Consumption, Sustainability, and Social Benefits

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Life Cycle Assessment

•A systems methodology for compiling information on the flow of materials and energy throughout a product chain

•LCA evolved from industry needs to understand manufacturing, and market behavior, and make choices among competing designs, processes, and products

•Defines four general sections of the product chain:

- •materials acquisition
- •manufacturing/fabrication
- •product use
- •downstream disposition of the product

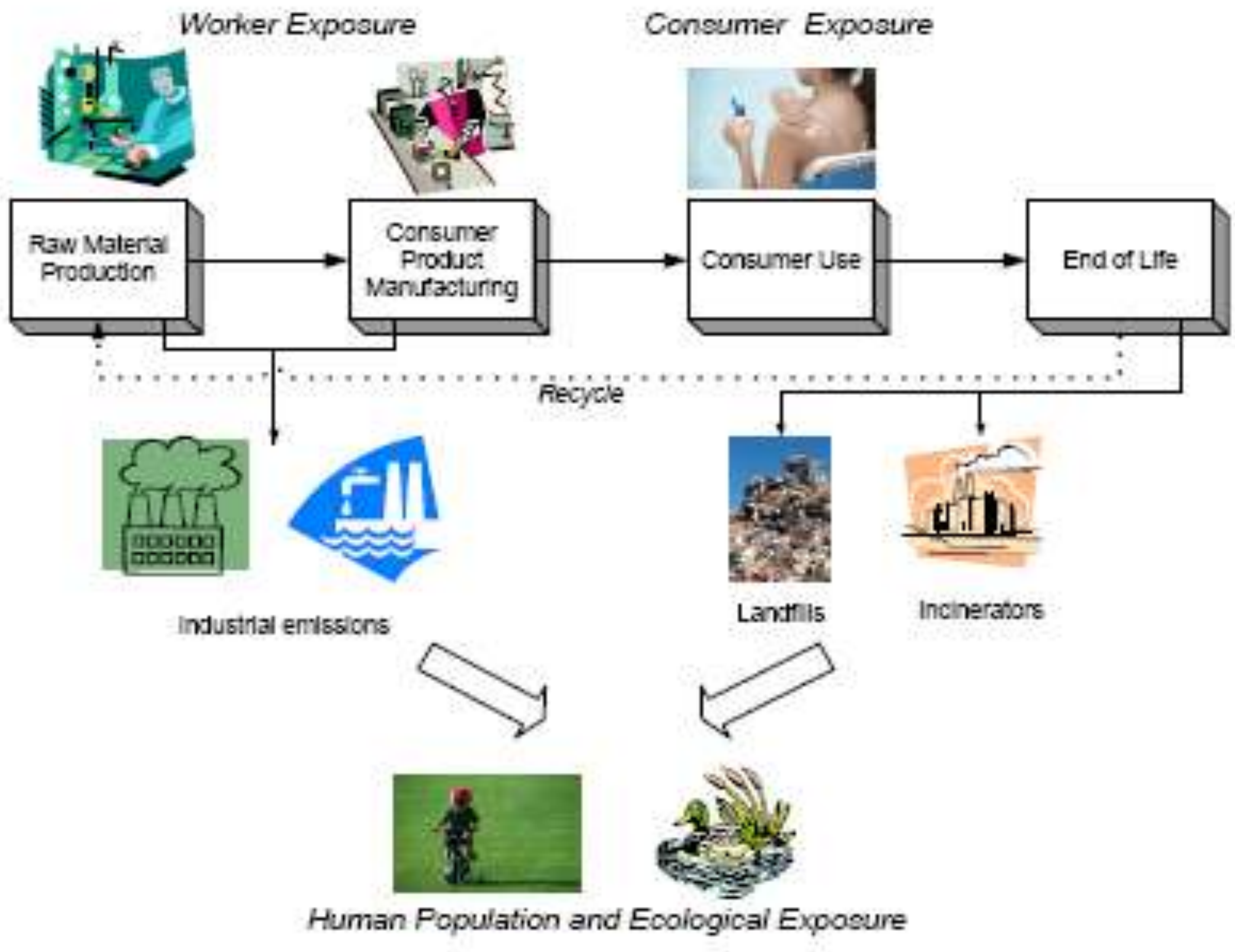
What is Life Cycle Good For?

