Illuminating
ENGINEERING SOCIETY

Welcome

to the

IES Roadshow II

Compiled by
Pat McGillicuddy, IES, LEED-AP
Manager of Technology, IES

The IES and Disruptive Technology Affecting the Lighting Industry

Fred Oberkircher, FIES, Educational IALD, LC

Emeritus Professor

Texas Christian University

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to constitute approval, sponsorship or endorsement by the AIA of any method, product, service, enterprise or organization. The statements expressed by speakers, panelists, and other participants reflect their own views and do not necessarily reflect the views or positions of The American Institute of Architects or of AIA components, or those of their respective officers, directors, members, employees, or other organizations, groups or individuals associated with them. Questions related to specific products and services may be addressed at the conclusion of this presentation.

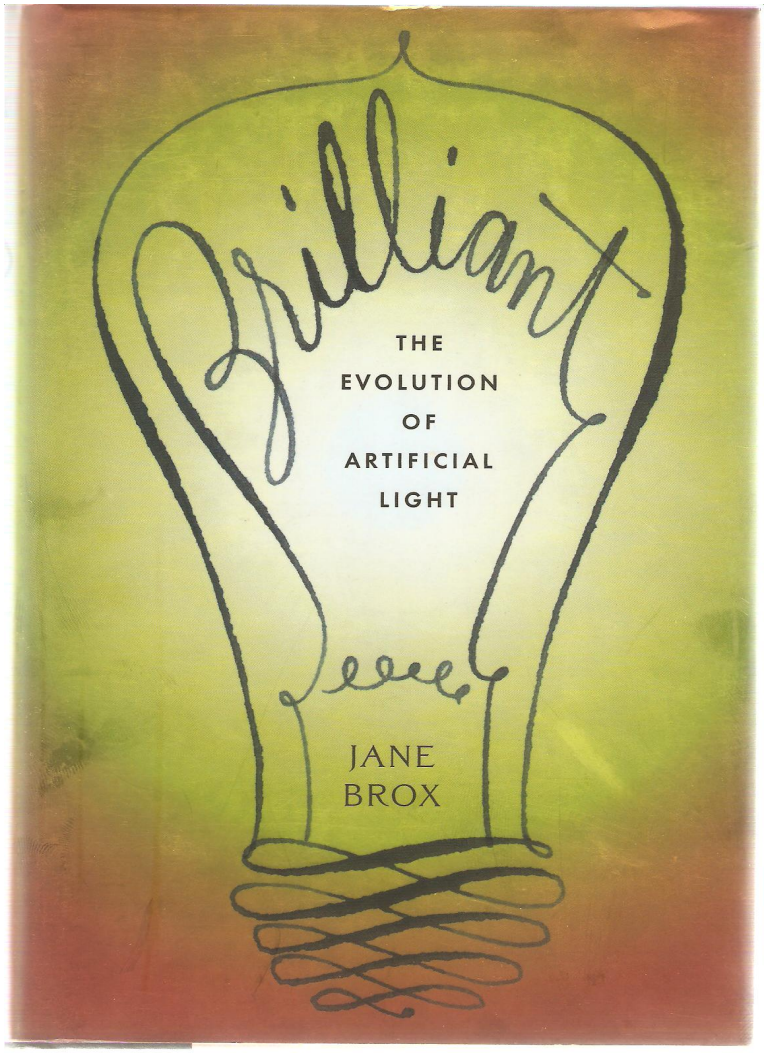
Learning Objectives

1. Identify the key changes in the Society's search to identify light
2. Compare the significant metrics used
3. Analyze the current state of evolving disruptive technology
4. Predict the effects of these disruptions to the future of light

2012 IES Annual Conference

Brilliant – The Evolution of Artificial Light

Jane Brox's best seller (who would think that lighting could be a best seller) chronicles the series of disruptive technological changes that evolved light.



Columbian Exposition 1893

Illuminating Engineering Society - 1906

An era of disruption

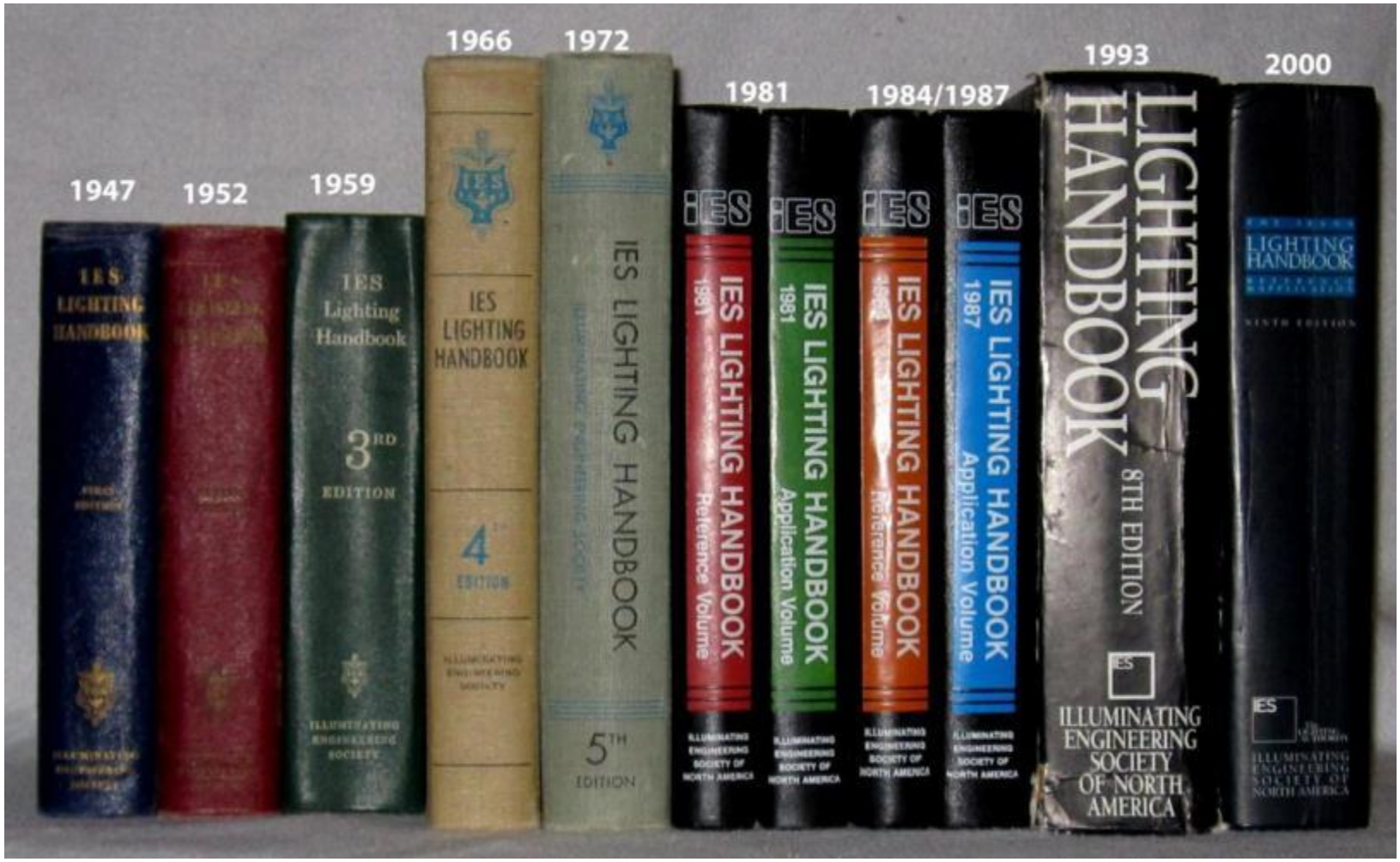
When founded in 1906, 80% of the IES membership was in the gas industry.

The first IES paper, written by Louis Marks concerned the problem of glare in the new incandescent lamp.

New York World's Fair - 1939

First major use of fluorescent lighting. Interestingly, phosphor technology for "white" light was not very advanced…..

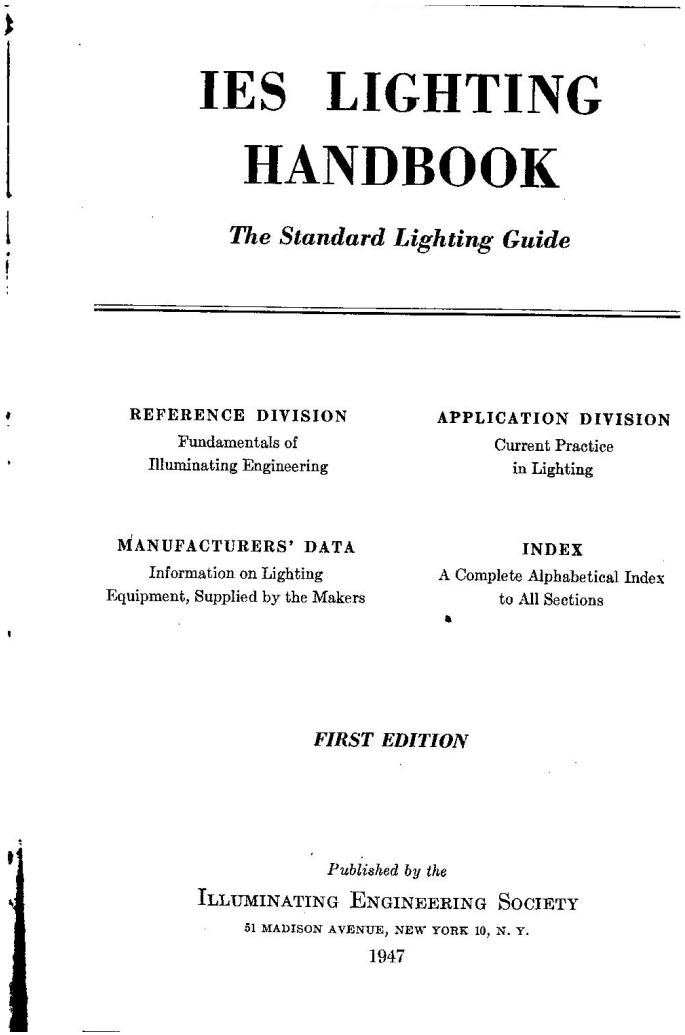
So the first fluorescent lamps were colored!


