WATT WORKS

Cashmans

LIGHTING DESIGN & POWER

How Lighting is Measured and Designed for Specific Applications

Electrical Power required from Utility Grid or Solar Off-Grid & Batteries

Lighting Requirements for Equine Environments

<u>Health Related Stall Lighting – typically 20 to 50 FC required</u>

Assessment of Condition; Eyes, Gums, Bleeding, etc

Reading Medication Instructions, administering

<u>Artificial Lighting for Mares – minimum 10 FC at eye level</u>

Induce Estrous Cycling

- See paper by Dr. Bob Wright in Appendix

Control Winter Hair Growth

<u>Spooky Shadows in Practice Arenas – Lighting Design required</u>

Lighting Basics - Photometrics

LUMENS – measures the brightness generated by a light source

CANDELAS – measures the illuminance created at a distance

FOOT-CANDLES – measures the illumination of a surface

(It's all about the old candle-light before electricity)

1 standard Candle, one foot away, from a surface of one square foot, creates one foot-candle of illumination on that surface. That amount of light from a source is defined as one Lumen, which creates one Candella of illumunance.

USING BASIC PHOTOMETRICS

Practical Example, a 50 ft x 100 ft building, requiring an *average* illumination of 20 foot-candles on the floor;

Total square feet = 5,000

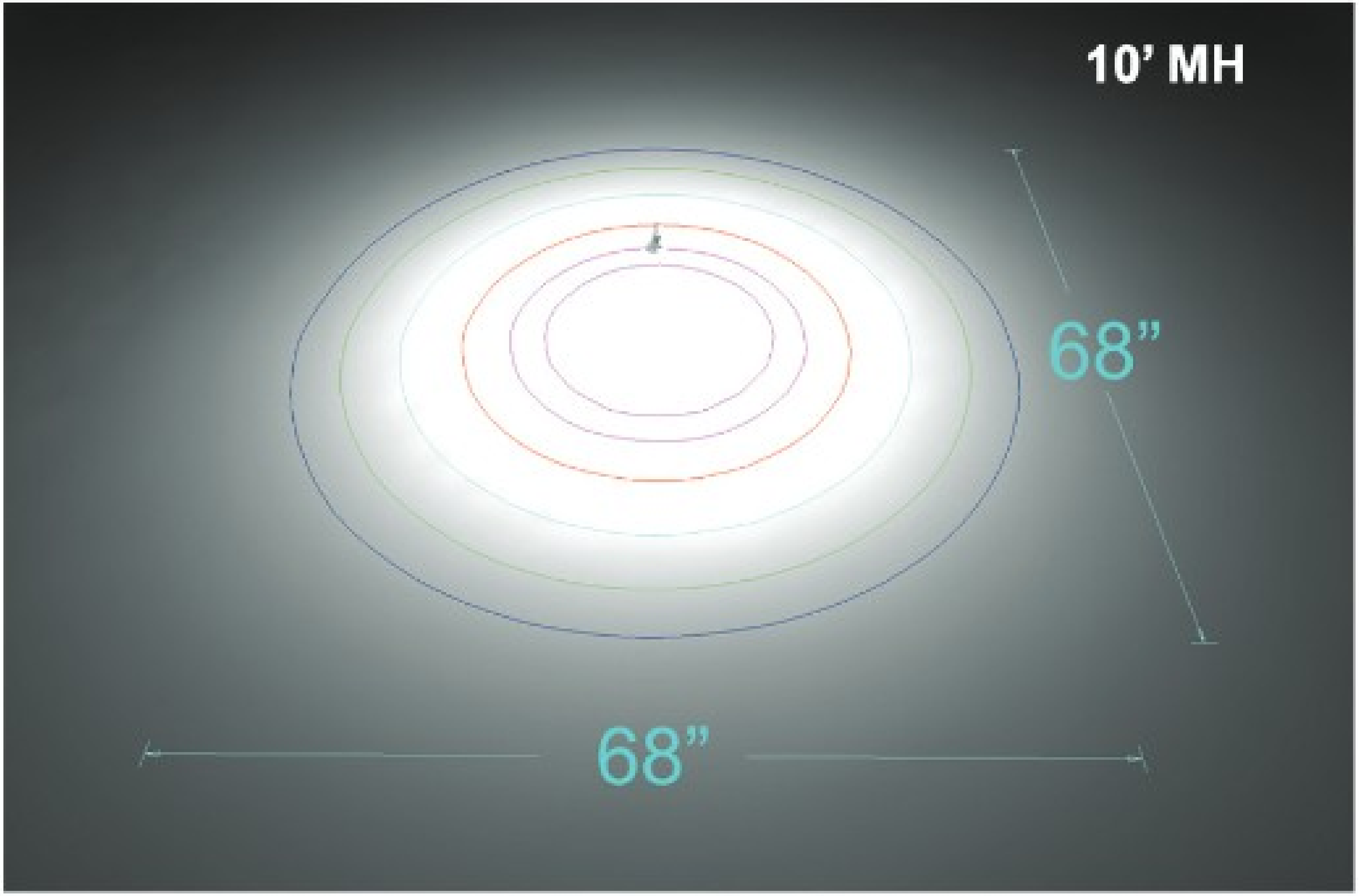
Therefore Lumens required is 20 for every square foot (20 F-C)

X 5000 sq ft = 100,000 Lumens

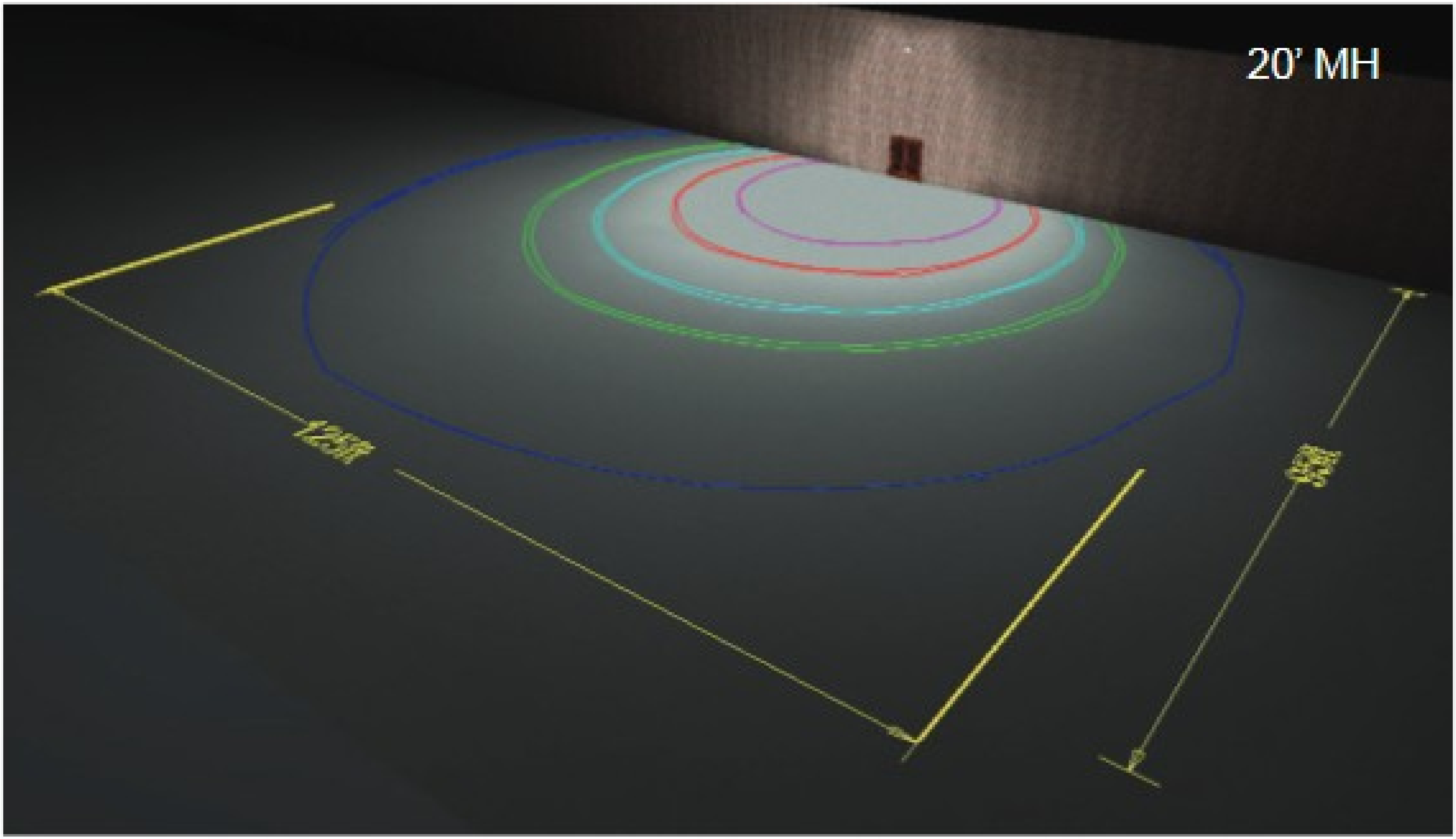
Using Light Fixtures that emit 10,000 Lumens each, it would require 10 of these Fixtures

