The challenges of risk migration in sustainable innovation

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Recent example

Review article

Non-exhaust PM emissions from electric vehicles

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H I G H L I G H T S

- A positive relationship exists between vehicle weight and non-exhaust emissions.
- Electric vehicles are 24% heavier than their conventional counterparts.
- Electric vehicle PM emissions are comparable to those of conventional vehicles.
- Non-exhaust sources account for 90% of PM_{10} and 85% of $PM_{2.5}$ from traffic.
- Future policy should focus on reducing vehicle weight.

Atmospheric Environment **134 (2016)** p.10-17

Key questions

- To what extend does the development and introduction of sustainable consumer products introduce novel unforeseen risks?
- Under what conditions does that occur?
- What are promising strategies for detection and avoidance of such risks early in the innovation trajectory?

Related projects

- EEA **Late Lessons II**
  "Seed-dressing systemic insecticides and honeybees"
- EU FP7 **EPINET** "Integrated Assessment of Societal Impacts of Emerging Science and Technology from within Epistemic Networks" 2012-2016
  - Universities of Bergen, Lancaster, Brussels, Utrecht, Barcelona and EU JRC
  - Smart Grid, Robotics, Wearable sensors, In Vitro meat

Types of risk migration / risk transformations

- Physical change
- Interpretational change

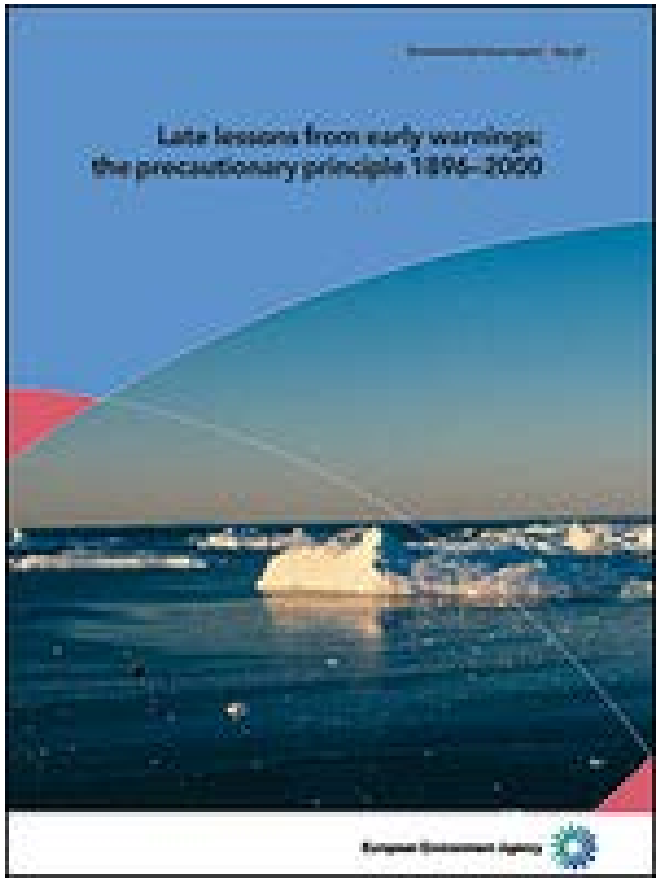
- Translational (replacing one risk with another)
- Diffusional (adding to a stock of risk)

Busby et al (2012)

Historic cases

- Asbestos for isolation
  - Shifts short term fire risk to long term health risk
- Halocarbons for refrigeration
  - shifts small scale, near-term risk to a global environmental risk
- Neonicotinoid insecticides
  - shifts a human health risk and risks for birds of prey to an ecological and food security risk (pollinator loss) and risks for insectivorous birds
- Hydrogen-powered road traffic vehicles
  - Shifting environmental and safety risks to other environmental and safety risks
- Nanotech products
  - shifts an environmental issue (material and energy consumption) to a health and environmental issue.