1947
1952
1959
1966
1972
1981
1984/1987
1993
2000
IES LIGHTING HANDBOOK
IES Lighting Handbook
3RD EDITION
IES LIGHTING HANDBOOK
4TH EDITION
IES LIGHTING HANDBOOK
5TH EDITION
IES LIGHTING HANDBOOK 1981 Reference Volume
IES LIGHTING HANDBOOK 1981 Application Volume
IES LIGHTING HANDBOOK 1984 Reference Volume
IES LIGHTING HANDBOOK 1987 Application Volume
LIGHTING HANDBOOK 8TH EDITION
ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA
LIGHTING HANDBOOK
NINTH EDITION

IES Handbook, 1st Edition, 1947

Although the IES was founded in 1906, it took until 1947 for the first IES Handbook to be created.

Recommended Practices came before that date, but 1947 marks the first time that the recommendations of the Society were all brought together in one document.



IES LIGHTING HANDBOOK

The Standard Lighting Guide

REFERENCE DIVISION
Fundamentals of Illuminating Engineering

APPLICATION DIVISION
Current Practice in Lighting

MANUFACTURERS' DATA
Information on Lighting Equipment, Supplied by the Makers

INDEX
A Complete Alphabetical Index to All Sections

FIRST EDITION

Published by the
ILLUMINATING ENGINEERING SOCIETY
51 MADISON AVENUE, NEW YORK 10, N. Y.
1947

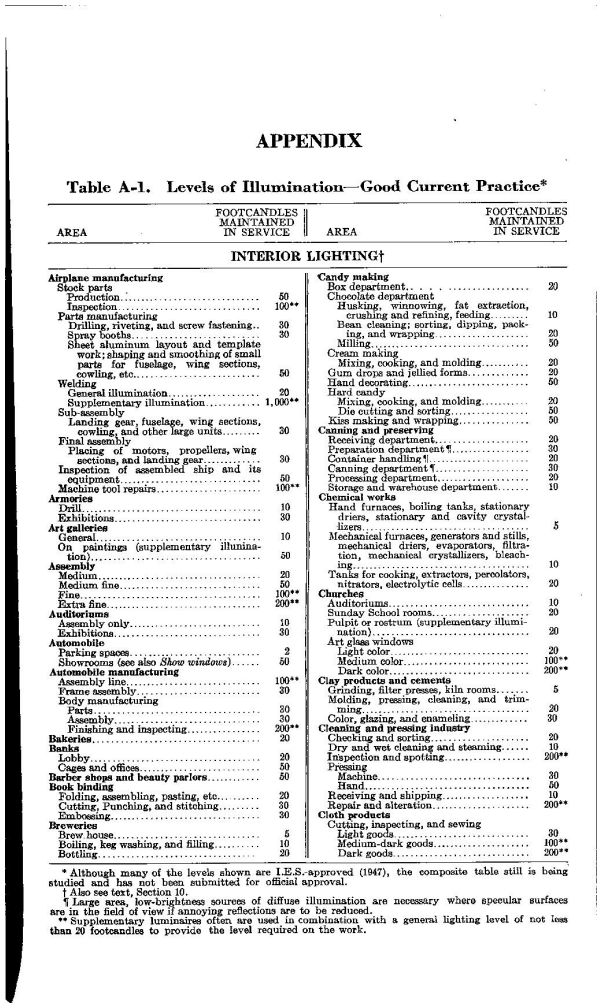
IES Handbook, 1st Edition, 1947

Appendix A provided **Levels of Illumination – Good Current Practice**

- Assembly, medium 20
- Assembly, fine 100
- Bank cages & Offices 50
- Breweries, bottling 20
- Churches, pews 10

  Art glass windows

- Light color 20
- Dark color 200



APPENDIX

Table A-1. Levels of Illumination—Good Current Practice*

AREA	FOOTCANDLES MAINTAINED IN SERVICE
INTERIOR LIGHTING†	
Airplane manufacturing	
Stock parts	
Production	50
Inspection	100**
Parts manufacturing	
Drilling, riveting, and screw fastening	30
Spray booths	30
Sheet aluminum layout and template work; shaping and smoothing of small parts for fuselage, wing sections, cowling, etc.	50
Welding	
General illumination	20
Supplementary illumination	1,000**
Sub-assembly	
Landing gear, fuselage, wing sections, cowling, and other large units	30
Final assembly	
Placing of motors, propellers, wing sections, and landing gear	30
Inspection of assembled ship and its equipment	50
Machine tool repairs	100**
Armories	
Drill	10
Exhibitions	30
Art galleries	
General	10
On paintings (supplementary illumination)	50
Assembly	
Medium	20
Medium fine	50
Fine	100**
Extra fine	200**
Auditoriums	
Assembly only	10
Exhibitions	30
Automobile	
Parking spaces	2
Showrooms (see also *Show windows*)	50
Automobile manufacturing	
Assembly line	100**
Frame assembly	30
Body manufacturing	
Parts	30
Assembly	30
Finishing and inspecting	200**
Bakeries	20
Banks	
Lobby	20
Cages and offices	50
Barber shops and beauty parlors	50
Book binding	
Folding, assembling, pasting, etc.	20
Cutting, Punching, and stitching	30
Embossing	30
Breweries	
Brew house	5
Boiling, keg washing, and filling	10
Bottling	20
Candy making	
Box department	20
Chocolate department	
Husking, winnowing, fat extraction, crushing and refining, feeding	10
Bean cleaning; sorting, dipping, packing, and wrapping	20
Milling	50
Cream making	
Mixing, cooking, and molding	20
Gum drops and jellied forms	20
Hand decorating	50
Hard candy	
Mixing, cooking, and molding	20
Die cutting and sorting	50
Kiss making and wrapping	50
Canning and preserving	
Receiving department	20
Preparation department¶	30
Container handling¶	20
Canning department¶	30
Processing department	20
Storage and warehouse department	10
Chemical works	
Hand furnaces, boiling tanks, stationary driers, stationary and cavity crystallizers	5
Mechanical furnaces, generators and stills, mechanical driers, evaporators, filtration, mechanical crystallizers, bleaching	10
Tanks for cooking, extractors, percolators, nitrators, electrolytic cells	20
Churches	
Auditoriums	10
Sunday School rooms	20
Pulpit or rostrum (supplementary illumination)	20
Art glass windows	
Light color	20
Medium color	100**
Dark color	200**
Clay products and cements	
Grinding, filter presses, kiln rooms	5
Molding, pressing, cleaning, and trimming	20
Color, glazing, and enameling	30
Cleaning and pressing industry	
Checking and sorting	20
Dry and wet cleaning and steaming	10
Inspection and spotting	200**
Pressing	
Machine	30
Hand	50
Receiving and shipping	10
Repair and alteration	200**
Cloth products	
Cutting, inspecting, and sewing	
Light goods	30
Medium-dark goods	100**
Dark goods	200**

* Although many of the levels shown are I.E.S.-approved (1947), the composite table still is being studied and has not been submitted for official approval.

† Also see text, Section 10.

¶ Large area, low-brightness sources of diffuse illumination are necessary where specular surfaces are in the field of view if annoying reflections are to be reduced.

