Modern Lighting Systems and their effect on facility infrastructure—ITEAC conference

1. Background—What power are we using now?—review ETC Load survey
2. Important concept—we can only save or eliminate wasted power—the presence of high efficacy fixtures is not likely to reduce the lumen requirements in the theatre. We still need a certain level of light and controllability.
3. Wide use of high efficacy fixtures in the theatre is all but certain over an unknown adoption period.

4. The comparison tells the story of why (explain each of these sources and their issues):

	Spot/Ellipsoidal— "Lumens on the wall" Fixture efficacy, lum/W	**Typical CRI**	
Candle	0.3	100	
Incandescent (120V quartz halogen)	12 - 18	100	
HID - Moving light spot	15 - 30	70 - 90	(High wattage MSR)
HID - Fixed focus ellipsoidal	40 - 50	80 - 90	(Low wattage Mastercolor)
Plasma	20 - 30	85	(Claimed figure for Nemo)
LED - White 5600K	15 - 30	65 - 75	(MAC 350 Entour is 19 lum/W)
LED - White 3200K	10 - 20	75 - 85	
LED - RGB	10 - 15	60 - 80	(White light)
LED - RGBA or more	10 - 15	70 - 90	(White light)
New redirected-IR tungsten sources	Expected 25-30	100	
Ideal theoretical 5800K white source. (Visible radiation only from 400 - 700nm. This is an unachievable 100%-efficient source, but it shows the upper limit.)	251	100	

5. We know these new sources are coming, our challenge as new-venue infrastructure designers is to get the timing right. If we pull out too much power and HVAC capacity before the theatre is ready to adopt new sources for all applications, the result will be poor. Venues built with too much initial infrastructure for new sources can still reap the benefits of those new sources as they reduce operating costs over their period of adoption. Venues built with reduced infrastructure that is "ahead of the curve" on new-source adoption run the risk of serious limitations while new-source fixture development and adoption by the theatre catches up.

6. Widespread adoption of new sources will occur when they reach the *"Good Enough Line"* (GEL). The GEL will be different for each type of venue and theatre user—presumably higher for professional theatre and lower for community and educational venues. Some new sources will always be adopted as *niche tools* before they reach the GEL, but for widespread total adoption and infrastructure change, getting to the GEL is a must.

7. Factors that can drive the GEL higher for a given new source:

    - Quality of light—theatre is art, not task lighting. Some high-efficacy sources do not have the spectral distribution to meet designer requirements for CRI.
    - Need for a wide variety of fixture types with new sources—each with its own beam control characteristics. Theatre users are unlikely to forego key elements of their artistic toolbox simply for efficacy gains.
    - Initial cost per lumen—alternate sources will have a higher initial cost per lumen than tungsten for some time. Total cost of ownership is a new concept for many theatre users.
    - Low duty cycle of tungsten vs. on-all-the-time necessity of some high efficacy sources.
    - Appearance of new redirected-IR tungsten sources at 25-30 lpw—increased efficacy with benefits of tungsten
    - Increased complexity and presumably worse MTBF of most new-source fixtures that have considerable electronics.

8. Factors that can lower the GEL for a given new source:
    - High efficacy
    - Much more light onstage in saturated colors for much less power
    - Units with multi-bandwidth emitters go a long way towards solving the “quality of light” issue.
    - The seduction of “free” color-changing on every fixture
    - Low cost of operation
    - Less electrical infrastructure
    - Less HVAC infrastructure
    - “Green Fever”—increasing awareness and desirability of a sustainable lighting fixture.
    - Legislated efficiency—the performance lighting system has heretofore been exempt from this, but there is no guarantee that will continue.

9. Infrastructure changes and implications
    a. As data-eating constant-power fixtures proliferate, a distributed model becomes desirable. However:
        i. Current data distribution schemes are cumbersome when applied to 100% of fixtures in a venue.
            1. Wireless is unlikely to provide sustainable reliability in the long term
            2. Open-source, interoperable power-line transmission of data becomes an attractive solution.
    b. Constant-power circuits are likely to drift to widely available traditional power distribution: the breaker panel solution.
        i. This presents an issue with fault-current coordination—the solution to this was previously “free”.
        ii. Potential lack of on/off control of branch circuits may be problematic
        iii. Much of the theatre world is used to 100% loading of branch circuits—this may not be possible with conventional breaker panels.

iv. As fixtures with switch-mode power supplies proliferate, harmonic problems may become more severe, and traditional mitigation methods used with current systems may not be effective—new methods may be necessary.

    1. Switch-mode devices produce harmonics at 100% load, while most current dimming systems produce the most harmonics at reduced load.