Sustainable outdoor lighting for reducing energy and light waste

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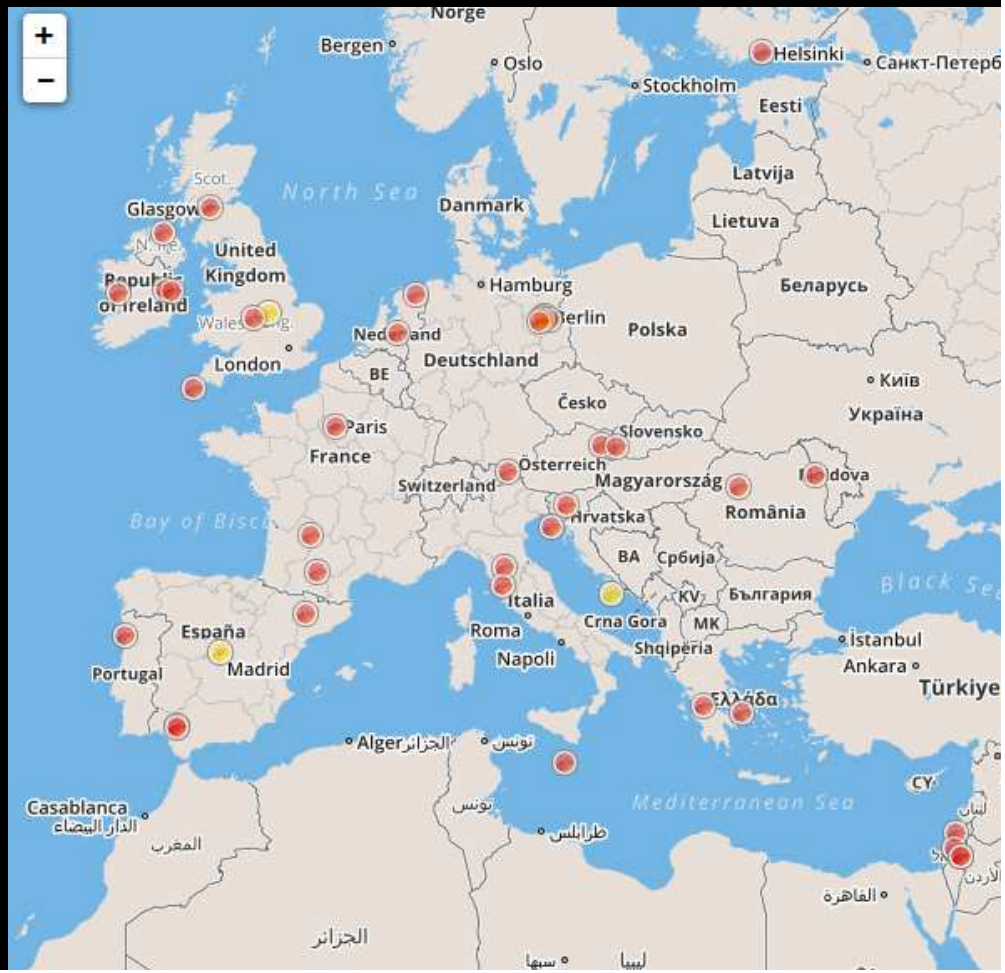
- oldest and widest European intergovernmental framework for transnational COoperation in Science and Technology
- COST supports networking of research activities across all its member countries (36 actually) and beyond
- open to all disciplines, to all novel and ground-breaking science&technology ideas, to all categories of partners
- supported by the EU RTD Framework Programme, European Science Foundation, and the Council of the European Union, now under Horizon 2020
- Loss of the Night Network (LoNNe) COST Action ES 1204, 2012-2016

LoNNe
ES1204
Loss of the Night Network

Network of institutions from 18 countries

- Studying the multifaceted aspects of artificial light at night
- Transfer of existing knowledge between fragmented national research projects
- Stimulating future transdisciplinary research
- Initiating dialogue regarding light pollution with the whole range of concerned and involved stakeholders,
  in particular the general public



The problem of light pollution:

- view of the starry sky/nightscapes
  - oldest cultural good (time, calendar, position)
  - art and literature
  - science and curiosity, fascinating nature

- biodiversity
  - rest-/activity phases of day/night active livings
  - orientation of birds, insects, bats ....
  - reproduction, nesting

- human health
  - circadian rhythms
  - rest phases
  - production hormone melatonin

- energy waste

Bayer-Kreuz Leverkusen

since 1933/1958

1712 40W light bulbs, 51 m diameter

exchanged by 5 W LED same brightness

Study *Hermann Brombach*, NABU Leverkusen

1964-1979 28.5 dead birds/year

since 1980 switch-off Sept. and April (migrating birds) 22:00 – 04:00

1983-1999 1.8 dead birds/year

Posttower Bonn

energy saving building
(no artificial climatisation)

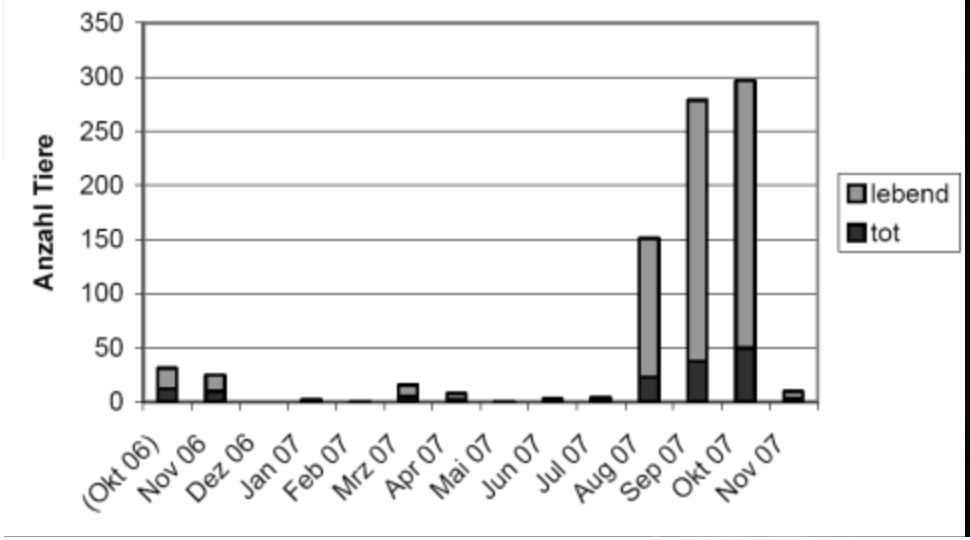
moon

Illumination:

beamers

colors

facade



Posttower Bonn

Towerkill

Heiko Haupt:

1000 birds collide at facade

close to natural areas

common firecrest

European robin

FLAP Toronto:

34 800 t CO_2 saved

Platz der Vereinten Nationen, Bonn

Heiko Haupt: Berichte zum Vogelschutz 47/48, 161 (2011)
Skylark (*Alauda arvensis*) without orientation
attracted by Posttower (1 km)

Hafencity Hamburg

urban regeneration of old port warehouses

bridge spider *Larioinides sclopetarius* propagates 300 x faster

food from emerging insects from water attracted by lights

Cobwebs are annoyance to the residents

costs for cleaning

Facade illumination in Greece

145 cd/m²

65 cd/m²

24.5 cd/m²

31.5 cd/m²

- E3 zone EN 12464-2 10 cd/m²

Facades in Greece

1590 cd/m²

5041 cd/m²

- **E2: 400 cd/m²**
- **E4: 1000 cd/m²**

often too high luminance values!

Light emission from above

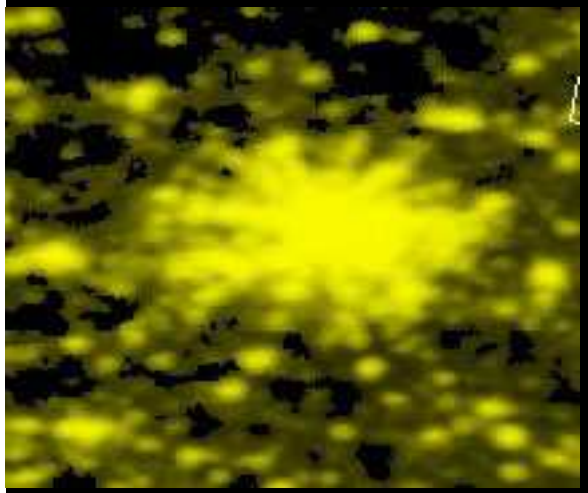
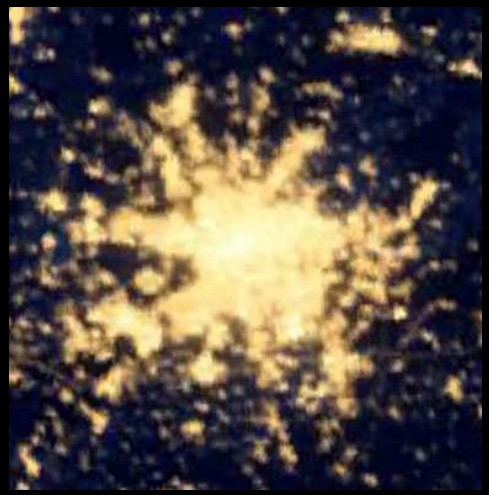
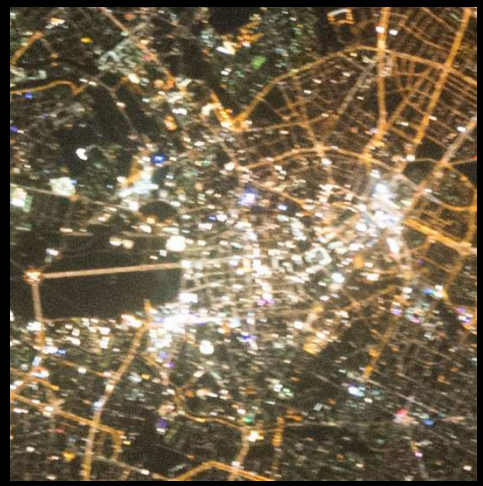
using platforms from above helps to identify polluting sources with increasing spatial resolution:

DMSP: Earth at Night 5000 m

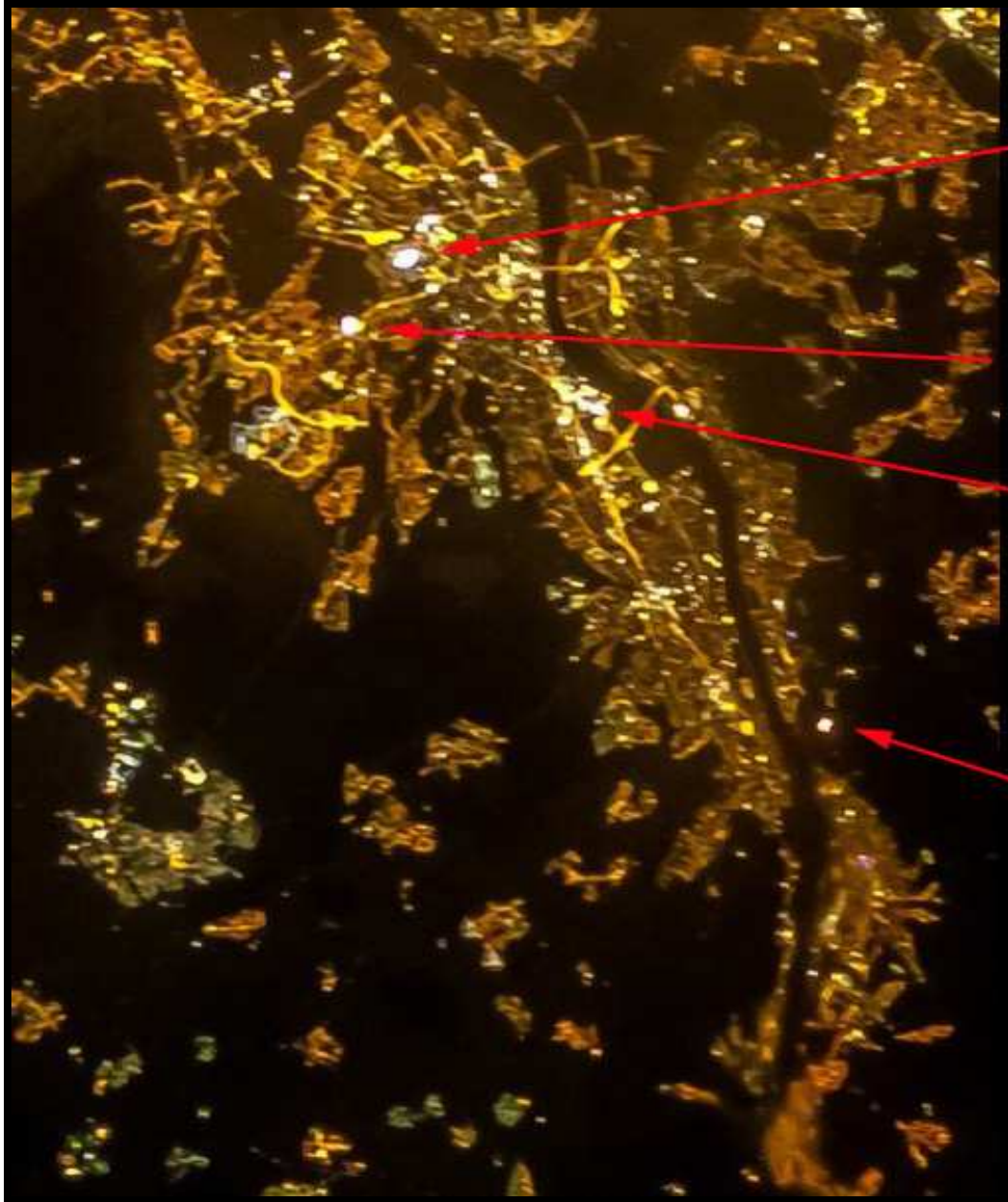
VIIRS: Black Marple 750 m

ISS: Cities at Night >10 m

Flights (Kyba) >1 m


Light emission from above: ISS Bonn



Telekom

Posttower

Drachenburg

Light emission from above: ISS Strasbourg

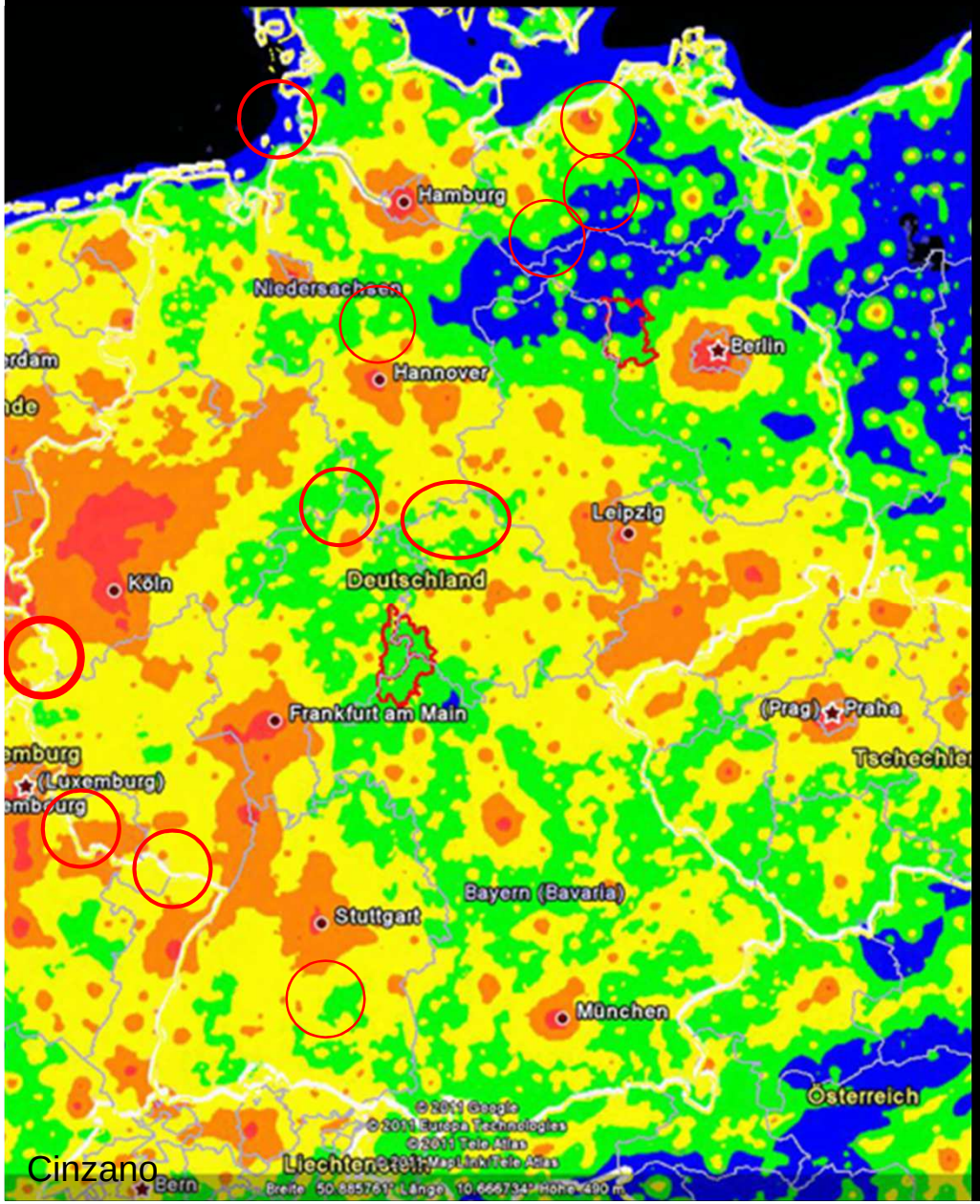
sports areas

magazines

museum

bridge

Star Parks (IDA Dark Sky Reserves)



- protected areas with relatively dark skies
- protecting these areas through sustainable lighting reducing light pollution:
  - necessity of lighting
  - full cut-off lighting
  - adaptive lighting
  - reduced blue content (<3000K)
- best practice exemples for sustainable lighting

UNESCO Biosphere Reserve (IDSReserve) Rhön

church Brüchs:

2 x 400 W floodlights
badly oriented

switched-off!