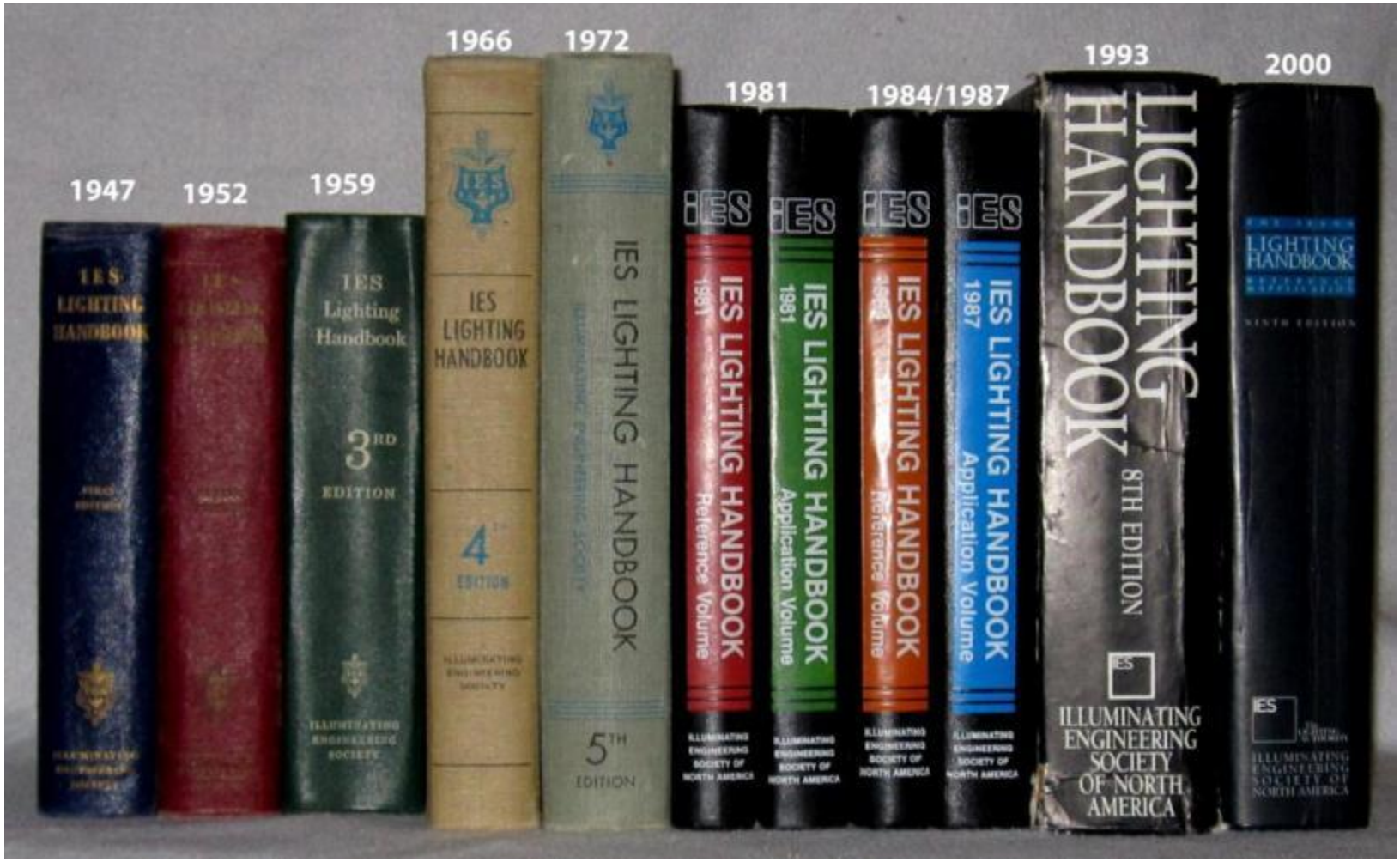
** Supplementary luminaires often are used in combination with a general lighting level of not less than 20 footcandles to provide the level required on the work.

IES Handbook, 1st Edition, 1947

Offices

- Typing 50
- Conference room 30
- Desk work 30
- Prolonged close work 50
- Filing 30
- Lobby 10

AREA	FOOTCANDLES MAINTAINED IN SERVICE
Flat work ironing, weighing, listing, marking	20
Machine and press finishing, sorting	30
Fine hand ironing	50
Leather manufacturing	
Vats	5
Cleaning, tanning, and stretching	10
Cutting, fleshing, and stuffing	20
Finishing and scarfing	30
Leather working	
Pressing, winding, and glazing	
Light	30
Medium	50
Dark	100**
Grading, matching, cutting, scarfing, and sewing	
Light	30
Medium	100**
Dark	200**
Library	
Reading room	30
Stack room	10
Locker rooms	10
Machine shops	
Rough bench and machine work	20
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing*	30
Fine bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing¶	100**
Extra-fine bench and machine work, grinding, fine work	200**
Meat packing	
Slaughtering	10
Cleaning, cutting, cooking, grinding, canning, packing	20
Milling—grain foods	
Cleaning, grinding, and rolling	10
Baking or roasting	20
Flour grading	30
Museums	
General	10
Special displays (supplementary illumination)	50
Offices	
Bookkeeping, typing, and accounting	50
Conference room	
General meetings	30
Stairways	10
Desk work	
Intermittent reading and writing	30
Prolonged close work, computing, studying, designing, reading blueprints and plans	50
Filing and index reference finding	30
Lobby	10
Mail sorting	30
Reception rooms	10
Stenographic work	
Prolonged reading of shorthand notes	50
Vault	20
Packing and boxing	10
Paint manufacturing	
General	20
Comparing mix with standard	100**
Paint shops	
Dipping, spraying, firing, rubbing, ordinary hand painting and finishing	20
Fine hand painting and finishing	50
Extra-fine hand painting and finishing (automobile bodies, piano cases, etc.)	100**
Paper-box manufacturing	
Light	20
Dark	50
Storage	5
Paper manufacturing	
Acid towers, beaters, deckers, digester house, knotters, drying cylinders, calendering, settling tank house, soda room, sulphur room, and pulp grinding	10
Bleachers, paper cutters, layboys, trimmers, lappers, Thune press, and wood chipping	20
Hand counting, wet end of paper machine	30
Paper machine reel, paper inspection, and laboratories	50
Rewinder	100**
Storage	5
Plating	10
Power plants, engine room, boilers	
Boilers, coal and ash handling, storage battery rooms	5
Auxiliary equipment, oil switches, transformers, engines, generators, blowers, compressors	20
Control room	
Switchboards and meters	30
Post office	
Lobby	20
Sorting, mailing, etc.	50
Storage	10
File room	30
Corridors and stairways	5
Printing industries	
Type foundries	
Matrix making, dressing type	100**
Font assembly—sorting	50
Hand casting	30
Machine casting	20
Photography	
Dry plate and film	2,000**
Wet plate	3,000**
Printing on metal	2,000**
Electrotyping	
Molding, routing, finishing, leveling molds	100**
Trimming	30
Blacking, tinning	30
Electroplating, washing, backing	20
Photoengraving	
Etching, staging	20
Blocking	30
Proofing	50
Tint laying, routing, finishing	100**
Printing plants	
Presses	30
Imposing stones¶	100**
Proofreading	100**
Composing	100**
Professional offices	
Waiting rooms	20
Consultation rooms	30
Examination rooms (supplementary illumination)	100**
Dental chairs (supplementary illumination)	200**
Receiving and shipping	10
Restaurants, lunch rooms, cafeterias	
Dining area	10
Food displays	50
Kitchens	20
Rubber tire and tube manufacturing	
Stock preparation	
Plasticating, milling, and Branbury	20
Calendering	30
Fabric preparation—stock cutting and bead building	30
Tube and tread tubing machines	20
Tire building	
Solid tires	20
Pneumatic tires	50
Curing department	
Tube and casing	50
Final inspection	
Tube	50


1947
1952
1959
1966
1972
1981
1984/1987
1993
2000
IES LIGHTING HANDBOOK
IES Lighting Handbook
3RD EDITION
IES LIGHTING HANDBOOK
4TH EDITION
IES LIGHTING HANDBOOK
5TH EDITION
IES LIGHTING HANDBOOK 1981 Reference Volume
IES LIGHTING HANDBOOK 1981 Application Volume
IES LIGHTING HANDBOOK 1984 Reference Volume
IES LIGHTING HANDBOOK 1987 Application Volume
LIGHTING HANDBOOK 8TH EDITION
ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA
LIGHTING HANDBOOK
NINTH EDITION

IES Handbook, 4th Edition, 1966

Levels of Illumination Currently Recommended saw significant change.

- Assembly, medium 100
- Assembly, fine 500
- Bank cages & Offices 150
- Breweries, bottling 50
- Churches, pews 15
- Art glass windows
- Light color 50
- Dark color 500

Fig. 9–53. Levels of Illumination Currently Recommended

While for convenience of use this table sometimes lists locations rather than tasks, the recommended footcandle values have been arrived at for specific visual tasks. The tasks selected for this purpose have been the more difficult ones which commonly occur in the various areas.

In order to assure these values at all times, higher initial levels should be provided as required by the maintenance conditions (see page 9–15).

Where tasks are located near the perimeter of a room special consideration should be given to the arrangement of the luminaires in order to provide the recommended level of illumination on the task (see page 9–16).

The illumination levels shown in the table are intended to be minimum on the task irrespective of the plane in which it is located. The commonly used lumen method of illumination calculation (see page 9–1) gives results only for a horizontal work plane. The ratio of vertical to horizontal illumination will generally vary from 1/3 for luminaires having narrow distribution to 1/2 for luminaires of wide distribution. Where the levels thus achieved are inadequate, special luminaire arrangements should be used or supplemental lighting equipment employed.

Supplementary luminaires may be used in combination with general lighting to achieve these levels. The general lighting should be not less than 20 footcandles and should contribute at least one-tenth the total illumination level.

Many of the following values have appeared, or in the future will appear, in other reports of the Society, some of which are jointly sponsored with other agencies and organizations.

