Life Cycle Assessment of Smart Lamp for residential indoor lighting

TASK 3:
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LCA of residential smart lighting

LED

DOE US (2012)

Dillon & al. (2019)

Stand-by & gateway consumption

Lower efficacy

Increased amount of materials

Increased comfort and well-being

Reduced usage ?

Smart LED

(8 LED / house)

Scenario 1 : 2,5h / day

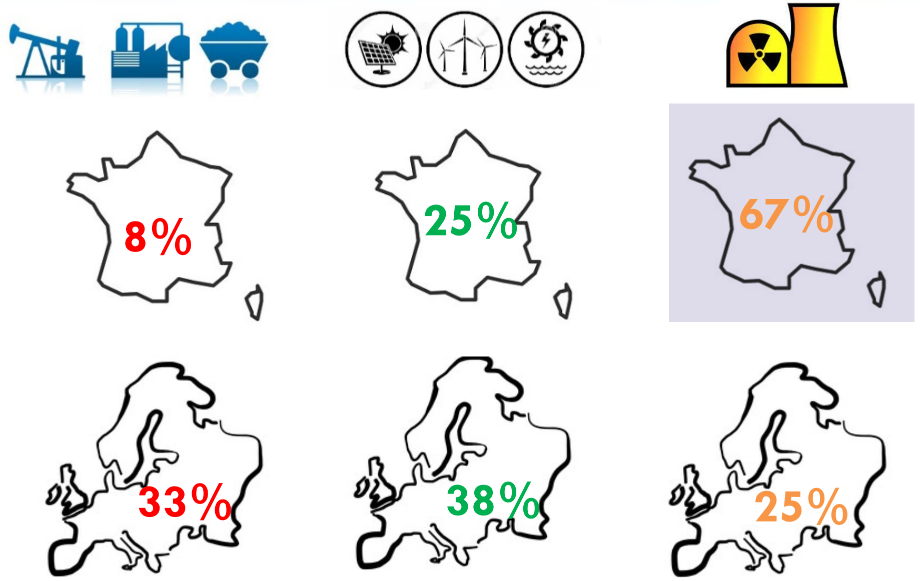
Scenario 2 : 1,5h / day

CFL E27

Naviguant

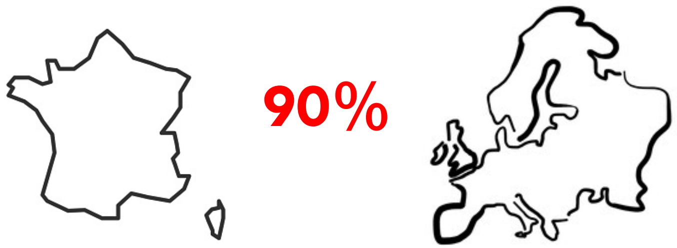
(2009)

MADE IN CHINA



Landfilled / Burned LED

(low volume)



An interesting report on digital sufficiency

https://theshiftproject.org/en/article/implementing-digital-sufficiency/

- ✓ Analyse the energy relevance of connected projects
- ✓ Manage the digital transformation of an organization to make its IT system sustainable
- ✓ Explore and understand the links between human uses and digital tools
- ✓ 3 Residential Smart lighting scenario :
  - ✓ **Functional indoor residential lighting**
  - ✓ Functional + recreational indoor residential lighting
  - ✓ Recreational indoor residential lighting
- ✓ 2 tertiary building Smart lighting scenario

In order to evaluate the energy relevance of the introduction of a smart layer in an environment, a global cost function G(t) can be defined

$$G(t) = C.E_{saving}(t) - E_{smart}(t)$$

G(t) : Global Cost
C : conversion factor of electrical energy to primary energy (C = 3)
$E_{saving}(t)$: Decrease in energy consumption due to smart layer

$$E_{saving}(t) = E_{ini}(t) \times \alpha$$

α : *energy saving coefficient*
E_{ini} : *initial consumption of the system*

$E_{smart}(t)$: **operating energy** + **embodied energy** (energy needed to manufacture smart layer)

$$E_{smart}(t) = C \cdot E_{smart\ funct}(t) + E_{smart\ embodied}$$

Energetic neutrality : $G(T_{PB}) = 0$ (with T_{PB} the payback time)

