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Catalyzing Markets for Modern Lighting

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Life Cycle Energy Benefits from Off-Grid Lighting

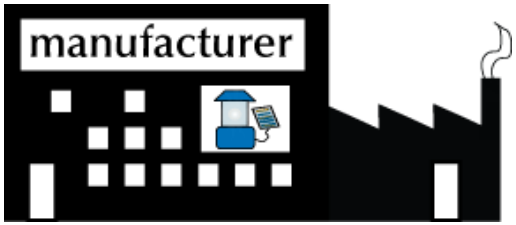
Peter Alstone and Patricia Lai (黎德惠)

Sustainability Session

3rd International Off-Grid Lighting Conference and Trade Fair

November 12, 2012

Does off-grid lighting “pay” its energy and carbon debt from manufacturing?



http://www.gocomics.com/joelpett/2009/12/13/

What if using off-grid lighting doesn't reduce overall carbon emissions because the energy from manufacturing and delivering the products is too high?

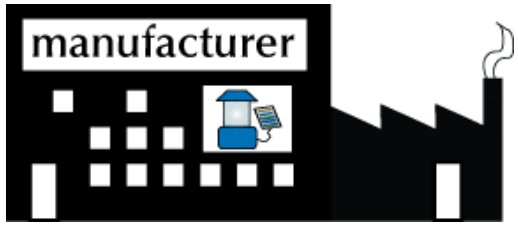
Improved Service Quality and Level

Saved Money

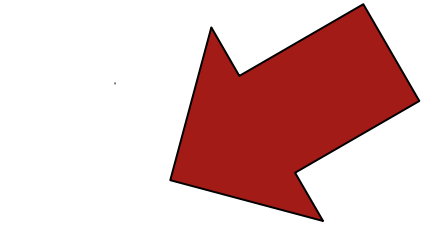
Reduced sickness and accidents

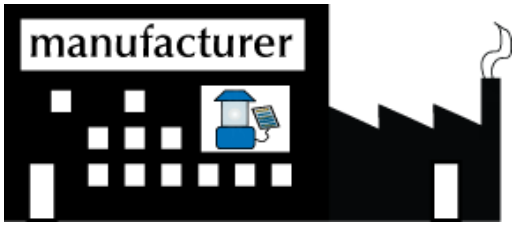
Built small businesses

Does off-grid lighting “pay” its energy and carbon debt from manufacturing?



Does off-grid lighting “pay” its energy and carbon debt from manufacturing? **YES!**



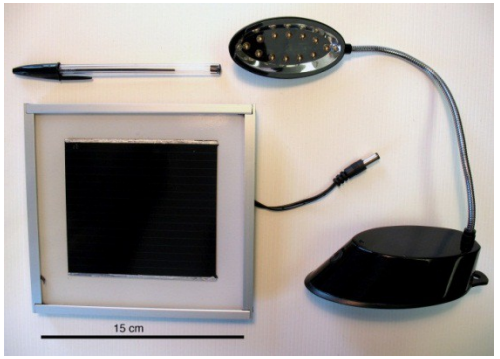


Technique: "**Life Cycle Analysis**" accounting for embodied energy of manufacturing and offsets in the field

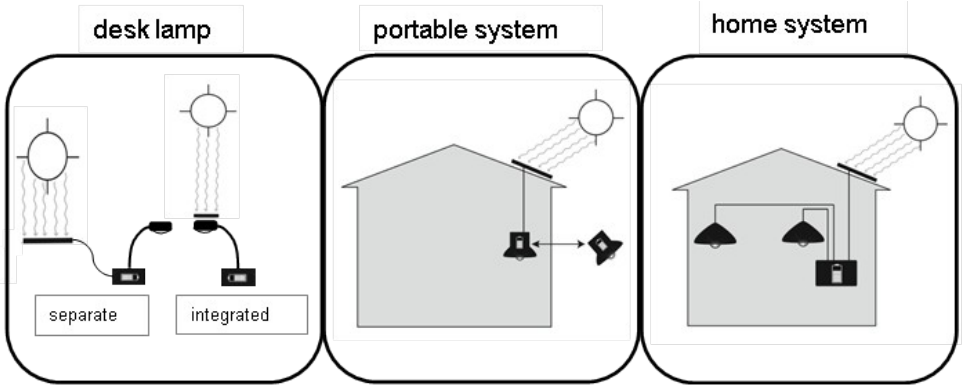
1) Estimate total **energy to manufacture** and deliver product.
2) Estimate **reduction in kerosene** consumption rate as a result of adoption.
3) **Energy Payback** = How fast until break-even
4) **Energy Return on Investment (EROI)** = ratio of total kerosene offset to embodied energy over the product lifetime

Two stage study

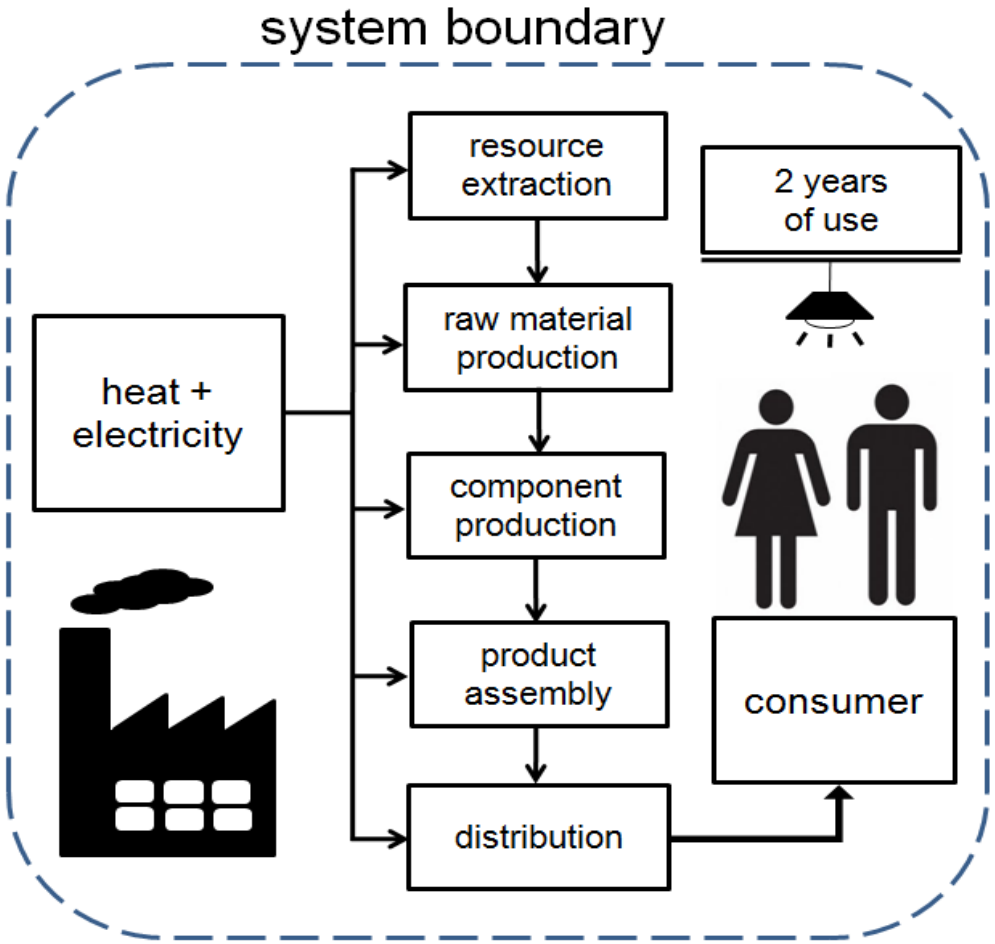
- **Initial Study**: focus on single lamp (circa 2008) to develop techniques



- **Expanded Study**: multiple lamps (circa 2012) to show range of results



Life Cycle Analysis boundary: important to define

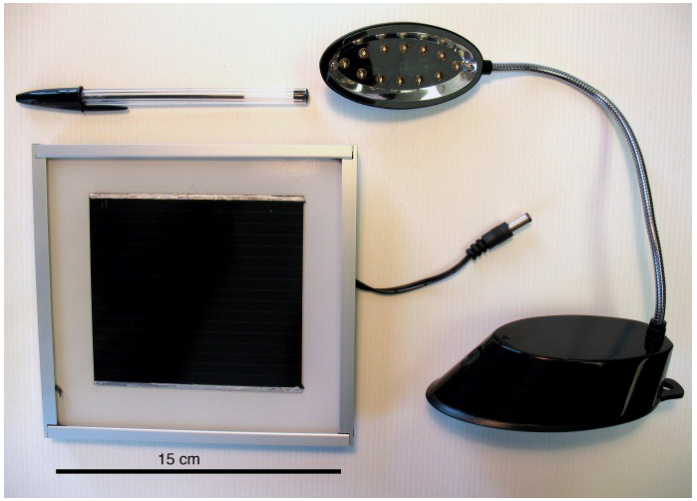


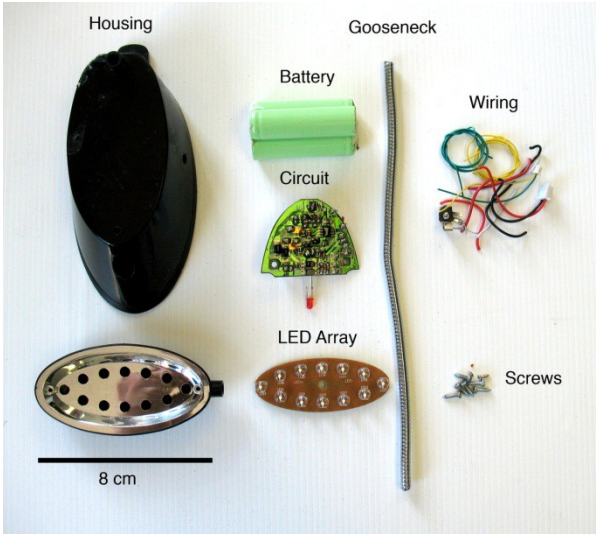
Lamp Production Energy:

Account for *materials* and *processes* required for lamp manufacturing and transportation to market

1) Break down product into materials and processes

2) Use database of energy intensity estimates





Category	Item	Value	Units	Boundary
				Manufacturing
Components	"Large" Integrated Circuits (high estimate).	8022	MJ/kg	Materials and Manufacturing
Components	"Small" Integrated Circuits (low estimate).	1787	MJ/kg	Materials and Manufacturing
Components	Surface mounted devices and LEDs (avg.)	2969	MJ/kg	Materials and Manufacturing
Components	Lead-free solder	234	MJ/kg	Materials and Manufacturing
Components	Slots and External Connectors for PCB	187	MJ/kg	Materials and Manufacturing
LED	LED Package	1.107	MJ/Wp	Front and Back End Processing
LED	LED Package	3.6	MJ/LED	Manufacturing Process
LED	200 mm wafer (general semiconductor)	17653	MJ/kg	Cradle to Gate
Metal	Stainless Steel	56.7	MJ/kg	Cradle to Gate
Metal	General Steel	35.3	MJ/kg	Cradle to Gate

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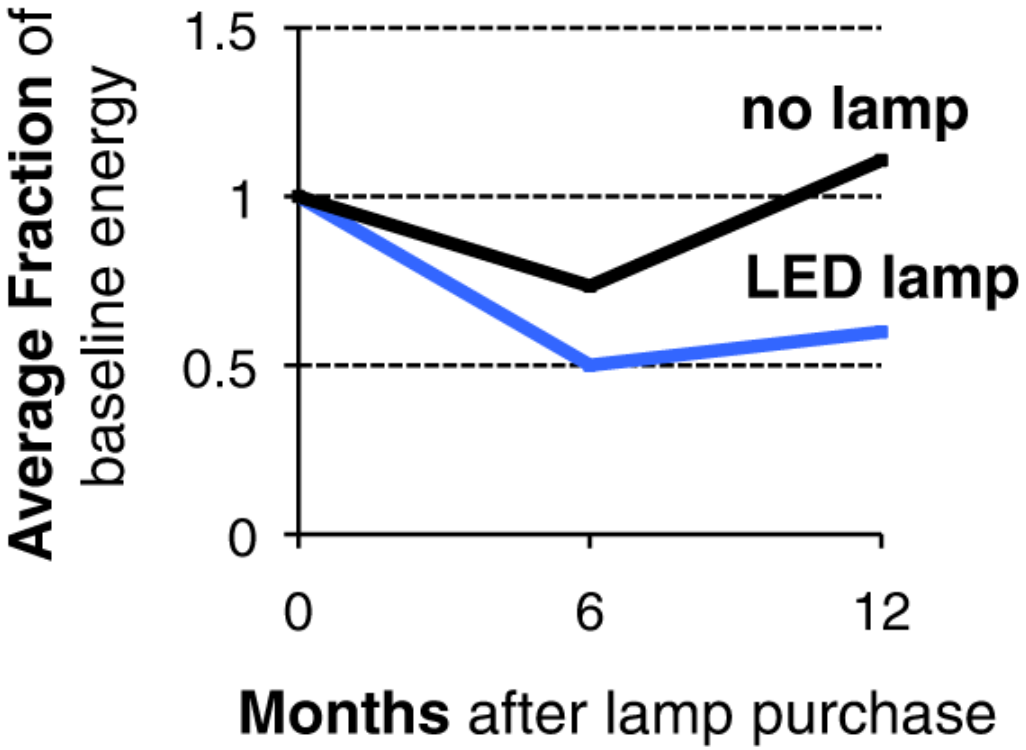
Impacts: Understand use patterns of people who buy off-grid lighting

A 2008-9 study of Night Market Vendors in Kenya

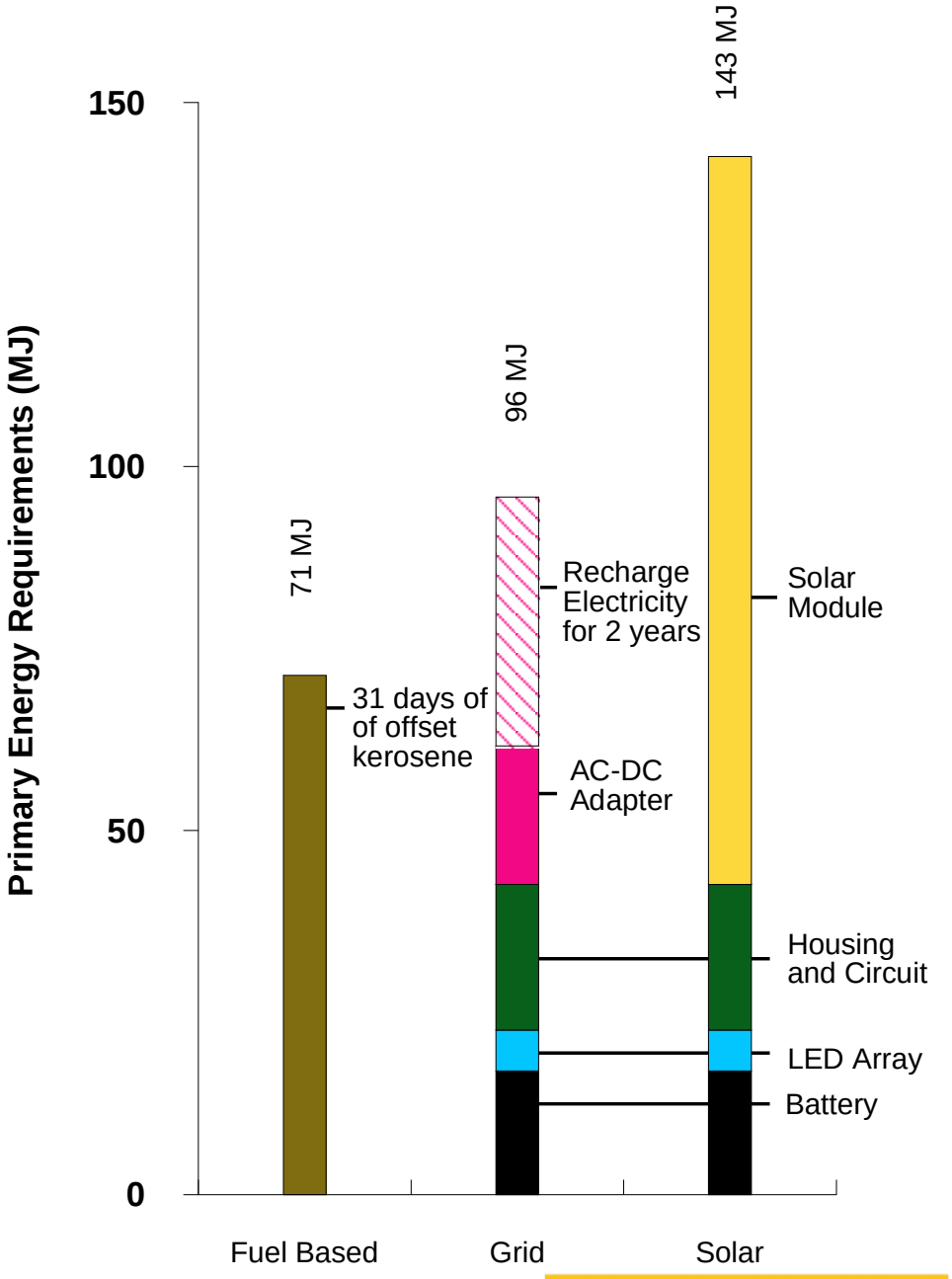
Impacts: Best estimate is a 50% reduction in kerosene from baseline



Results:
2008 Barefoot Firefly in Kenya

Payback: ~2 months

EROI (2 years):
13:1 (solar charge)
20:1 (grid charge)