The light on the floor would be brightest under the Fixtures and dimmest around the outside walls

- # Example of light distribution

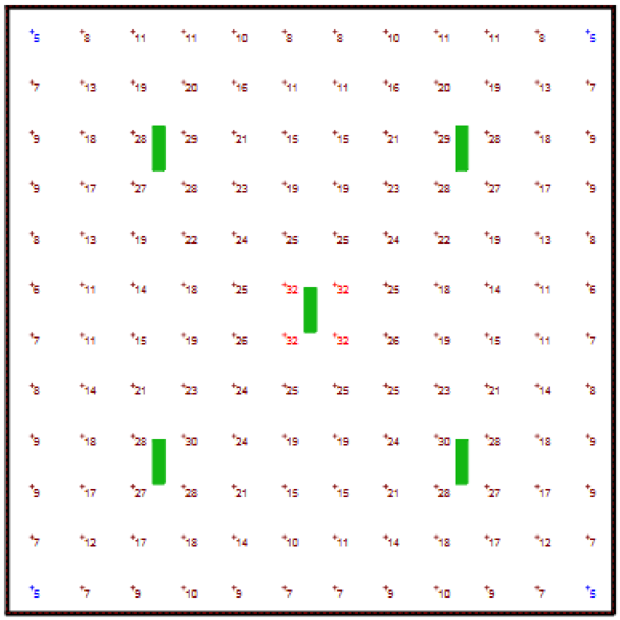


• Exterior Wall – Pack Example



LIGHT DISTRIBUTION PHOTOMETRICS

Foot candle distribution Plots



Plan View
Scale - 1" = 12'

Schedule

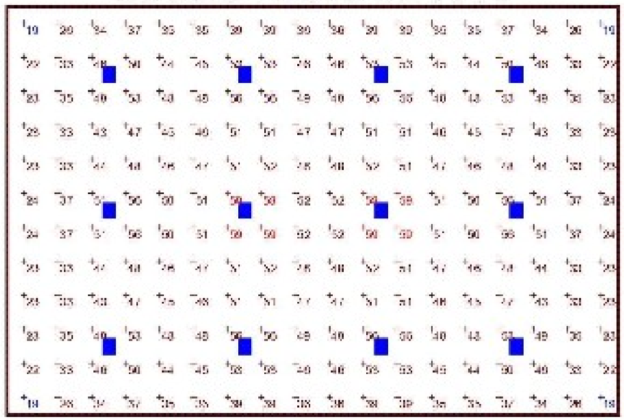
Symbol	Label	Quantity	Manufacturer	Catalog Number	Description	Lamp	Number Lamps	Lumens Per Lamp	Light Loss Factor	Wattage
[green rectangle symbol]	B	5	TechBrite LLC	VH48SS1B50CXXXX	White cast aluminum housing, white aluminum reflector, cle ar plastic prismatic lens enclosure	584 white LEDs, eight boards with 73 LEDs each	1	14362.63	0.988	119

Statistics

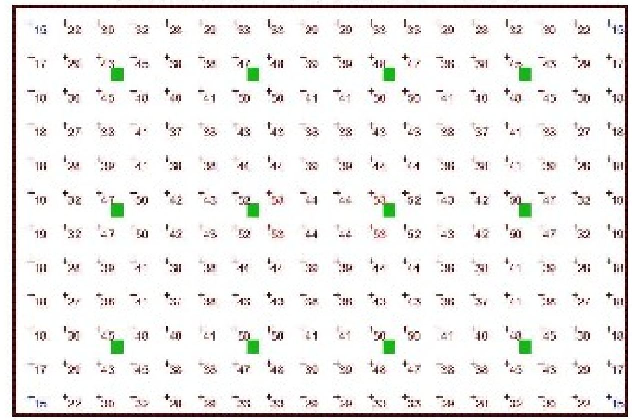
Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
VH48SS1B50C0000	[+ symbol]	17 fc	32 fc	5 fc	6.4:1	3.4:1

LIGHT DISTRIBUTION PHOTOMETRICS

EB2204SS1B5E0000



EB2204SS1B5EF000



Plan View
Scale - 1" = 20'

Schedule

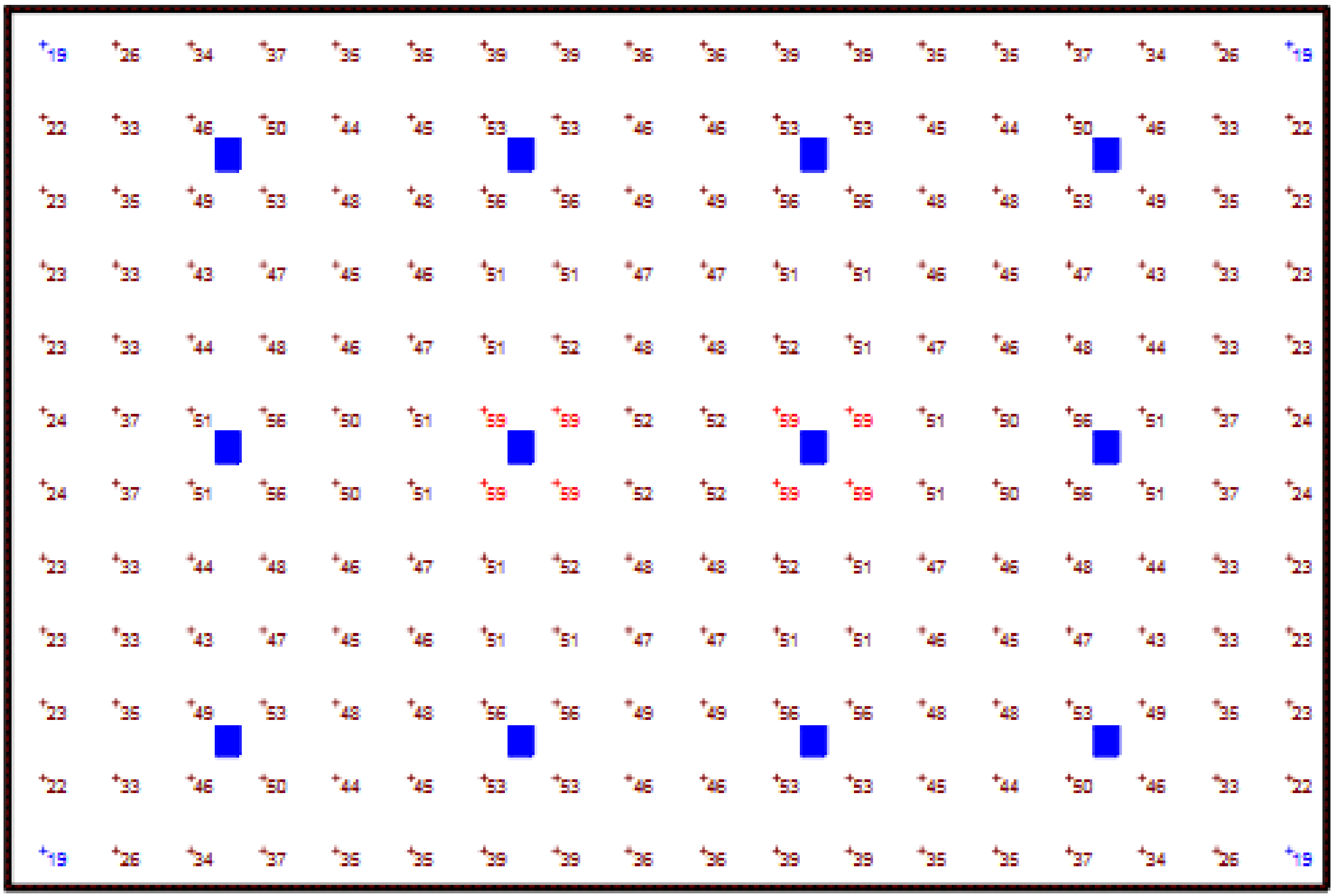
Symbol	Label	QTY	Catalog Number	Description	Lamp	Number Lamps	Lumens per Lamp	LLF	Wattage
□ (blue)	A	12	EB2204SS1B5E0000	White steel housing / reflector, no enclosure	624 white LEDs	1	19661	1	127.1
□ (green)	B	12	EB2204SS1B5EF50K	White steel housing, white steel reflector, frosted plasti c lens enclosure	468 white LEDs, three boards with 156 LEDs each	1	17240	1	127