Interior Lighting

Area	Footcandles on Tasks*
Aircraft manufacturing	
Stock parts	
Production	100
Inspection	200
Parts manufacturing	
Drilling, riveting, screw fastening	70
Spray booths	100
Sheet aluminum layout and template work, shaping, and smoothing of small parts for fuselage, wing sections, cowling, etc.	100[j]
Welding	
General illumination	50
Precision manual arc welding	1000[a]
Subassembly	
Landing gear, fuselage, wing sections, cowling, and other large units	100
Final assembly	
Placing of motors, propellers, wing sections, landing gear	100
Inspection of assembled ship and its equipment	100
Machine tool repairs	100
Aircraft hangars	
Repair service only	100
Armories	
Drill	20
Exhibitions	30
Art galleries	
General	30
On paintings (supplementary)	30[b]
On statuary and other displays	100[c]
Assembly	
Rough easy seeing	30
Rough difficult seeing	50
Medium	100
Fine	500[a]
Extra fine	1000[a]
Auditoriums	
Assembly only	15
Exhibitions	30
Social activities	5
Automobile showrooms (see Stores)	
Automobile manufacturing	
Frame assembly	50
Chassis assembly line	100
Final assembly, inspection line	200
Body manufacturing	
Parts	70
Assembly	100
Finishing and inspecting	200
Bakeries	
Mixing room	50
Face of shelves (vertical illumination)	30
Inside of mixing bowl (vertical mixers)	50
Fermentation room	30
Make-up room	
Bread	30
Sweet yeast-raised products	50
Proofing room	30
Oven room	30
Fillings and other ingredients	50
Decorating and icing	
Mechanical	50
Hand	100
Scales and thermometers	50
Wrapping room	30
Banks	
Lobby	
General	50
Writing areas	70
Tellers' stations	150
Posting and keypunch	150
Barber shops and beauty parlors	100

* Minimum on the task at any time. For general notes see beginning of tabulation. For other notes see end of tabulation.

IES Handbook, 4th Edition, 1966

Offices also saw an increase in lighting levels:

- **Difficult** **150**
- **Ordinary** **100**
- **Casual** **20**
- Typing 50
- Conference room 30
- Desk work 30
- Prolonged close work 50
- Filing 30
- Lobby 10

Fig. 9–53. *Continued*

Area	Footcandles on Tasks*
Materials handling	
Wrapping, packing, labeling	50
Picking stock, classifying	30
Loading, trucking	20
Inside truck bodies and freight cars	10
Meat packing	
Slaughtering	30
Cleaning, cutting, cooking, grinding, canning, packing	100
Municipal buildings—fire and police	
Police	
Identification records	150
Jail cells and interrogation rooms	30
Fire hall	
Dormitory	20
Recreation room	30
Wagon room	30
Museums (see **Art galleries**)	
Nursing homes	
Corridors and interior ramps	20
Stairways other than exits	30
Exit stairways and landings, on floor	5
Doorways	10
Administrative and lobby areas, day	50
Administrative and lobby areas, night	20
Chapel or quiet area, general	5
Chapel or quiet area, local for reading	30
Physical therapy	20
Occupational therapy	30
Work table, course work	100
Work table, fine work	200
Recreation area	50
Dining area	30
Patient care unit (or room), general	10
Patient care room, reading	30
Nurse's station, general	
Day	50
Night	20
Nurse's desk, for charts and records	70
Nurse's medicine cabinet	100
Utility room, general	20
Utility room, work counter	50
Pharmacy area, general	30
Pharmacy, compounding, and dispensing area	100
Janitor's closet	15
Toilet and bathing facilities	30
Barber and beautician areas	50
Offices	
Cartography, designing, detailed drafting	200
Accounting, auditing, tabulating, bookkeeping, business machine operation, reading poor reproductions, rough layout drafting	150
Regular office work, reading good reproductions, reading or transcribing handwriting in hard pencil or on poor paper, active filing, index references, mail sorting	100
Reading or transcribing handwriting in ink or medium pencil on good quality paper, intermittent filing	70
Reading high-contrast or well-printed material, tasks and areas not involving critical or prolonged seeing such as conferring, interviewing, inactive files, washrooms	30
Corridors, elevators, escalators, stairways	20*
Packing and boxing (see **Materials handling**)	
Paint manufacturing	
General	30
Comparing mix with standard	200*
Paint shops	
Dipping, simple spraying, firing	50
Rubbing, ordinary hand painting and finishing art, stencil and special spraying	50
Fine hand painting and finishing	100
Extra-fine hand painting and finishing	300*
Paper-box manufacturing	
General manufacturing area	50
Paper manufacturing	
Beaters, grinding, calendering	30
Finishing, cutting, trimming, papermaking machines	50
Hand counting, wet end of paper machine	70
Paper machine reel, paper inspection, and laboratories	100
Rewinder	150
Plating	30
Polishing and burnishing	100
Power plants (see **Central station**)	
Post Offices	
Lobby, on tables	30
Sorting, mailing, etc.	100
Printing industries	
Type foundries	
Matrix making, dressing type	100
Font assembly—sorting	50
Casting	100
Printing plants	
Color inspection and appraisal	200*
Machine composition	100
Composing room	100
Presses	70
Imposing stones	150
Proofreading	150
Electrotyping	
Molding, routing, finishing, leveling molds, trimming	100
Blocking, tinning	50
Electroplating, washing, backing	50

* Minimum on the task at any time. For general notes see beginning of tabulation. For other notes see end of tabulation.

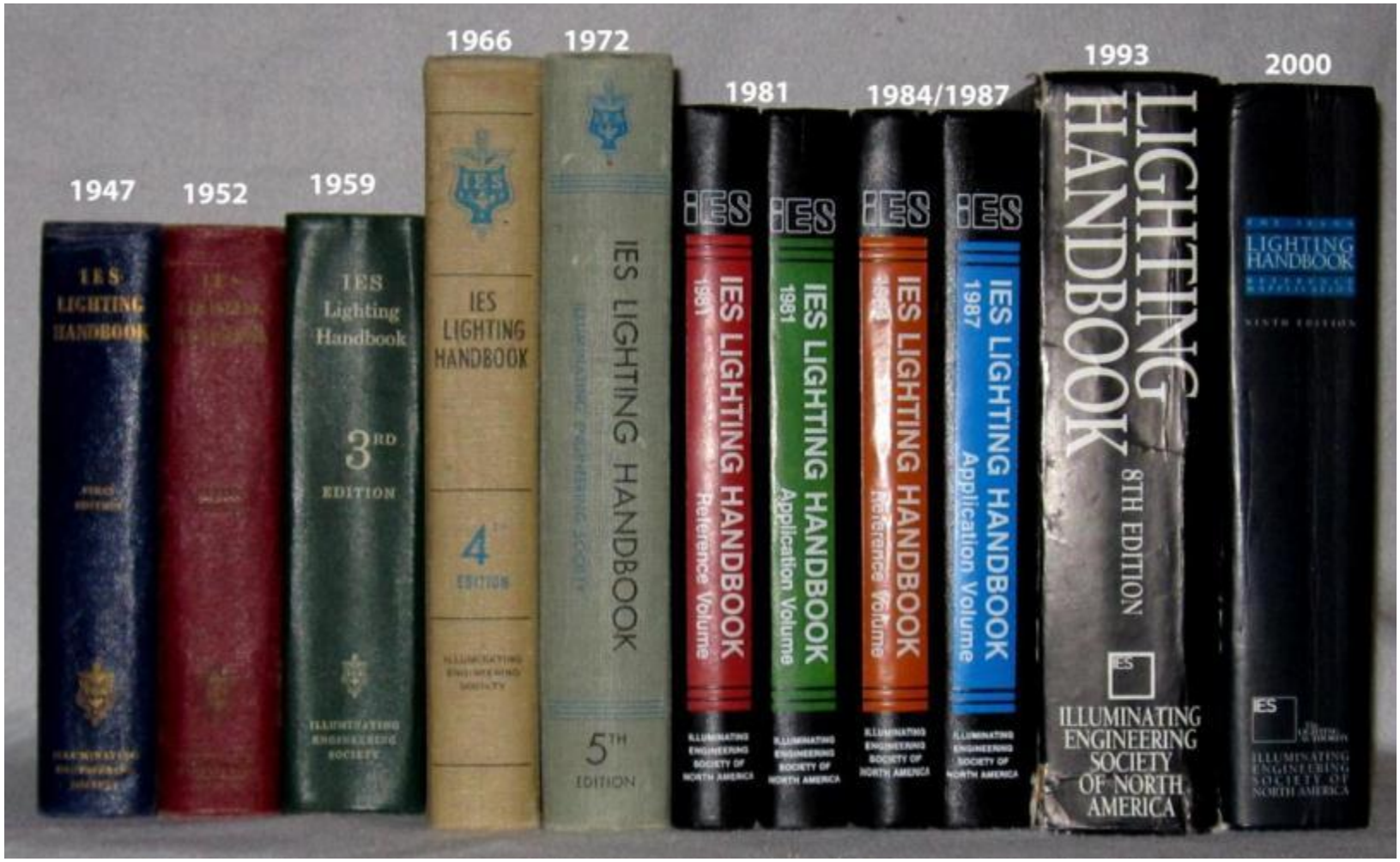
Comparison

1947 and 1952		1966	
• Assembly, medium	20	• Assembly, medium	100
• Assembly, fine	100	• Assembly, fine	500
• Bank cages & Offices	50	• Bank cages & Offices	150
• Breweries, bottling	20	• Breweries, bottling	50
• Churches, pews	10	• Churches, pews	15
• Typing	50	• Difficult	150
• Conference room	30	• Ordinary	100
• Desk work	30	• Casual	20
• Prolonged close work	50		
• Filing	30		
• Lobby	10		

The Disruption of oil and its effect on energy

During the early 1970's the United States went through its first energy crisis due to the Arab oil embargo.