Light in Rhön VIIRS data 2012 - 2014

1 church Brüchs: 2 x 400 W beamer

Thüringen: 3 Geisa (4700 inh.), 4 Dermbach (3000), 7 Frankenheim (1100)

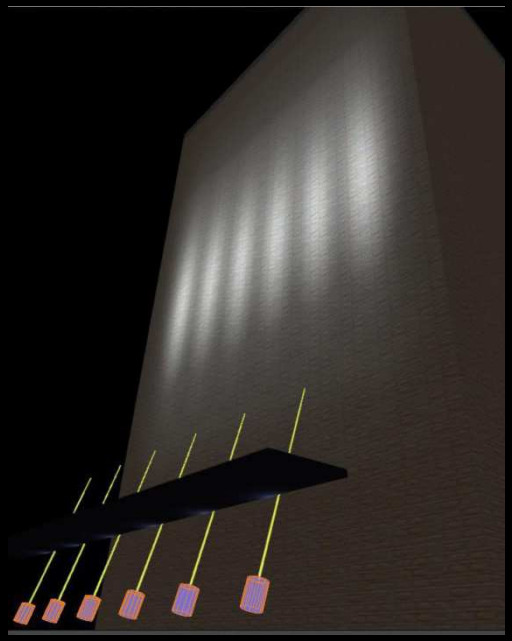
Hessen: 5 Tann (4400), 6 Hilders (4600)

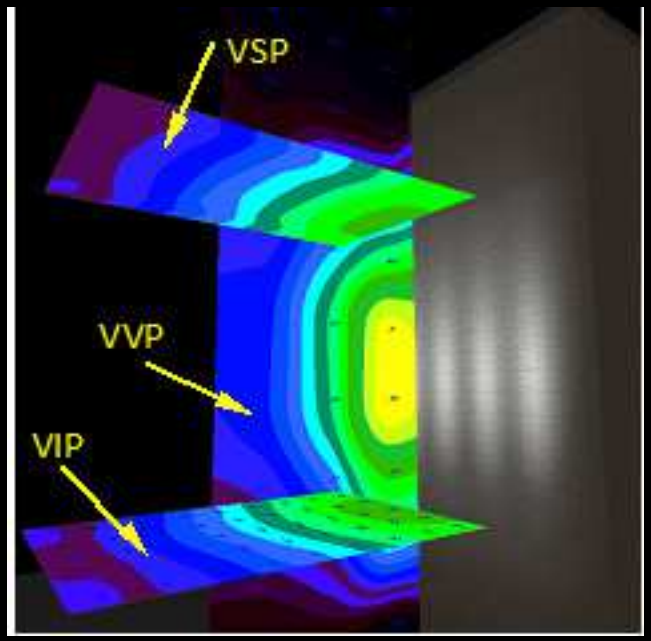
Eastern villages brighter than Western?

Street Lighting

- Europe: 56 mio. luminaires
- typ. 100 W with 8000 lm
- totally 450 billion lm emitted
- typically 2.5% upward light ratio:
  11 billion lm directly emitted towards sky
- 7% reflected: 32 billion lm indirectly emitted towards sky
- 43 billion lm towards sky!
- use full cut-off luminaires
  ULR = 0%, luminous class G6

Solutions

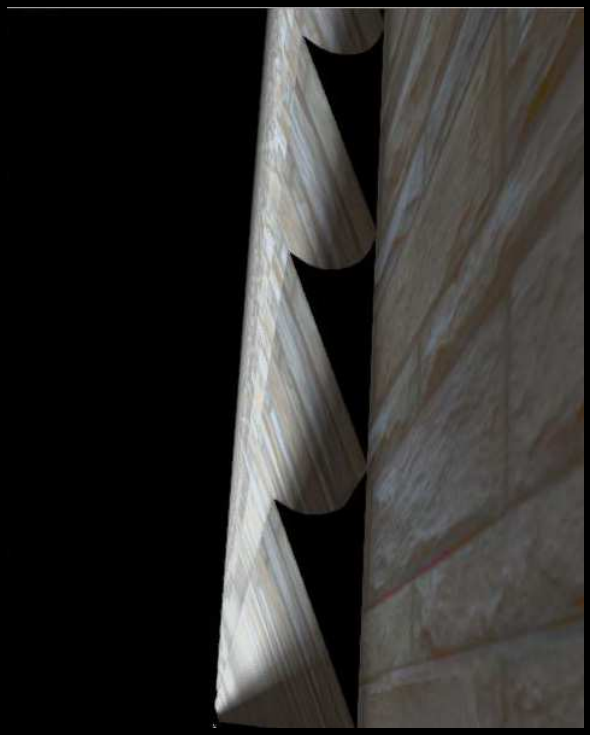


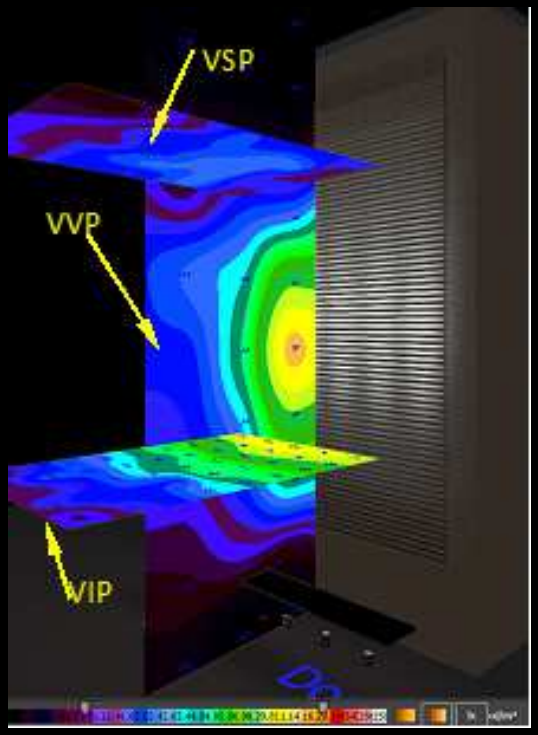


- diffuse reflection from a wall illuminated from below
- VIP: 3.9/7.4 lx, VSP: 4.0/7.4 lx

adding an asymmetric micro profile to the surface:

Solutions





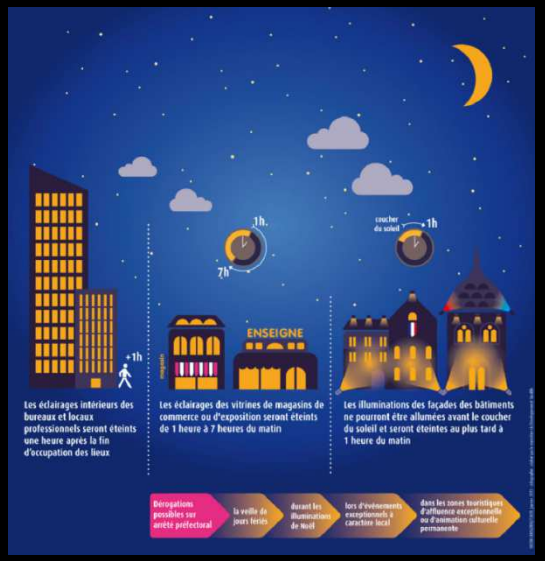
- VIP: 5.6/13.2 lx, VSP: 2.1/4.4 lx
- reduction of upward light (light pollution) by 63%
- reduction of energy consumption by 30%

Conclusion: Smart Lighting

Intensity of light

illuminated signs < 1-2 cd/m², self luminating < 110 cd/m²

disturbing light >1 lx on vertical sleeping room window ("Lichtimmissionsrichtlinie")



Adaptive reduction of light

France:
switch off 01:00 – 06:00 (advertising, facade illumination)
offices 1 h after last usage

