting

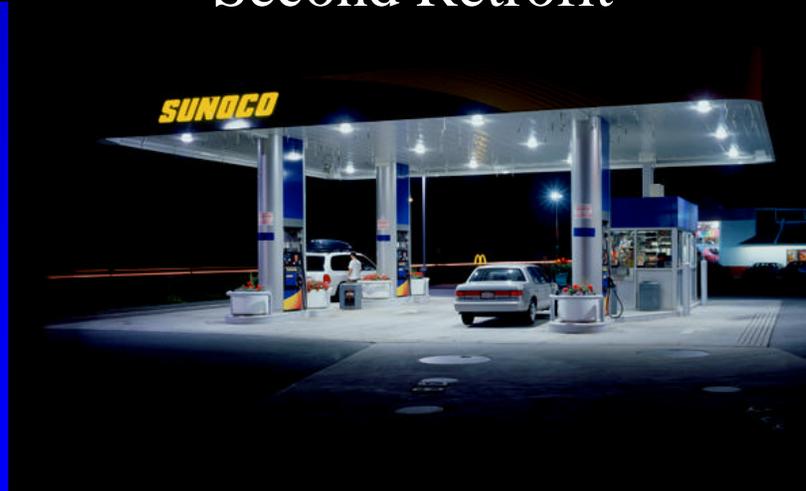
Original



First Retrofit



Second Retrofit



# Method - Procedures

- Evaluation teams visited the gas station twice for each lighting installation
  - Recorded photometric measurements, the frequency of drivers turning in, and patron opinions
  - Arrived at the station about 8 p.m., photometric measures were taken after 9 p.m. (well after sunset)
  - The number of vehicles passing the front of the station was recorded on a hand-held counter in ten-minute intervals, as was the number of vehicles that turned into the station
  - Patrons fueling their vehicles were asked to complete a short questionnaire about the lighting of the gas station

# Method - Procedures

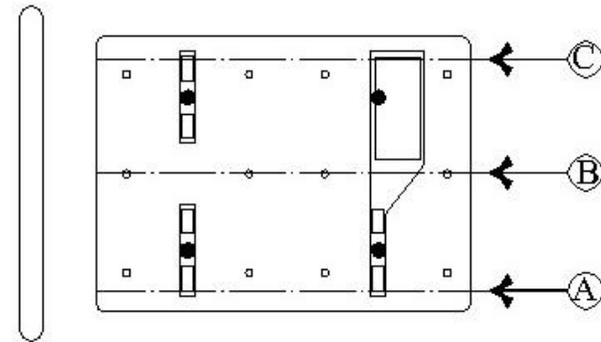
- A panel of six community leaders was formed
    - One city planner, one lighting expert, two utility representatives, one senior manager from a major corporation, and one employee of a small business
    - The panel looked at six gas stations, including the site evaluated
      - ☞ The panel answered a short questionnaire about the appearance of the gas station from a distance
      - ☞ The panel also moved into the gas station and assessed the lighting.
  - The daily gasoline sales data from May 1, 2000 to May 31, 2001, were supplied
  - The lighting power density of the three lighting installations was calculated
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# Results

- **Illuminance**

Lighting Installation	Axis A (lx)	Axis B (lx)	Axis C (lx)
Original lighting (measured)	299 (76)	378 (98)	265 (67)
Original lighting (estimated as new)	440	559	390
New Flat-lens lighting	642 (191)	1055 (201)	698 (152)
New Drop-lens lighting	643 (166)	906 (190)	664 (158)

Site Plan with Measurement Axis

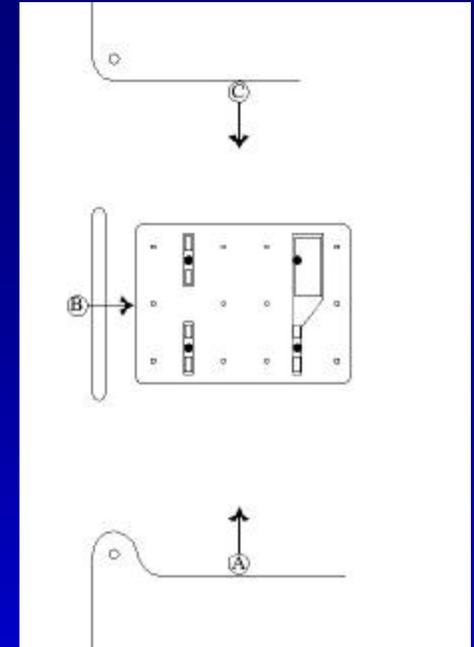


The mean illuminance on all three axes under the canopy is lower under the original lighting than under either of the new lighting installations

