Solid State and Fiber Optics

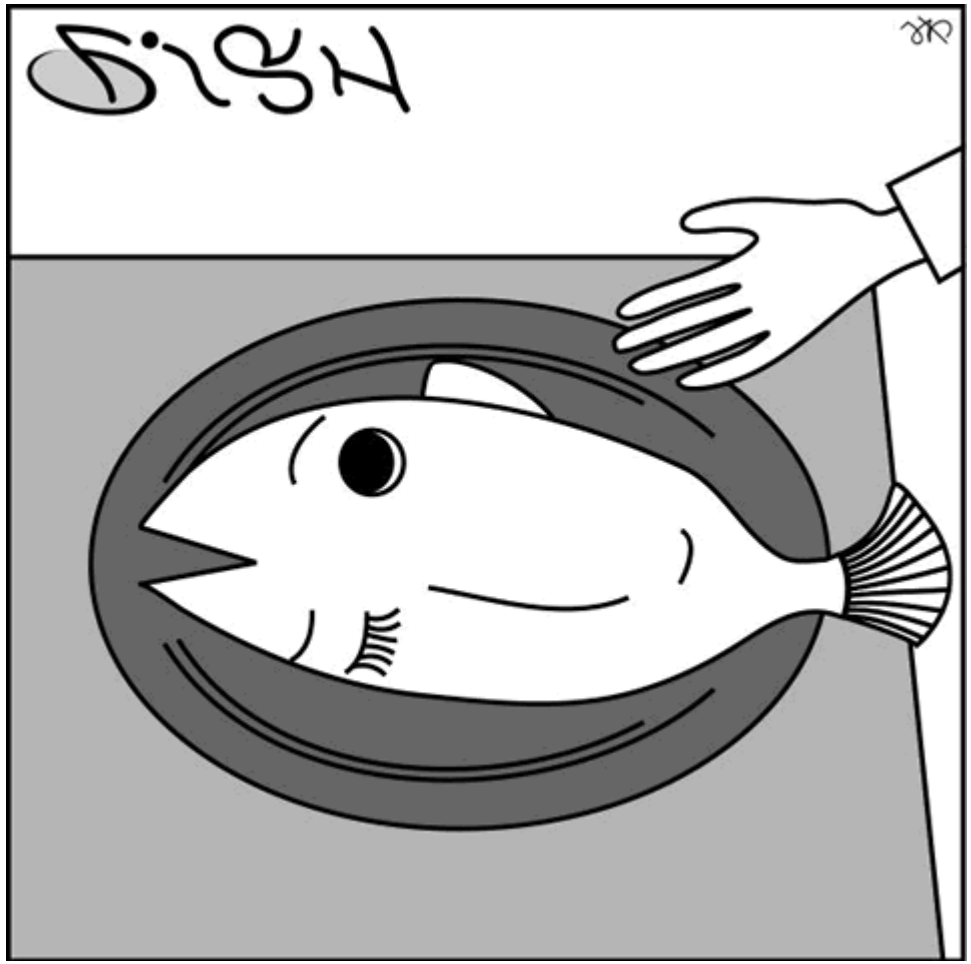
The Quest for Efficiency

Agenda

- LEDs Myths vs. Reality
- Fiber Optics – Overview
- Fiber Optics – Achieving Energy Efficiency
- Fiber Optics – Future Developments

