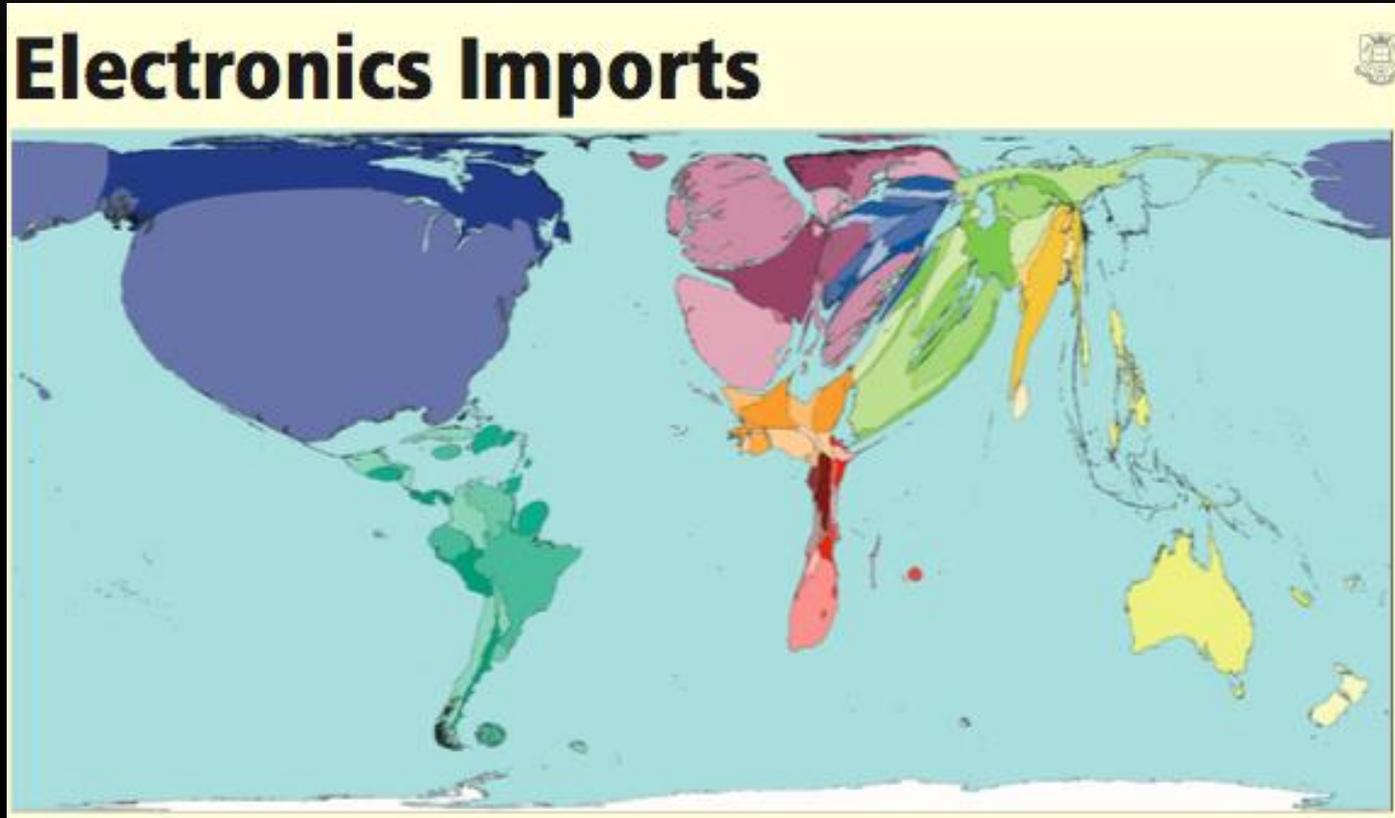


SSL SYSTEMS: OPPORTUNITY FOR SUSTAINABILITY BEYOND ENERGY SAVINGS

Dr. Chips Chipalkatti

Innovate & Illuminate ©

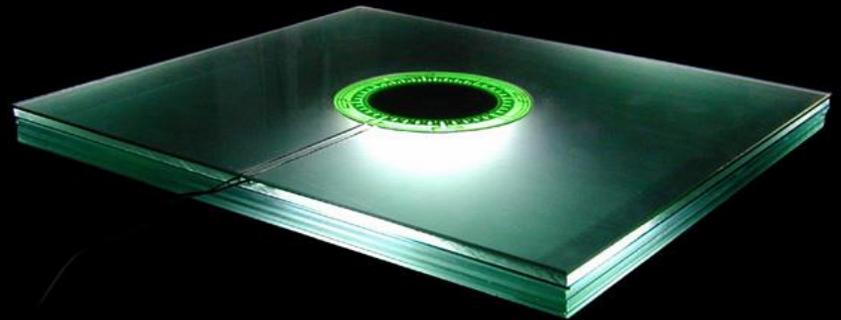
WORLD VIEW: SUSTAINABILITY POTENTIAL



THE TYPICAL OPTIONS FOR SUSTAINABLE BEHAVIOR

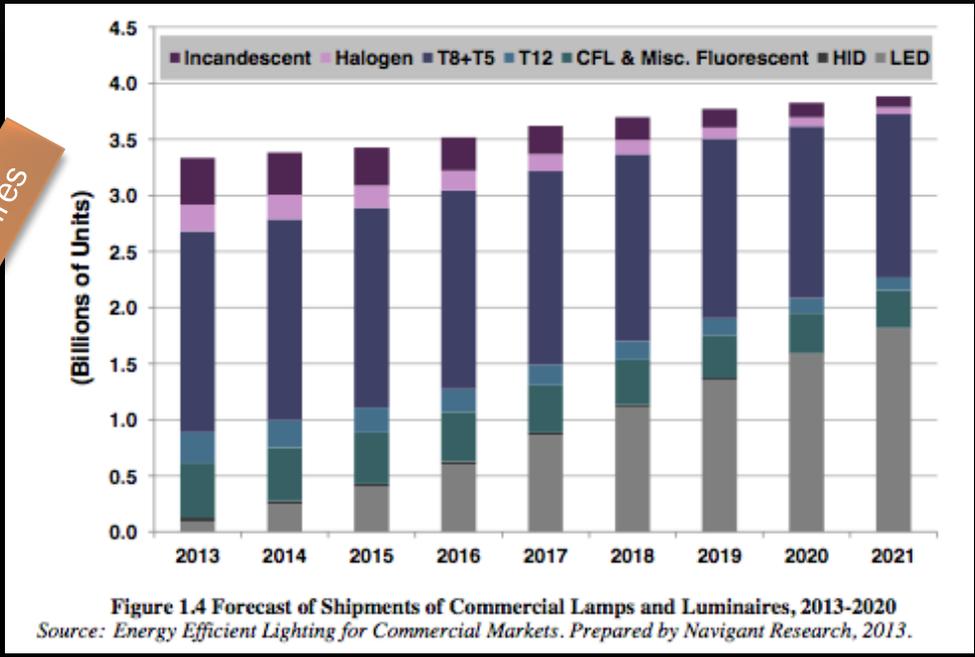
Three Steps:

- Reduce
- Reuse
- Recycle
- Are there other opportunities at end of life?
- What happens at premature end of life ?
 - Is just fulfilling the warranty “environmentally sufficient”?
 - What happens to premature failures after replacement?



COMMERCIAL LIGHTING EXAMPLE: THAT'S A LOT OF LEDS!

Lamps and Luminaires



- We launched LED business in 2000!
- With even a 10 year life of LEDs, those early units are now failing

LOOKING AT EARLY DATA OF FAILURES FROM STREET LIGHTING

5 years into rollout data from Kinzey, PNNL May 2015

- 5+ Million street lights installed
- **Average** number of failures is **1%** based on limited responses
 - Traffic signal report suggests higher failure rates (MSSLC Report)