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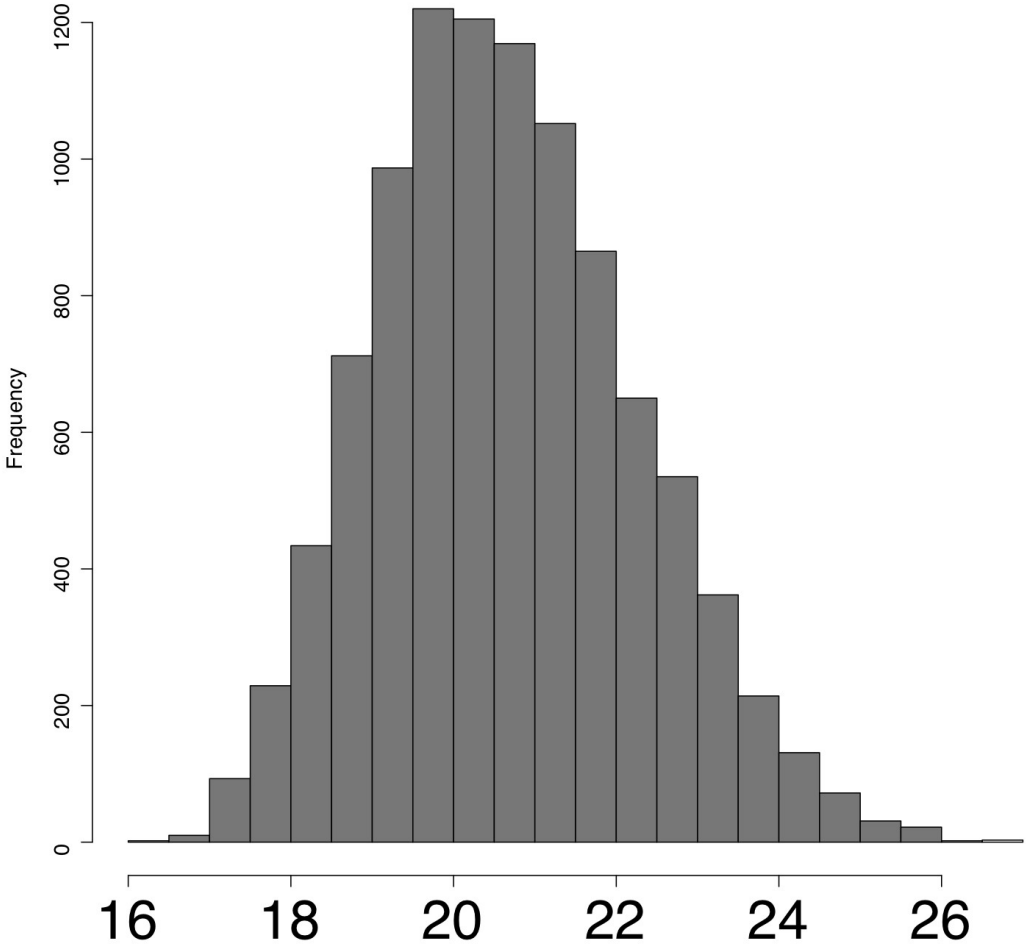
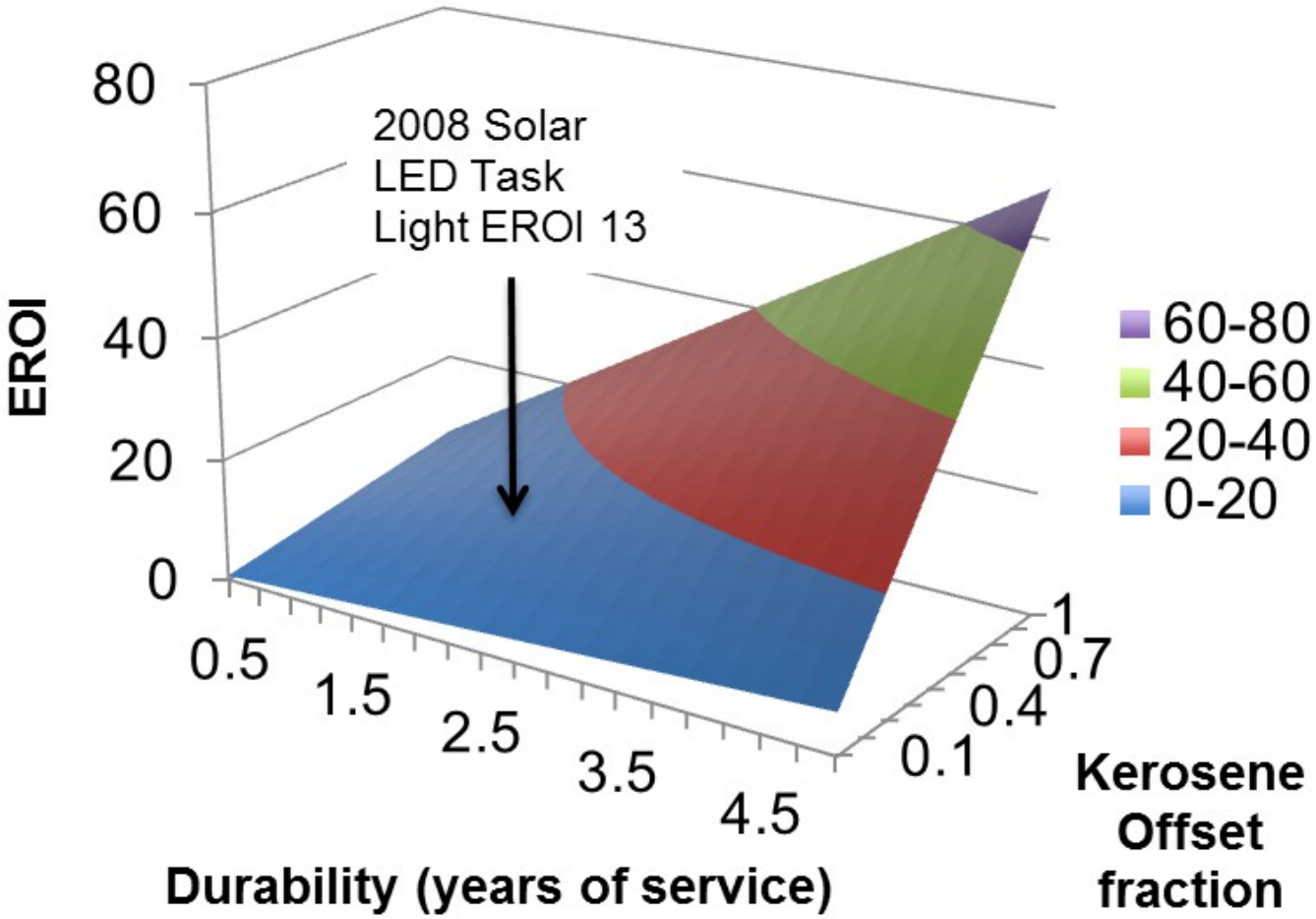
Uncertain Results? Benefits are clear



(Distribution of 10,000 Monte Carlo runs)

Sensitivity: EROI vs. product lifetime and performance (i.e., offset fraction)



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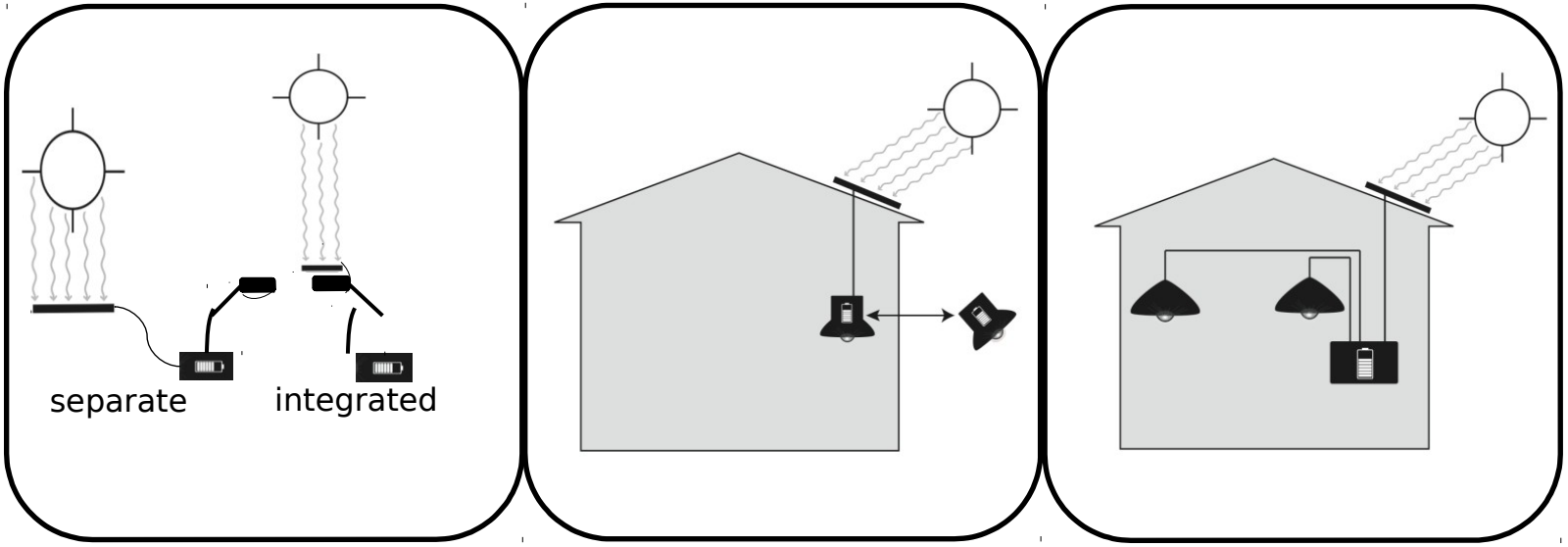
Expanded Life Cycle Analysis