LEDs Myth vs. Reality

All is Not as It May Seem



LEDs: Myth vs. Reality

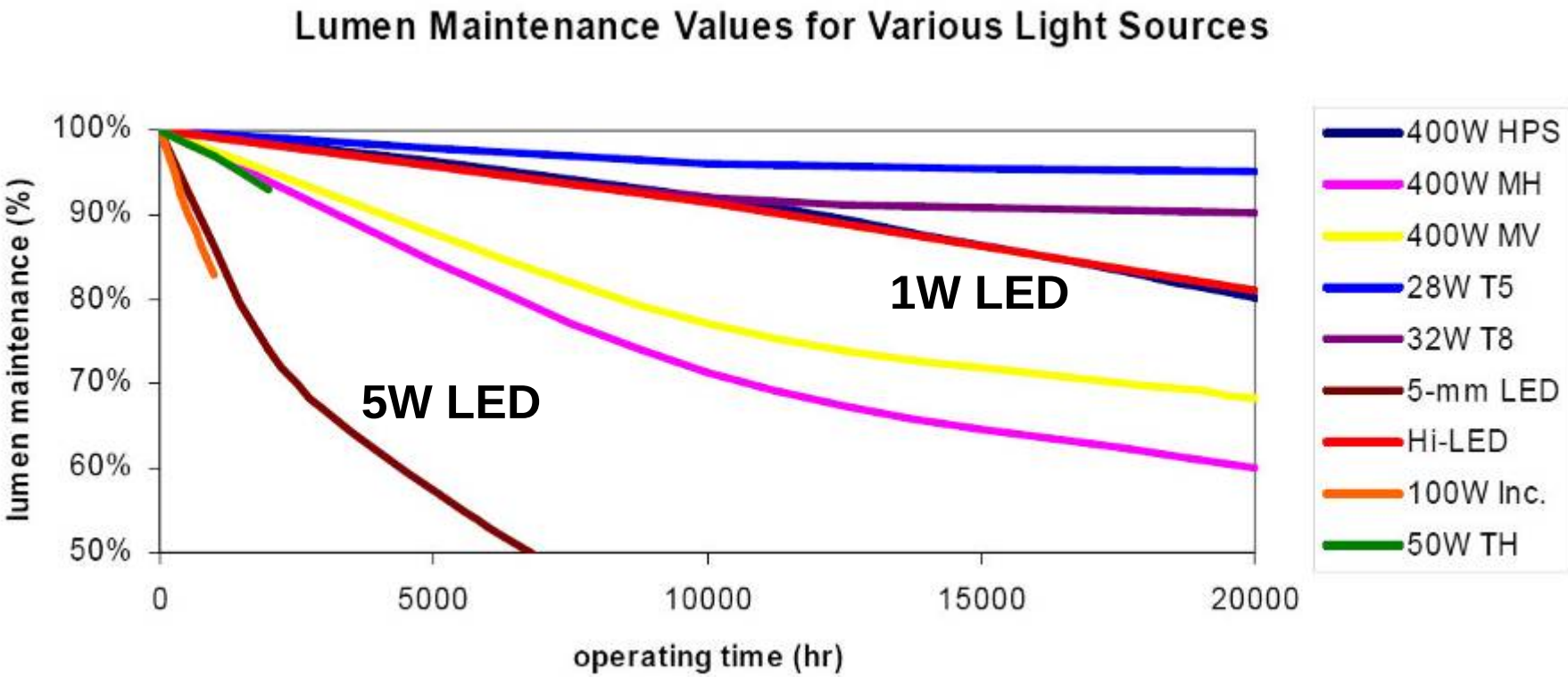
- MYTHS
  - Long Life
  - Highly Efficient
  - Compact Size
  - No Heat
  - Rugged
  - Green technology

- This information is mostly from the DOE, IES and 23 years of industry experience
- Purpose is for education

LEDs: Myth vs. Reality

- Myth: LEDs have a very long life
- Reality:
  - LEDs fail passively, they progressively dim
  - No universally accepted standards
    - Widely accepted to be at 70%
  - A 5W White LED is 50% by 10,000hrs

LEDs: Myth vs. Reality



LEDs: Myth vs. Reality

- Myth: LEDs are Highly Efficient
- Reality:
  - Efficacy ratings are performed by the chip manufacturers
  - Testing only the chips
    - This is not an LED!
    - Only the chip that is achieving stated numbers
  - Tested Under ideal conditions
    - Does not account for the resin housing, resistance in the leads, inefficiencies in the board, ambient temperatures, or optics

Table 1. Summary of DOE SSL CPTP Round 1 Results
Energy Performance and Color Metrics