- Anecdotal reporting of failures is significantly higher (where low cost – low quality units were deployed)
- **1% = 50,000 units**

Responses to MSSLC Failure Questionnaire, March – April 2015

	Street Lights		Area Lights	
	Number ^a	Percent ^a	Number ^a	Percent ^a
Number Installed	139,655		3,763	
Out of Box Failures	219	0.16%	25	0.66%
- Shipping/Installation Damage	43	19.6%	3	10.0%
- Internal Electrical Issues	126	57.5%	23	90.0%
Longer-term Failures	1113	0.80%	18	0.48%
- Human-caused ^b	221	19.9%	2	13.3%
- Nature-caused ^b	90	8.1%	8	46.7%
- Component failure ^c	799	71.8%	18	100.0%
• Individual LEDs fail to light	67	8.3%	4	24.4%
• Power supply	537	67.2%	6	31.1%
• Photocell	85	10.6%	2	13.3%
• Other	125	15.7%	4	20.0%
TOTALS	1,332	0.95%	43	1.14%

^a Numbers may not add due to: breakdown not provided on every reported failure; single failures falling into multiple categories; and rounding error.

^b Human-caused failures include vandalism, accidents, pinched wiring, etc. Natural causes include lightning strikes, wind, moisture, etc. ^c Not mutually exclusive with the previous two categories.