One of the prevalent solutions to immediately saving energy was to remove one or more lamps from fluorescent fixtures.


1947
1952
1959
1966
1972
1981
1984/1987
1993
2000
IES LIGHTING HANDBOOK
IES Lighting Handbook
3RD EDITION
IES LIGHTING HANDBOOK
4TH EDITION
IES LIGHTING HANDBOOK
5TH EDITION
IES LIGHTING HANDBOOK 1981 Reference Volume
IES LIGHTING HANDBOOK 1981 Application Volume
IES LIGHTING HANDBOOK 1984 Reference Volume
IES LIGHTING HANDBOOK 1987 Application Volume
LIGHTING HANDBOOK 8TH EDITION
ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA
LIGHTING HANDBOOK
NINTH EDITION

IES Handbook, Application Volume 1987

For the first time, illuminance considerations included a **Weighting Factor** that took into consideration:

Age of the Workers

- **Under 40 -1**
- **40-55 0**
- **Over 55 +1**

Room Surface Reflectances

- **> 70% -1**
- **30 – 70% 0**
- **< 30% +1**

Fig. 2-3. Weighting Factors to be Considered in Selecting Specific Illuminance Within Ranges of Values for Each Category

a. For Illuminance Categories A through C

Room and Occupant Characteristics	Weighting Factor		
	–1	0	+1
Occupants ages	Under 40	40-55	Over 55
Room surface reflectances*	Greater than 70 percent	30 to 70 percent	Less than 30 percent

b. For Illuminance Categories D through I

Task and Worker Characteristics	Weighting Factor		
	–1	0	+1
Workers ages	Under 40	40-55	Over 55
Speed and/or accuracy**	Not Important	Important	Critical
Reflectance of task background***	Greater than 70 percent	30 to 70 percent	Less than 30 percent

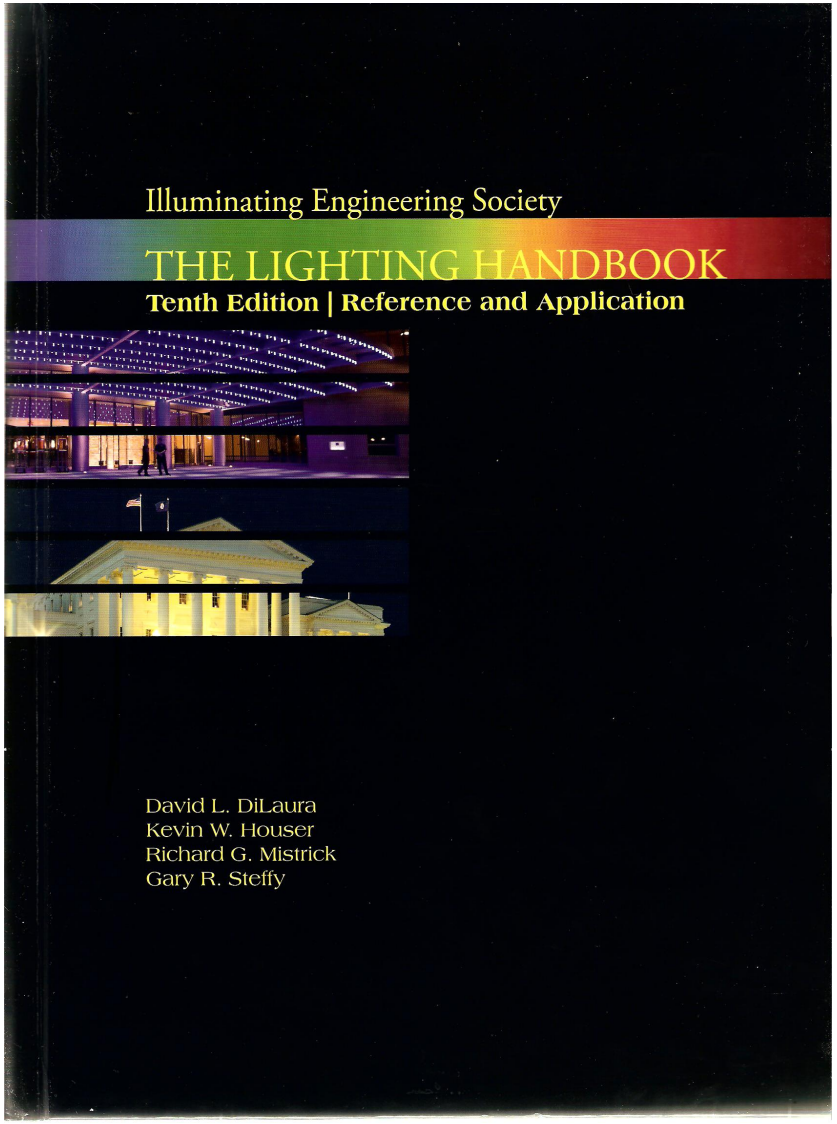
* Average weighted surface reflectances, including wall, floor and ceiling reflectances, if they encompass a large portion of the task area or visual surround. For instance, in an elevator lobby, where the ceiling height is 7.6 meters (25 feet), neither the task nor the visual surround encompass the ceiling, so only the floor and wall reflectances would be considered.

** In determining whether speed and/or accuracy is not important, important or critical, the following questions need to be answered: What are the time limitations? How important is it to perform the task rapidly? Will errors produce an unsafe condition or product? Will errors reduce productivity and be costly? For example, in reading for leisure there are no time limitations and it is not important to read rapidly. Errors will not be costly and will not be related to safety. Thus, speed and/or accuracy is not important. If however, prescription notes are to be read by a pharmacist, accuracy is critical because errors could produce an unsafe condition and time is important for customer relations.

*** The task background is that portion of the task upon which the meaningful visual display is exhibited. For example, on this page the meaningful visual display includes each letter which combines with other letters to form words and phrases. The display medium, or task background, is the paper, which has a reflectance of approximately 85 percent.

IES Handbook, 10th Edition - 2011

Which brings us to the current Handbook.



IES Handbook, 10th Edition - 2011

Graphics are used to provide information not available in previous Handbooks.

- **Daylight media Scale**
- **Daylight Luminances**
- **Luminaire Layout**
- **Luminaire Luminances**

Design | Components of Lighting Design

Figure 12.3 | Daylight Media Scale
Numbered notes are keyed to Table 12.1a. The scale of the skylight in two dimensions (in plan view) ❶ is based on the architectural bay defined by the columns. In three dimensions ❷ the skylight depth addresses glare control. The stepped well is a further refinement of scale, eliminating the blockiness of a less elegant straight-wall deep well and making the most of a relatively small skylight—a means of using standard-sized skylights but achieving a custom-look and a proportionally appropriate aperture in the ceiling. This stepped splay also reduces the harsh contrast between relatively dark ceiling plane (because it is unlit) and the bright exterior sky that is common with shallow- or no-well skylights.
» Image ©Rodney Hyett; Elizabeth Whiting & Associates/Corbis

Figure 12.4 | Daylight Luminances
Numbered notes are keyed to Table 12.1a. The wall luminance patterns ❸ are appealing and make sense visually (allowing for ready identification of solar orientation and time of day). The orientation, sun path, and skylight transmittance and the regular array of structural elements combine to achieve visual order and interest over time ❹. Skylights employed in these situations (residential, hospitality, lounge, waiting area) and in orientations where sun patterns only fall on wall surfaces or confined zones avoid the annoyance of direct glare and temporal pattern shift on occupied sitting/working areas.
» Image ©Rodney Hyett; Elizabeth Whiting & Associates/Corbis

Figure 12.5 | Luminaire Layout
Numbered notes are keyed to Table 12.1a. Layout relationships, patterns, and rhythms all contribute to the lighting approach. The planning and activity zones of the waiting area are defined by a collected light array consisting of coves and rectilinear downlights ❺. Seating areas are addressed—softly featured—with downlights ❻. Transitional circulation areas are addressed with cove lighting. The groupings and rhythm of the interiors planning then established the groupings and rhythm of the lighting.
» Image ©Adrian Wilson/Beateworks/Corbis

Figure 12.6 | Luminaire Luminances
Numbered notes are keyed to Table 12.1a. The visual appeal of this hotel lobby is, in part, due to the luminance patterns created by the more conventional chandeliers seen in the background juxtaposed with the more unique in-wall luminaires in the foreground. Patterns of luminaires and lighting effects ❼ make sense visually and reinforce the circulation and lounge seating. The in-wall lighting introduces strong visual attraction and combines with architectural finishes to establish appeal ❽. All of these techniques work together to break what could be monotonous application of a single lighting effect or treatment throughout the area. Other techniques resulting from review of spatial factors/pleasantness contribute to the success of the lighting solution. For example, in-wall lights that are within reach of users are scaled accordingly, depending on architectural setting and style. Here, larger in-wall lights in such close proximity to users may be considered physically overwhelming and annoying. Lamping and lensing of such in-wall luminaires are selected to avoid glare or visual discomfort.
» Image ©Mark Edward Atkinson/Blend Image/Corbis

IES 10th Edition

The Lighting Handbook | 12.5

IES Handbook, 10th Edition - 2011

Table 32.2 | Office Facilities Illuminance Recommendations continued from previous page