- ID energy/material/waste hot spots
- Compare options
- Improve product/service chain
- Avoid displacing pollution
- Very good at framing policy issues

What is it not especially good for?

- Detailed risk assessments

Life Cycle Assessment Stages (USEPA)



“Greening” product chains

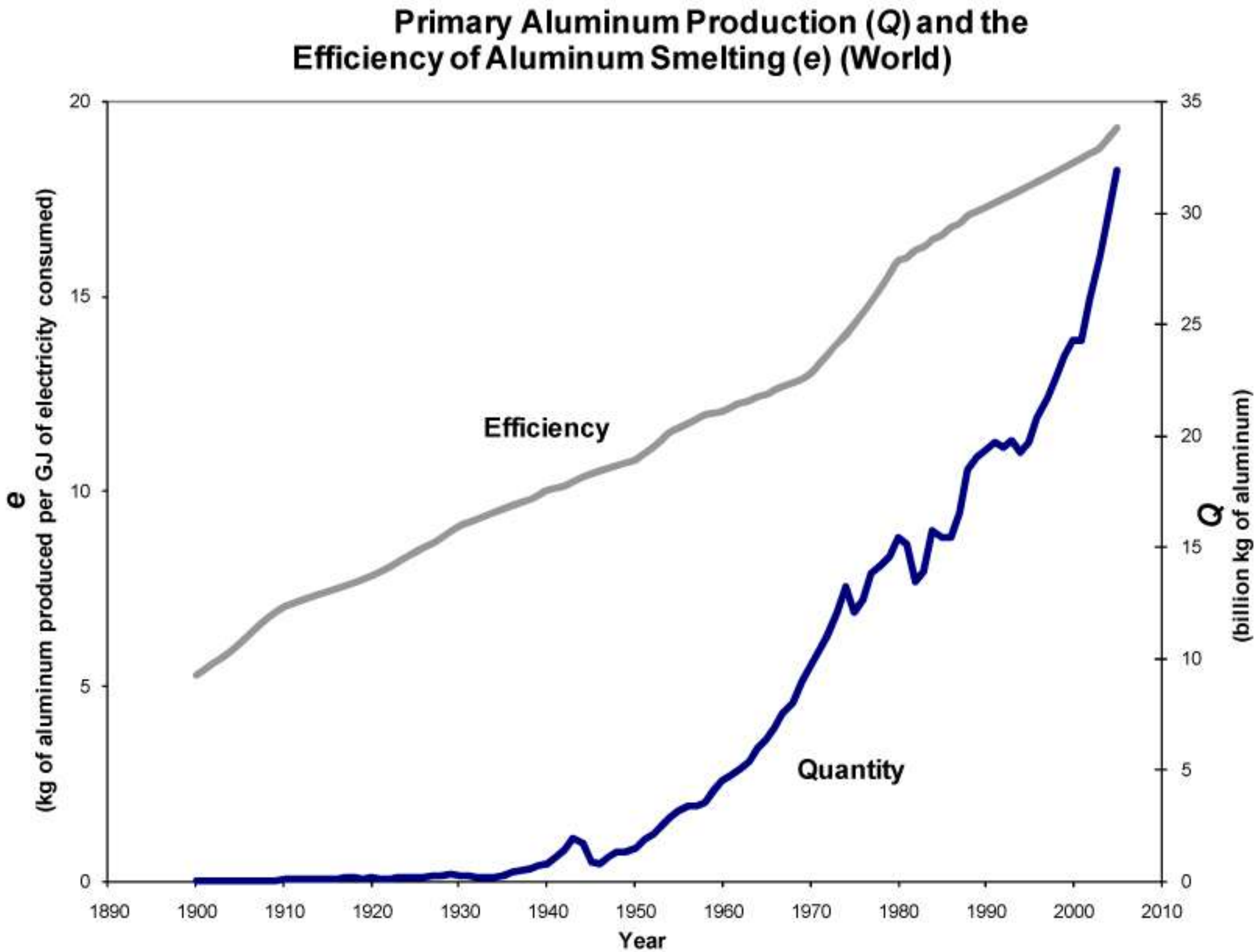
Product conceptualization, development, manufacturing, distribution, marketing, use, and post-use disposition that incorporate