Late lessons from early warnings EEA 2001/2013 reports



EEA Report | No 1/2013

Late lessons from early warnings:
science, precaution, innovation

ISSN 1725-9177

European Environment Agency

Late Lessons II report 2013

- Key decisions on innovation pathways made by few on behalf of many
- Lack of (institutional) mechanisms to respond to early warning signals
- Misleading market prices fail to reflect all costs and risks to society and nature

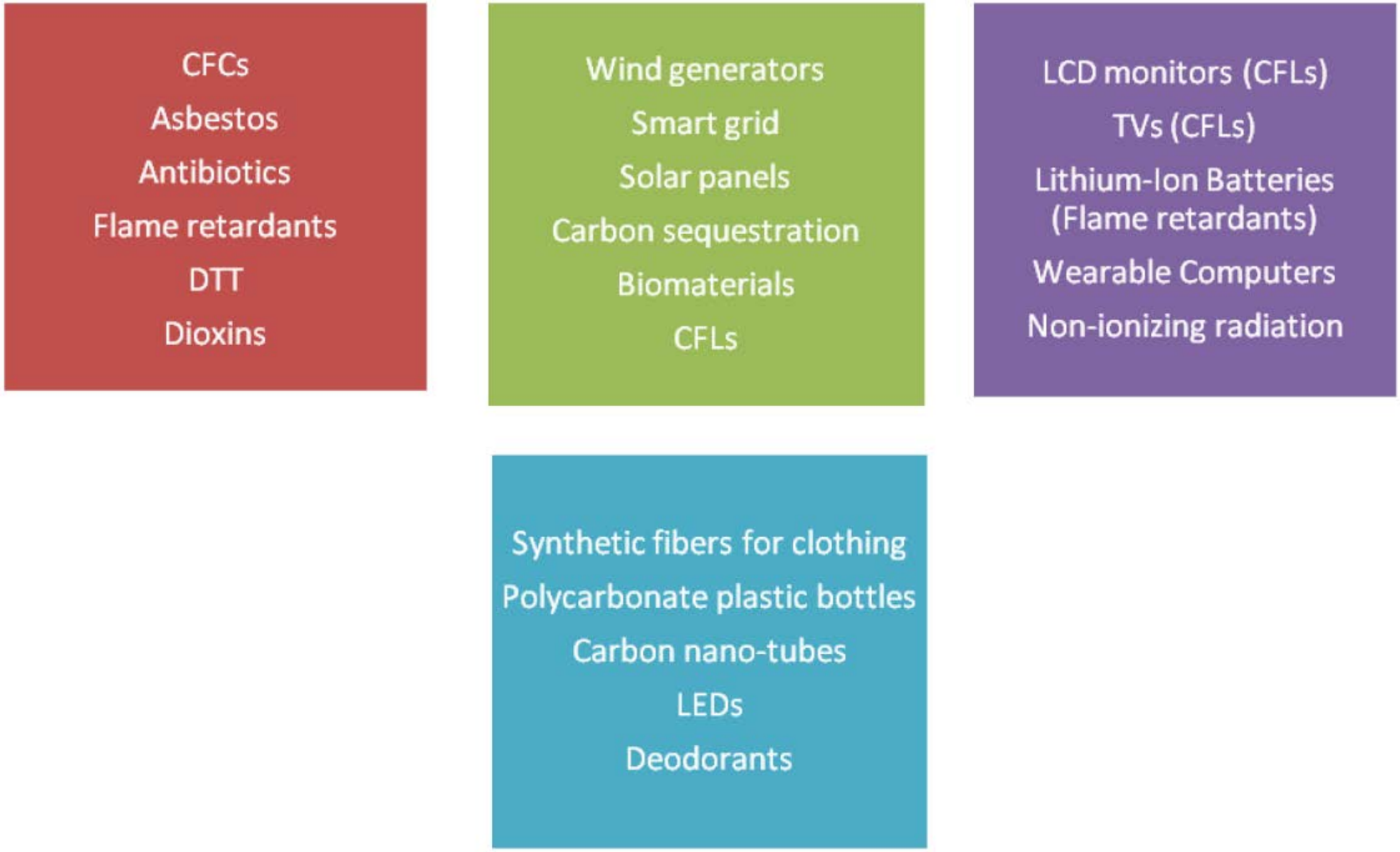
✓ Broaden application of the principles of precaution, prevention and polluter-pays