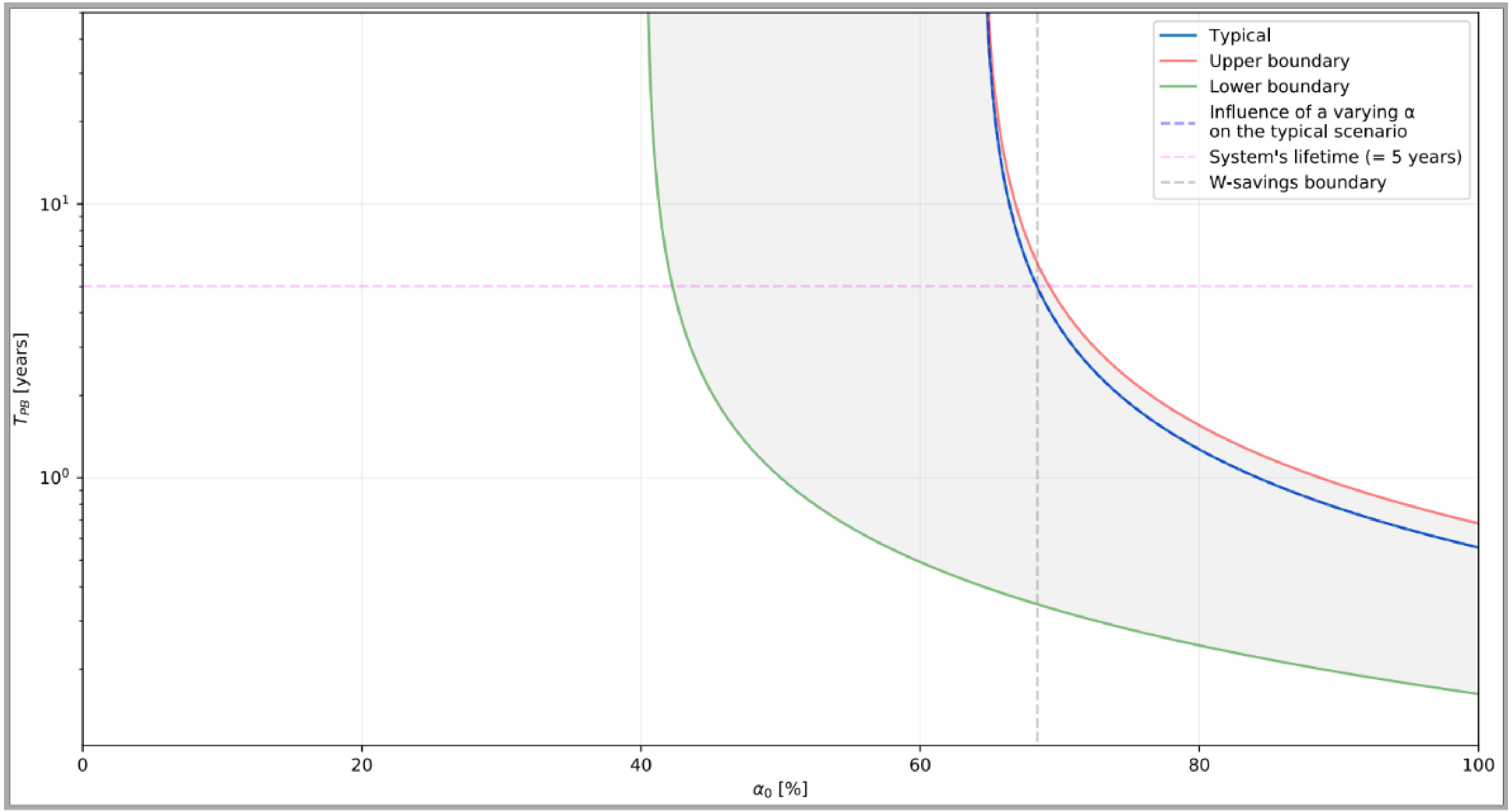
Indoor functional lighting scenario

- ✓ 1 Gateway
- ✓ 2 Motion Sensor
- ✓ 8 Smart lamps
- ✓ 5800 lumens over $58m^2$ (average illuminance 100lux)
- ✓ 1000h/yr of illumination (2,7h/day)

- ✓ **40% < α < 65%**

Reduction of uses between 1h and 1h45 per day per lamp seems quite difficult to achieve

- ✓ T_{PB} = 3,5yr for α = 70%



Energy consumption scenario

Examples of annual energy consumption for 8 common 9W smart lamp per building

(Lamp providing 810 lm, gateway power 1.5W)

On time (h/day)	Annual Energy for ON (kWh/yr)	Stand by consumption (W)	Annual Energy in stand by (kWh/yr)	Annual Energy for Gateway (kWh/yr)	Total energy per lamp per year (kWh/yr/lamp)	Lifetime (yr)	Total lifetime consumption (KWh)
2,5	65,7	0,33	20,72	13,14	12,44	16,4	204,6
1,5	39,42		21,68		9,28	27,4	254,25
2,5	65,7	0,1	6,28		10,64	16,4	174,9
1,5	39,42		6,57		7,39	27,4	202,5
2,5	65,7	0,01	0,63		9,93	16,4	163,29
1,5	39,42		0,66		6,65	27,4	182,25