Statistics

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
EB2204SS1B5E000 0	+	40 fc	59 fc	19 fc	3.1:1	2.1:1
EB2204SS1B5EF000	+	37 fc	53 fc	15 fc	3.5:1	2.5:1

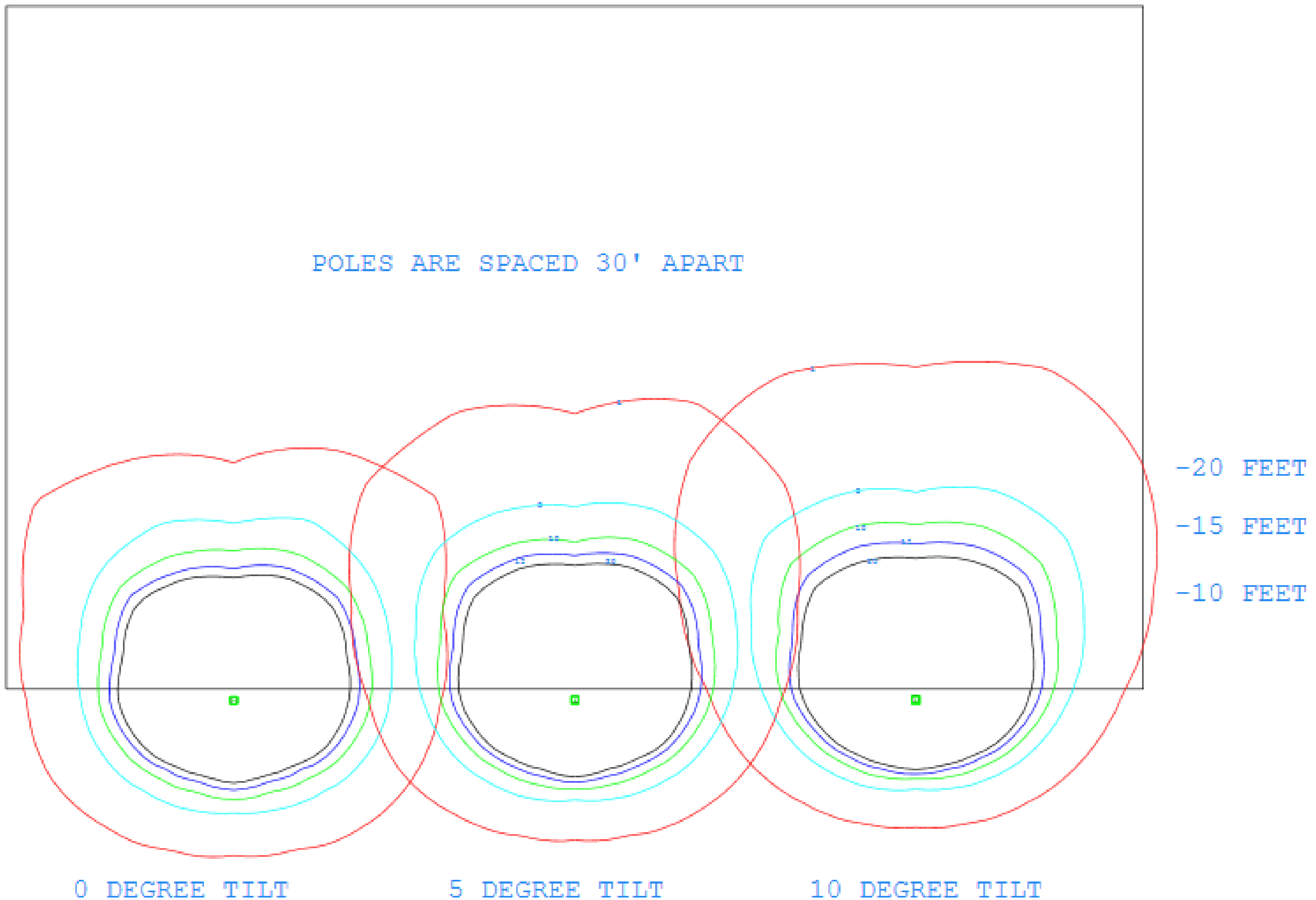
TECHBRITE
Saving energy in the best possible LIGHT