Photometrics based on LM-79 for • Complete luminaires • 25° C ambient temperature		Light Output (lumens)	Luminaire Efficacy (lm/W)	Correlated Color Temperature (K)	Color Rendering Index
CPTP 06-01 Downlight (manufacturer published LED luminous efficacy = 40 lm/W)		193	12.8	3012	70
CPTP 06-02 Undercabinet (manufacturer published LED luminous efficacy = 55 lm/W)		166	16.1	3483	78.2
CPTP 06-03 Downlight (manufacturer published LED luminous efficacy = 45 lm/W)		298	19.4	2724	67.3
CPTP 06-04 Task Light (manufacturer published LED luminous efficacy = 36 lm/W)		114	11.6 [7.1]	6392	76
CPTP 06-05 Outdoor Area (manufacturer published luminaire efficacy = 24 lm/W)		2638	23.9	4661	20
CPTP 06-06A Surface Mount (manufacturer published LED luminous efficacy = 55 lm/W)	A	960	23.5	3405	75
	B	967	23.8	3414	75
CPTP 06-07A Wall/Step	A	23.8	4.0	2833	70.3
	B	25.9	4.3	2874	69.8
CPTP 06-08 Undercabinet		375	21.6	7003	72.3
CPTP 06-09 Task/Desk		327.5	15.3 [11.6]	3841	84.9
CPTP 06-10 Undercabinet		166	32.8] [21.9]	4103	77.3
CPTP 06-11 Task/Desk		215	17.0 [8.2]	5973	74
CPTP 07-02 Task/Desk	*CFL*	236	24.2 [13.3]	3432	79
CPTP 07-03 Task/Desk	LED	226	18.4 [8.6]	5939	74

Adjusted efficacy values in brackets [] include the effect of measured off-state power consumption assuming 3 hours on-time per day. See below for discussion of the impact of off-state power consumption on average yearly efficacy.

LEDs: Myth vs. Reality

Example: Comparison of CFL and LED Downlight Luminaires		
	CFL	LED
Light Source		
Lamp lumen rating	1800 lm	
Light source wattage	26 W	*3 W*
LED manufacturer declared "typical luminous flux"		*~100 lm per LED**
Number of lamps/LEDs per fixture	1	10
Luminaire Measurements		
Luminaire lumens	1062 lm	475 lm
Measured luminaire wattage	26 W	28 W
Fixture efficiency	59%	
Luminaire efficacy	40 lm/W	17 lm/W

Items in *italics* are not based on industry standard test procedures as published by ANSI/IESNA.
*Depends on specific LED used. Estimate is based on "typical luminous flux" declared by LED manufacturer on the product datasheet, which assumes 25°C LED junction temperature.

LEDs: Myth vs. Reality

- Myth: LEDs are highly compact
- Reality:
  - They are small.
  - They are easy to control the light
  - It’s true! Sometimes things are as they seem.

LEDs: Myth vs. Reality

- Myth: LEDs produce no heat
- Reality:
  - LEDs can heat up to 90°C
  - Up to 75-85% of their energy is converted to heat, not light!
  - Touch a 5W
  - Heat will cause the LED to prematurely fail

LEDs: Myth vs. Reality

- Myth: LEDs are rugged and durable
- Reality:
  - These are electronics
  - Small wires and leads
  - Solder connections
  - PCB boards subject to breakage and fracture
  - Sensitive to voltage and current fluctuations and static

LEDs: Myth vs. Reality

- Myth: LEDs are a Green technology
- Reality:
  - PCB Boards production use many harmful chemicals for processing, Gallium Arsenide
  - Lead in solder
  - Use Rare Earth Metals
    - Indium and Gallium
    - Byproducts of coal, aluminum and iron production
      - Water, energy and other resources are required for the purification process
    - Environmental contaminant – toxicity buildup

LEDs: Myth vs. Reality

- Summary:
  - Don’t believe all of the hype
  - LEDs are not bad
  - They are getting better
  - Ideal applications will present themselves
    - Architainment / Colour Changing
    - Art and Museum displays
    - Indicators
    - Traffic signals
    - Brake lights
    - LED/Fiber optics
    - Wayfinding