- Design for the environment principles
- Green engineering
- Green chemistry
- Business practices built upon the concepts of systems thinking and “eco-efficiency”

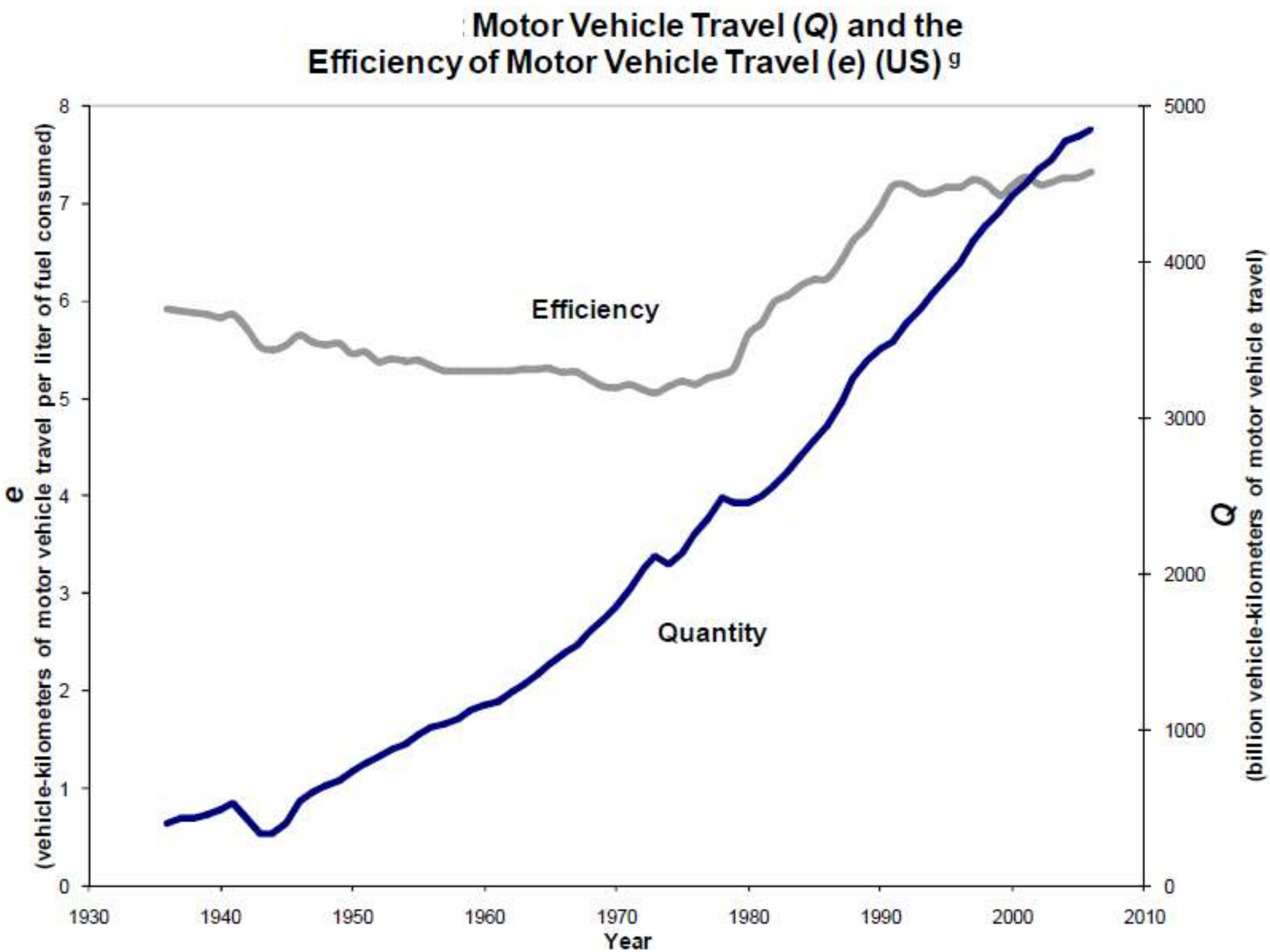
Underlying assumptions…

It is generally believed that if these principles and practices can become widespread (i.e. if the complete product chain can be "greened" enough), then better material and energy efficiencies will result, effectively "decoupling" environmental impacts from the consumptive habits of the human population