LIGHT DISTRIBUTION PHOTOMETRICS
Light is more uniform and Shadows reduced



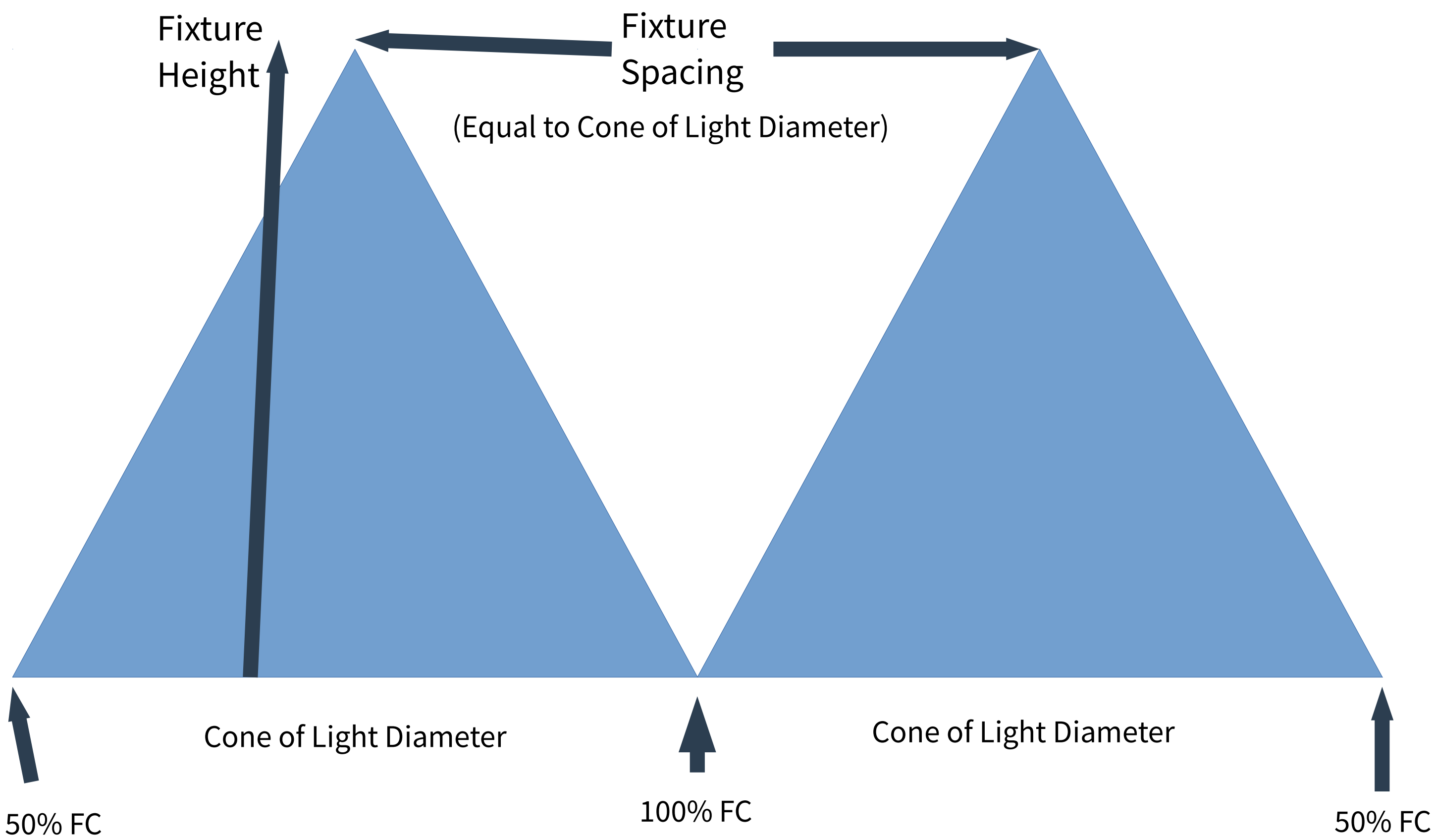
Plan View

LIGHT DISTRIBUTION PHOTOMETRICS
60 x 90 Outdoor Arena – Equipotential FC Lines



Cone of Light method for Spacing LED Fixtures

Results in uniform foot-candle distribution as each fixture overlaps



How Many Foot-Candles do you need?

Illuminating Engineering Society (IES) Standards Handbook

Office Desk = 30 to 50 FC

Warehouse Isle = 5 to 15 FC

Shop Workbench = 50 to 100 FC

Horse Race Track = 50 Horizintal, 75 Vertical @ 5 feet above track

Exterior Parking, Entrance, Security = 0.5 to 10 FC

Direct Sunlight = 2000 to 10000 FC

Work-Surface Illumination is brighter than the Floor

- Closer to the light source = brighter

ARENAS & BARNS AISLES and STALLS

TYPICAL Foot-Candles & Vertical vs Horizontal

Horse Racing – Vertical @ 5 feet above track = 50 to 70 FC

- Horizontal @ track = 30 to 50 FC

Practice Arena – 20 to 30 FC Floor

Barn Stalls - 10 FC (floor) to 30 FC (5 feet)

Barn Aisles - 5 FC minimum to 10 FC Average

LUMENS FROM LIGHT FIXTURES

Bulb Lumens VS Delivered Lumens

Beam angle / Distribution Pattern

Bulb type fixtures waste up to 50% of emitted Lumens

LED fixtures project all Lumens in 100% useful Gaussian distribution

Lumen Depreciation L70 spec = hours to 70 % of Initial Lumens

Efficiency in Lumens/Watt for Fixture including losses

LEDs use Efficacy for chip specs L/W

LIGHT SOURCE COMPARISONS – High Bay Fixtures

Source	Lumens	Watts	L/W	CT	CRI	Life
HID-MH	15,000	450	33	5000	70	15,000
HPS	60,000	450	133	2200	35	20,000
F32T8 x 6	10,000	220	50	4000	70-80	10,000+
Incand A	1200	100	12	2900	100	1,000
LED HiBay	15,000	118	130	4000	70-80	50,000+

(LEDs safer due to low operating temps and DC voltage)

LIGHT SPECTRUM VARIABLES

Human Eye sensitivity = Light Meter sensitivity

Light Fixture Color Temperature (CT) in degrees Kelvin (K)

Light Fixture Color Rendering Index (CRI) 0 to 100

Plant spectrum absorbed for Photosynthesis

Absorbs Red And Blue, reflects Geen, Yellow

Animal sensitivities for Breeding functions

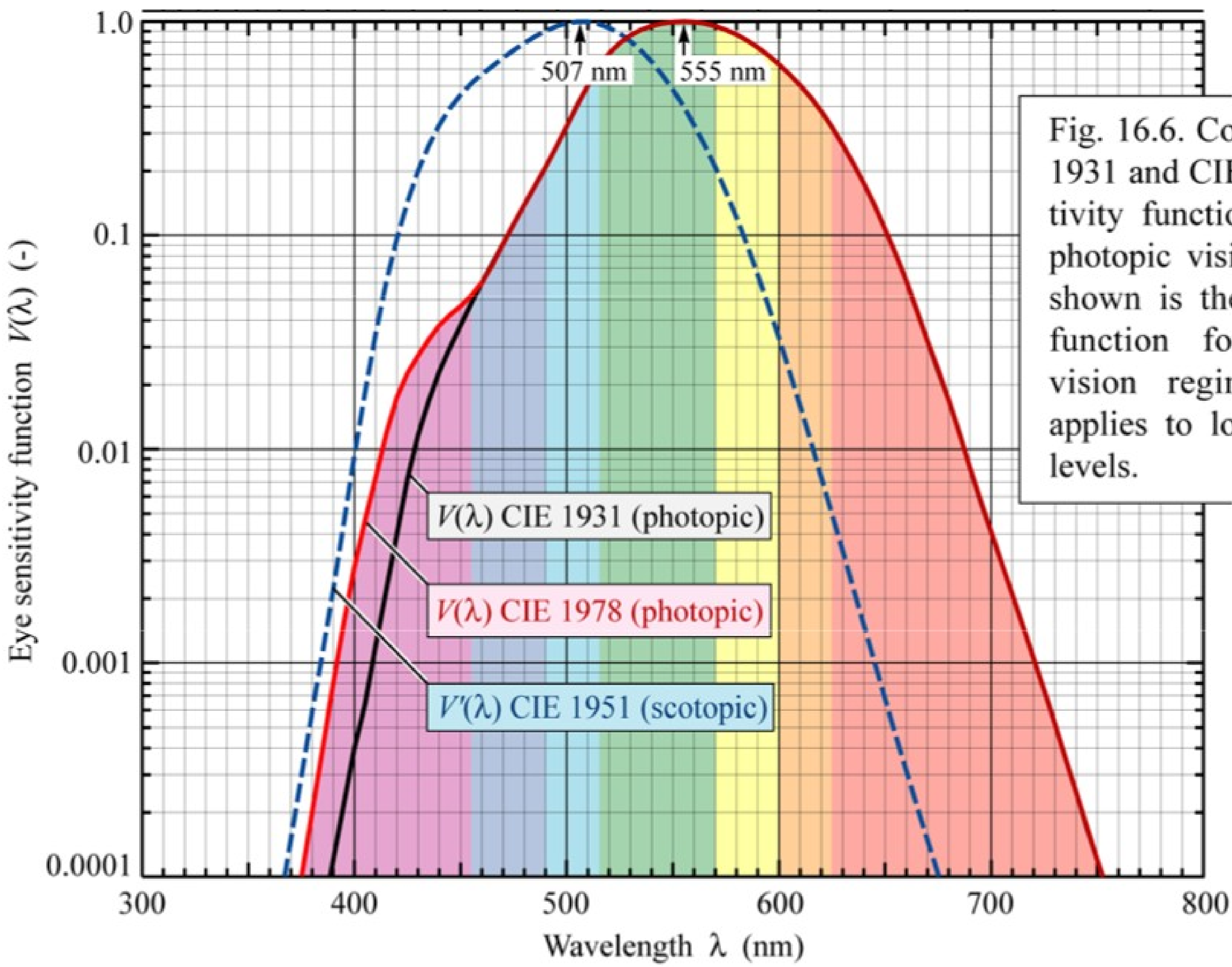
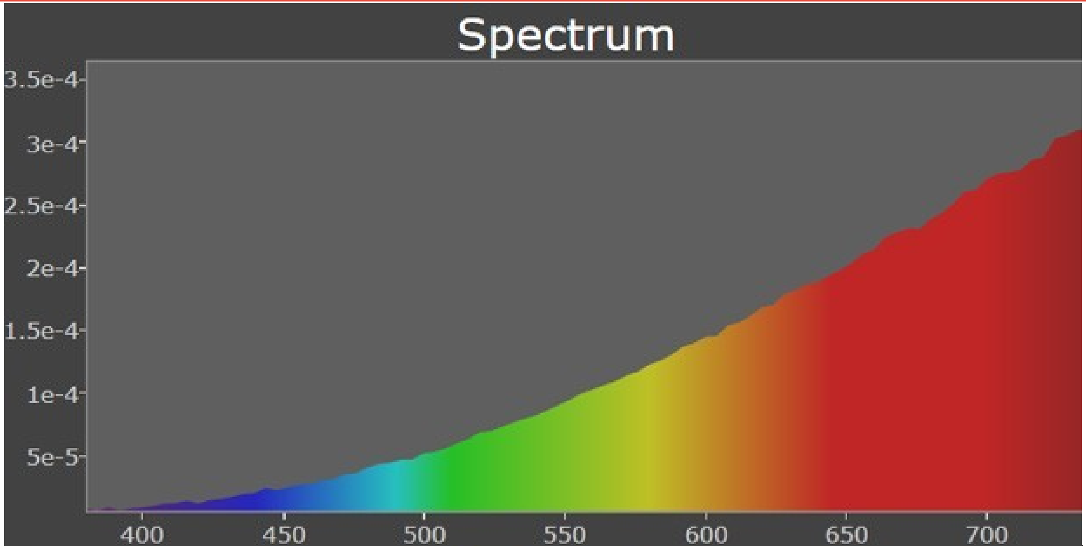