✓ Make government and business accountable

✓ Broaden evidence considered (lay/local knowledge) and public engagement

✓ Build resilience in governance systems and institutions

Case	Type of product or innovation	Aimed sustainability improvements	Potential risks introduced	Other relevant aspects
1. Hydrogen vehicles	New energy carrier (gaseous) plus related energy conversion systems.	Environmental (greenhouse gas emissions; long term). Human health (air quality, noise; short and long term).	Environmental (atmospheric impacts of leaked hydrogen, waste, greenhouse gas emissions). Safety (fire, explosion, traffic accidents due to silent vehicles; short term).	Prior experience with small scale use, but not with large scale. Emission reduction depends on assumed way of production.
2. Nanotech	Novel material (small solid particles) with special properties (due to small size and structure).	Environmental (material saving, energy saving).	Human health (medium and long term). Environmental (ecosystem health; long term). Functioning of societal systems (e.g. waste water treatment).	Special material properties (small size, persistence) a problem. Rapid spread to large scale application. Existing risk assessment frameworks & tools insufficient.
3. Asbestos insulation	Novel material (small solid particles) with special properties (due to small size and structure).	Environmental (energy saving). Safety (fire-resistant).	Human health (long term).	Special material properties (small size, persistence in body) a problem. Rapid spread to large scale application.
4. Halocarbons for refrigeration	Novel material (gaseous) with special properties (low reactivity).	Safety (replaces aggressive alternative).	Environmental (ozone layer, climate change; long term).	Special material properties (low reactivity, i.e. environmental persistence) a problem. Rapid spread to large scale application.
5. Compact fluorescent lamps	New lighting product.	Environmental (energy saving, material saving).	Ecological (mercury; short term) Human health (mercury, light frequency; short term).	Risks due to both components (mercury) and product itself (light frequency).
6. Neonicotinoid insecticides	Novel material (water soluble) with special properties (systemic, specific).	Human health (replaces acutely toxic alternative). Ecological (replaces non-specific alternative).	Ecological (pollinator loss, risk for insectivorous birds). Food security (via pollinator loss).	Unforeseen non-acute, sub-lethal low-dose effects. Persistent in both plant and environment.



Cases of risk migration mentioned in the interviews divided in categories: Classical cases (Red), Sustainable Products (Green), Electronics (Purple), Other Products (Blue)

Survey results: selected cases I

- Flat screen for computers and televisions
  - Energy efficiency / CO_2 reduction,
  - NF_3 world production increase (strong GHG)
- Spray Urethane Foam (PUR)
  - Floor insulation / energy efficiency
  - Sensitisation to Methylene Diphenyl Diisocyanate (MDI)
- Styrofoam (polystyrene)
  - Insulation . Energy efficiency;
  - persistence, bioaccumulation, styrene possible human carcinogen
- Ceramic tiles with (radioactive) zirconium
  - Zero energy buildings
  - Indoor exposure to ionizing radiation
- Windmills and biofuels
  - Renewable energy
  - Loss of biodiversity and landscape values

Selected cases II

- Biomaterials
  - Renewable resources
  - Land availability for food / intensification agriculture
- Computers & electronic communication
  - Reduced paper use; reduced travel
  - Toxic waste generation in developing countries
- UV filters in cosmetics
  - Reduced UV exposure
  - Bioaccumulation in breast milk
- Bottled water
  - Reducing water-borne diseases
  - Depletion of ground water & increased toxicity of ground water
- Recycling of waste
  - Resource efficiency
  - Health risks for waste collecting workers / endotoxins