3 categories

desk

portable

home



Expanded Life Cycle Analysis

7 products

	desk		portable			home	
	A	**B**	**C**	**D**	**E**	**F**	**G**
Battery	Li-Ion	NiMH	Li FePO4	Li FePO4	Li FePO4	Li FePO4	PbA
Solar Panel	A-Si	poly-Si	poly-Si	mono-Si	A-Si	mono-Si	poly-Si
LED	through hole	surface mount	surface mount	surface mount	surface mount	through hole	surface mount
Phone Adapters	no	no	yes	no	yes	no	yes
Accessories	no	no	yes	no	yes	yes	yes

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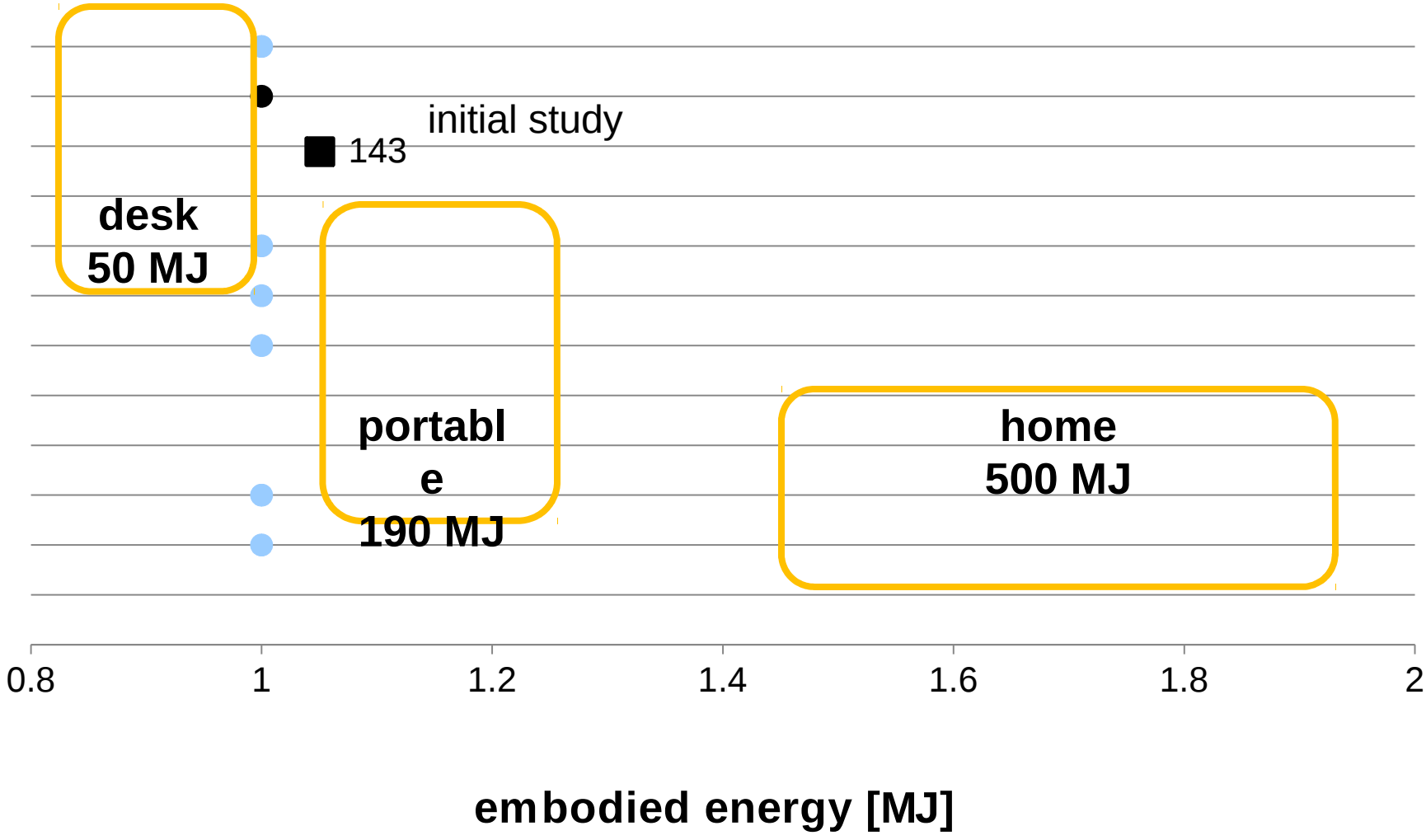
Expanded LCA Results