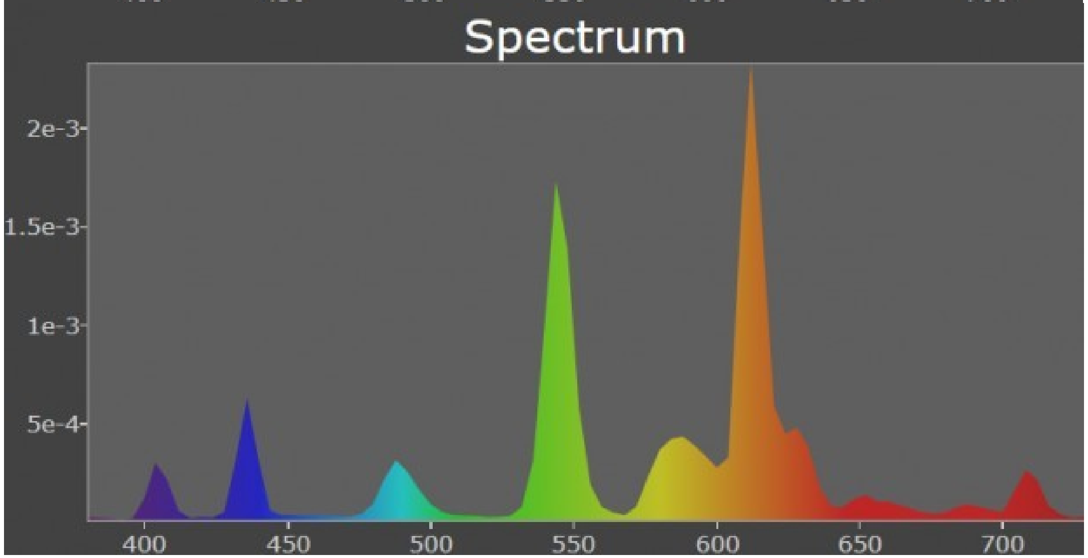
Fig. 16.6. Comparison of CIE 1931 and CIE 1978 eye sensitivity functions $V(\lambda)$ for the photopic vision regime. Also shown is the eye sensitivity function for the scotopic vision regime, $V'(\lambda)$, that applies to low ambient light levels.