LCA Parameters

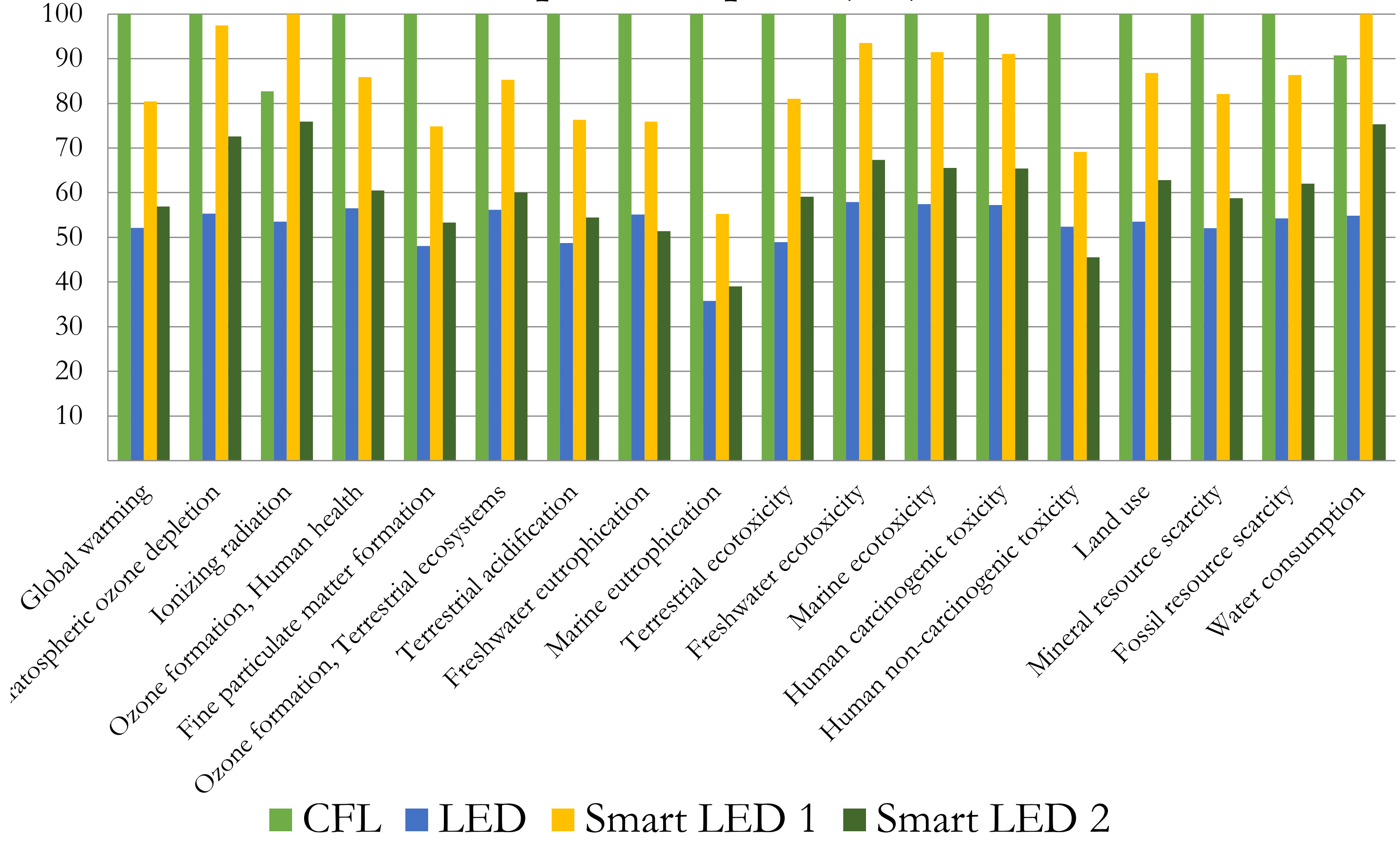
	CFL	LED	Smart LED 1	Smart LED 2
Power (W)	12	7.7	9	9
Efficacy (lm/W)	68	104.9	90	90
Flux (lm)	816	808	810	810
Lifetime (kh)	10	15	15	15
Day use (h)	2.5	2.5	2.5	1.5
Lifetime (year)	10.96	16.43	16.43	27.40
Annual consumption(kWh/yr)	10.95	7.02	13.2	10.0
Klm.yr (UF)	8.94	13.27	13.31	**22.19**
Reference flow	2.48	1.67	1.67	1

- Average efficacy of classic LED over 700 lamps on FR market : 104,9 lm/W
- Average efficacy of smart LED over 224 lamps worldwide : 74 lm/W
- Gateway consumption for smart lamps : 1,5W
- Stand-by mode consumption : 0,33W
- Average use of lamp for residential lighting : 2,5h/day
- Increase of production phase impact for the smart layer : +10% embodied energy → need to be verify