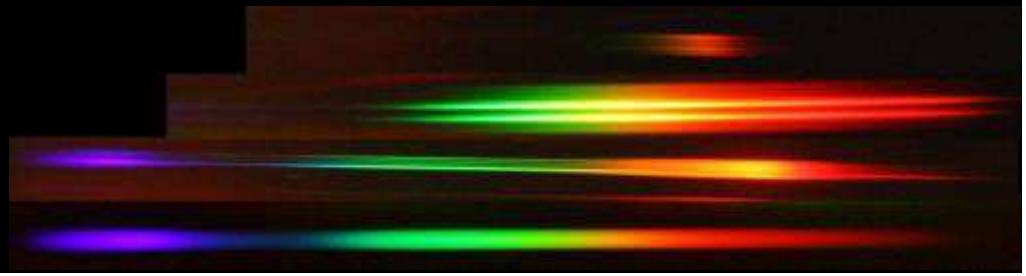
Lighting colour

use reduced blue content:
better mesopic vision <> influence on circadian rythms

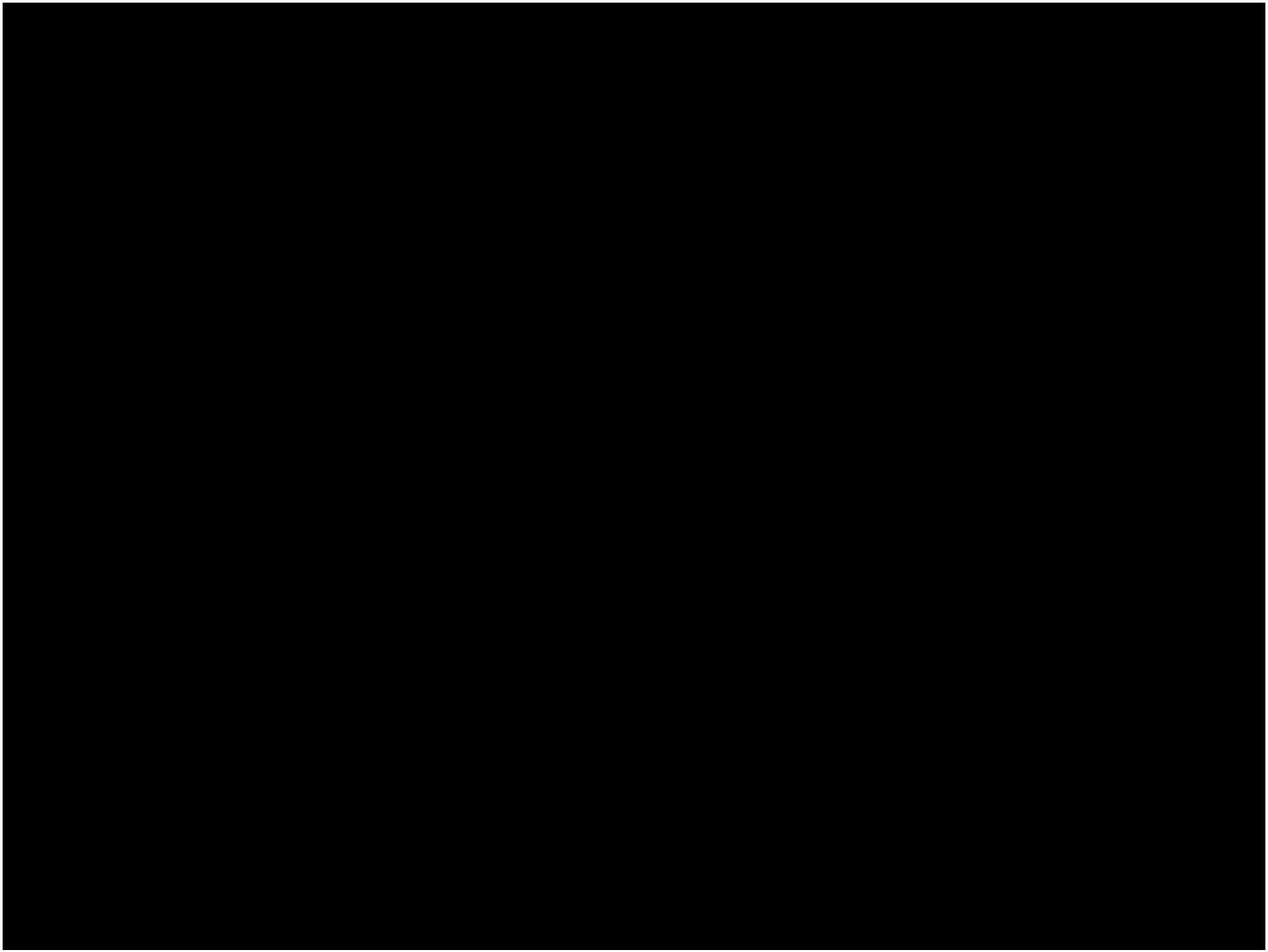
Demonstration road Fulda

full cut-off

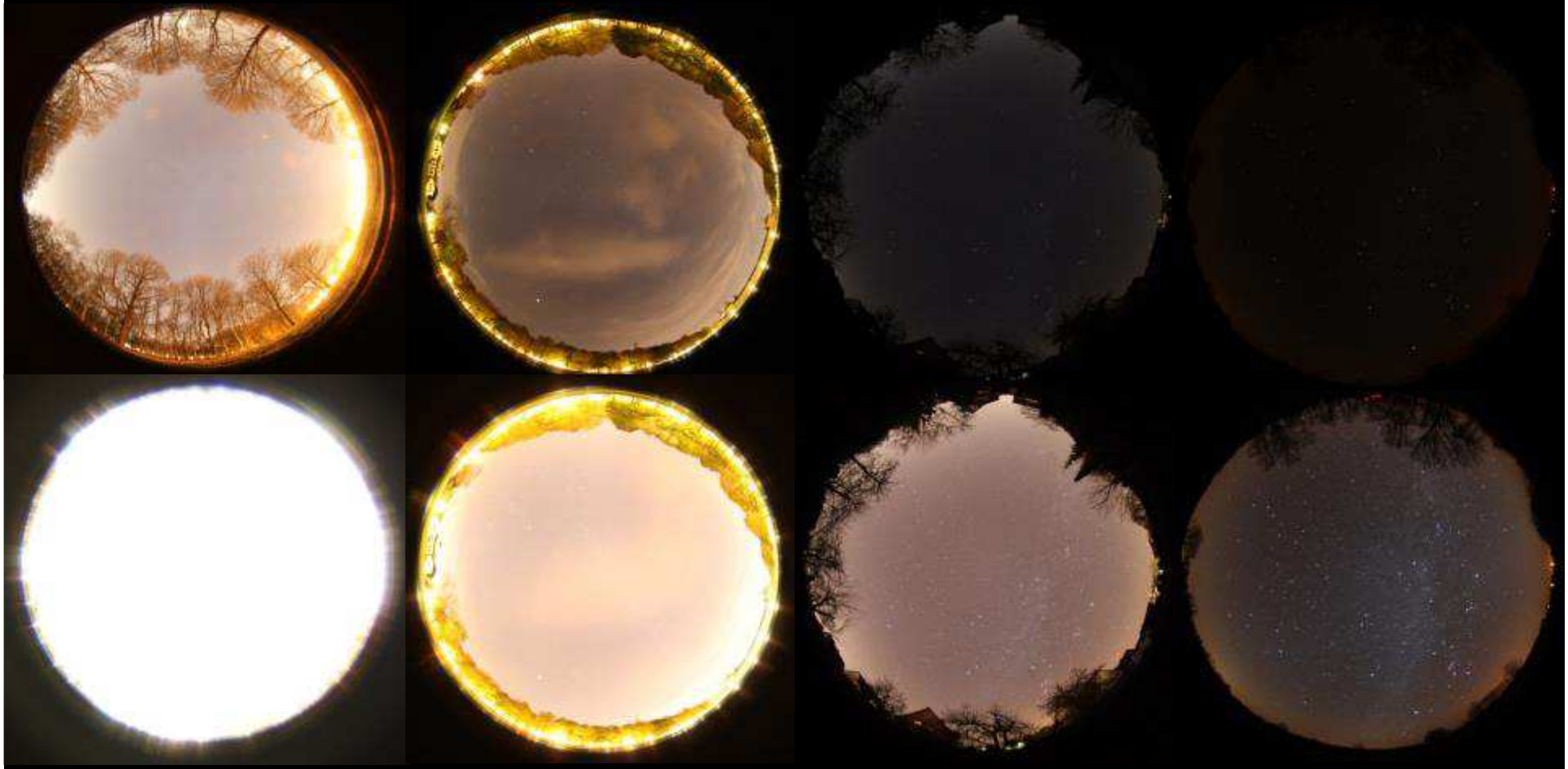
cct <= 3000 K LED




Natural Bridges
National Monument
National Park Service
Department of the Interior



Night sky brightness (30/180 sec exposure, 1:2,8, 800 ASA)