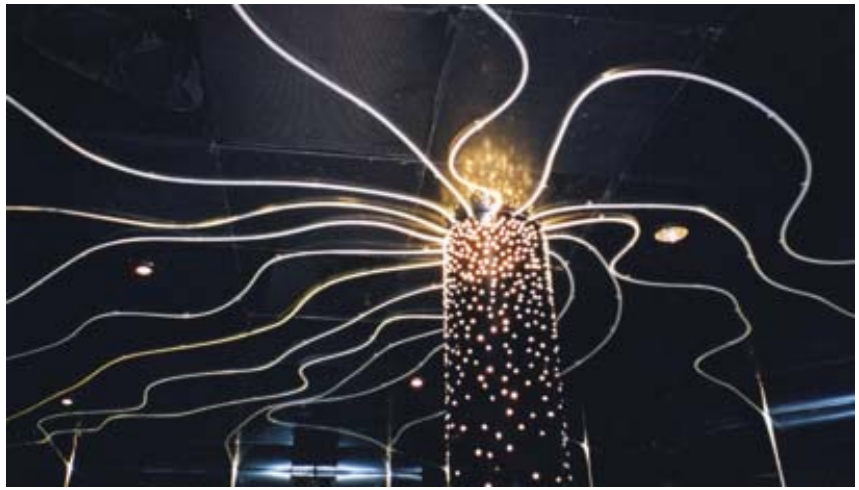
FIBER OPTICS OVERVIEW

Fiber Optics – Benefits

- Separates source from output
- Non-current bearing
- No heat
- No UV/IR
- Extremely durable
- Colour changing

Fiber Optics – Parts of the System

- Illuminators
  - Metal Halide
  - Halogen
- Optical Fiber
  - Side Light
  - End Light
- Other Parts



Illuminators

- Provide the light for fiber to carry
- 2 major types
  - Metal Halide HID
  - Halogen
- Other types
  - LED
  - Fusion / Sulfur
  - Laser
  - Daylight

Illuminators – Metal Halide

- Industry workhorse
- For commercial, industrial, and significant-use residential
- Components
  - BL uses a 150W
  - Has colour or twinkle wheel
  - UV/IR Filter
  - Coupling device

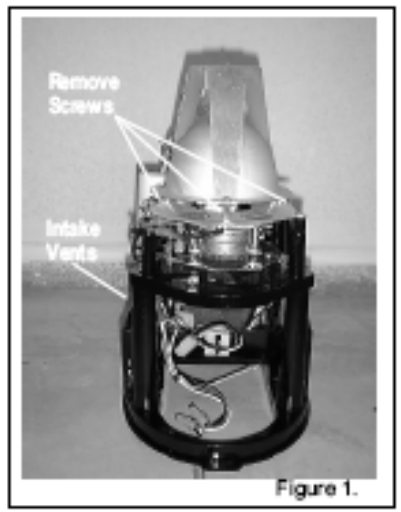


Figure 1.

Illuminators – Halogen

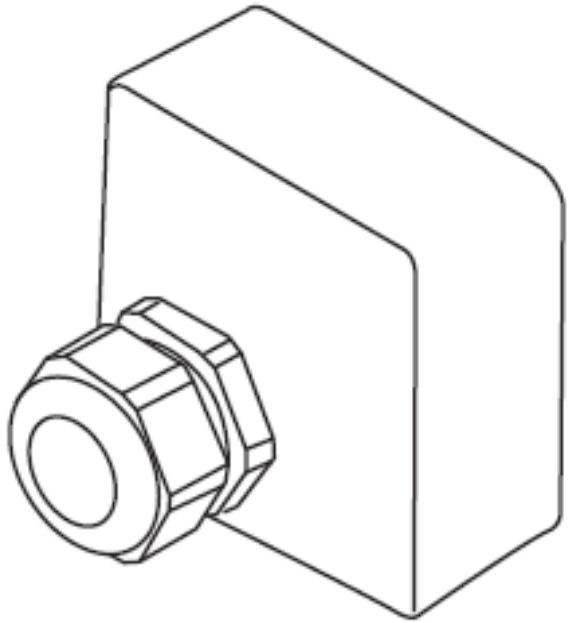
- Has same components as HID
- Not as bright or efficient as HID
- Physically smaller
- Significantly less expensive

Fixtures

- Finished End Piece for End Light
- Many styles, sizes and finishes
- Optical effects

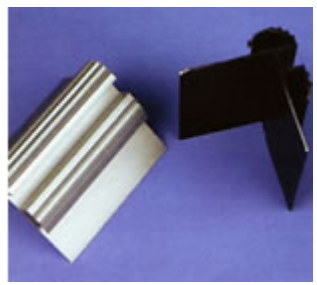
Fiber Driver

- Solid Core to Stranded coupler
- Energy and Material efficiencies
- Single Solid Core input fiber
  - Carries light majority of distance
  - Decreased light loss
  - Decreased cost
- Up to 1200 output stranded fibers
  - Increase number of stranded fibers per illuminator
- Can have twinkle or colour wheel