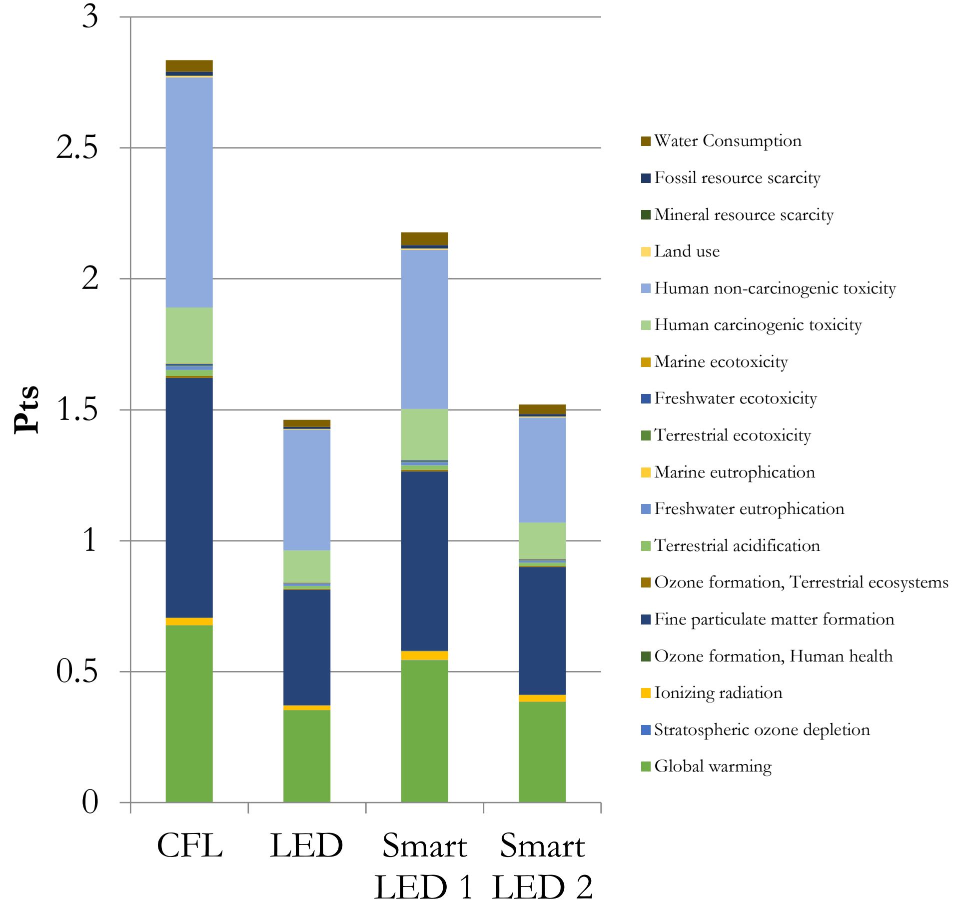
Midpoint and Endpoint Impacts (FR)

For 1 smart lamp with a stand by consumption : 0,33W

Impacts Midpoint (FR)

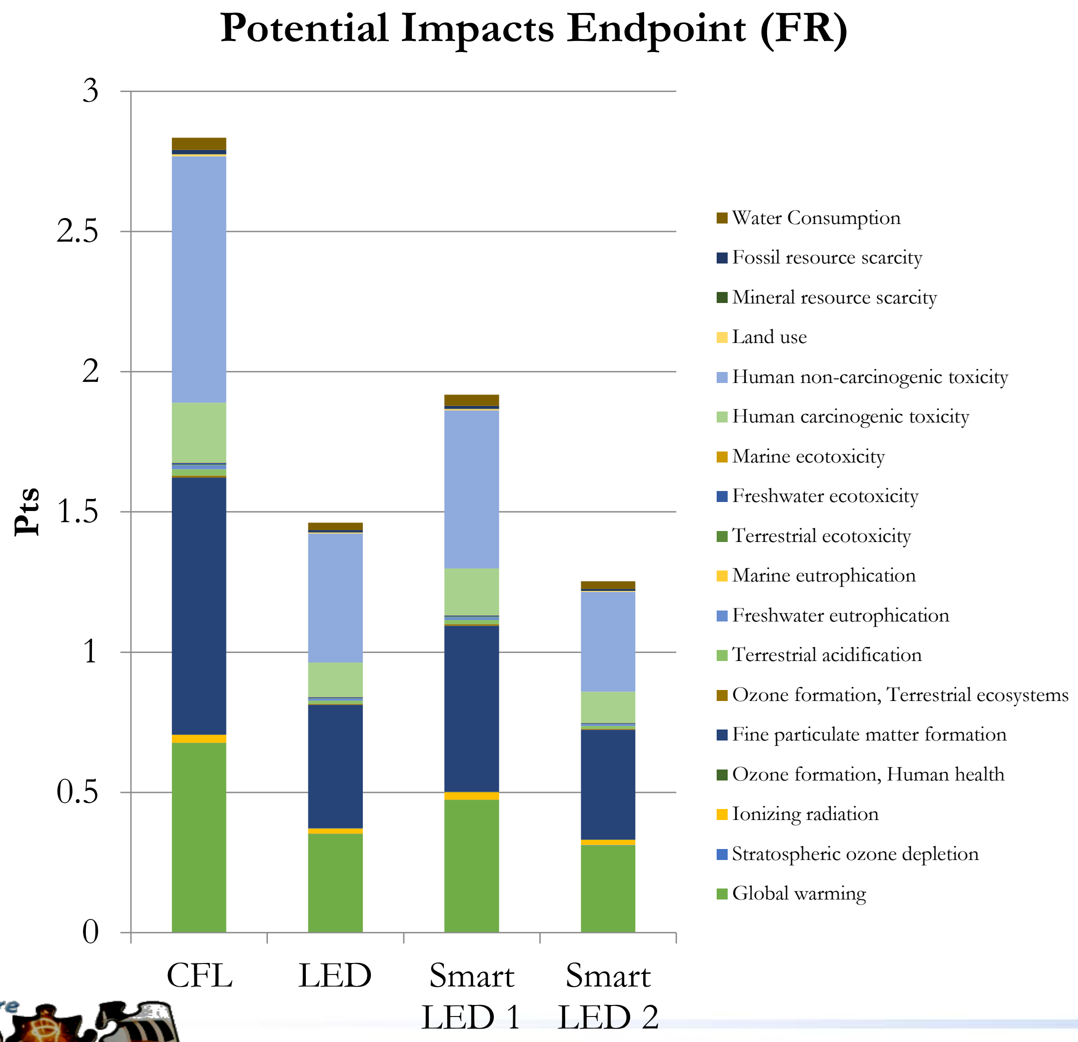


Impacts Endpoint (FR)