IN STREET LIGHTING

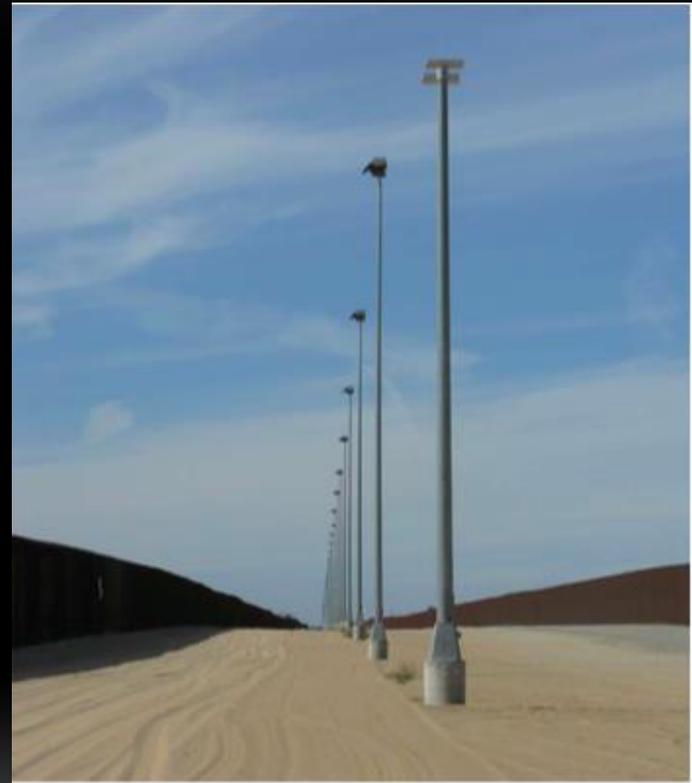
- The failure modes can be a range of behaviours
 - Light is out
 - Light is blinking
 - Optics and glare issues are serious
 - Controls do not work
 - Light output or distribution is below specifications
- **LED component and mechanical parts usually still usable**
 - Working parts may have the highest level of embodied energy!
 - Traditional lights which are still in use have significant embodied energy

RECENT WORK ON STREET LIGHT PERFORMANCE

- Study under extreme conditions may be an accelerated test of system!
 - (A. Wilkerson, J. McCullough, PNNL Sept 2015)
- LED outdoor lights installed in area with average high temp of 90 C (Yuma)

Preliminary results:

- Lumen depreciation of nearly 30% in approximately 1 year (in some zones)
- Early failure may be due to unique lamp characteristics
- Further studies needed and are ongoing



BOTTOM LINE

1. Millions of traditional lighting fixtures installed – with **substantial embodied energy** vested in them
2. Millions of SSL units installed over the last decade, some with **early failures**
3. Millions of SSL units installed over the last decade, still working but already **obsolete** or not state of the art

Old lighting mindset: install -> burnout -> replace
New lighting attitude: install -> upgrade -> reuse?

EMBODIED ENERGY AND ENVIRONMENTAL IMPACTS OF SSL UNITS

Table 1: Embodied energy in LED task lights and charging accessories

Product	Component	Energy (MJ)
Lamp	NiMH Batteries	17
	5 mm LED Array	6
	Balance of System and Assembly	20
	Total	43
PV Module	PV Laminate Assembly	78
	Balance of System and Assembly	21
	Total	100
AC/DC Adapter	Power Electronics	15
	Balance of System and Assembly	4
	Total	19

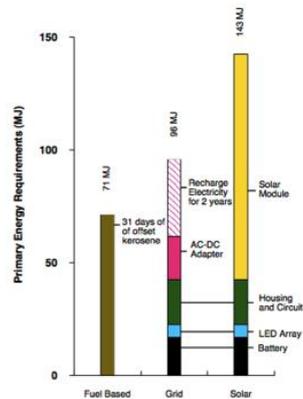
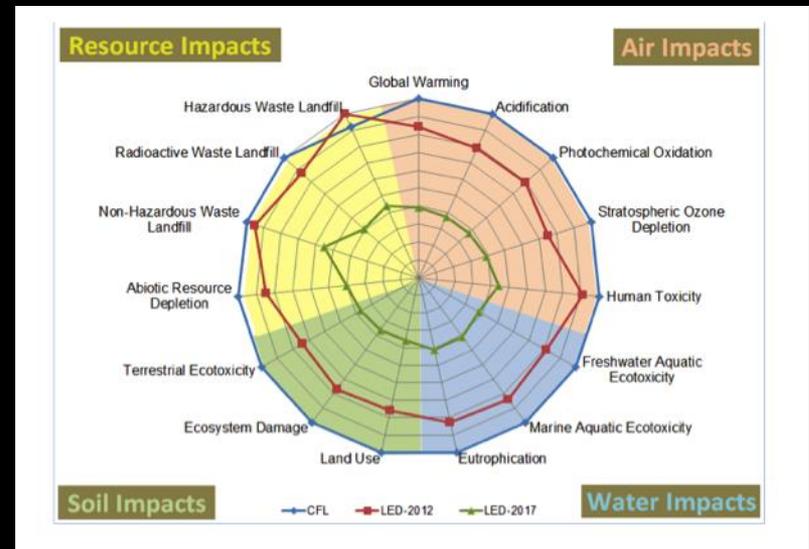