The social benefits of consumption are less clearly understood, but it is assumed that a greater variety of more efficient and environmentally-conscious products and services, sometimes made available at lower costs, will necessarily yield societal benefits, thereby moving toward at least partial fulfillment of the sustainability paradigm



From: Dahmus and Gutowski, (2011) JIE (in press)



Source: Dahmus and Gutowski (2011) JIE (in press)

Historical Efficiency and Consumption Trends

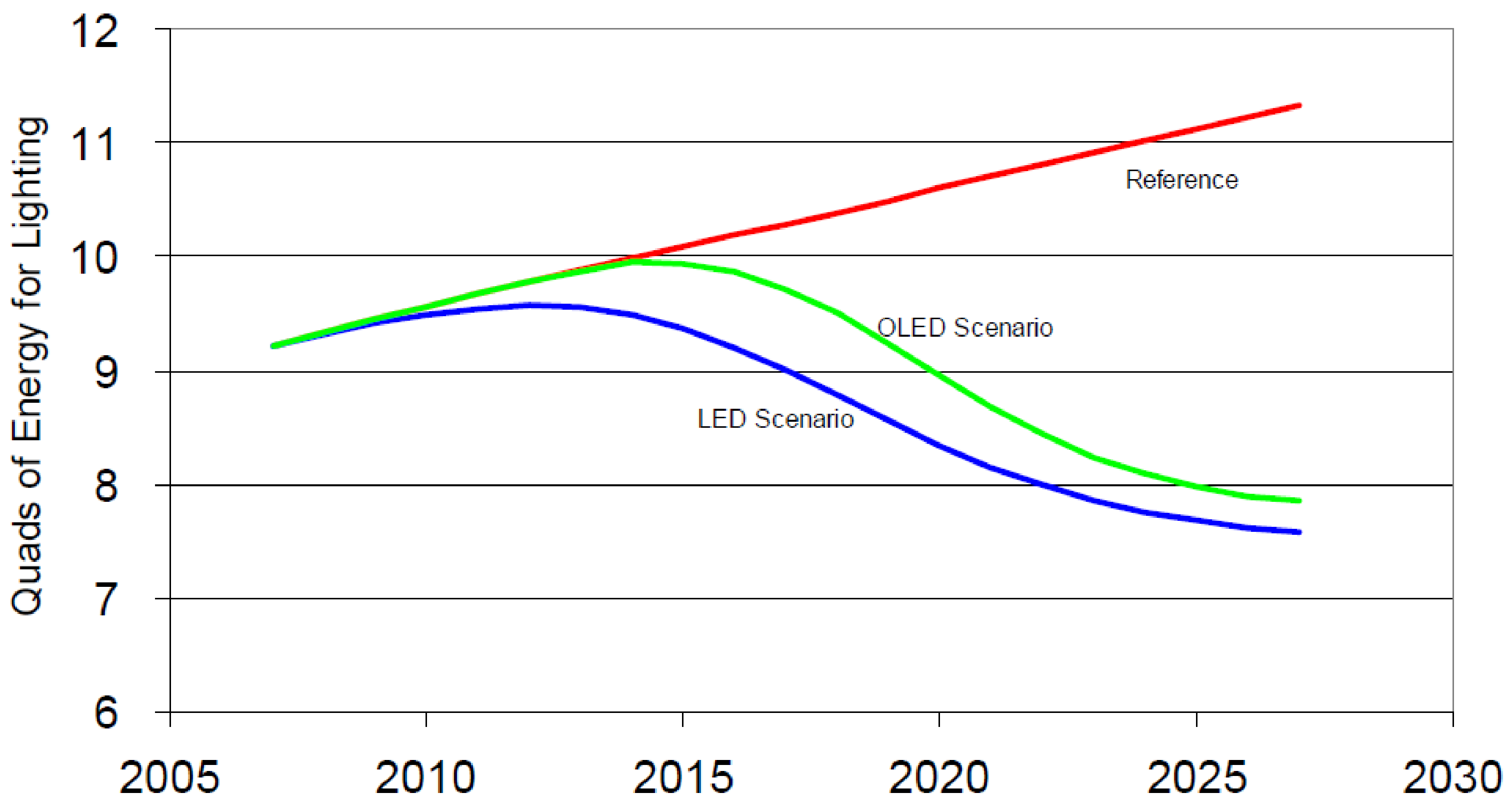
(Dahmus and Gutowski, JIE 2011)