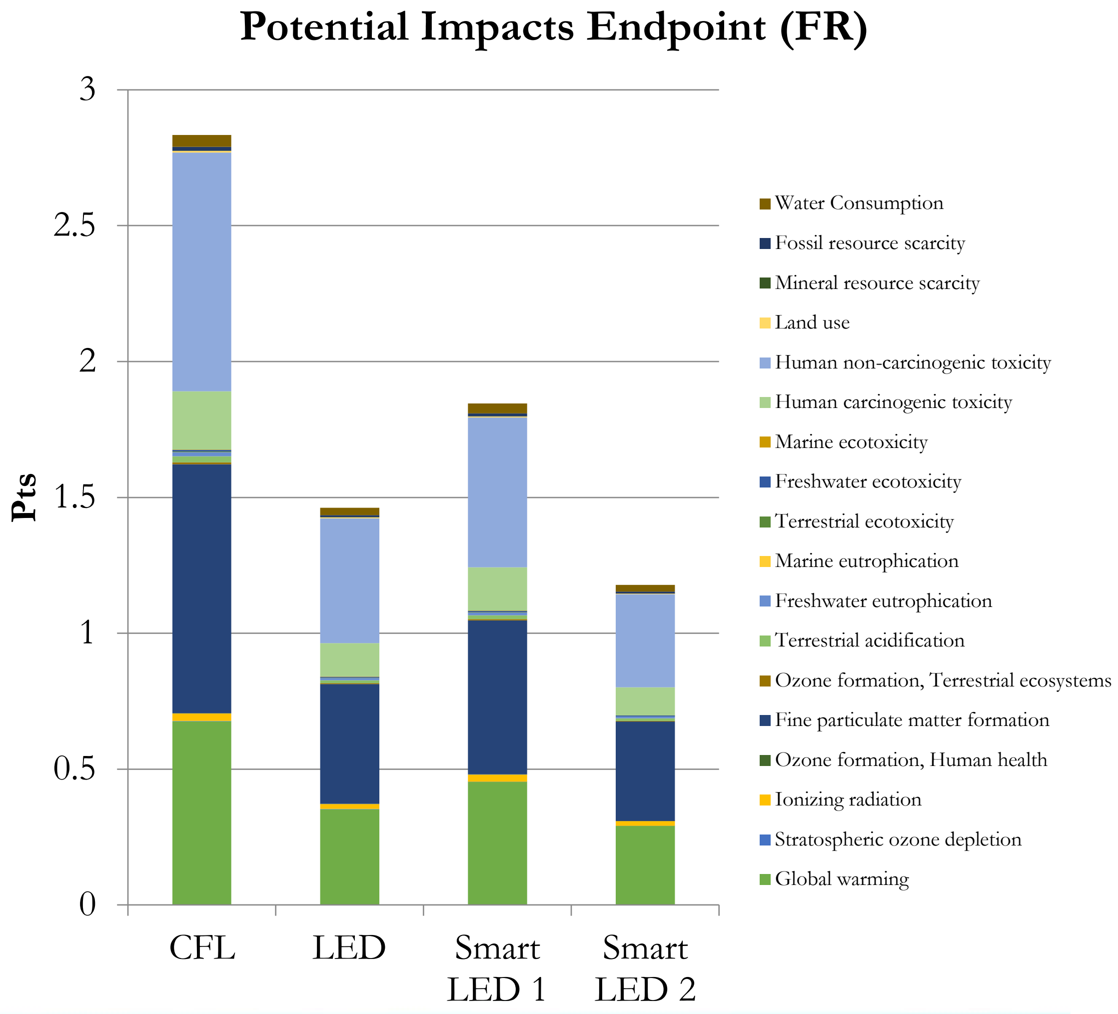


Alternative Stand by consumption (FR)