Figure 3: Primary energy embodied in LED lamps by component over a two-year period (two charging strategies) compared to one month of kerosene consumption for fuel-based lighting.



DOE LCA report 2012

Better than traditional lighting but still real!

Peter Alstone*, Evan Mills†, and Arne Jacobson, Humboldt/PNNL 2011

DOE Report

HOW DO WE CONSERVE EMBODIED ENERGY?

Options:

- Reduce
- Reuse
- **Remanufacture**
- Recycle
- Landfill

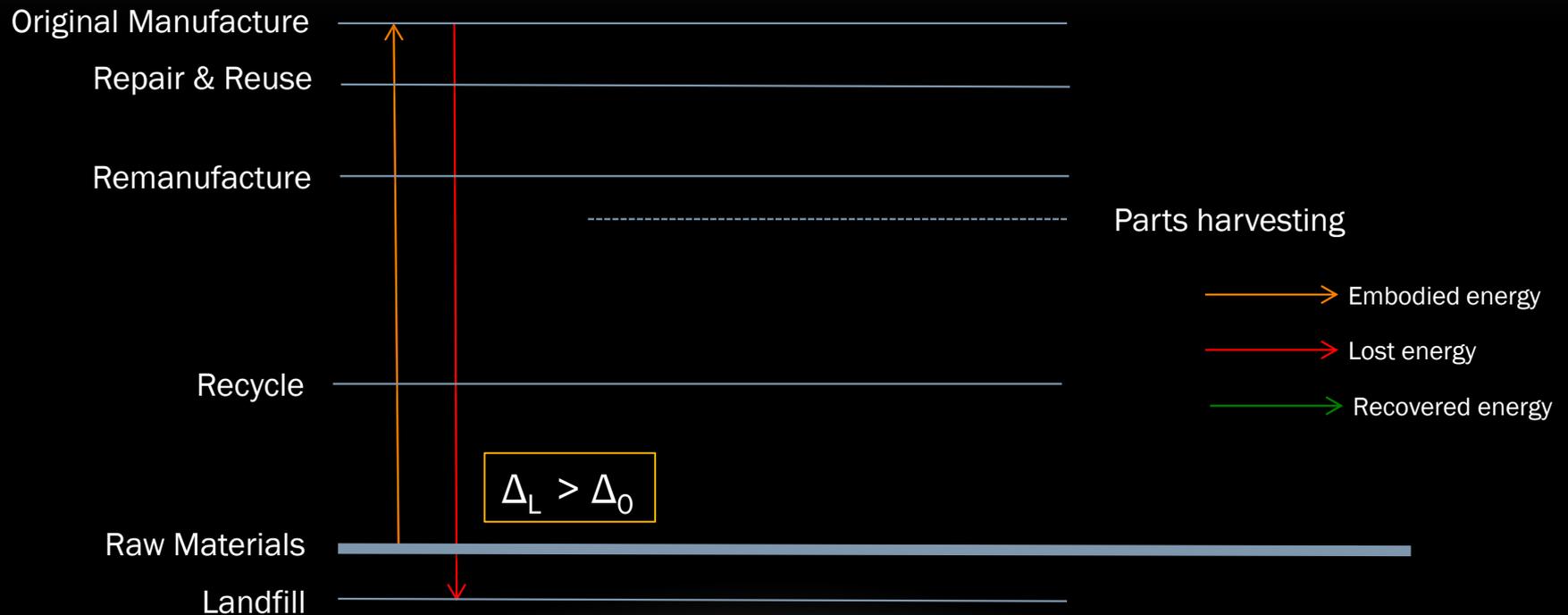


THINKING ANEW: PROPOSING AN EMBODIED ENERGY DIAGRAM



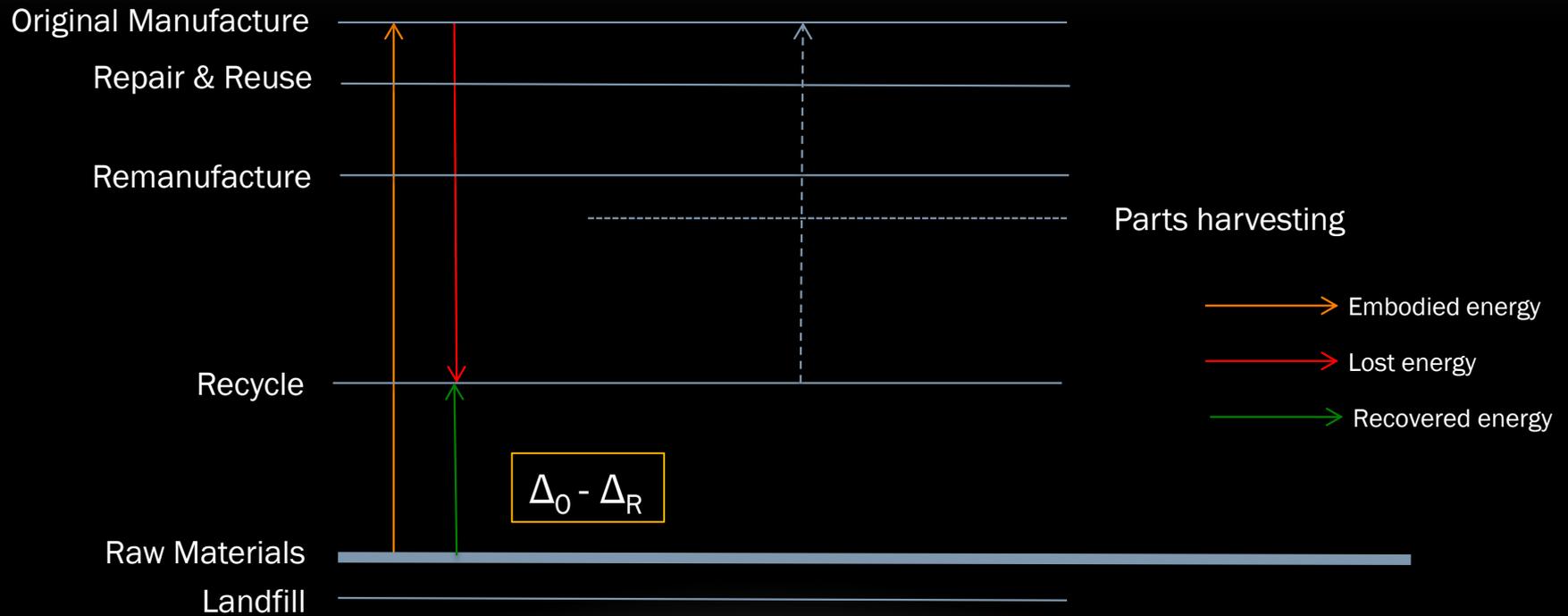
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WORST CASE SCENARIO - DUMP



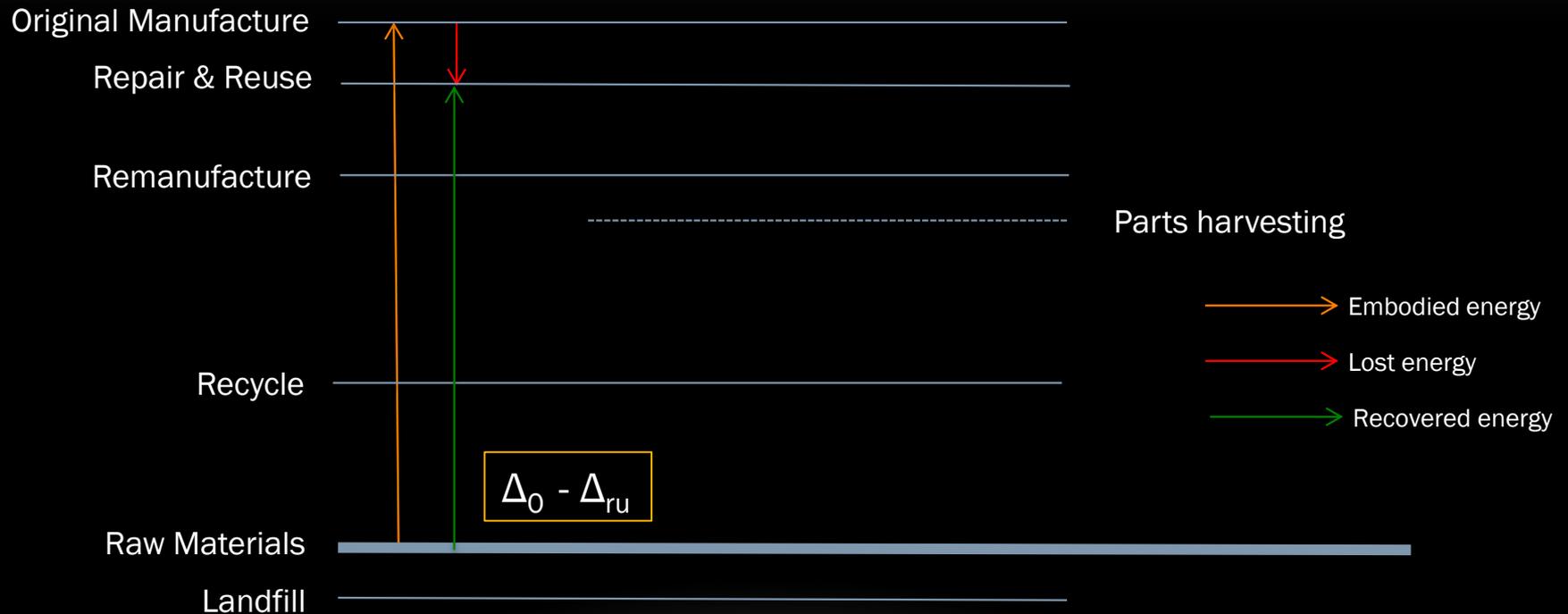
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CURRENT PRACTICE - RECYCLE