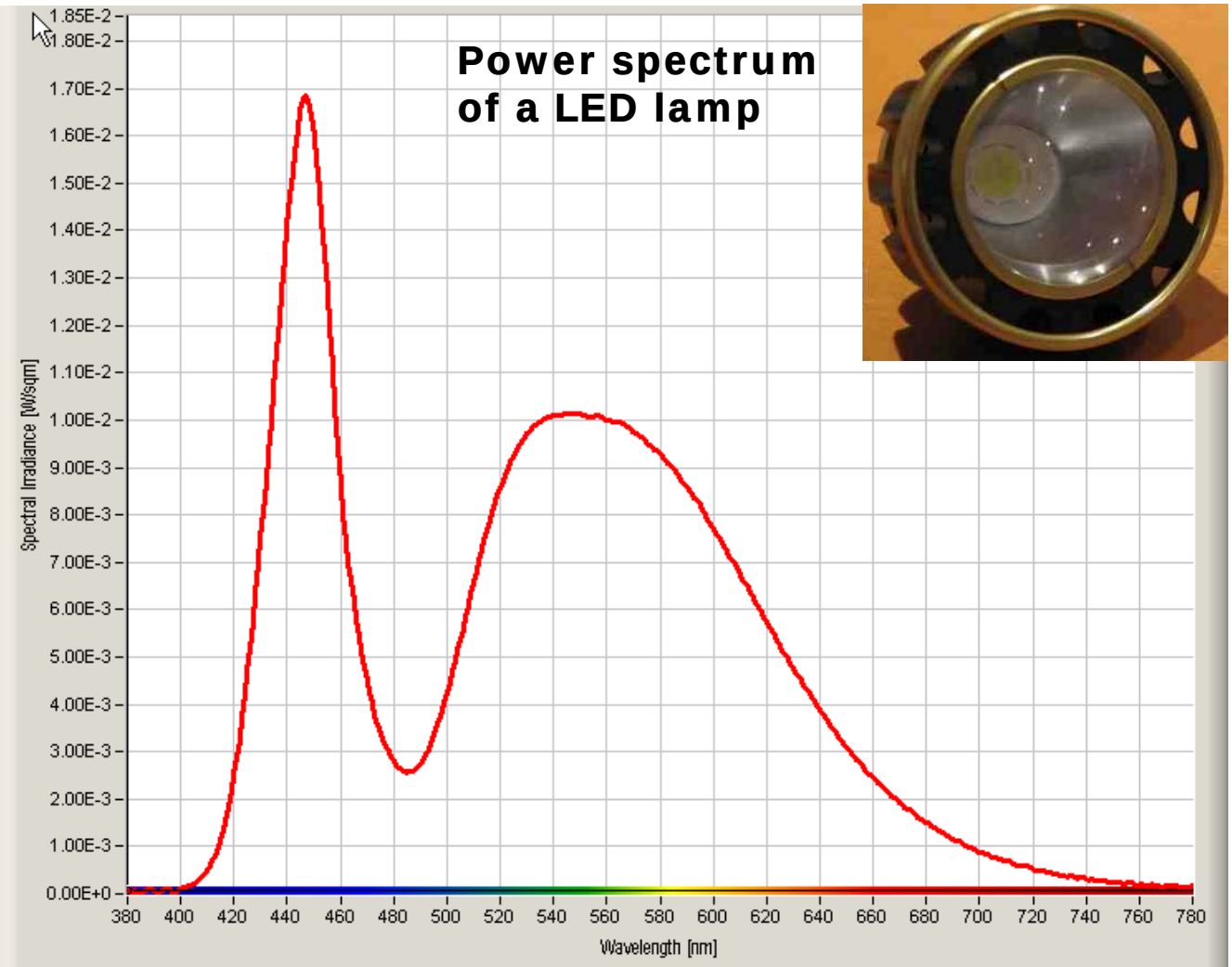
Selected cases III

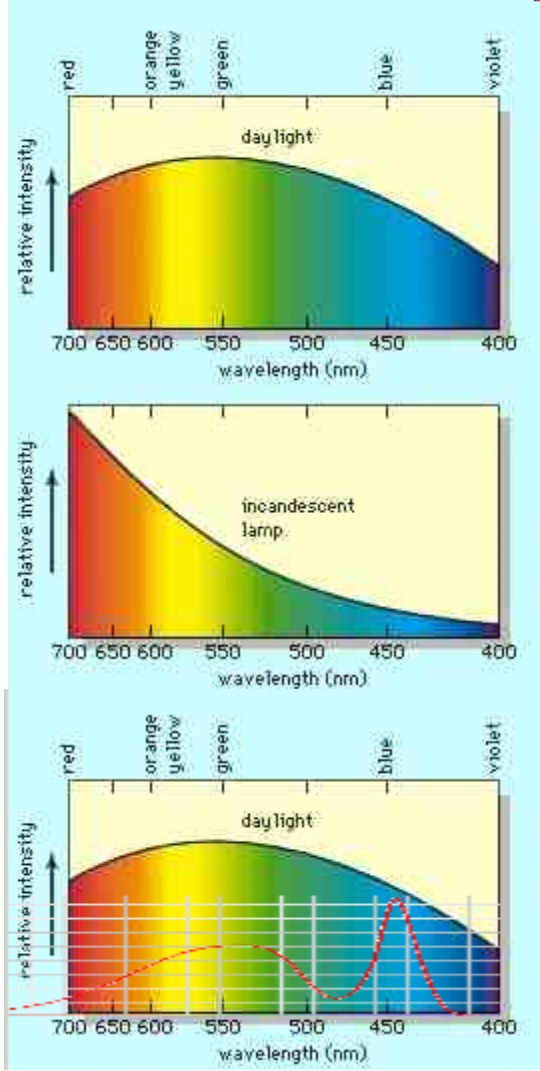
- TriCresyl Phosphate (TCP) in jet-oil
  - Prolonged lifetime of jet engines
  - Aerotoxic Syndrome in aircraft passengers & crew
- Plastics
  - Packaging protects high-value goods; fish nets provide income
  - Persistence, accumulation, plastic soup
- Phosphate free washing powder
  - Reduce eutrophication of rivers and lakes;
  - reduced phosphorous resource depletion
  - Substitutes are endocrine disruptors
- SO2 Scrubbers
  - Reducing air pollution & acidification
  - Increased CO2 emissions per kWh
- Composite dental fills
  - Reduced mercury exposure
  - bisphenol A-glycidyl methacrylate (BISGMA): Increased BPA exposure