Embodied Energy



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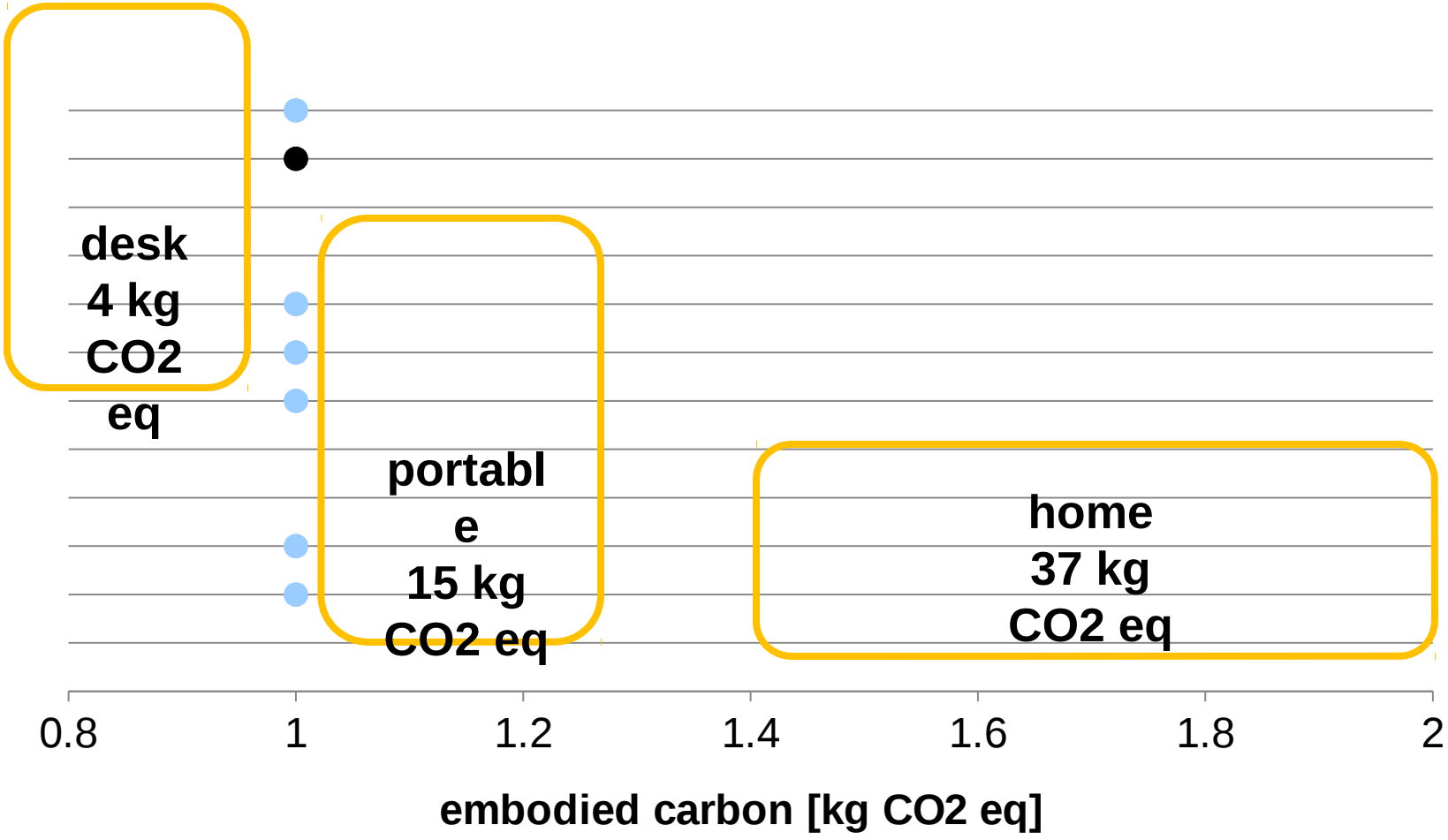
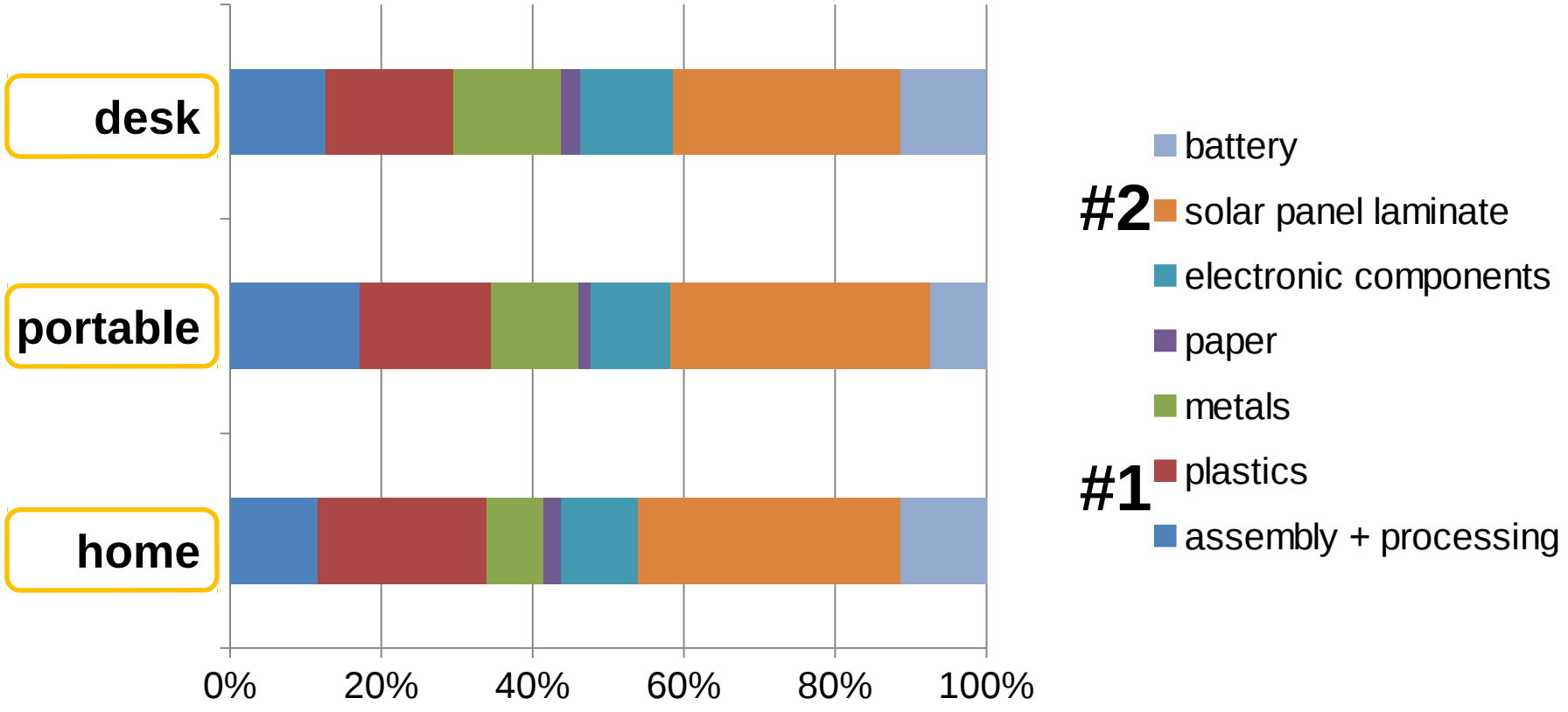
Expanded LCA Results

Embodied Carbon



Embodied Energy Composition

Similar across all 3 categories, the solar panel laminate and plastics were the largest contributors in the off-grid lighting system.