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BEST OPTION (ENERGY) REPAIR AND REUSE



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A NEW APPROACH WHICH RECOVERS ENERGY AND HAS POTENTIAL TO FUTURE PROOF LED INVESTMENTS - REMANUFACTURE



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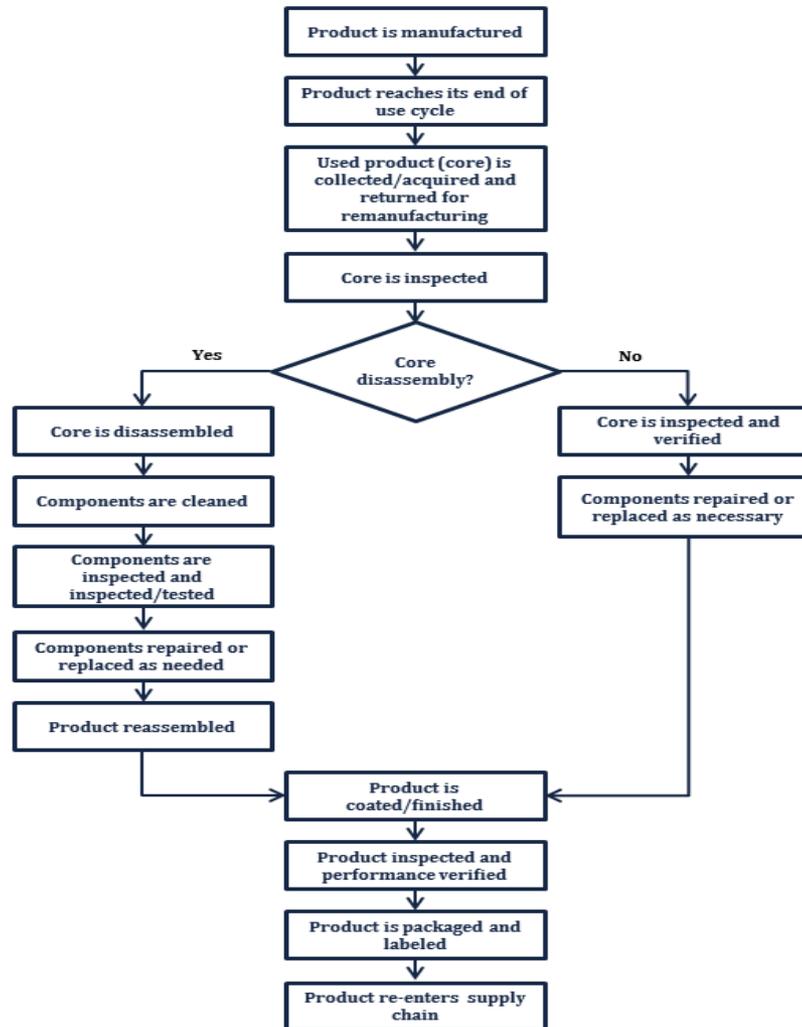
REMANUFACTURING IS NOW IMPLEMENTED IN HOME GOODS AND APPLIANCE INDUSTRY

Leading appliance remanufacturer:

- Saved several million appliances from landfill over 4-5 years
- Also repaired > 35K discontinued appliances in one year
- How can lessons learned be applied to SSL?
- What are key drivers for an industry wide solution?
- How to apply ideas of circular economy for an economically viable solution?
- What role can public policy play?