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b, c, d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where **at least half** are <25	Category	25-65	Gauge	>65	Gauge	Vertical (E_v) Targets: Visual Ages of Observers (years) where **at least half** are <25	Category	25-65	Gauge	>65	Gauge
OFFICES	See READING AND WRITING, establish tasks and normalize to illuminance of most important task or most common task; use controls to provide illuminance variability if tasks so demand.												
PARKING	See 26 | LIGHTING FOR EXTERIORS												
PEDESTRIAN WAYS	See 26 | LIGHTING FOR EXTERIORS												
READING AND WRITING													
• Computer	See READING AND WRITING/VDT Screen and Keyboard												
• Electronic Readers													
• Electronic Ink Devices	E_h and E_v @height of device		P	150	300	600	Avg	N	75	150	300	Avg
• LCD or LED Devices	E_h and E_v @height of device		N	75	150	300	Avg	K	25	50	100	Avg
• Facsimile													
• Analog	E_h @2' 6" AFF; E_v @4' AFF[j]		R	250	500	1000	Avg	M	50	100	200	Avg
• Digital	E_h @2' 6" AFF; E_v @4' AFF[j]		P	150	300	600	Avg	L	37.5	75	150	Avg
• Handwritten Work	Based on fair-to-good penmanship/hand print on white or canary paper												
• Pencil													
• Graphite/HB	E_h @2' 6" AFF; E_v @4' AFF[j]		P	150	300	600	Avg	L	37.5	75	150	Avg
• Red	E_h @2' 6" AFF; E_v @4' AFF[j]		R	250	500	1000	Avg	M	50	100	200	Avg
• Ballpoint/Rollerpoint/Felt-tip													
• Black	E_h @2' 6" AFF; E_v @4' AFF[j]		P	150	300	600	Avg	L	37.5	75	150	Avg
• Red, Green, Blue	E_h @2' 6" AFF; E_v @4' AFF[j]		Q	200	400	800	Avg	L	37.5	75	150	Avg
• Laptop	See READING AND WRITING/VDT Screen and Keyboard												
• Microforms (Projected)			L	37.5	75	150	Avg	I	15	30	60	Avg
• Print Media	Digital-printing-press-generated, white paper												
• 6-pt Font													
• Matte paper and ink	E_h @2' 6" AFF; E_v @4' AFF[j]		R	250	500	1000	Avg	L	37.5	75	150	Avg
• Specular paper and ink	E_h @2' 6" AFF; E_v @4' AFF[j]		R	250	500	1000	Avg	L	37.5	75	150	Avg
• 8- and 10-pt Font													
• Matte paper and ink	E_h @2' 6" AFF; E_v @4' AFF[j]		P	150	300	600	Avg	K	25	50	100	Avg
• Specular paper and ink	E_h @2' 6" AFF; E_v @4' AFF[j]		P	150	300	600	Avg	K	25	50	100	Avg
• 12-pt Font													
• Matte paper and ink	E_h @2' 6" AFF; E_v @4' AFF[j]		O	100	200	400	Avg	K	25	50	100	Avg
• Specular paper and ink	E_h @2' 6" AFF; E_v @4' AFF[j]		O	100	200	400	Avg	K	25	50	100	Avg
• VDT Screen and Keyboard													
• CSA/ISO Types I and II	See Figure 12.16 | CSA/ISO Computer Screen Qualities												
• Positive polarity	E_h @2' 6" AFF; E_v @3' 6" AFF[j]		P	150	300	600	Avg	N	75	150	300	Avg
• Negative polarity	E_h @2' 6" AFF; E_v @3' 6" AFF[j]		N	75	150	300	Avg	K	25	50	100	Avg
• CSA/ISO Type III	See Figure 12.16 | CSA/ISO Computer Screen Qualities												
• Positive polarity	E_h @2' 6" AFF; E_v @3' 6" AFF[j]		N	75	150	300	Avg	K	25	50	100	Avg
• Negative polarity	E_h @2' 6" AFF; E_v @3' 6" AFF[j]		L	37.5	75	150	Avg	I	15	30	60	Avg
• White Board													
• Analog or Digital													
• Reading (reference)								N	75	150	300	Avg
• Reading (with presenter)	Presenter at white board							P	150	300	600	Avg

Table 32.2 | Office Facilities Illuminance Recommendations continued next page

Uniformity Targets[e] Over Area of Coverage: 1st ratio $E_h/2^{nd}$ ratio E_v if different uniformities apply: Max:Avg	Avg:Min	Max:Min	[f]	[g]	Typical Area of Coverage[h]: Task Proper or Task Area	Room or Designated Area
2:1						
2:1						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
see Table 12.6						
3:1						
3:1						

Notes for Table 32.2

The table column headings are discussed in detail in 32.3 Illuminance Criteria. See 12.5.5 Illuminance for discussion on procedures for establishing illuminance targets for a project. See Table 32.3 | SI Dimensional Conversions.

a. Applications, tasks, or viewing specifics encountered on any given project may be different from these and may warrant different criteria. See 32.3.1 Applications and Tasks. The designer is responsible for making final determinations of applications, tasks, and illuminance criteria.

b. Values cited are to be maintained over time on the area of coverage.

c. Values cited are consensus and deemed appropriate for respective functional activity. In a few situations, code requirements are within 10% of IES recommendations. This is apparently an artifact of metrication. Footcandle conversions of any values cited in Table 32.2 should be made at 1 fc to 10 lx. Regardless, codes, ordinances, or mandates may supersede any of the IES criteria for any of the applications and tasks and the designer must design accordingly.

d. Targets are intended to apply to the respective plane or planes of the task.

e. Illuminance uniformity targets offer best results when planned in conjunction with luminance ratios and surface reflectances.

f. Applications and tasks cited with sunburst icon are candidates for strategies employing any combination of daylighting and electric lighting to achieve target values during daylight hours. Daylighting may require unconventional approaches.

g. Tasks with specular components, like computers with CSA/ISO Type III screens or printed tasks with glossy ink or glossy paper, are prone to veiling reflections. The likelihood of an application's or task's predisposition to veiling reflections is indicated by the reflected-light icon: black and white signals high likelihood; gray and white signals moderate likelihood; pale gray and white signals some likelihood; and all-white signals little-to-no likelihood.

h. The designer must establish areas of coverage to which targets apply. Green highlight identifies task proper or task area as the typical area of coverage for respective cited targets. Amber highlight identifies room or designated area as the typical area of coverage for respective cited targets.

i. For applications where task position is indefinite, such as some types of flexible meeting rooms, the typical area of coverage is "Room or Designated Area." For applications where task position is known, such as an office desk or a reading chair, or conference table a more efficient approach is likely achieved when target illuminance is applied to the "Task Proper or Task Area."

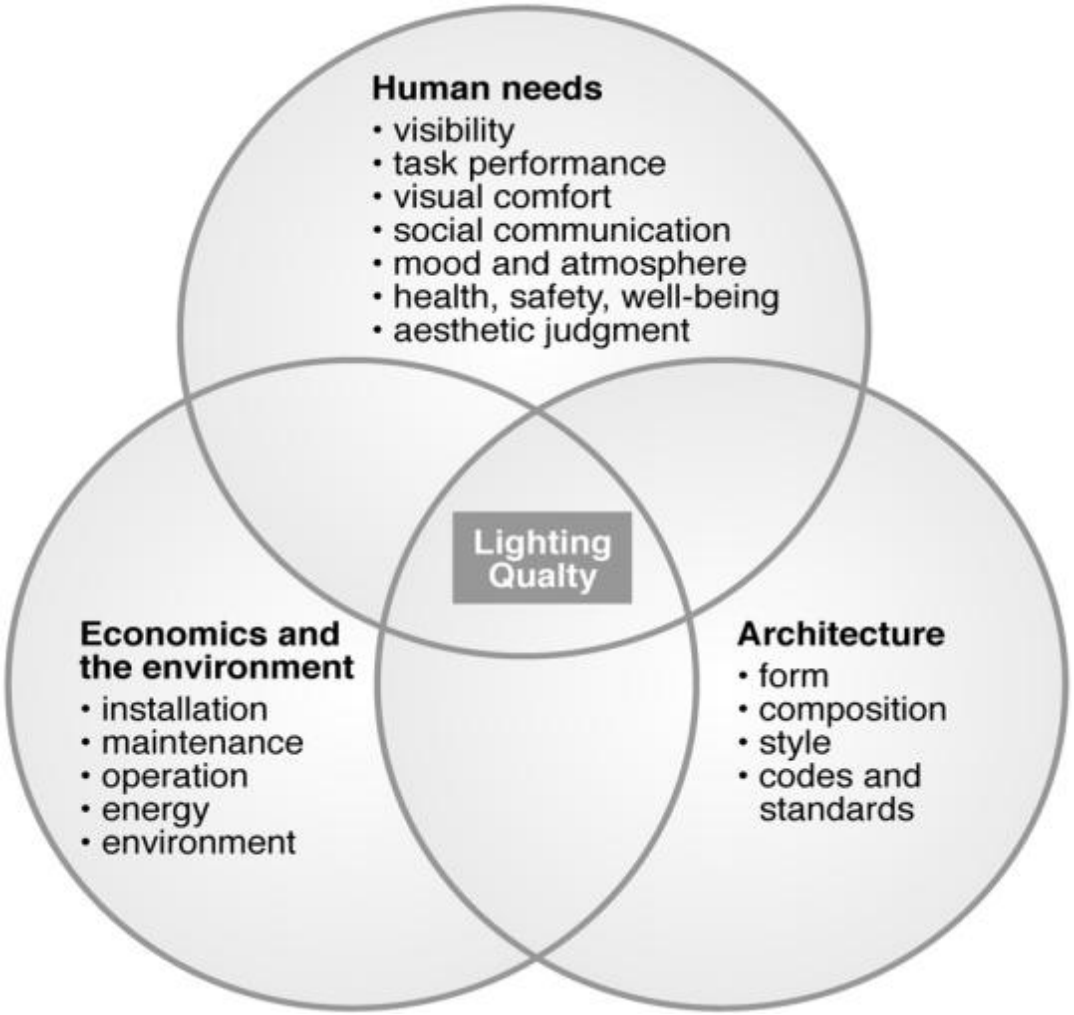
j. E_h and E_v elevations are based on conventional worksurface and seated eye height. Where other elevations are programmed, designer must adjust illuminance-criteria planes of interest accordingly.

k. See Table 22.4 | Indoor and Nighttime Outdoor Activity Level Definitions.