Incandesent Bulb vs Compact Florescent Spectrum

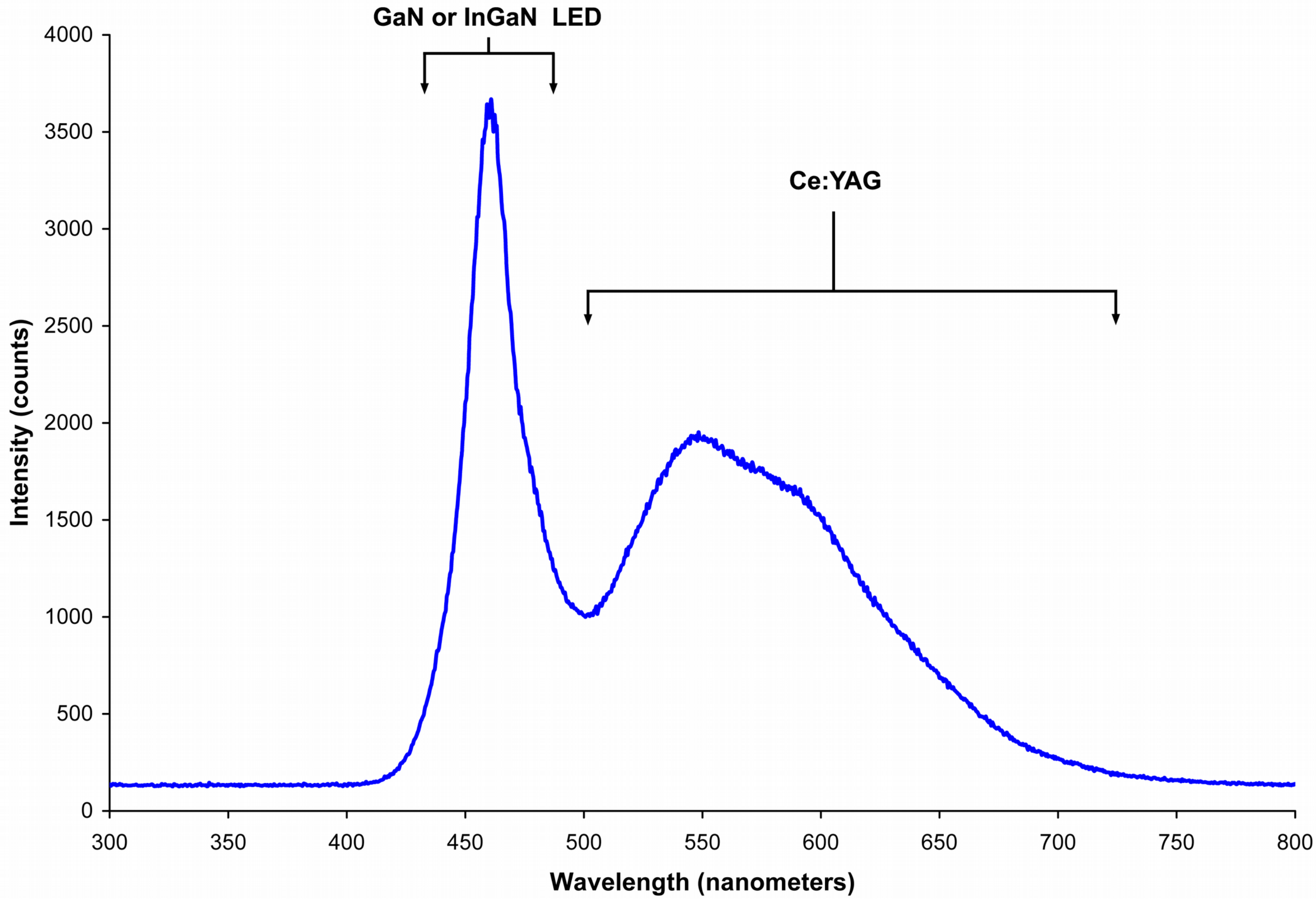
2480 K



2750 K

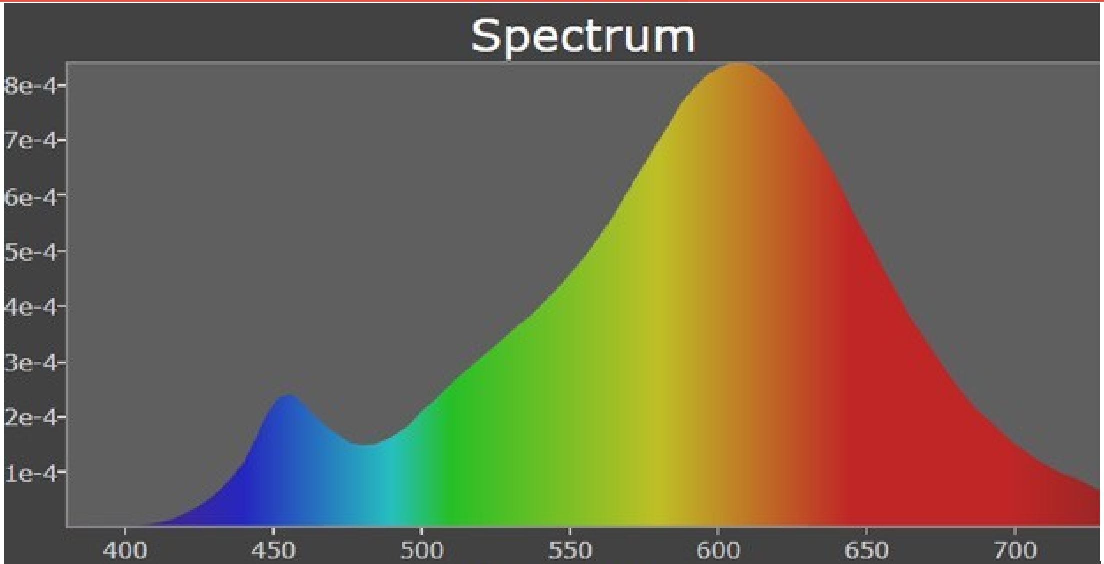


- **Spectrum of a white LED showing blue light directly emitted by the LED and the more broadband emitted by the phosphor.**

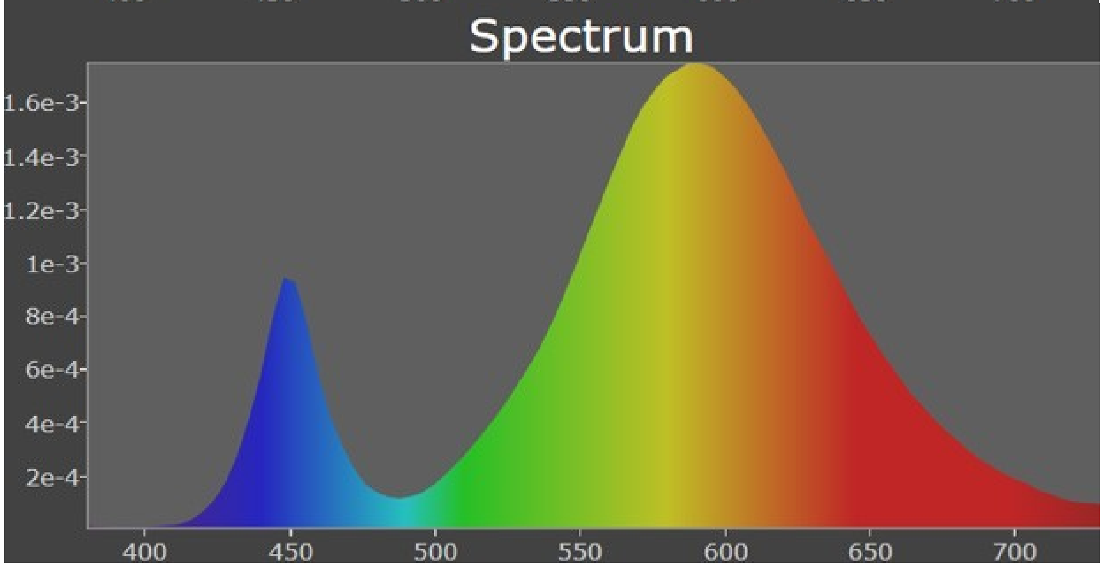


Warm White Led Spectrum (High CRI)

