

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



Solar Powered Lighting Systems with LEDs: Claims and Facts



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Background Information:

Off Grid Electrification Program: Electrification of in total 7876 remote villages in SINDH and Balochistan



- ✍ First batch of 400 villages under implementation
- ✍ Individual houses to be equipped with SHS (for lighting and low consumption loads only)
- ✍ Planning, Execution and Monitoring by AEDB in collaboration of Provincial Governments
- ✍ Private companies contracted for installation and 1st year Operation and Maintenance
- ✍ One local operator per 200 SHS for basic O&M, fee collection
- ✍ **7 800 villages with 70 systems each: more than 2 million lamps!**

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Overview



- † Characteristics of white Light Emitting Diodes (LEDs)
- † Functionality of white LEDs
- † Small Power-LED versus Power-LED
- † Operation of LED
- † Degradation of LED light output
- † „Wheat and Chaff“
- † Future highlights

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Main Parameters of Light Sources as Loads of Solar Home Systems:

1. **Absolute Power Consumption [W]**
important for load / demand calculation within a PV SHS
2. **Light Intensity [lm]**
important for quality of energy service / lighting
3. **Illumination Angle**
important for illumination purpose
4. **Specific Light Intensity (luminous efficacy) [lm/W]**
indicator for product quality
5. **Degradation over time [%/t]**
Indicator for product quality

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Characteristics of White LEDs

- | | |
|----------|--|
| Positive | ⌘ Small power demand (ca. 0,1 W – 5 W)
(CFL: P > 10W) |
| | ⌘ High luminous efficacy 35 - 80 lm/W
(Incandescent lamp 12 lm/W) |
| | ⌘ Very high lifetime (10.000 - 50.000 hours) |
| | ⌘ Small form factor |
| | ⌘ Extreme high mechanical robustness |
| | ⌘ Easy to process |
| Negative | ⌘ (Controlled) Current source for operation necessary |
| | ⌘ Sensitive against thermal stress
(degradation of fluorescent pigments and thus luminous efficacy) |
| | ⌘ Price at present (still) too high (Power-LEDs) |
| | ⌘ Colour rendering index not sufficient |

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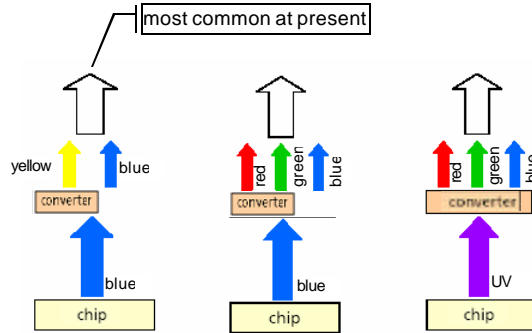




How Are White LEDs Working?

Luminescence-Conversion:

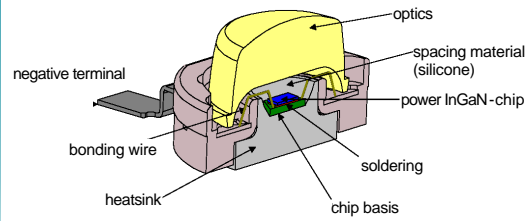
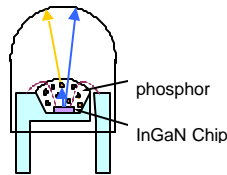
Light of high frequency (blue, UV) is transformed in complementary colours with the help of a converter (phosphor). The mixed complementary colours resulting in white light.



Quelle: Fraunhofer IAF, 2002



Small-Power-LED versus Power-LED





Small-Power-LED versus Power-LED II

Parameter	Small-Power-LEDs	Power-LEDs
Electrical power (per chip) P_{LED} [W]	0,05 – 0,3	1 - 5
Operation current (chip) I_{LED} [mA]	20 - 100	350 – 1500
Light power [Lumen]	1 - 24	50 - 400
Total thermal resistance R_{th} [K/W]	40 - 200	3,5 – 10
Useful lifetime [h]	Almost not specified	25,000 – 50,000 at 30 % Degradation
Manufacturers	Many companies from Asia	Osram, Philips, Cree, Seoul Semi ...

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Operation of LED: General Issues

- † LEDs electrical behavior is like any semiconductor diodes
- † LED forward current is strongly related to the LED forward voltage
- † Even LEDs of the same production batch show a strong scattering of their I-V-curves
- † The LED forward voltage strongly depends on the temperature

Therefore

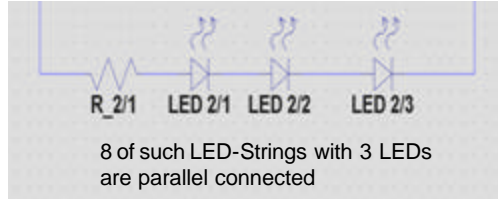
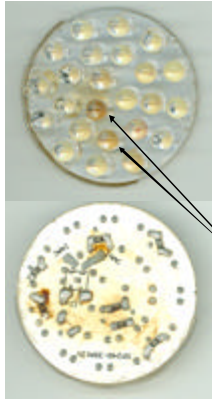
- † Operation **only** with **constant current sources!**
- † If any possible use serial connection in case of operation more than one LED