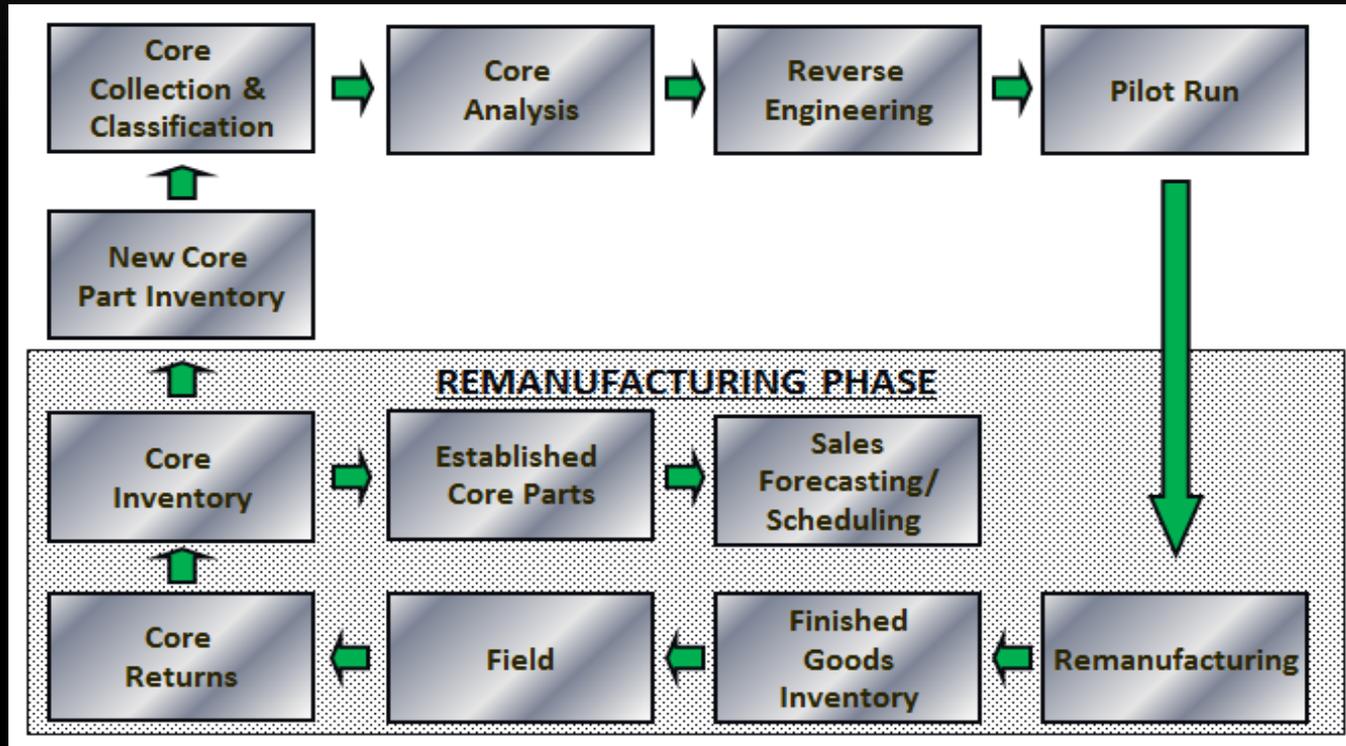


THE CURRENT PROCESS FOR REMANUFACTURED APPLIANCES



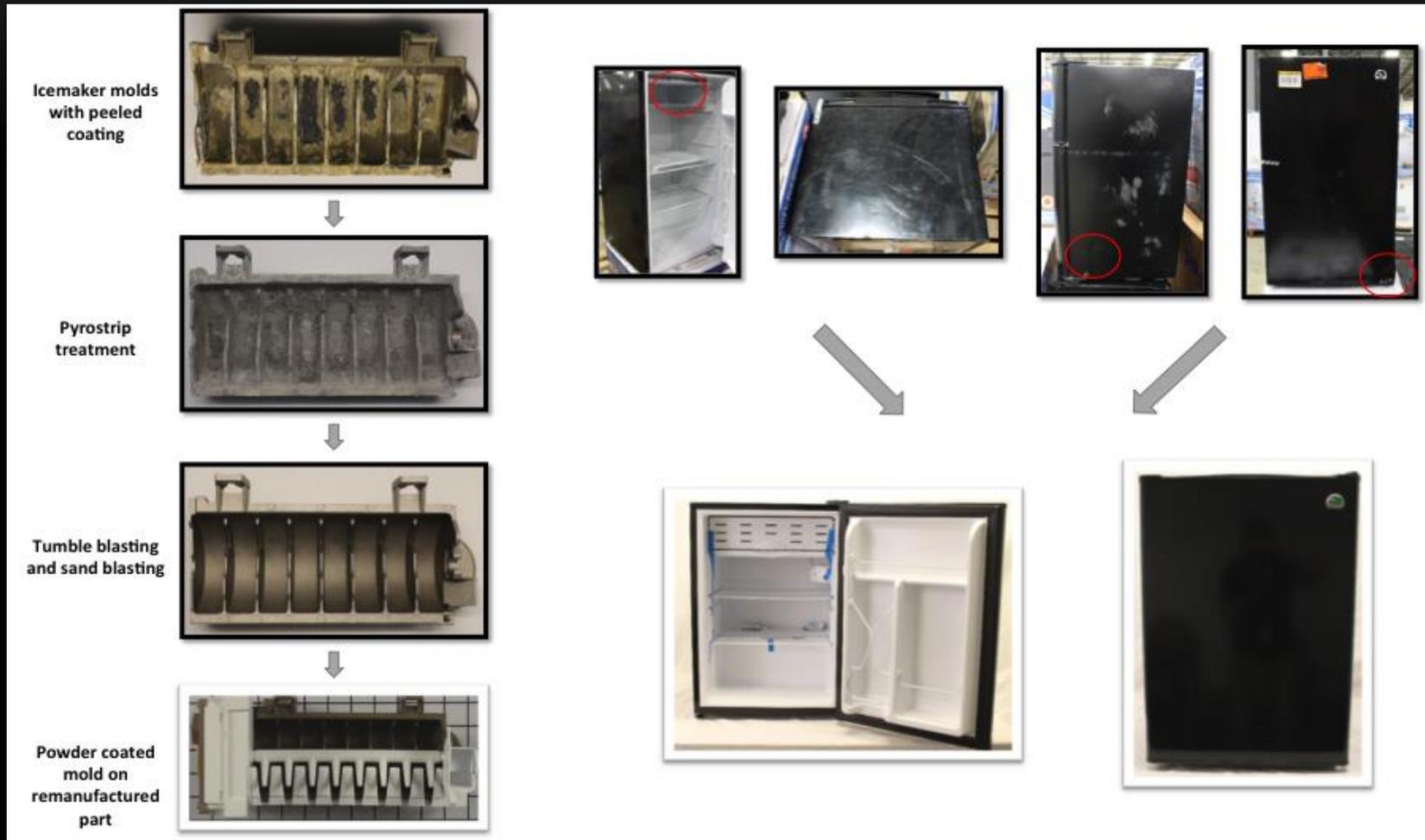
Courtesy: [CoreCentric Solutions Inc](#)

ECOSYSTEM FOR REMANUFACTURING

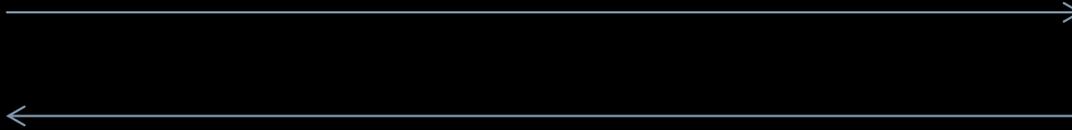


Courtesy: [CoreCentric Solutions Inc](#)

WHAT IT ACTUALLY LOOKS LIKE IN PRACTICE



TO BE MEANINGFUL A MASSIVE SCALE IS REQUIRED INVOLVING ALL STAKEHOLDERS



Courtesy: [CoreCentric Solutions Inc](#)

HOW TO APPLY LESSONS FROM APPLIANCES TO SSL?

- Let us be *proactive*
- Apply to high value fixtures and applications first
- Potential candidates: Outdoor and area lighting, high bay, other specialty fixtures
- Remanufacture extends product life by incorporating UPGRADE
- Government buildings, municipalities and academic institutions are ideal initial candidates due to public interest philosophy
- It is time for a **pilot project to develop ideas and ecosystem**



CONSIDER TYPICAL SSL PRODUCTS



BALC October 4-7, 2015 Savannah, GA

Mittelman, Utility Services of America

Which components can be:

1. Reused?
2. Remanufactured?
3. Recycled?



Margery Conner, Webinar 2014

STAKEHOLDERS WANTED!

- Stakeholder categories?

- End-users, public units
- Collection services
- Recyclers
- OEMs
- Resellers and installers



Remanufacturers

Ecosystem: develop a pilot program to explore remanufacturing to implement a circular economy for SSL



THANK YOU

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