# Results

- **Glare**

- Ratio of the illuminance reaching the eye of an observer from above and below a horizontal plane containing the view direction
- Glare ratios above 4.0 are glaring while those below 4.0 are free from glare
- The least glare is seen in the flat lens installation
  - ↳ Both retrofits are acceptable

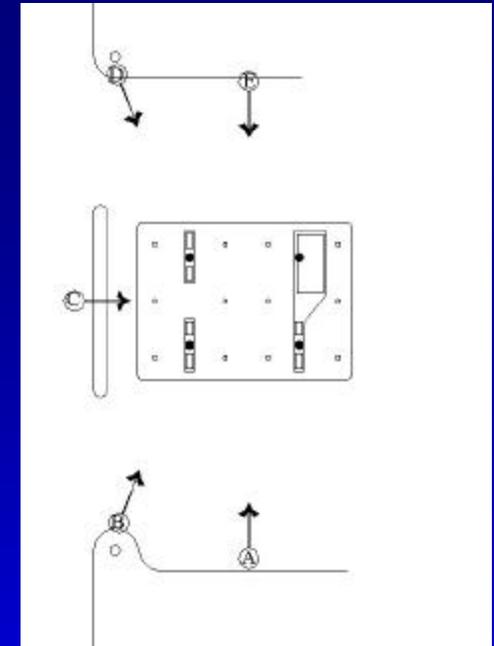


Lighting Installation	Position A	Position B	Position C
Original lighting	9.8	7.2	6.2
New flat-lens lighting	1.5	0.8	1.3
New drop-lens lighting	2.6	3	2.3

# Results

- **Light trespass**

- Illuminance at the boundary of the site on a vertical plane, facing towards the site (IESNA, 1999)
- If the light sources in the original lighting had been new, the illuminances would have been increased by 47%

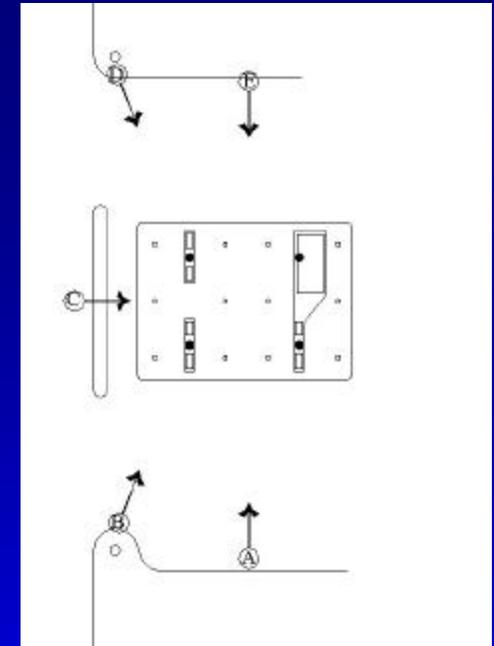


Lighting Installation	Position A (lx)	Position B (lx)	Position C (lx)	Position D (lx)	Position E (lx)
Original Lighting	95	115	239	108	98
New Flat-lens lighting	30	61	89	42	30
New Drop-lens lighting	43	74	108	58	47

# Results

- **Light trespass**

- Traditional measurement ignores impact
- To overcome this vertical illuminances at eye level were measured with the normal to the plane of measurement directed towards the installation, and then 180° away
- Measured illuminance ratios shown below



Lighting Installation	Position A	Position B	Position C	Position D	Position E
Original Lighting	9.7	1.3	18.1	2.1	4.1
New Flat-lens lighting	4.3	0.5	9.8	0.8	1.4
New Drop-lens lighting	4.8	0.6	15	1.2	2.5

# Results

- **Energy efficiency**

- All luminaries used same sources

- ☞ Power demand 4.38 kW and the lighting power density 2.55 W/ft<sup>2</sup> (27.4 W/m<sup>2</sup>) are identical in all cases

- Lighting designs have different application efficiencies (efficiency with which they deliver a fixed illuminance to a defined area under the canopy)

- ☞ Original lighting - 1394 W / 100 lx (948 W / 100 lx)

- ☞ Flat lens installation - 549 W / 100 lx

- ☞ Drop lens installation - 593 W / 100 lx

# Results

- **Tendency of drivers to turn-in**
  - Results show an increase in the percentage of vehicles turning in for the new flat-lens and drop-lens lighting over the original lighting

Lighting Installation	Time duration for which traffic flow was recorded (mins)	Number of vehicles passing	Number of vehicles turning in	% turning in
Original lighting	210	2150	41	1.87
New Flat-lens lighting	210	1991	49	2.40
New Drop-lens lighting	200	2015	59	2.84

# Results

- Patron opinions
  - Only the response to the statement “The amount of light in different areas of this gas station varies a lot” shows a statistically significant difference