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Bad LED Lamp (a series resistance works as a „current source“)



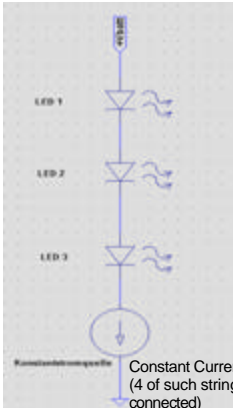
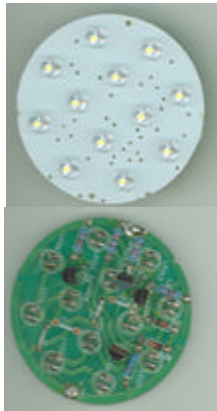
- † LED forward current depends on operation voltage
- † Risk of overloading single LEDs
- † Reduced lifetime!
- † Brightness of LEDs depends on operating voltage
- ✗ Series resistance is a bad “current source”

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Quelle: Fraunhofer ISE 2003



Well Designed LED Lamp (Constant Current Source, CCS)



- † One CCS powers 3 LEDs series connected
- † Every LED is driven by the same constant current
- † Enhanced lifetime
- † Brightness of LEDs independent of operating voltage

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Quelle: Fraunhofer ISE 2003

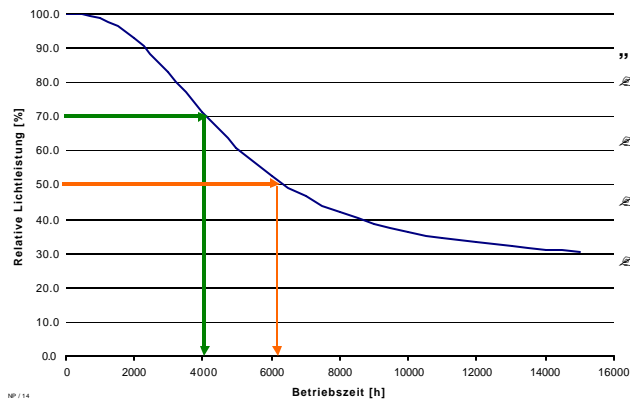
About the Definition of LED Lifetime

- † LEDs exhibit very long physical life characteristics, that means they rarely fail (under optimal operation conditions)
- † Like all light sources LEDs slowly decrease in light output. There are three main reasons:
 - ⚡ Degradation of Phosphor
 - ⚡ Turbidity of packaging
 - ⚡ Degradation of semiconductor-chip
- † The important point is how much light a LED still emits after a certain time of operation.
- † Definition of “useful lifetime”: operation time to 70 % lumen maintenance (L_{70%} lifetime)

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Degradation of Light Small-Power-LEDs (Example)



„Useful Operating Lifetime“

- ⚡ Ca. 4.100 h at a lumen maintenance of 70 %
- ⚡ Ca. 6.200 h at a lumen maintenance of 50 %
- ⚡ This example shows a very good Small-Power-LED.
- ⚡ A majority of SP-LEDs on the market do not reach L_{70%} @ 1000 h!

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Summary I: „Wheat and Chaff”

Only 1 of 20 Small-Power-LEDs available on the market shows a sufficient lifetime!

To separate the “wheat” from the “chaff”:

- † Are the LEDs operated by a Constant Current Source?
 - ⚡ Visual check of the electronics
 - ⚡ Measure the operating current: remains it approx. constant in case of variation of the operation voltage?
- † Do not use LED-lamps with a high packing density of Small-Power-LEDs
- † Prefer LED-lamps with SMD- or better Power-LEDs
- † Technical specs of the lamps must clearly show information regarding useful lifetime of the LEDs. Avoid manufactures not giving such information!!

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Summary II: Future Highlights

- † Luminaries for Solar Home Lighting Systems and Solar Home Systems will more and more use Power-LEDs
- † Future luminaries will have higher light output
- † There is a clear trend for PV powered luminaries of high quality



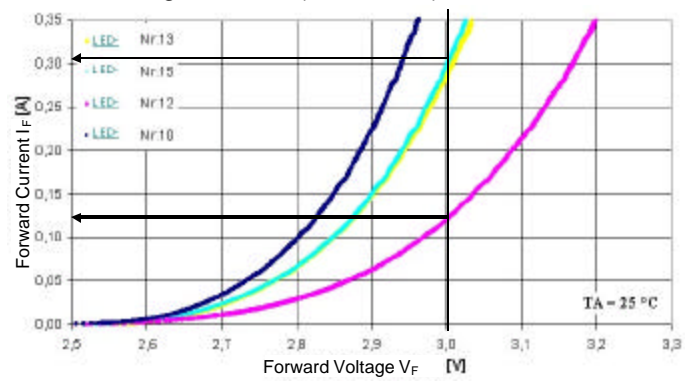
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Operation of LEDs: Current-Voltage Curves (I-V-Curves)



Operation of LEDs:

Negative Temperature-Voltage Behavior