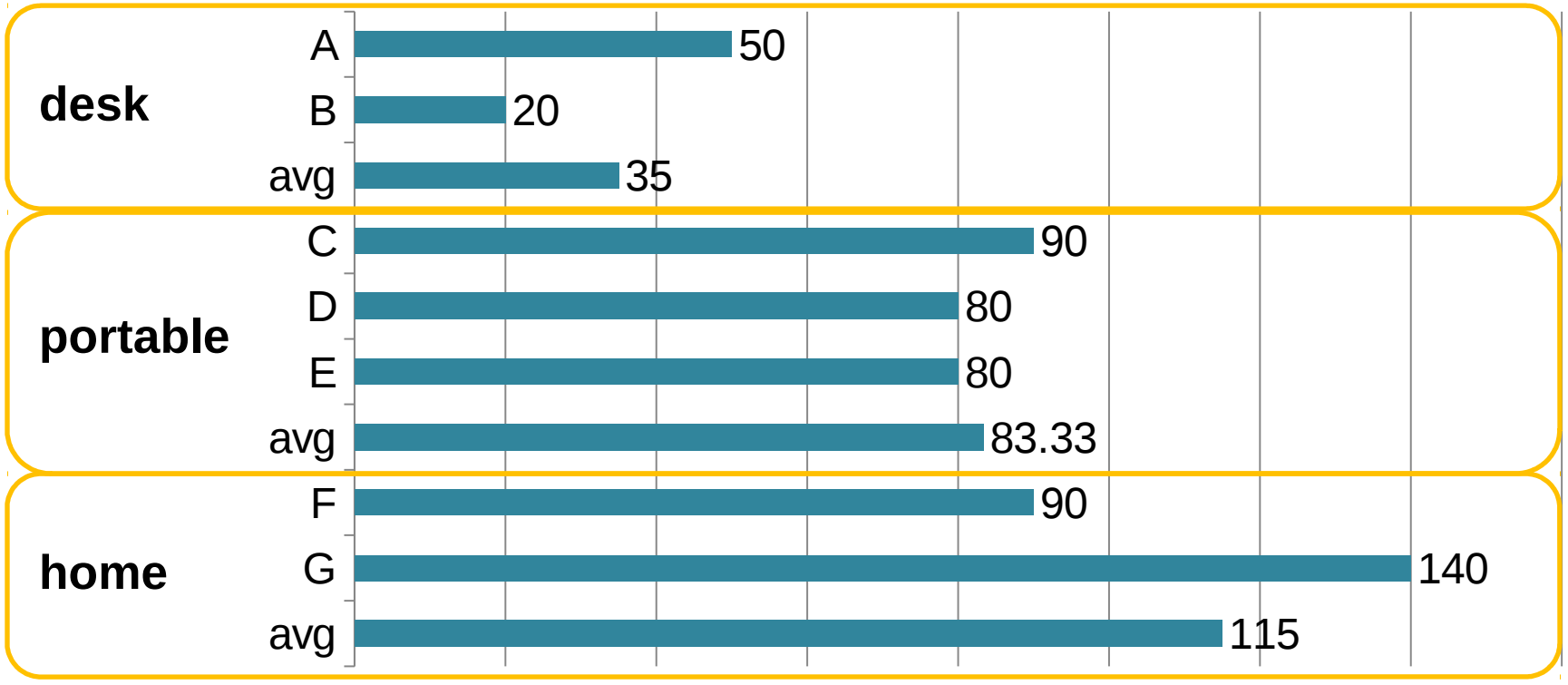


embodied energy composition by material

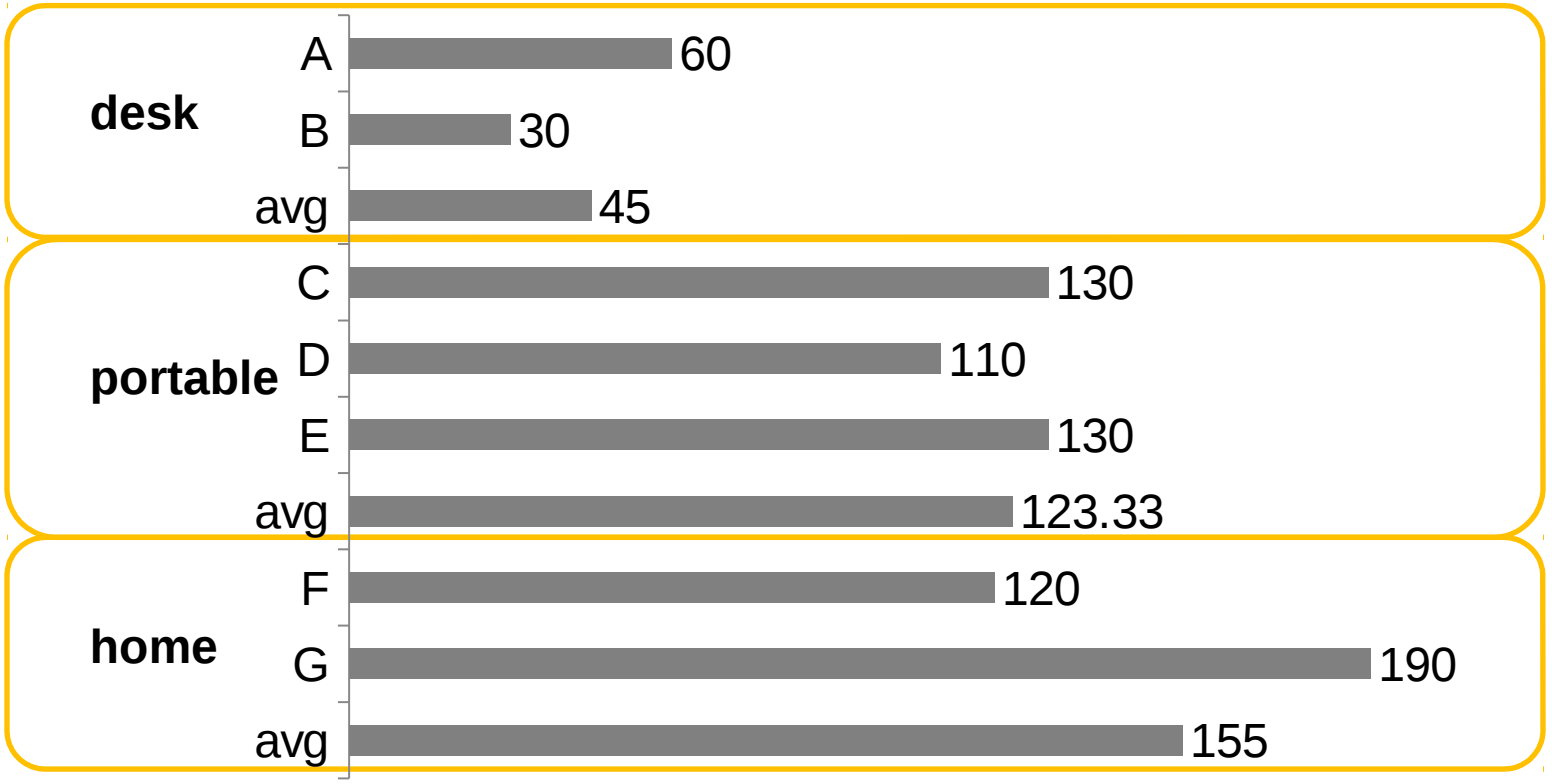
Payback Period of Energy

By displacing kerosene, the energy invested is paid back in about

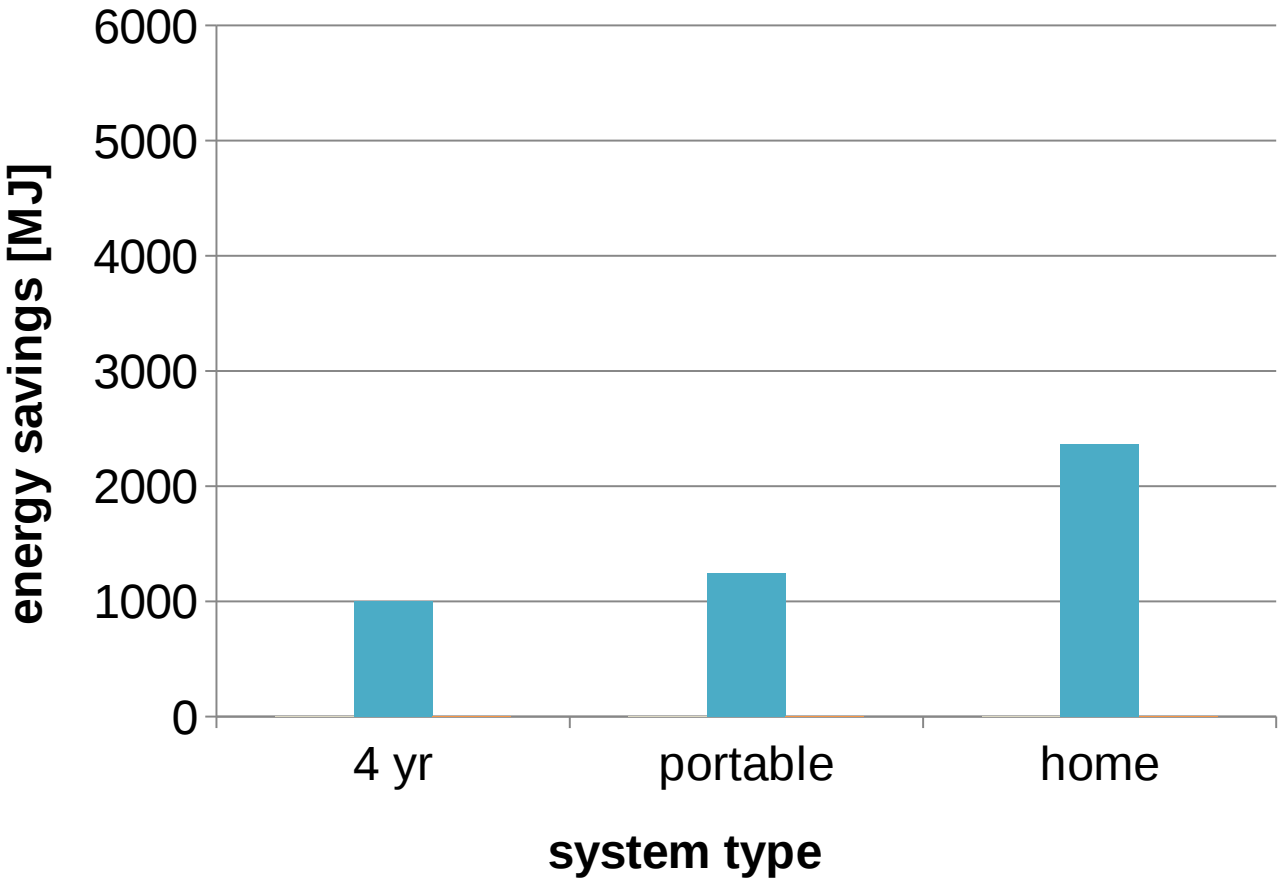
- 1 month – desk lamp
- 3 months – portable system
- 6 months – home system