Stand by consumption : 0,1W



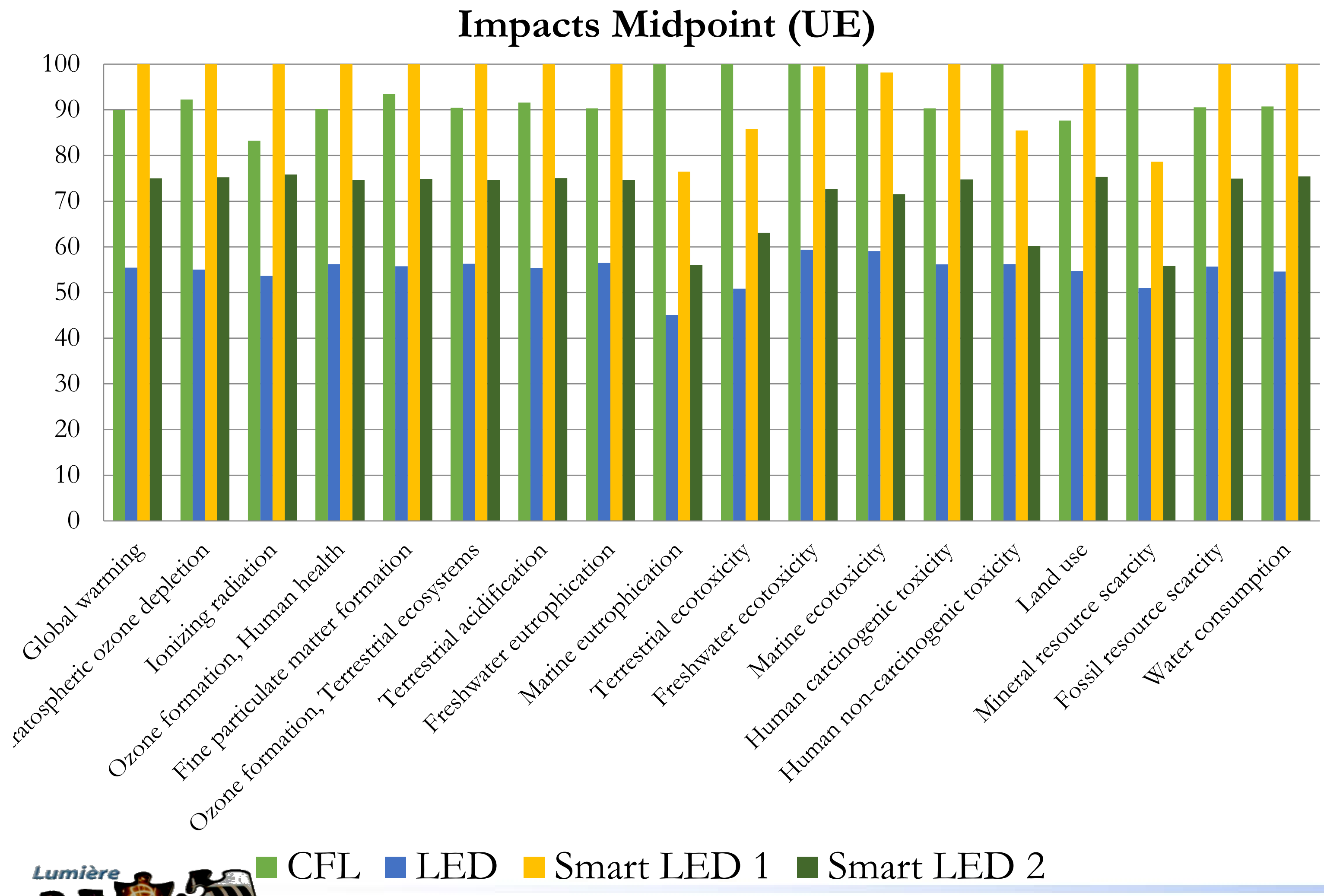
Stand by consumption : 0,01W

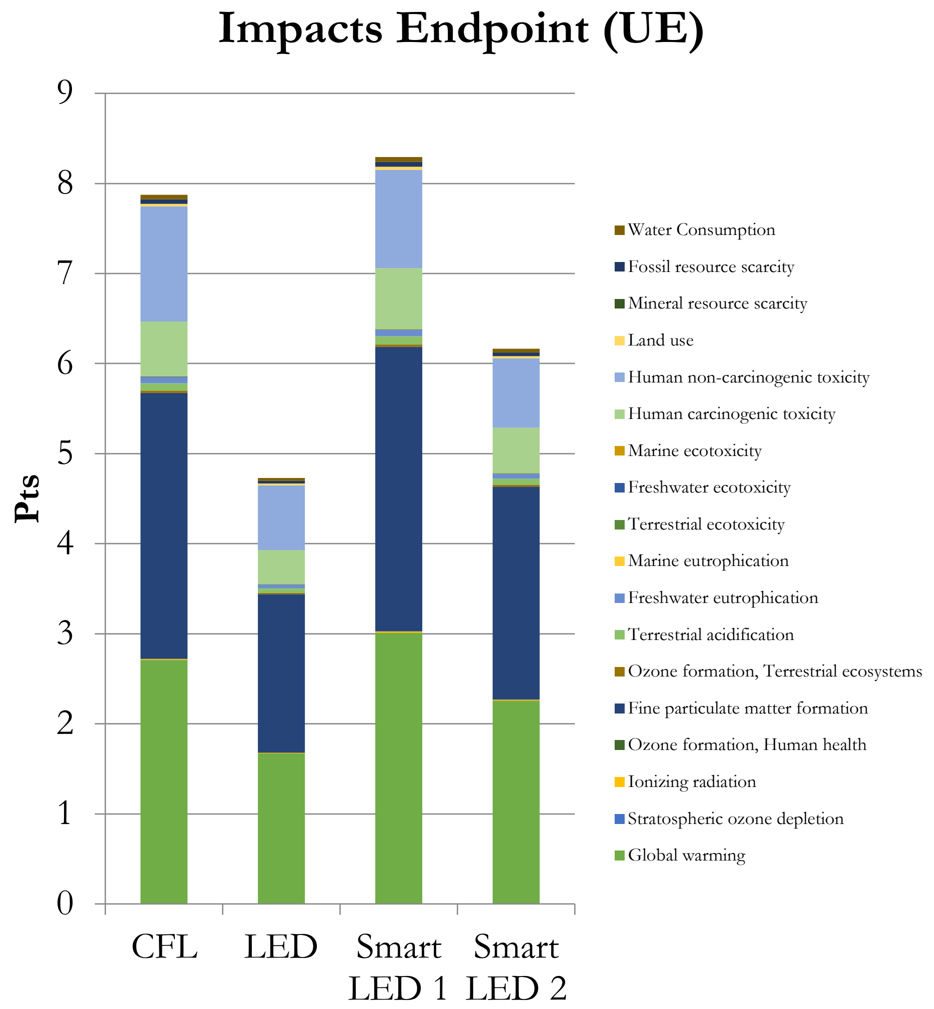


Midpoint and Endpoint Impacts (EU)