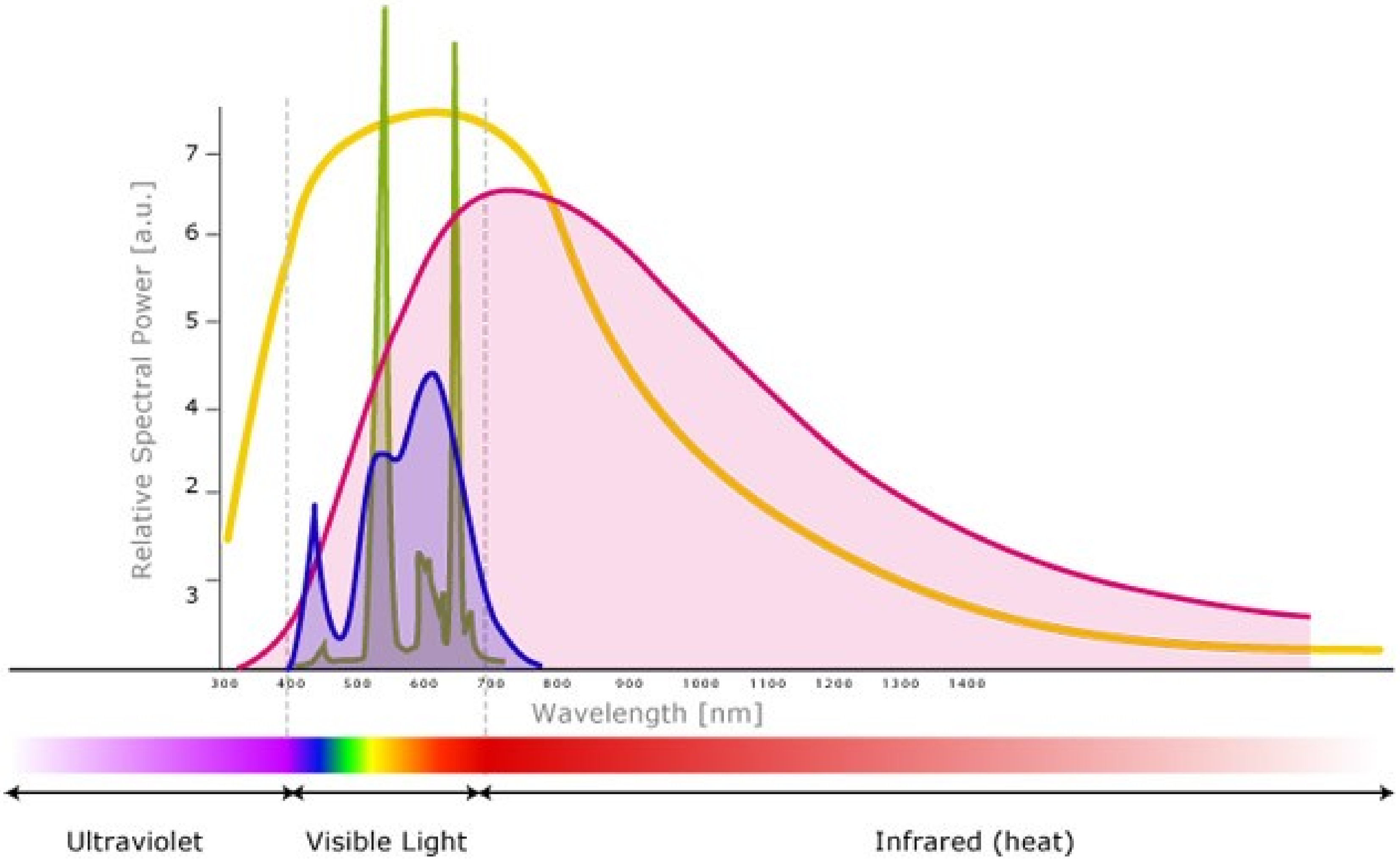
2760 K



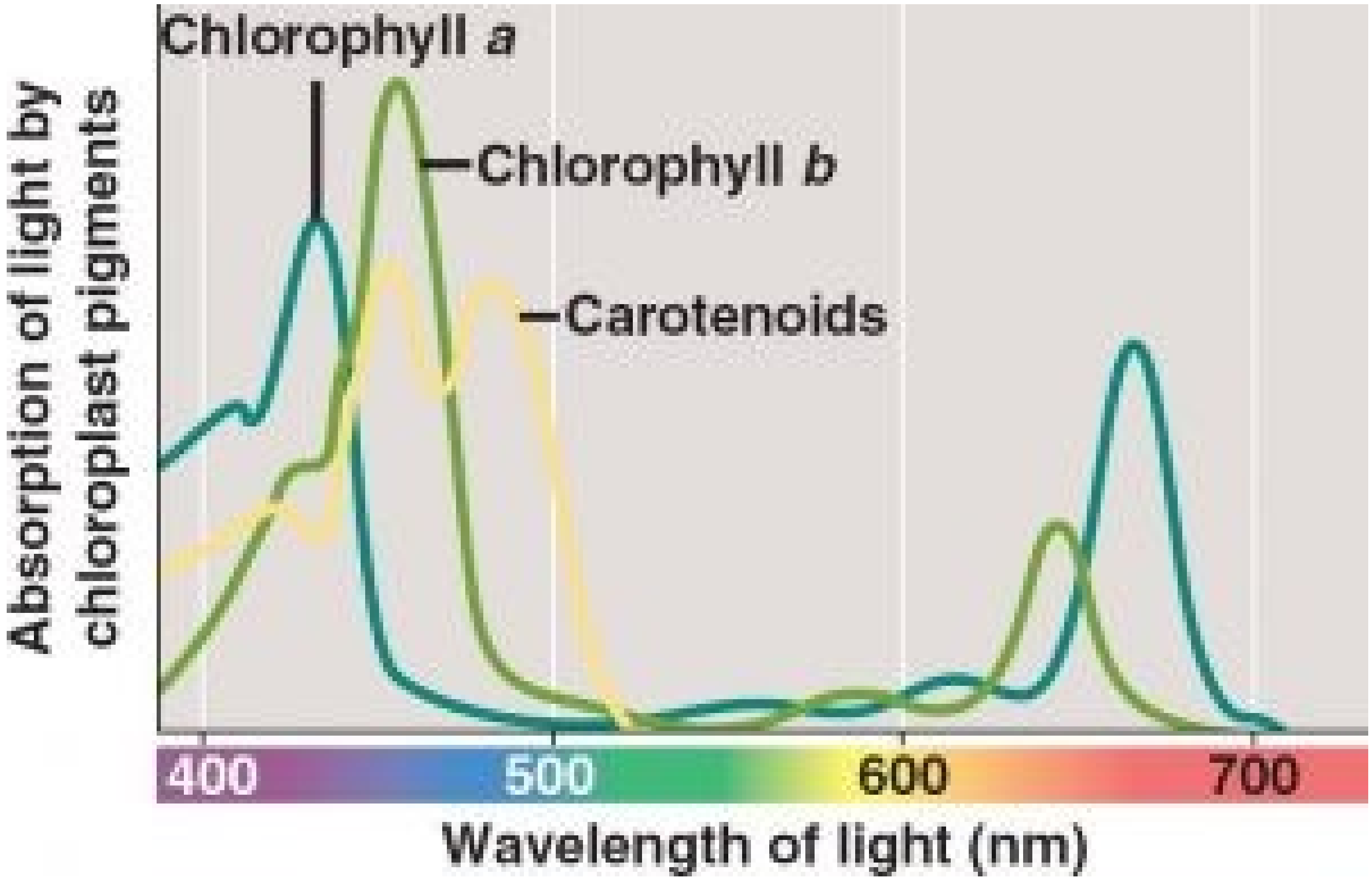
2850 K



Sun vs LED, CFL, Incandescent



Plants use UV-Blue and deep red for Photosynthesis -- not Green or Yellow



Is MADE IN USA Important?
higher price-better quality

LED Fixture Quality

typical cost-cutting that reduces life and reliability

Heat Management – chips life inverse of operating temp

Power supply – failure means LEDs out

Chinese sources disappear / no replacements – Warranties?

Techbrite in Cincinnati OH

Lumecon In Detroit MI

REBATES – AEP

Requires pre-approval for project funding

Typical $0.31/watt reduced for DLC rated LED fixtures

Also can apply to LED replacements of Fluorescent Tubes

ELECTRICAL ENERGY REQUIREMENTS

TOTAL POWER DEMANDED BY LIGHTING = WATTS

TOTAL ENERGY PER DAY CONSUMED = WATT-HOURS

Utility costs = cents/kWh + Demand charges + time of day rates + minimum meter billing