Payback Period of Carbon

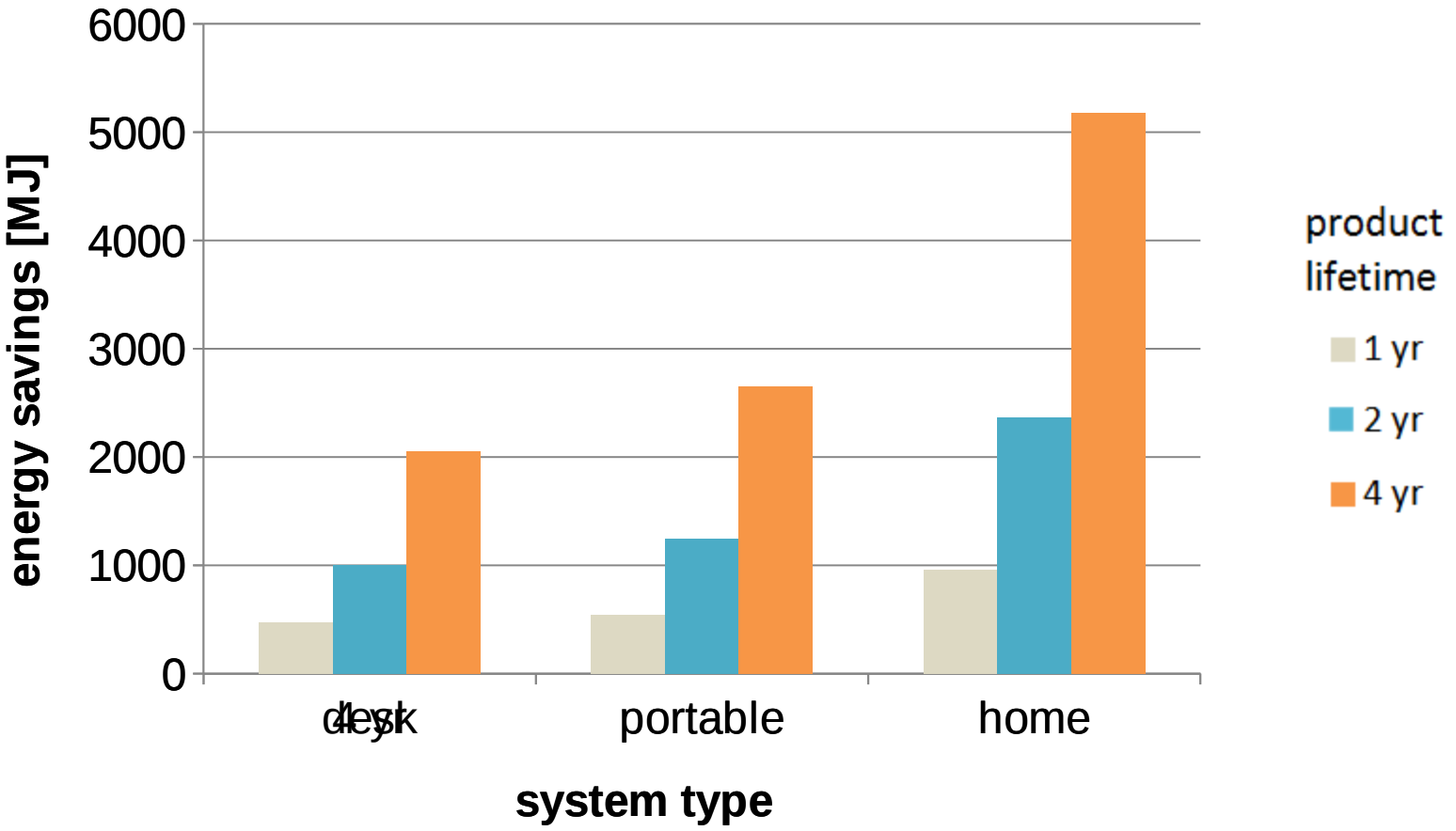


Energy Savings



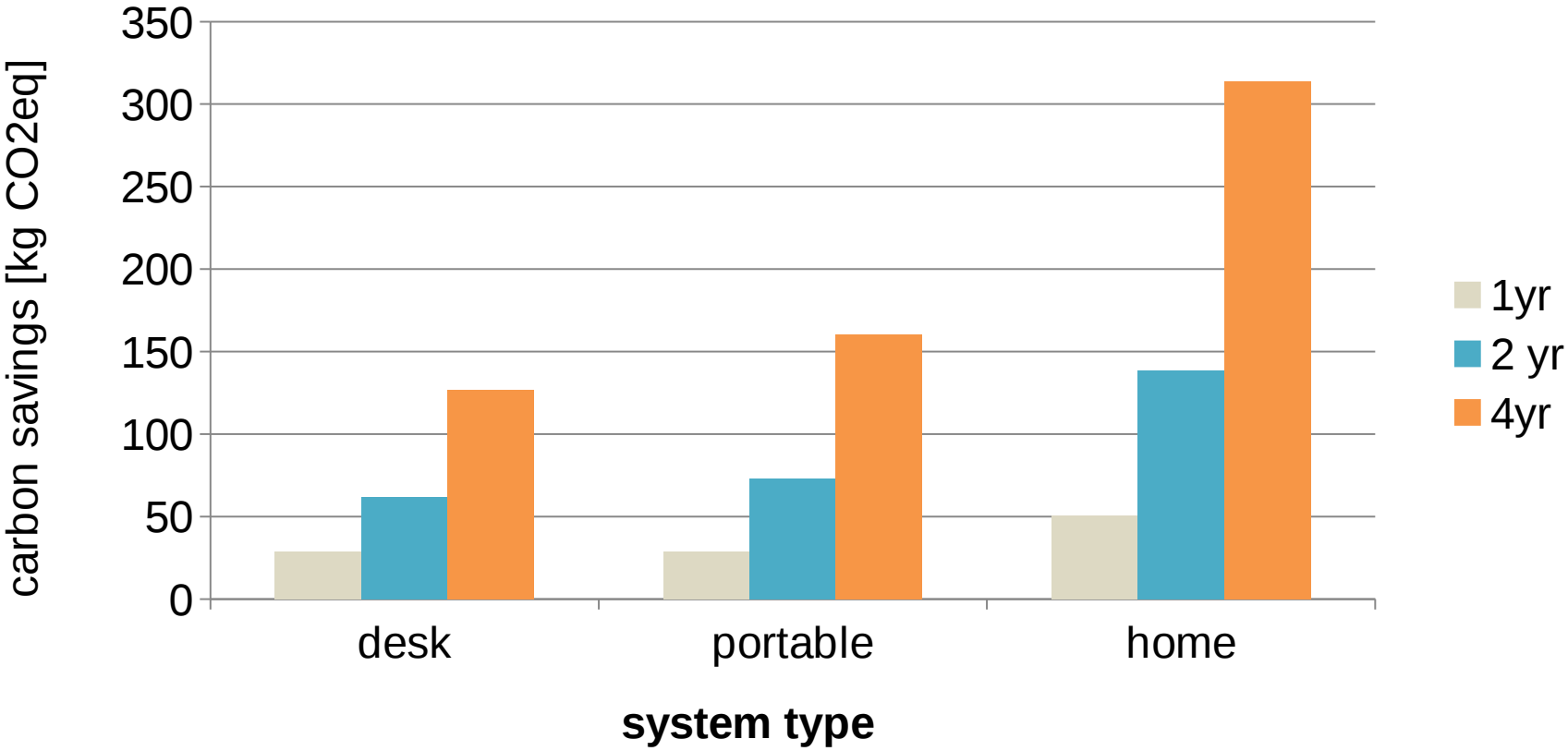
Over a 2 year lifespan, substantial savings will be generated.

Energy Savings



However, actual savings will depend on product longevity and performance.