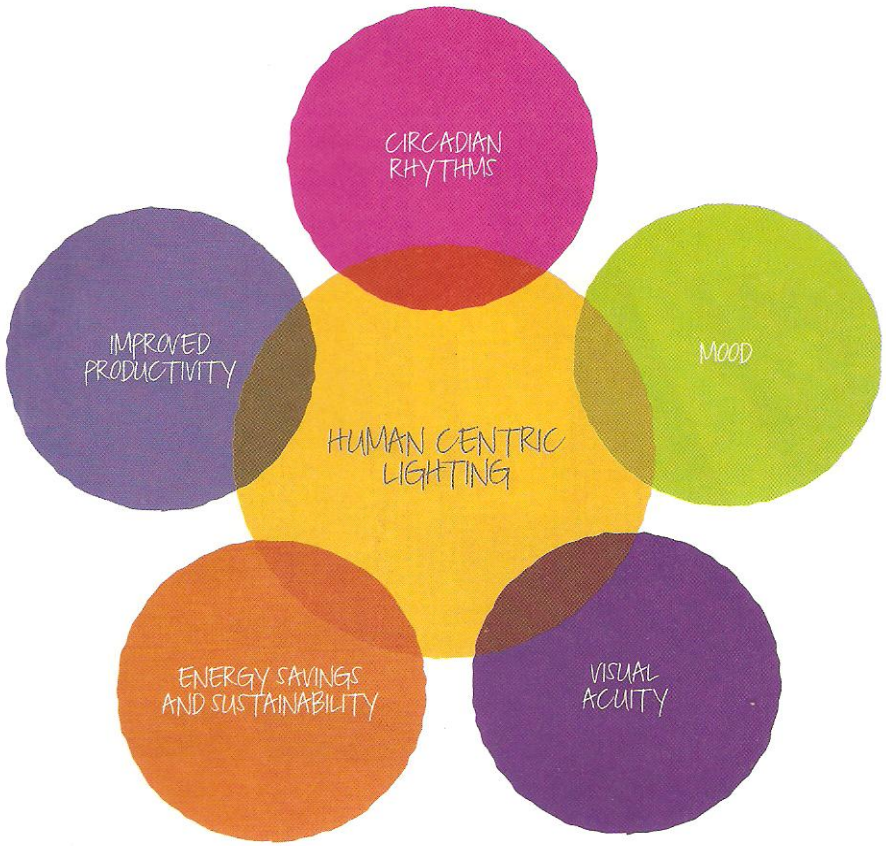
IES Handbook, 10th Edition - 2011

Recommended Maintained Illuminance Targets (lux)[b, c, d]									
Horizontal (E_h) Targets					Vertical (E_v) Targets				
Visual Ages of Observers (years) where **at least half** are					Visual Ages of Observers (years) where **at least half** are				
	<25	25-65	>65			<25	25-65	>65	
Category				Gauge	Category				Gauge
ances (likely fixed seating); For dedicated theaters see 28 | LIGHTING FOR HOSPITALITY AND									
ontrast markings with steps, curbs, and ramps, localized lighting may be deemed appropriate.									
	2	2	2	Min	F	5	10	20	Avg
L	37.5	75	150	Avg	K	25	50	100	Avg

The IES Defines "Lighting Quality"



“Human Centric Lighting” – A More Descriptive Alternative



HUMAN CENTRIC LIGHTING

Thanks to developments in solid-state lighting there now exists a whole new capability to dir

The most Disruptive Lighting since Incandescent

Interesting parallels between the rise of the incandescent lamp in the late 1800's…..

and the rise of the LED in the early 21st Century

- **Solid state technology**
- **DC vs AC current**

3. XLamp high-brightness LED light sources from Cree meet the DoE's stringent LM-80 test data for use in LED fixtures. The standard was developed by the Illumination Engineering Society of North America.

Computer Disruption - Tablet, E-Reader Ownership Soars

- 29% of Americans owned at least one tablet or e-reader as of the beginning of January 2012….

  Up from 18% in December

- Tablets will outsell laptops in 2013 – 84.1 million

- 63% of adults use smartphones to access internet – up from 31% in 2009

- Currently 10 Billion internet connections globally

The Disruption of Data Acquisition

"Some experts expect data to grow on the planet by 20 times between 2012 and 2020. So just the sheer mass of data is going to grow exponentially. That is now coming from things you might think of as non-intelligent, but that will become intelligent, things such as refrigerators, appliances, and oil rigs with sensors that can start communicating real-time information back into an infrastructure."

Mark Hurd

CEO, Oracle

Note: 90% of all digital data in the world was created in the last two years

Sensors - What can we do with the data?

"Our message is that LED solid state lighting systems will completely revolutionize lighting systems. This transition will occur through the convergence of advanced digital lighting, novel, distributed illumination sensors and new methods of control and communication between lights and between lighting systems and other building systems."

Bob Karlicek

Director, Engineering Research Center

Sensors – What can we do with the Data?

"We view future, LED enabled illumination systems as cyber physical systems that can:

- **'see' where the light is going**
- **'know' the environment that is using its lighting**
- **'decide' how best to save energy and meet the illumination needs (quality?) of the customer."**

"We call this Smart Lighting Systems that Think."

Bob Karlicek

Director, Engineering Research Center

Entertainment, Light Source, or ?

Samsung's Curved

OLED HD-TV

- **Two different programs shown at the same time.**
- **Ear buds built into 3-D glasses**

Sensors – What can we do with the Data?

"… the predictable pathways of information are changing: the physical world itself is becoming a type of information system. In what's called the Internet of Things, sensors and actuators embedded in physical objects – from roadways to pacemakers – are linked through wired and wireless networks. ….What's revolutionary in all this is that these physical information systems are now beginning to be deployed, and some of them even work largely without human intervention."

Michael Chui, Markus Loffler, Roger Roberts

March 2010 McKinsey Quarterly

Environmental Systems Require Human Intervention

- Open and close windows for air flow
- Raise and lower solar shades for glare control
- Open and close curtains for window heat gain/loss control

- Set and change heating/cooling temperature settings
- Alter heating/cooling settings for day/week/activities

- Turn on/off lighting
- Set/Control lighting intensity

…And that Lack of Intervention is Costly

- Manual control of environmental systems is not sustainable
- Increasingly complex environmental systems beyond the interest of the average consumer
- Constant environmental settings are convenient but waste energy
- Constant environmental settings are not consistent with human activity cycles nor human circadian cycles
- Sustainable systems need to be both "Intelligent" and "Intuitive"

Intelligent or Intuitive

Does this match the definitions of either "intelligent" or "intuitive"?

Intelligent or Intuitive

While this might match the definitive of “intuitive”, how would it rank for “intelligent”?

Intelligent or Intuitive

How about this?

Intelligent Systems – What People Want

- Employ Sensor(s)
- Contain a logic component

They work by:

- Gathering data through the sensor(s)
- Comparing the data
    - To each other
    - To some predetermined data set
- Make decisions
- Sometimes make new decision based on previous decisions

Intuitive Systems – What People Want

- Make sense to vast majority of people
- Take only one or two cycles to learn
- Easily communicated to others
- Easily remembered

Intuitive Sustainability

Fisher Paykel Dryer

- **On-off button**
- **No controls/settings**
- **Dries clothes by weighting them. When clothes no longer lose weight – by definition, they are dry.**

Intuitive Sustainability

The Nest Thermostat

- Turns on when you approach
- Simple dial rotates to change temperature
- "Red" for heating, "Blue" for cooling
- Occupancy sensor knows when the space is occupied
- Learns occupant patterns and adjusts settings accordingly
- Cost $245 – 2011 production sold out

Environment

Reinventing the Wheel. A former Apple exec builds a better thermostat

By Harry McCracken

IN 1953 LEGENDARY INDUSTRIAL DESIGNer Henry Dreyfuss created the T-86 Round, the iconic Honeywell thermostat that wound up in tens of millions of postwar homes. Dreyfuss, whose many projects included the Bell System's Princess telephone and Polaroid's SX-70 camera, knew how to create products that consumers would notice, even covet.