UMR 5213

For 1 smart lamp with stand by consumption : 0,33W

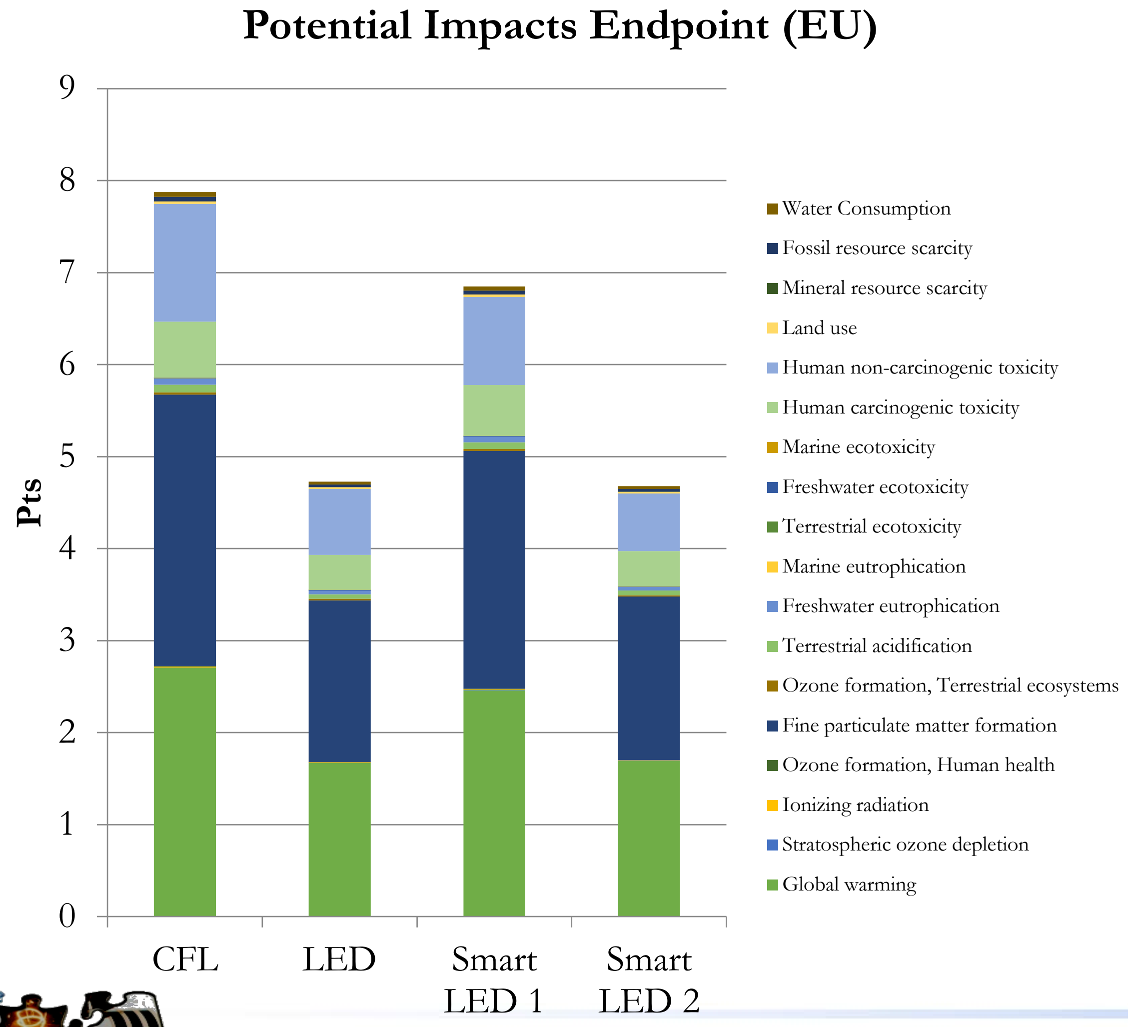




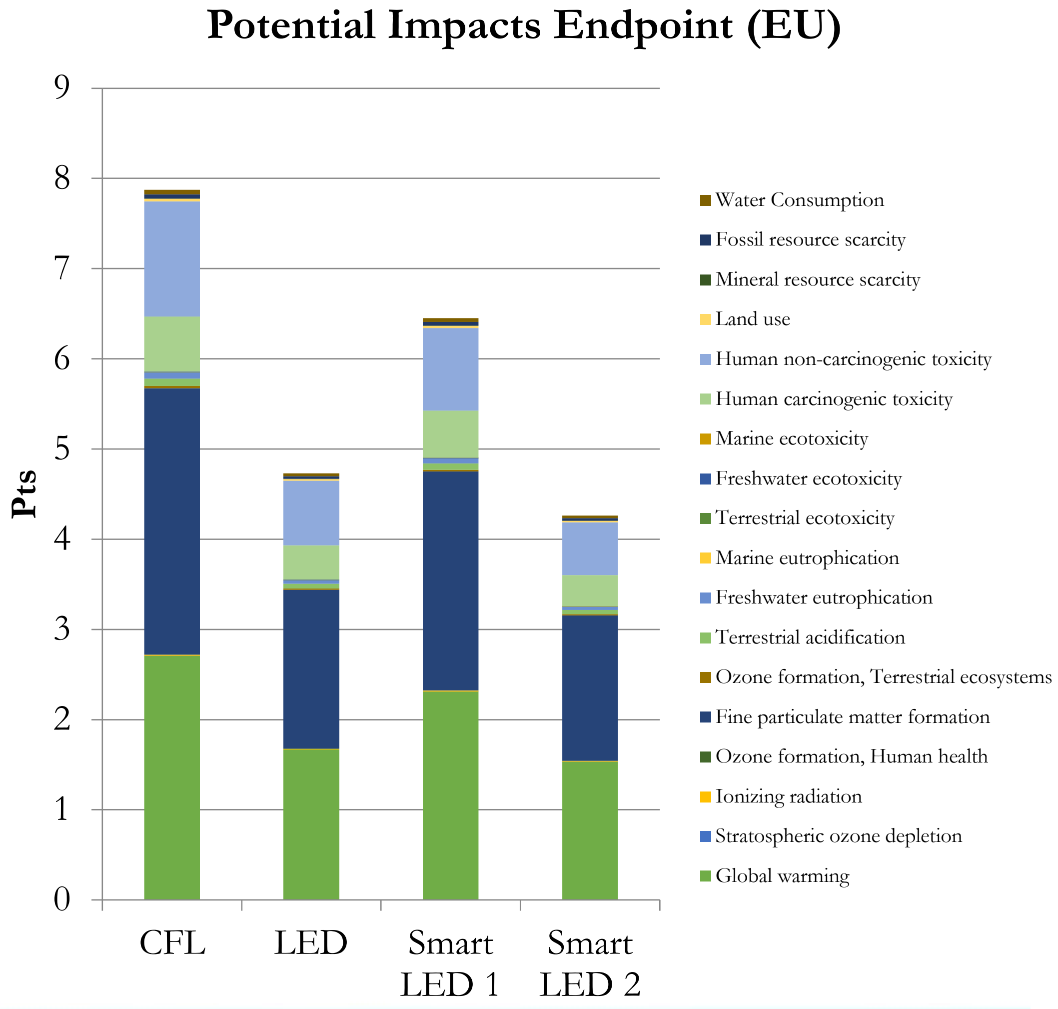
Alternative Stand by consumption (EU)

UMR 5213

Stand by consumption : 0,1W



Stand by consumption : 0,01W



Findings and Limits

- The first measurement campaigns and scientific work on smart lamps for residential use show that the increase in comfort that they can provide is achieved at the cost of a decline in energy and environmental performance.
- Findings are in line with Shift Project report for a French electricity mix
- Stand by consumption should be less than 0,1W for EU electricity mix
- Environmental impacts neutrality compared with classic LED lamp cannot be achieve without reducing the usage by 40% which seems to be difficult to achieve in residential context
  - What is the acceptable environmental cost of increased comfort for residential use?

- Limits of smart lamp LCA :
  - The consumption of the gateway is not fully allocated to the smart lamp
  - The 10% increased of manufacturing impacts due to embodied energy need to be verify
    - Inventory of smart lamp need to be done
  - End of life management probably more impacting than for classic LED lamps

Conclusion

- ✓ The use of smart lighting must be carefully considered according to the context. They can best fulfil their potential with much longer exposure times (tertiary building, care facilities, public lighting) → where they present a real potential for reducing usage and increasing comfort.

- ✓ Traditional LEDs already offer different colour temperatures that can be chosen according to the rooms in which they would be installed → similar gain in comfort without sacrificing the energy and environmental performance.
  - ✓ Need a greater consumer awareness on this topics to avoid gadget usage

- ✓ Next steps :
  - ✓ Material inventory of smart lamp + gateway
  - ✓ Update on classic LED lamp LCA (inventory from Mike and CLASP project for the new high efficiency and lifetime Philips lamp) to include in the next SSL report.

Thank you for your attention

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