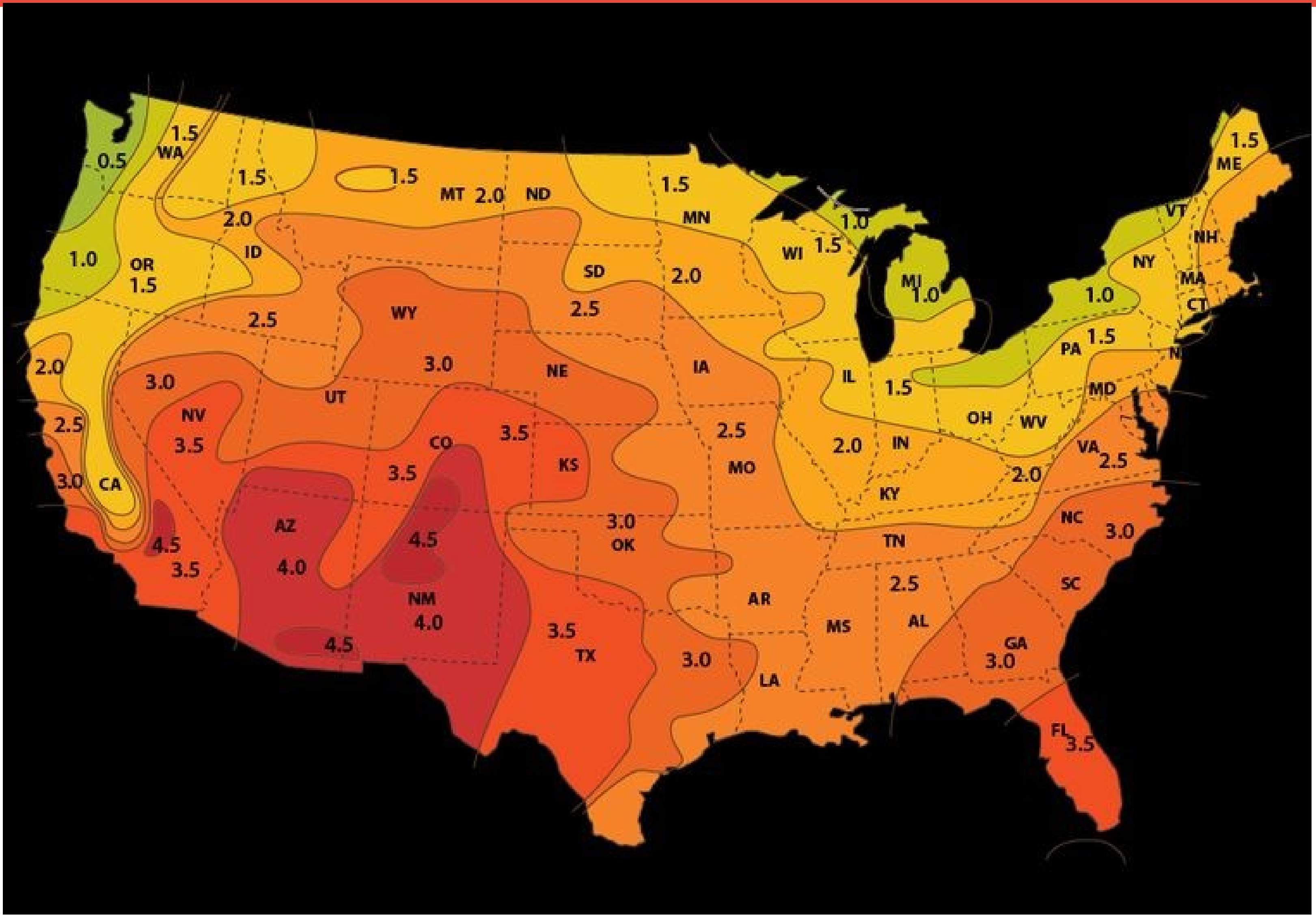
Cost of new power lines $2.00 to $8.00 per foot,

1 mile = $10,000 to $40,000

Is Solar Power a Practical Alternative ?

Solar Power is an expensive alternative, so the energy used has to be minimized, and it has advantages.

Average Minimum FULL-SUN Hours for Solar Power



• PRODUCING YOUR ENERGY WITH SOLAR PANELS AND STORING IT IN BATTERIES

TOTAL ENERGY NEEDED PER DAY/WEEK/MONTH

provided by

ENERGY GENERATED FROM SUNLIGHT

Considering worst-case scenarios depends upon your Location, operating schedule, time of year, time of day

Solar power systems with batteries $4,000 to $20,000

No Utility permitting requirements, Safe low voltage DC

Expense compared to cost of new Utility power lines

Duncan Run Hay Barn Solar Lighting

Duncan Run

Hay Barn

Solar Powered Lighting

Duncan Run Hay Barn Solar Lighting

Duncan Run

Security Lighting

Solar Powered

Duncan Run Hay Barn Solar Lighting

Solar Panels & Battery Bank

Artificial Lighting for Mares

Author:

Dr. Bob Wright - Veterinary Scientist, Equine and Alternative Livestock/OMAF

- **Artificial Lighting for Mares**

Mares are long-day breeders. This means that the majority of mares in temperate climates are stimulated to come into heat by increasing day light. Their normal ovarian cycle peaks in May to June. Most mares do not cycle during the shorter days of fall, winter and early spring. As day length increases in late spring, mares enter a transition period. This is the time when the ovaries return to cyclic activity by producing eggs or follicles. During transition, the follicles do not always ovulate due to low levels of luteinizing hormone. Estrus or periods of receptivity, during this period, may be prolonged (15-60 days) or result "in split heats".

Seventy-five percent of mares in a temperate climate, such as Canada, respond to the normal increase in day light as experienced in the spring. The other twenty-five percent of mares living in temperate climates, cycle year round. Horses residing at the equator also cycle year round. Ponies are more seasonal than horses. Natural selection may have favoured a more confined breeding season for ponies which evolved under harsher climatic conditions than horses. This would ensure that foals were born under the best climatic conditions.

The natural breeding period of May to July is the period of highest ovarian activity. Some owners prefer to have a breeding season from January to May. Many farms use artificial lighting to induce an earlier onset of regular ovarian activity. Artificial lighting is used to increase the day length to14-16 hours. Mares which are normally housed outside should be brought into individual stalls before dark to ensure that they are within 8 feet of the artificial light source. Stalls, where mares are normally housed, should have adequate window space to ensure adequate natural light during the day.

Research suggests that extending the day length by adding light starting in the late afternoon is better than turning the lights on earlier in the morning and shortening the night length. In practice, the additional day light is usually split and added to both the beginning and end of the natural daylight period. Day length should be lengthened starting 8-10 weeks prior to the desired period for resumption of normal ovarian activity. For a breeding season starting February 15th, the lighting program should be started December 1st.

The length of artificial lighting required will vary with the latitude location of your farm and, therefore, the natural day length at that location. For example, the day length on December 1st at Kapuskasing, Ontario, is 8.7 hours, while at Toronto, it is 9.4 hours. If you want to determine the exact day length in your area, you can calculate it by accessing the following website: http://pro.hmso.gov.uk/modb-iec/dayleng.htm. You must know the Julian date and your approximate latitude to use this calculation. For example, December 1st is the 336th day of the year and Toronto is at latitude 43 degrees 41 minutes north.

Two systems of lighting are used:

hold a constant level of light for 14-16 hours throughout the light stimulation period (e.g. to the 9.4 hours of daylight in Toronto on December 1st., add 6 hours of light in the evening) or
increase the day light length in small increments by adding 30 minutes to the length of day at weekly intervals until 14-16 hours of light is achieved (e.g. 9.4 hours on December 1, 10.1 hours December 8th, etc.).

The wavelength and intensity of light is as critical, as is the length of exposure. There is a difference in light intensity between a horse stall with dark walls and one with lighter coloured walls. A 200 watt incandescent or two 40 watt fluorescent bulbs will generally give adequate illumination in a box stall, if placed within 7-8 feet of the mare. Various references cite a minimum of 2-10 foot-candles of light exposure at mare eye level. Most references cite 10 foot- candles as a minimum. The Manual of Equine Reproduction describes a practical method of measuring light intensity and differences between light and dark coloured walls can be seen and measured.

In this method, a 35-mm single lens reflex camera with a built-in light meter can be used to measure light intensity. Set the ASA to 400 and the shutter speed to 1/4 second. Cut the bottom off a styrofoam cup and fit the bottom of the cup over the lens to gather light. Hold the camera at the mare's eye level. If the aperture reading is equal to or greater than F4 (between F4 and F22), then the light intensity is greater than or equal to 10 foot-candles. An incident light meter intended for photography can also be used in a similar manner to measure reflected light intensity.

Horses will begin to shed the winter haircoat within 30-60 days and ovarian activity will commence within 60-90 days. During this time, mares will experience a normal transitional period of erratic follicular development and erratic estrous behavior.

Stallions are also affected by day length and have reduced fertility during the winter. Stallions should also be subjected to a similar lighting program to induce their fertility level to prime breeding season norms.

Mares who will be foaling early in the year should also be lighted to ensure that they do not slip into seasonal anestrus after their foaling heat. Therefore, it may be best to routinely start a lighting program for all breeding animals including barren mares, pregnant mares and stallions 8-10 weeks before your desired breeding season. Your veterinarian will be able to advise you on specific cases or problem breeders where hormone treatments may also be useful.

- **References**

Blanchard T.L., Dickson D.V., Schumacher J., Manual of Equine Reproduction, Mosby, p.20-21.
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Savage N., Notes to OVC Veterinary Students Toll Free: 1-877-424-1300
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