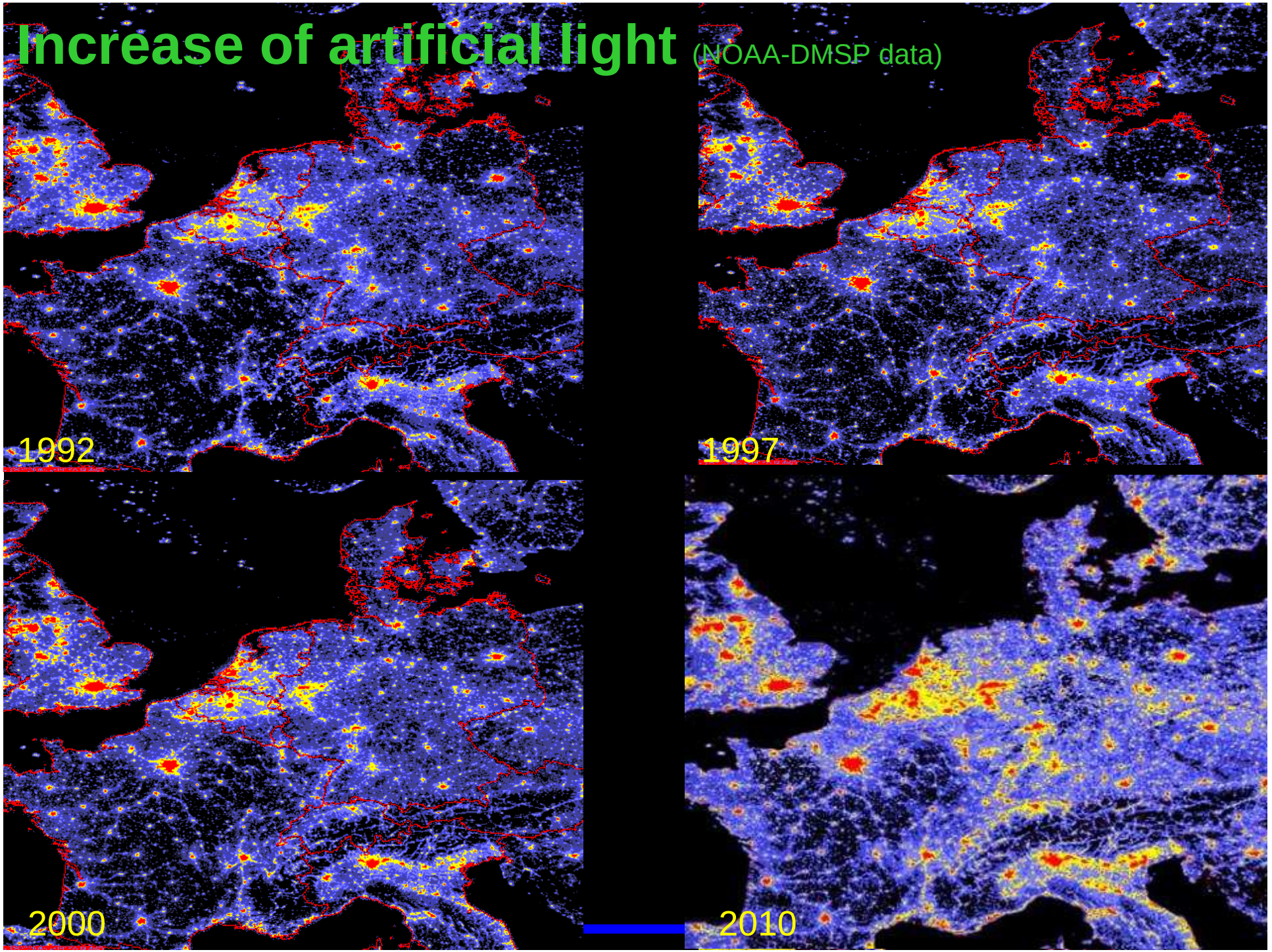
Berlin
18.2^{m}/arcsec²
5.7 mcd/m²

Bonn
19.2^{m}/arcsec²
2.3 mcd/m²

Osnabrück
20.6^{m}/arcsec²
0.6 mcd/m²

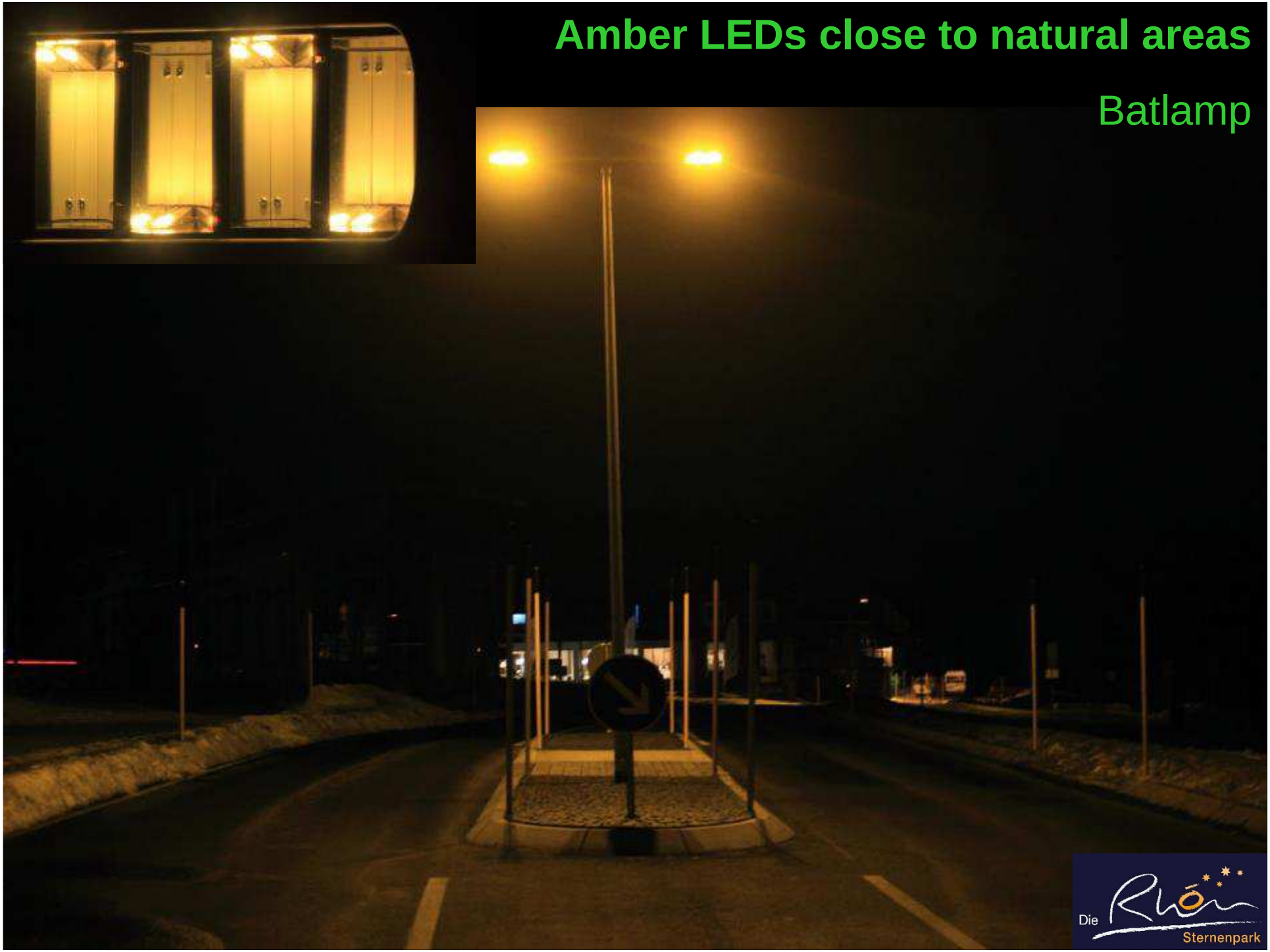
Westhavelland
21.4^{m}/arcsec²
0.3 mcd/m²