LED lamp and risk migration

- Unprecedented brightness of the (point)light source
- Unidirectional nature of LED light, analogy with risks of laser light
- Blue light hazard
- Blue light as endocrine disruptor: melatonin and the biological clock
- Indoor emissions of toxic substances from plastics used in LED lamps
- Electro-safety issues
- Impact of light quality on labour productivity

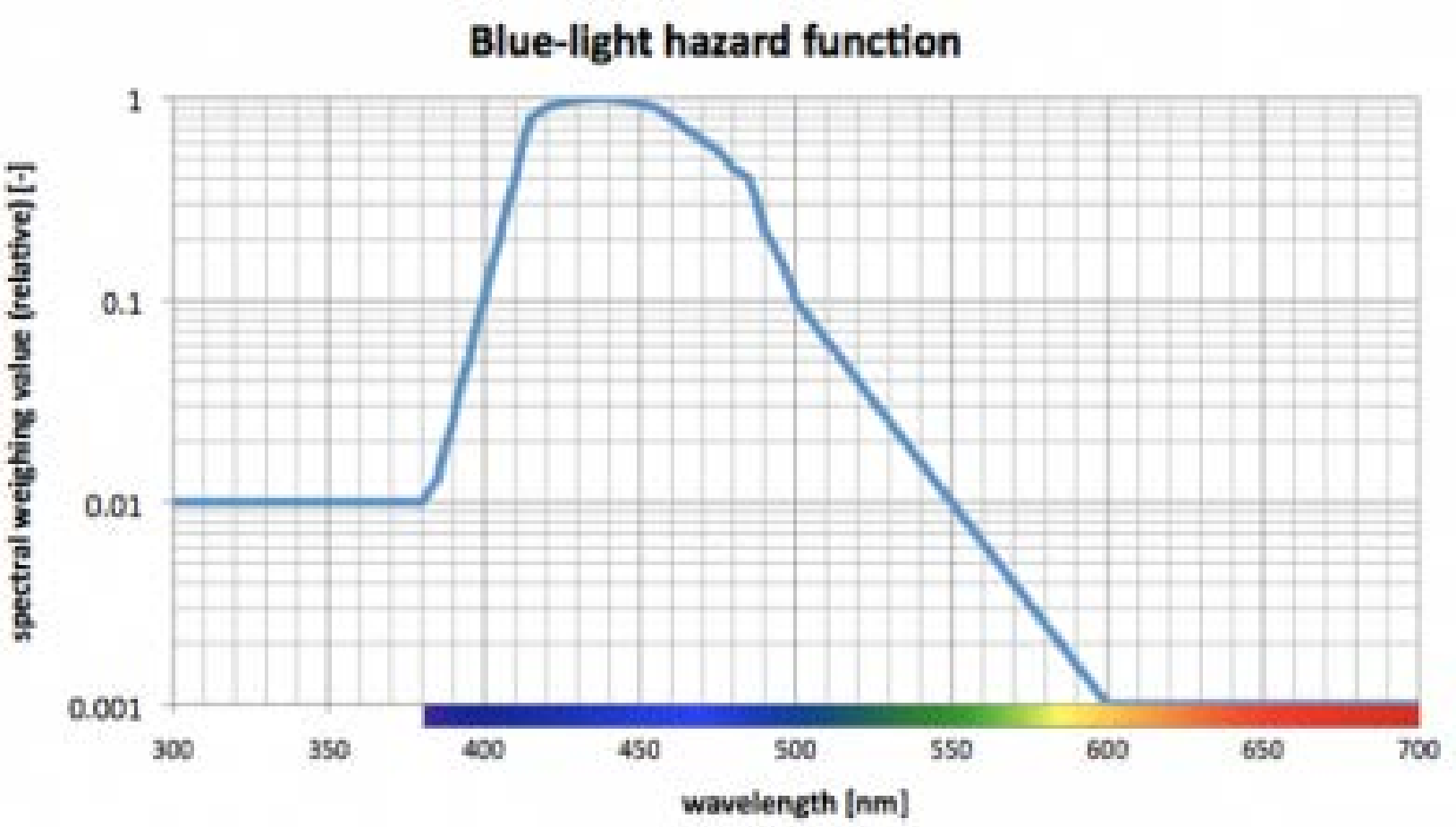
Led lamp: Blue Light Hazard ??
420–490 nm melatonine regulation??