Statement	Average Agreement for all Lighting n=109
Overall, the lighting in this gas station is comfortable (n.s.*)	97%
The lighting is too bright for pumping gas and checking my car (n.s.)	13%
The lighting is too dim for pumping gas and checking my car (n.s.)	8%
There is enough light to see under the hood of my car if I need to (n.s.)	93%
The lighting causes reflections that keep me from seeing well (n.s.)	10%
The amount of light in different areas of this gas station varies a lot (p<0.05)	32%
The light fixtures are too bright when seen from the street (n.s.)	8%
The lighting at this gas station attracted me to pull in (n.s.)	52%
The lighting at the gas station makes me feel safe (n.s.)	92%
Overall, the lighting in this gas station is attractive (n.s.)	88%

Statement	Original lighting (n = 26)	New Flat-lens lighting (n = 30)	New Drop-lens lighting (n = 53)
The amount of light in different areas of this gas station varies a lot (p<0.05)	15%	50%	32%

n.s. = no statistically significant difference between the three lighting installations

# Results

- Panel opinions

- 5-point scale: 1 = strongly disagree, 5 = strongly agree

Station 2 is the evaluation site with drop-lens cutoff lighting

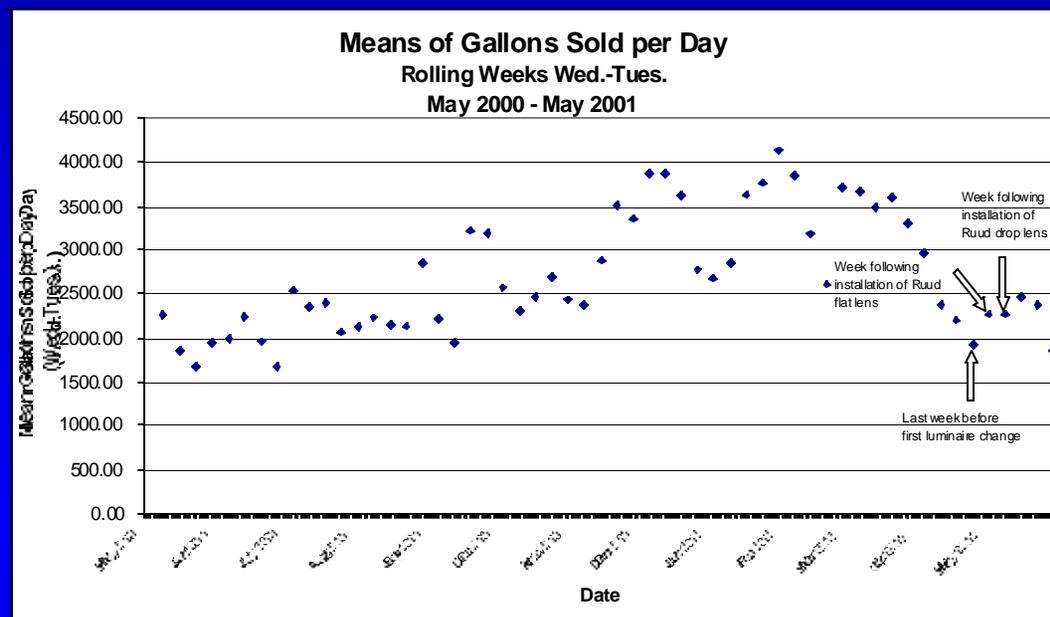
Station 4 has similar lighting to original design (non-cutoff)

Statement	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
1. The lighting of this gas station attracts attention	3.4	3.9	3.4	4.7	3	3.1
2. The lighting of this gas station would make me feel safe when using it	4	4.4	3.9	4.3	4	4.3
3. The lighting of this gas station is appropriate for the surroundings	3.7	4.3	3.6	2.4	4.1	4
4. The light fixtures are too bright when seen from the street	3	2.4	2.4	4.4	2	2.1
6. The lighting of this gas station is comfortable	3.3	4	3.7	3.1	3.4	2.7
7. There is plenty of light for pumping gas	4.1	4.9	4.7	4.6	3.7	4.1
8. <i>I would like to see lighting of this type for all gas stations</i>	2	3.9	3	1.9	2.7	2

# Results

- Sales Data

- Given the variability, it would be premature to conclude that the changes in the lighting produce an increase in gas sales
- However, the data do suggest that a more comprehensive investigation of the relationship between gas sales and lighting conditions would be worthwhile



# Discussion

- The photometric measurements are consistent with the luminaire luminous intensity distributions
- The percentage of drivers turning into the gas station and the mean number of gallons of gas sold daily both show an increase for the two new lighting installations – *merits further study*
- The widespread use of the original lighting in gas stations is considered undesirable, probably because of its brightness and the consequent glare

# Acknowledgements

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