Increase of artificial light (NOAA-DMSP data)



Amber LEDs close to natural areas

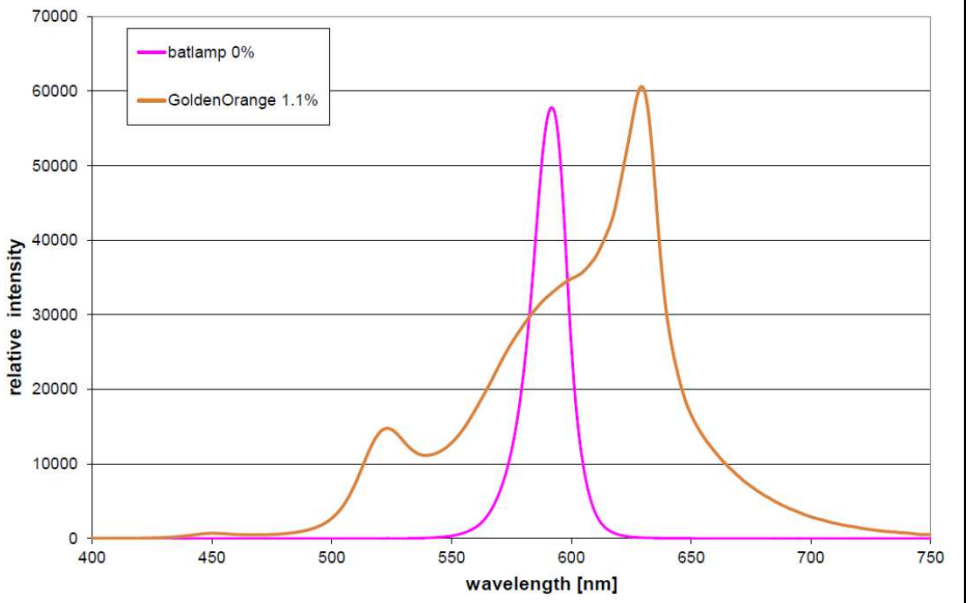
Batlamp



Good color rendition

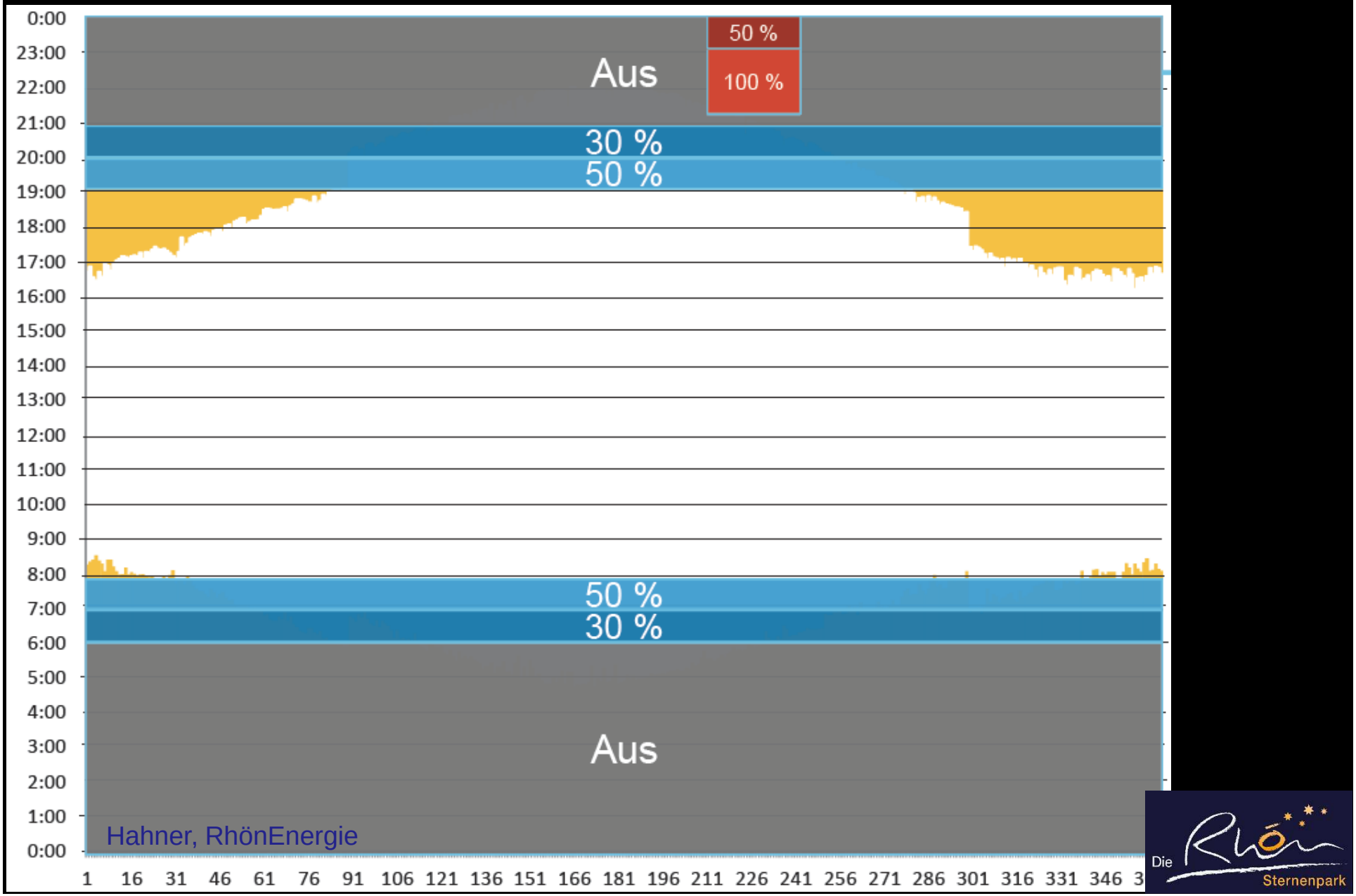
Batlamp

Golden Orange



Die Rhön Sternenpark

Reduction and switch-off!



German firms plan to offer amber LED!