Activity	Sector	Time Period	Avg Annual Efficiency Improvement (%)	Avg Annual Increase in Consumption (%)	Ratio: Consumption/ Efficiency
Pig Iron	Materials	1800-1990	1.4	4.1	3.0
Aluminum	Materials	1900-2005	1.2	9.8	7.9
N-Fertilizer	Food	1920-2000	1.0	8.8	8.9
Elec-Coal	Energy	1920-2007	1.3	5.7	4.5
Elec-Oil	Energy	1920-2007	1.5	6.2	4.2
Elec-Nat Gas	Energy	1920-2007	1.8	9.6	5.5
Freight Rail Travel	Transportation	1960-2006	2.0	2.5	1.2
Air Passenger Travel	Transportation	1960-2007	1.3	6.3	4.9
Motor Vehicle Travel	Transportation	1940-2006	0.3	3.8	11.0

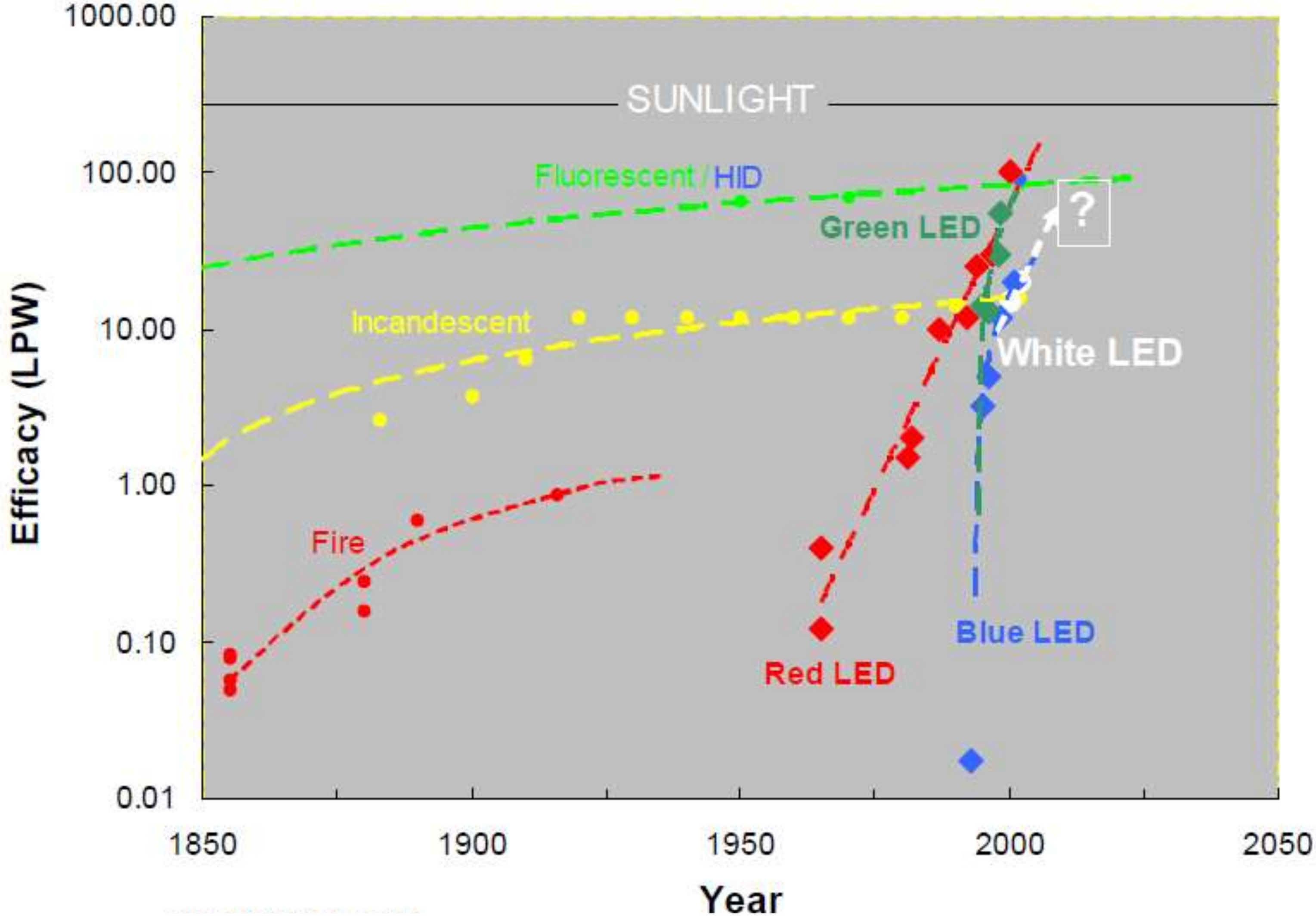
Example: Artificial Lighting

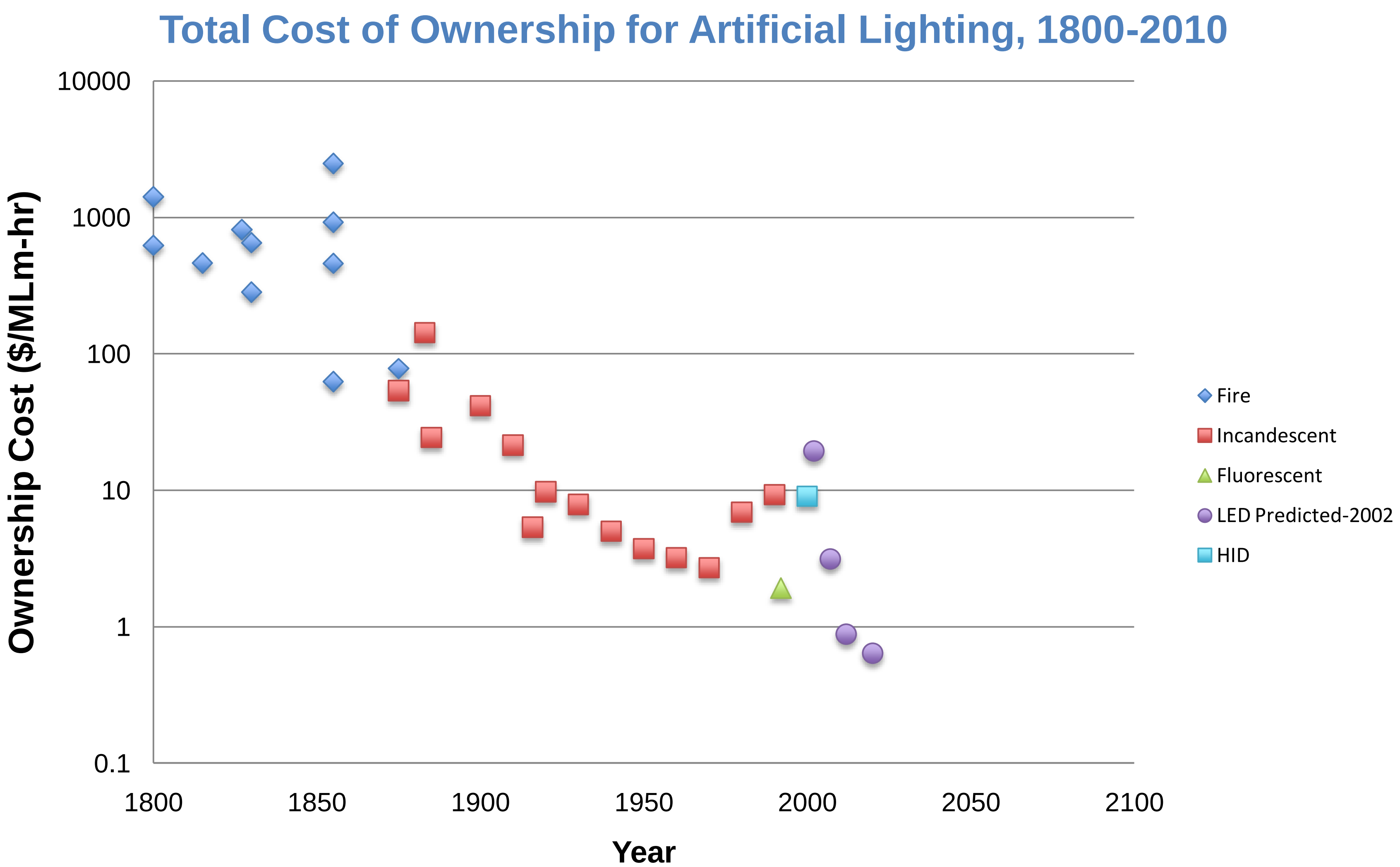
- No realistic substitutions
- Lighting is undergoing a “nano-enabled” evolution to SSL
- SSL: About 10 times as efficient as incandescent, 2 times fluorescent
- Last 30 times as long as incandescent, 3 times as long as CFLs
- So, we’ll use less energy and generate fewer energy-related emissions, right?