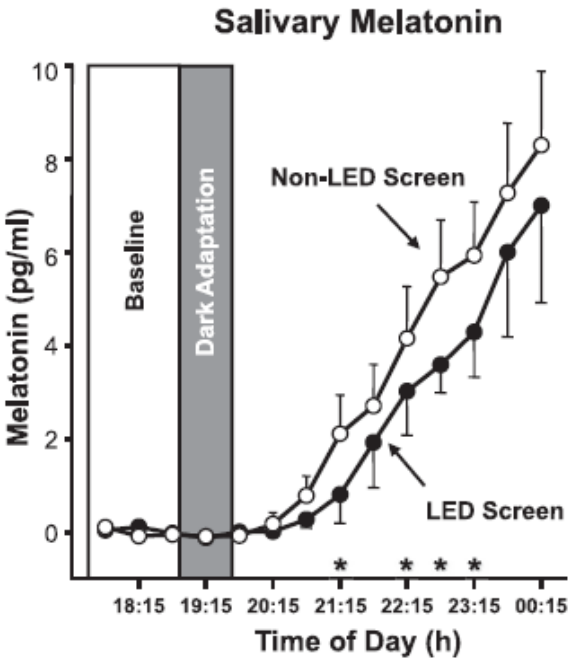


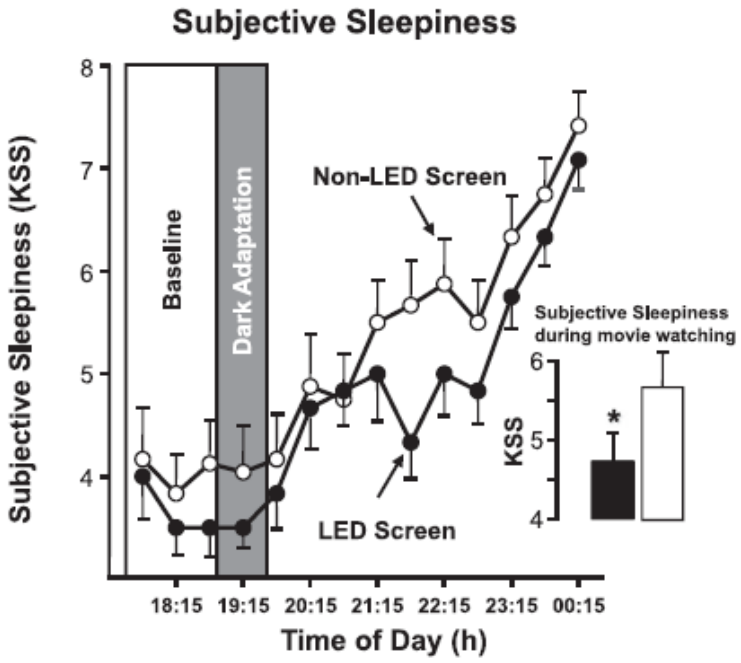


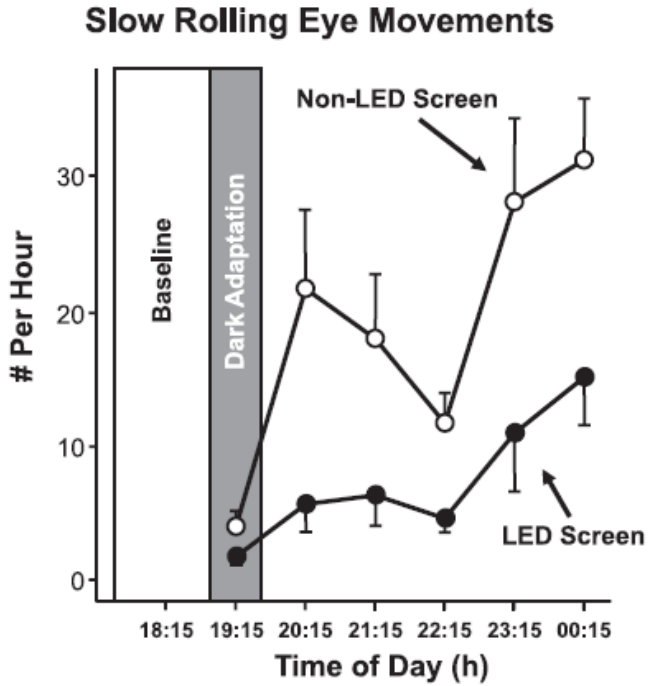
a. Daylight spectrum
b. Incandescent lamp spectrum
c. LED spectrum compared to daylight