Carbon Savings



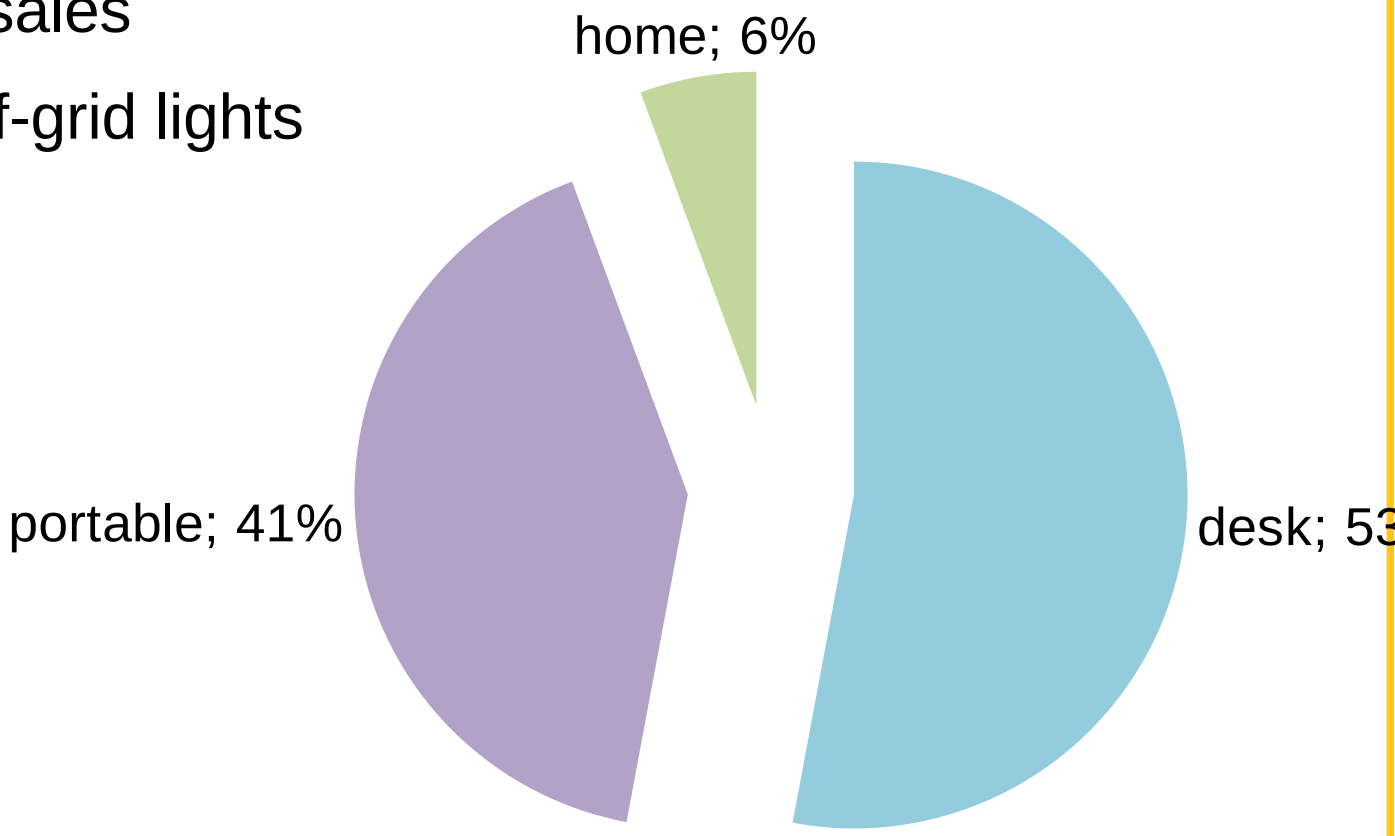
Energy Return on Investment

solar

Big Picture Implications

800,000 sales
of **quality** off-grid lights

FY 2010-2012



Big Picture Implications

Using LCA results,

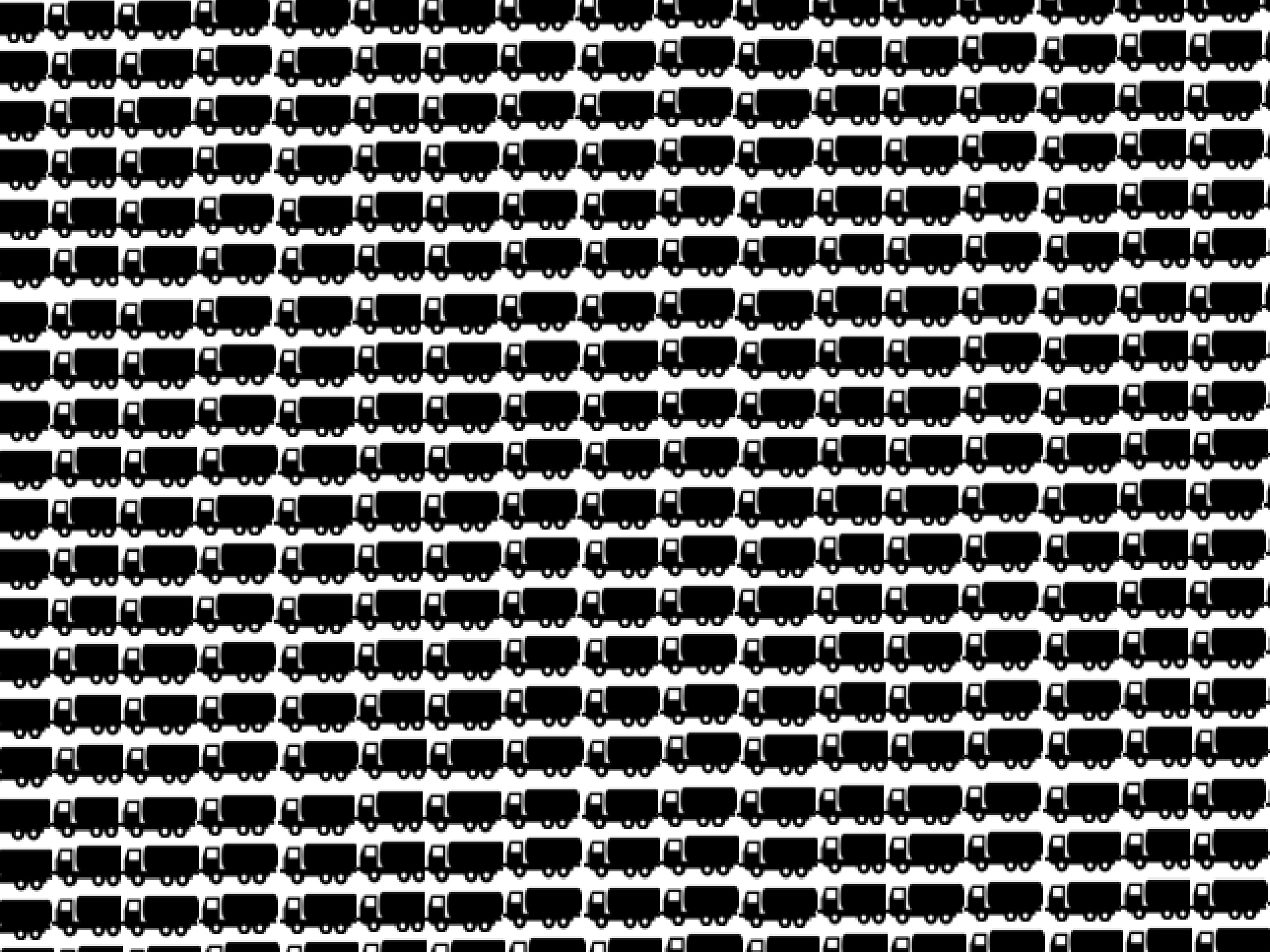
800,000
off-grid lights

over **2** years will generate

630 MMJ
energy savings

+

55,000 tonnes
CO2
carbon savings



Big Picture Implications

470 tanker trucks end-to-end is about 10 k

Still a long way to go…

Only 3% of off-grid households have adopted clean lighting and rapid growth is expected.

100% adoption is good for the climate and good for people.

Beyond carbon savings:

Lower cost and better service than kerosene.

Health benefits from reduced fire and burn risk and improved indoor air quality.

But…**proper waste management** is imperative.

Conclusions

Life Cycle Assessment tells us that **off-grid lighting pays environmental debts quickly and many times over**.

Product quality and performance assure environmental benefits as well as end-user satisfaction.

Acknowledgements

Schatz Energy Research Center
SERC

HUMBOLDT STATE UNIVERSITY

Arcata, California | where the redwoods meet the sea

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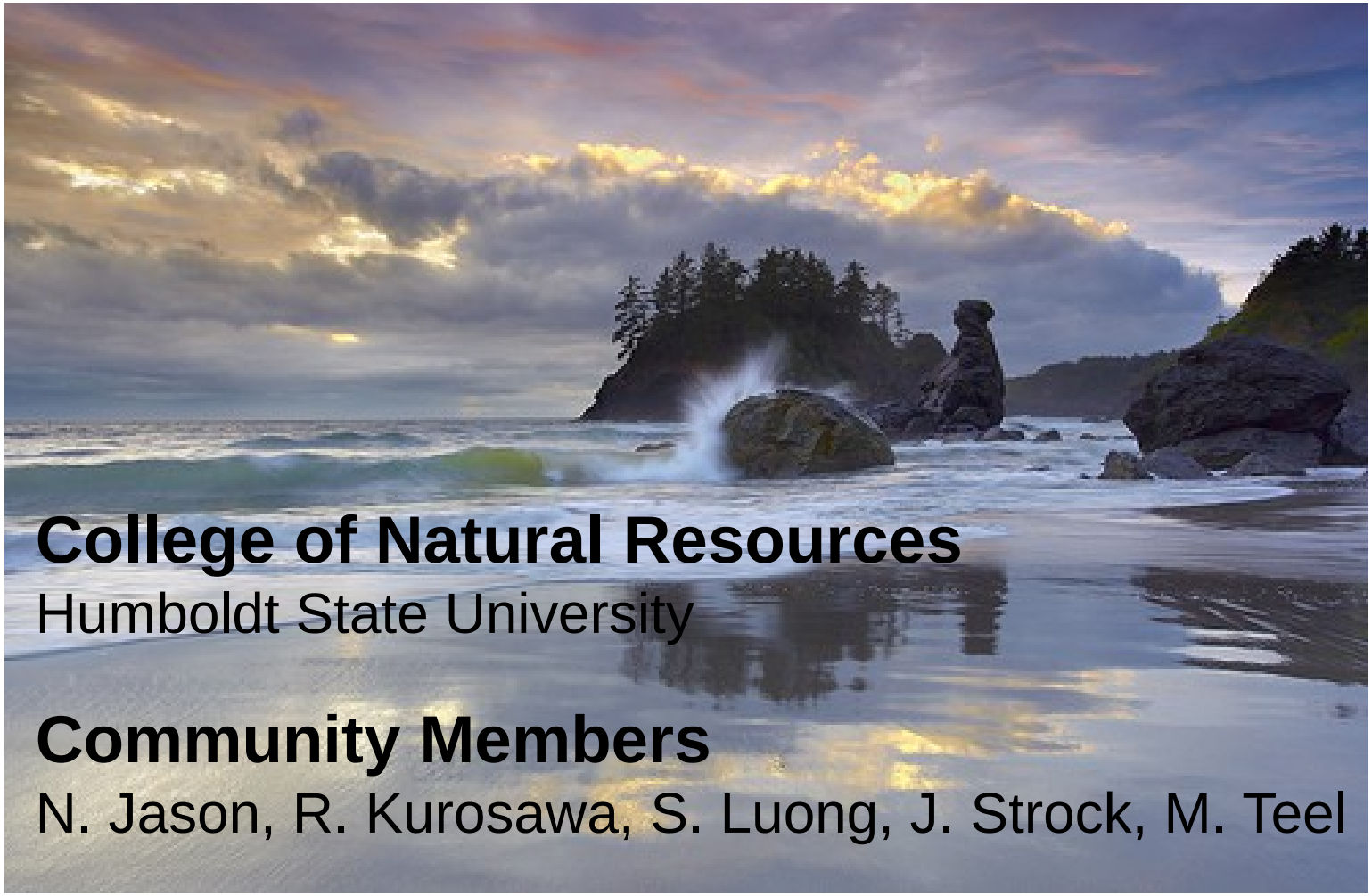

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from darkness

to light

the
future is
bright

thank you

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Next Steps: Improve understanding

- Key areas to improve understanding of impacts:
  - User behaviour
  - Specific industry information for micro-energy manufacturing
  - Supply chain energy intensity
- Even with uncertainty in exact results, the trends are clear: energy positive and good for the climate (along with the people)

Next Steps: Harmony between end-user needs and climate goals

- The most important things to “get right” for improving Life cycle impacts also benefit end-users:
  - QUALITY ASSURANCE: Improve lifetime and durability
  - Improve performance to wipe out the relevance of kerosene
  - Other aspects, like choosing batteries, casing, and LEDs will follow these.

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