Projections for Energy Consumption for Lighting Through 2027 (US)



"Energy Savings Potential of Solid State Lighting in General Illumination Applications", Navigant Consulting, Washington DC (2006)

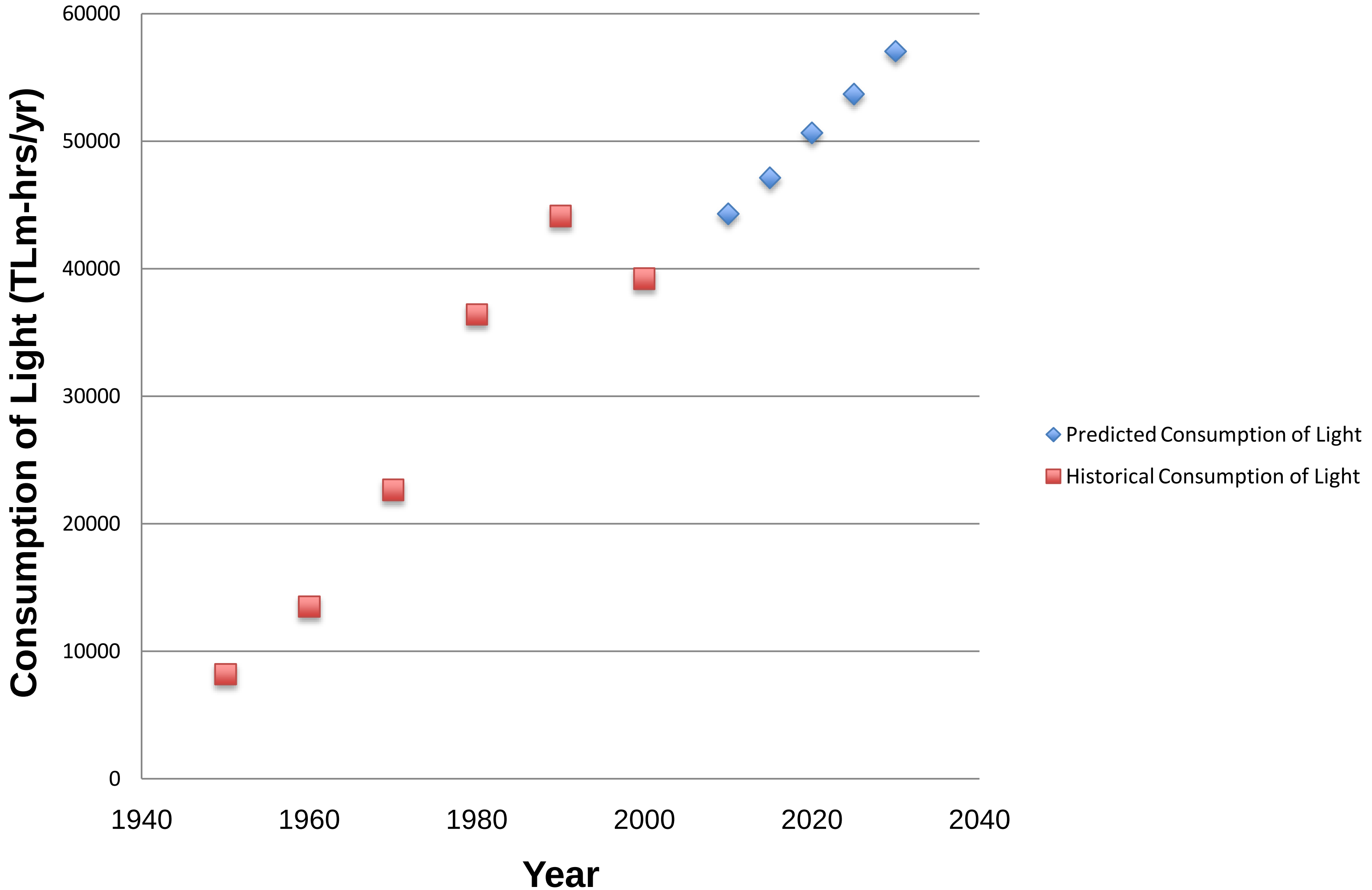

1000.00
100.00
10.00
1.00
0.10
0.01
SUNLIGHT
Fluorescent / HID
Green LED
?
Incandescent
White LED
Fire
Blue LED
Red LED
1850
1900
1950
2000
2050
Efficacy (LPW)
Year



Data for Fire and Incandescence modified from W.D. Nordhaus, In T.F. Breshnahan and R.J. Gordon, Eds., The Economics of New Goods (U of Chicago Press, 1997) pp. 29-70.
Data for SSL-LEDS taken from 2002 U.S. SSL Roadmap.

Expressed in 2010 dollar amounts

Past and Predicted Consumption of Light



Source for predicted consumption: Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010 to 2030 Navigant Consulting, 2010

Summary trends

YEAR	Real Price of Fuel	Efficiency of Lighting	Real Price of Light	Consump-tion of Light	Energy for Light	Energy/ Person for Light	% of Total Energy Devoted to Light
1800	1	1	1	1	1	1	1
1900	0.27	14.5	.024	220	8.97	2.45	~1
2000	0.18	700	0.0003	34,000	72.92	11.63	10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Costs and Benefits

(1) Each of these applications, viewed by itself, is more efficient than what it replaced.

(2) Many, maybe all, of these applications help us to be safer, healthier, happier, more productive, and "greener"

(3) But viewed collectively our energy and material consumption continues to increase.

We're "greener", but are we more sustainable?

Combining physical and social science…

J Y Tsao, H D Saunders, J R Creighton, M E Coltrin and J A Simmons (2010) “Solid-state lighting: an energy-economics Perspective”, *J. Phys. D: Appl. Phys*. 43 (2010) 354001

There is a massive potential for growth in the consumption of light if new lighting technologies are developed with higher luminous efficacies and lower cost.

This increased consumption may increase both human productivity and the consumption of energy associated with that productivity.

Is the increase in human productivity and quality of life due to an increase in consumption of light worth the increased energy burden?

Three general directions for sustainable product-chain research:

(1) Stronger interdisciplinary effort to understand the complex factors emergent across the complete product chain that contribute to resource consumption, environmental degradation, and human health risk, while recognizing benefits to society,

(2) Expansion of “green”, design for the environment, and organizational eco-design principles beyond their traditional focus on increasing efficiency and lowering pollutant loads per unit product to include economic and behavioral factors, and

(3) Investigation of the impacts of more highly integrated policies, based on the sustainability paradigm, that are able to meet human needs while capturing economic excesses and decoupling environmental degradation that have their roots in over-consumption.