Mounting

- Mounts fiber to surfaces
- Keeps fiber running in straight lines
- Protects from UV
  - Floor and step extrusions
  - C-Channel
  - Circular tubes
  - P-Clips



FIBER OPTICS - EFFICIENCIES

Fiber Optics – Efficiencies

- Segregate heat and output
  - Will not compete with refridgeration or HVAC
  - A well designed display case or freezer application can consume as little as 25% of the power of fluorescents
  - Explosion proof

Fiber Optics – Efficiencies

- Multiple output points from single source
  - One 70W MH can produce as much light as eight 50W halogen lamps

Fiber Optics – Efficiencies

- New High Efficiency Sources
  - As lamp technologies improve, Fiber system efficiencies improve exponentially
  - Ceramic Metal Halides
  - LED **

Applications – Task / General

- Bathroom Vanity Mirror
  - 100W Halogen Illuminator
  - 12 output points
  - 100 CRI, 3500K

  - Illumination from 4 sides
  - Eliminated shadows
  - Low profile, flush mounted fixtures

Applications – Architectural

- Exterior Cross
  - Stormy, salt air environment
  - Neon was not an option

  - 150W MH Illuminator
  - 130ft of fiber (85ft for Cross)
  - 1.8W/ft (Neon: 15W/ft)
  - Remote mounted source for maintenance

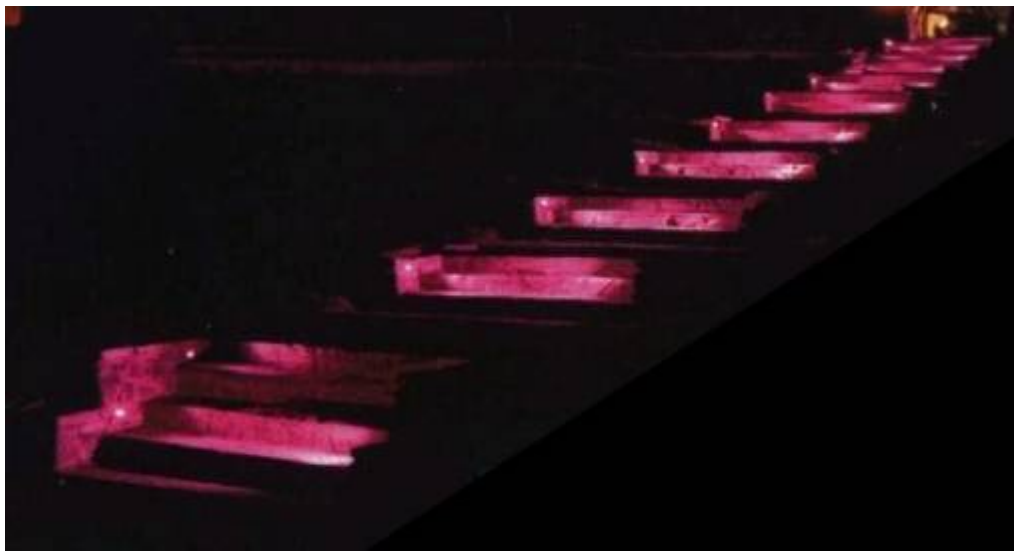
Applications – Linear Outlines

- Building Outlines
  - Stormy, salt air environment
  - Neon not an option
  - Wanted colour changing

  - 5x 150W MH Illuminator
  - 1000ft of fiber
  - 1W/ft (Neon: 15W/ft)
  - 61000KWh annual savings
  - Synchronized colour changing

Applications – Steps

- Safety Lighting
  - < 1 fc
  - High incidence of vandalism
  - Pedestrians had security concerns



- 2x 150W MH Illuminator
- 22 output points
- Replaced 25W Halogens
- Colour changing
- Vandal proof solution
- Created visual interest
- Became a focal point for the park
- Increased traffic led to increased safety

FUTURE DEVELOPMENTS

Future Developments

- Daylight integration
  - Ability to light multi-storey buildings, which normal skylights cannot do.
  - The incoming sunlight is captured and transformed producing a natural light output.
  - This system can be easily integrated with artificial lighting.
  - No heat loss and no heat gain.