So does Tony Fadell, the former Apple executive who shepherded the original iPod to market in 2001 and spent years guiding its world-changing success. After stepping down as head of the iPod division in 2008, Fadell started building a green home for his family near Lake Tahoe. While working on the house, he had a new brainstorm: Why not take the thermostat, one of the most boring devices on the planet, and make it interesting? Have it keep people happily engaged while nudging them to use less energy? He gathered some fellow Apple alumni as well as veterans of Google, Twitter and other tech companies, and the result is the Nest, the first thermostat since the T-86 with a shot at capturing the world's attention.

Resplendent in brushed-steel trim with a unique round, color LCD screen (orange means your system is heating, blue means it's cooling), Nest is a radical departure from other modern thermostats—plasticky, utilitarian boxes that are impossible to love and easy to ignore. The circular case, reminiscent of both Dreyfuss's T-86 and the iPod's click wheel, doubles as a dial you spin to set the temperature and perform other functions. It also has wi-fi that enables you to tweak things from afar with a smart-phone app. Just as the iPod wasn't the first MP3 player, Nest isn't the first thermostat that can be controlled remotely. But the user interfaces on other smart thermostats are clunky, and none have the Nest's ambition. Fadell says his team started "with a blank piece of paper. We were either ignorant or naive, and as we peeled the onion, we learned."

They designed a product that learns too. The device, which launched in October, looks for patterns in the adjustments you make so it can program itself. Built-in activity sensors let it detect when the house is empty and doesn't require as much heating or cooling. Nest also gently prods you into good habits: it may depart from your specified temperature by a degree or two to reduce energy use, and it rewards your conservation efforts by displaying a leaf icon.

For a thermostat, Nest is pricey at $249, but the company estimates that utility-bill savings can cover the cost in less than two years. The device works in most homes and is supposed to be as easy to install as a light switch. Early adopters have already made it a hit. It's sold out through the end of 2011, and units are fetching $899 and above on eBay. Who knew that home energy management could be so sexy? ■

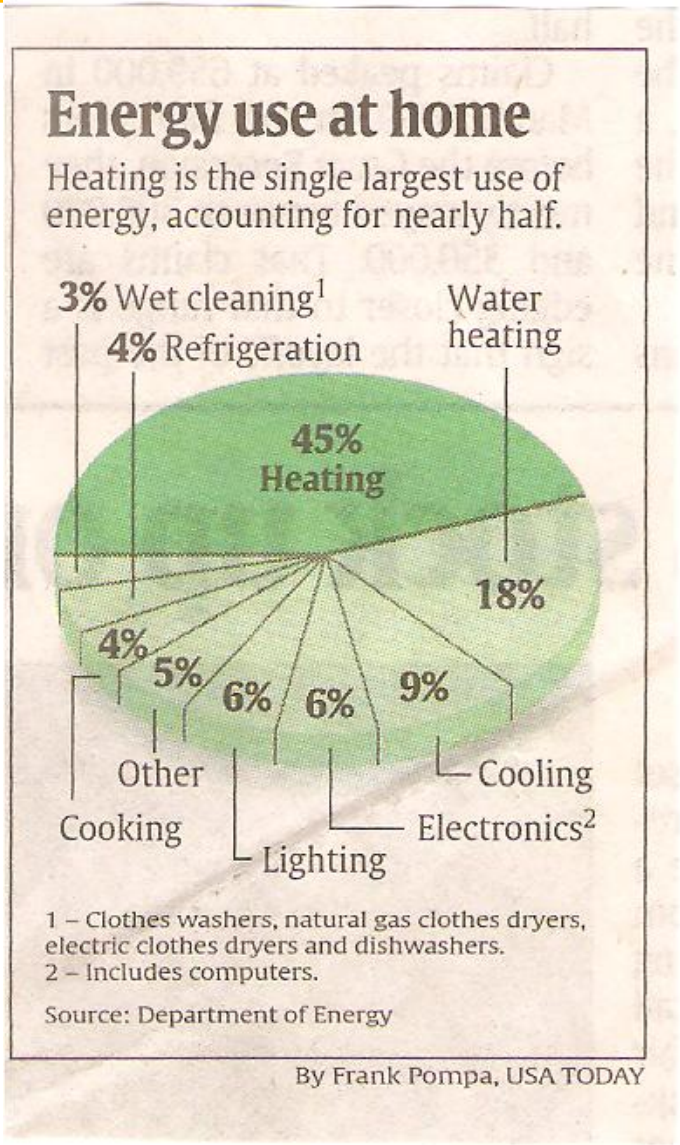
Residential Sustainability Accountability

Looking at this chart…

Where should the residential user spend money to save money?

Which area impacts sustainability to the greatest degree?

Now would you spend $245 to save from the 54% of your bill? (45% + 9%)



Human Centric System Leaders – The Auto Industry

- Cars/Trucks are a complete, packaged product with a specific human centric goal in mind
- Innovation begins at the high end and then filters down

- The Kate Moss Analogy

Dolby Labs Release new Sound System

- Theater owners seek better sound system to draw in viewers
- Dolby reviews and rejects adding more speaker output channels
- Dolby rethinks listener experience
- Sound experience transcends other brain functions
- Develops data input channels which lets editors separate up to 128 different sounds and place them spatially anywhere in the theater
- People experience the immediacy of three dimensional sound

Aspects of an Intelligent/Intuitive Lighting System

Lamps

- Capable of spectrum variation
- Capable of intensity variation

Luminaires

- Capable of beam variation
- Capable of varying degrees of diffusion

Controls

- Luminaire to luminaire two-way control protocol
- Time-of-day control of color spectrum and intensity
- Learns client's space usage preferences
- Intuitive control protocol

The Disruption of Solid-State Convergence

- We currently have emerging SSL technology
- The cost of all types of sensors is decreasing
- Data is expanding at an exponential rate
- Sensors and Data create the opportunity for algorithms
- People are drawn to systems that make their lives easier
- Products and services already exist that do this
- Currently lighting systems do not
- Who will make the next steps and how will that impact our industry?

Examples of Intelligent/Intuitive Lighting Systems?

Red Wood Systems

- Invented by former Cisco Systems Router engineers
- Companies buy this system solely to get their sensor network installed
- DC system with occupancy, daylight sensors
- Monitors fixture operating conditions

Enlighted Inc.

- Silicon Valley clean-tech start-up
- Occupancy, ambient light, and temperature sensors

A Disruptive Technology?

Meet Nick D'Aloisio

- **16 year old boy genius**
- **While studying for a history exam, he grew frustrated with the flood of text from Google search results.**
- **Developed a "genetic" algorithm to summarize content as a human does, in any language.**
- **Artificial Intelligence (AI) component extracts key points from masses of data.**
- **Think of the applications**

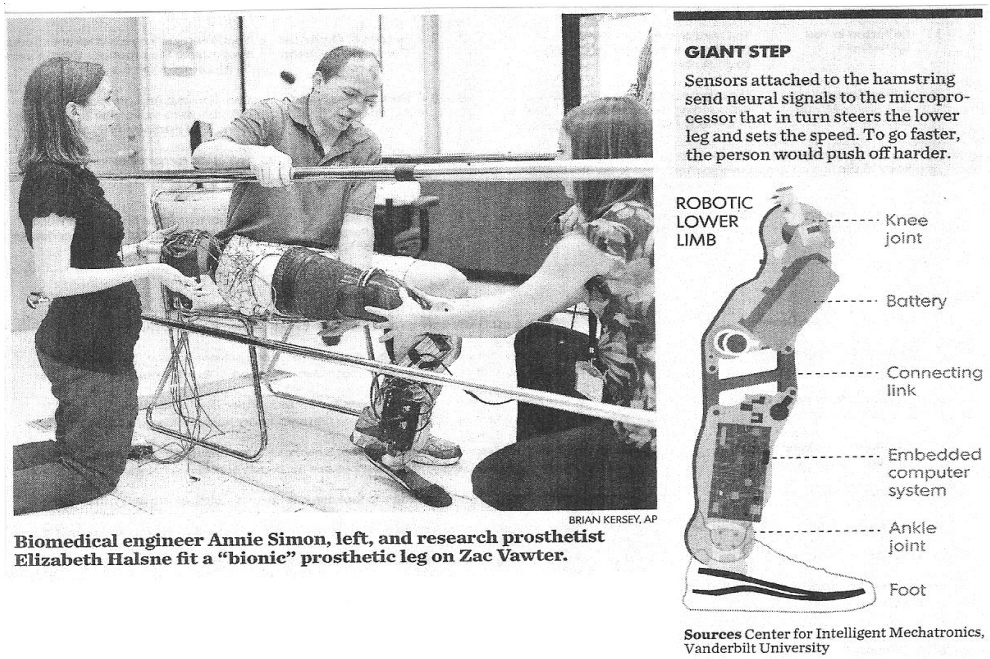
Forces which move humanity and make history, the ever – shifting powers that fit new thoughts to new conditions , and shape the destiny of mankind.

A Final Thought – Disruption or Opportunity?

Our current state in this story is like that of the dryer…lots of dials to make our lighted environment suit us.

Our near future is like the dryer that requires only one button for human lighted comfort.

The Right Direction + Inspiration



Amputee to climb

2.109 Stairs

- **Actively powered leg**
- **Neural signals from brain**
- **Doctor transplanted nerve cells to hamstring**
- **Center for Intelligent Mechatronics at Vanderbilt University**