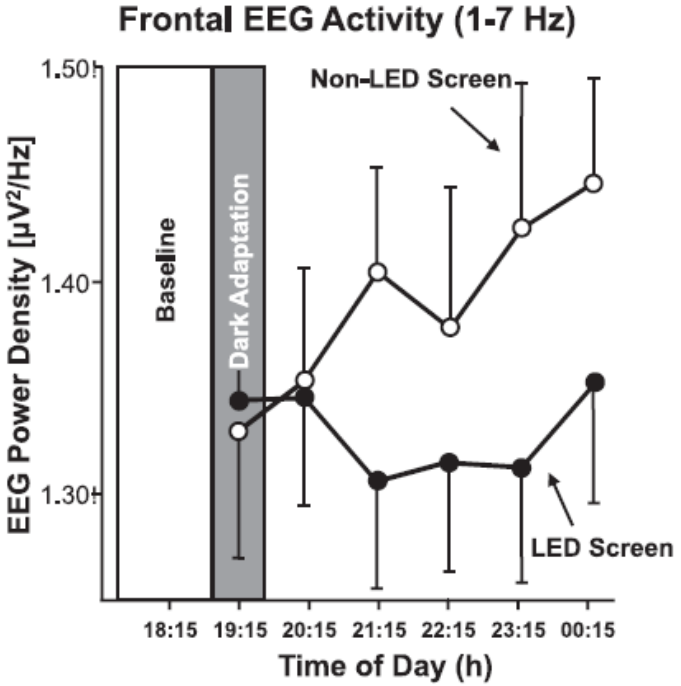
Blue Light Hazard











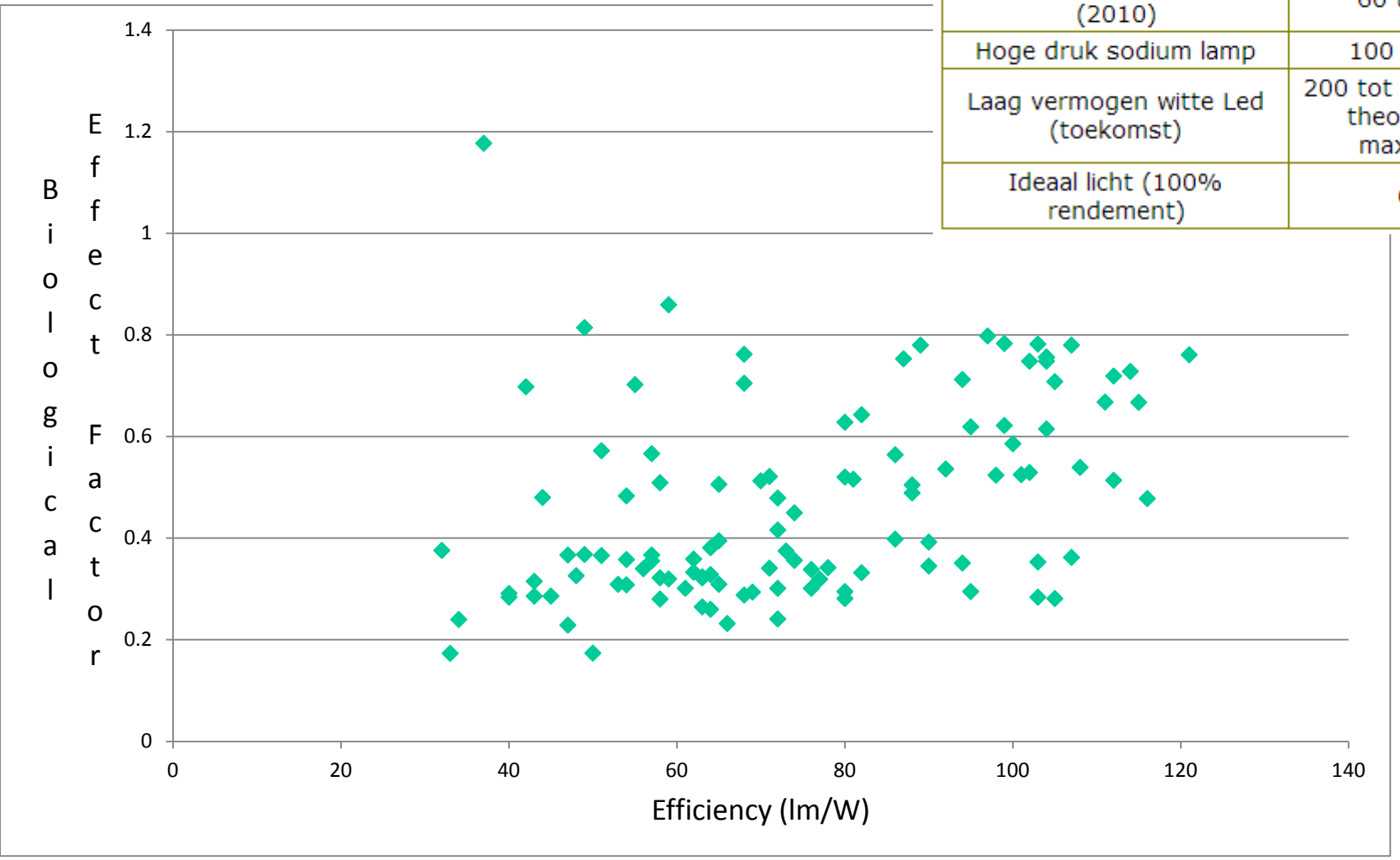
Cajochen e.a. 2011
Evening exposure to a light-emitting diodes (LED)-backlit computer screen affects circadian physiology and cognitive performance

LED-backlit screen emitted 3.32 times more light in the blue range between 440 and 470 nm than the non-LED-backlit screen. This is the major factor contributing to the observed effects."

LED LAMP:
Biological Effect Factor versus Lumen / Watt

Incandescent light bulb BEF 0.376
Day light BEF 1.040

Lamptype	Lumen per Watt [lumen]
Gloeilamp	12 tot 15
Halogeen	20
Hoog vermogen LED	20 tot 30
Spaarlamp	55 to 60
Laag vermogen witte Led (2010)	60 tot 100
Hoge druk sodium lamp	100 tot 200
Laag vermogen witte Led (toekomst)	200 tot 300 (300 is theoretische maximum)
Ideaal licht (100% rendement)	683



Blue light issues

- Attention of research community is growing (rapidly increasing amount of publications)
- On the agenda of International Electrotechnical Commission
- German Vornorm 2009

Lessons landed?

- Potential of known “late lessons” highly underutilized
- Not widely known / hardly internalized at frontiers of technological innovation
- Drivers of innovation very different from aims of sustainability
- Regulatory requirements drive what firms do as risk assessment
- ALARA in real life:
  “As Lousy As Regulators Allow”

Factors that hamper early detection of unintended negative side effects

- lack of critical reflection on risks and benefits
- bias in appraisal of risks and benefits
- required level of proof
- inadequate risk assessment
- data gaps
- lack of monitoring
- institutional factors
- interests / power

Top 10 of circumstances / characteristics of risk migration

Rank	Circumstance / characteristic	# cases
1	Lack of systems analytic approach	37
2	Incomplete life cycle assessment	27
3	Lack of critical reflection on risks and promised benefits	25
4	No incentives to meet ALARA	25
5	Persistence and/or bioaccumulation	17
6	Ignoring ignorance	14
7	Novel material / special unfamiliar properties	11
8	Mismatch novel aspects and authorization tests / standards etc	10
9	Unreflective upscaling from small scale experiences	9
10	Non standard situations	4

Barriers to early policy intervention

- Vested interests
- Lacking sense of urgency
- Perceived level of evidence too low to justify intervention
- Limited expertise
- Institutional barriers
- Funding
- Reluctance to act / lack of courage
- Flaws in leadership

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Background report:

http://epinet.no/sites/all/themes/epinet_bootstrap/documents/van_der_sluijs%20et_al_2013.pdf