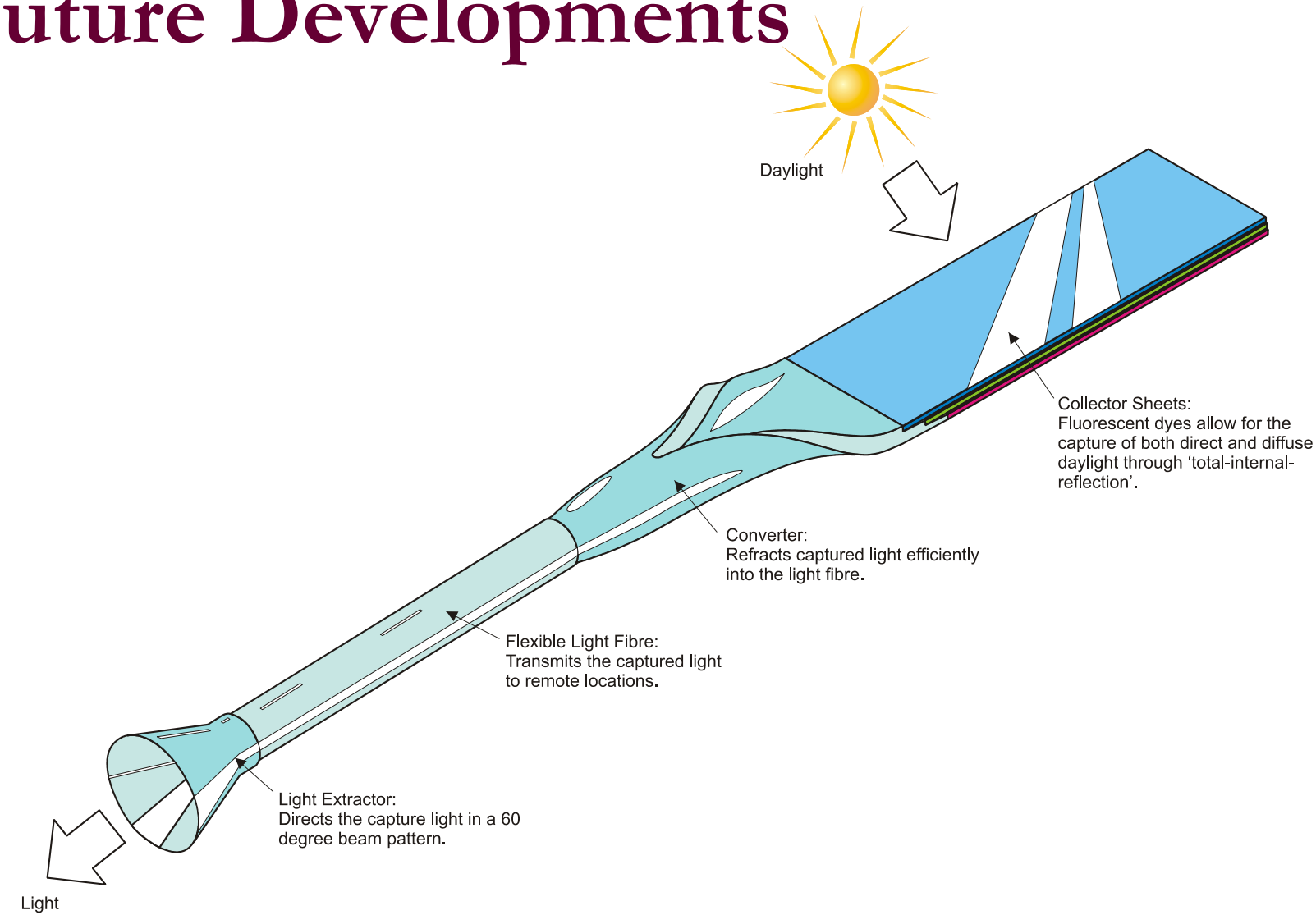
Future Developments

- A model by Professor Geoff Smith of UTS, based on the installation of the Australian domestic market indicates;
  - A saving of 10,000 T of CO_2 reduction.
  - There would be a 10,000,000 KWh energy savings.
  - A significant amount of ‘Carbon Credit’ trading.
  - A savings of approximately $1m from energy bills.

Future Developments

- Residential including single and multi-storey buildings;
  - New building,
  - Major refurbishment & renovation, and
  - Isolated home improvement.
- Commercial.
- Industrial.
- Other specialty applications including;
  - Mining,
  - Shipping, and
  - Hazardous areas.

Future Developments



Conclusion

- Questions?