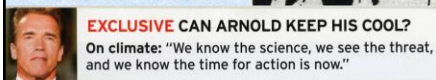
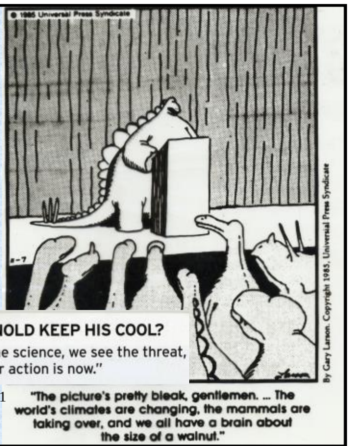
Environmental Cost vs. Economic Cost



While Governor of California 2003-2011



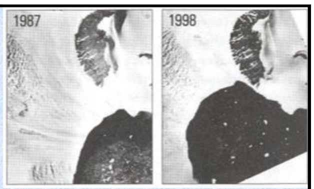
1

Economic Cost Analysis values energy in $$$$$$

the economic cost system is not sensitive to other costs, including:

- The total environmental, health and social costs
- The investment capital invested (or to be invested) in energy generation and distribution systems
- Future scarcities (prices are reactionary not predictive) the price won't rise until the scarcity exists

2



Sheldon Glacier, Antarctica

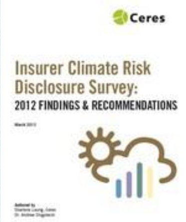
Environmental costs….

- Severe weather
- Icecaps melting

3

Friday, March 22, 2013
Mindy Lubber, the CEO of Ceres, noted that their groundbreaking study reveals that most insurers are not prepared for climate change. Without insurance, the cost of inaction on climate change becomes even more acute and carries deep implications for our economy.

http://www.ceres.org/



4

Replacing Economics with Ecology

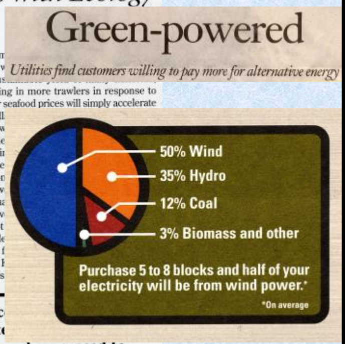
by Lester Brown

Global economic trends during the 1990s were remarkably bullish, but environmental trends were disastrous. The contrast could scarcely be greater. An economic system that worked well in times past when the demands of a smaller economy were well within the capacities of Earth's ecosystems is no longer working well. If current environmental trends—population growth, rising temperature, falling water tables, shrinking cropland per person, collapsing fisheries, shrinking forests and the loss of plant and animal species—cannot be reversed, we face a future in which continuing environmental deterioration almost certainly will lead to economic decline. The challenge is to redesign the economic system so that it will not destroy its environmental support systems, so that economic progress can continue.

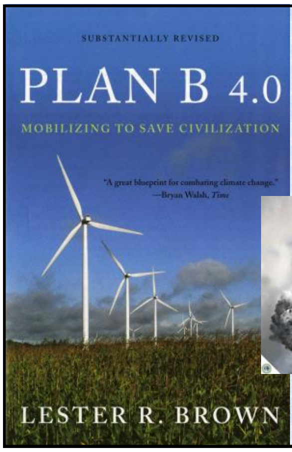
The time has come for what science historian Thomas Kuhn describes as a paradigm shift. In his classic work *The Structure of Scientific Revolutions*, Kuhn observes that as the scientific understanding of reality in a field advances, reaching a point where existing theory no longer adequately explains reality, then theory has to change. It has to be updated, replacing

This m… today, w… the sus… investing in more trawlers in response to higher seafood prices will simply accelerate the coll… exists w… The… ogists i… new ce… Econon… the low… sign tha… effectiv… are not… seeable… tables f… tries. I… world's…

Ec… det… and see a need to restructure the economy...



5



Why not go to plan B?

6

Table 13-2. Additional Annual Expenditures Needed to Meet Social Goals and to Restore the Earth

Goal	Funding (billion dollars)
Basic Social Goals	
Universal primary education	10
Eradication of adult illiteracy	4
School lunch programs for 44 poorest countries	6
Assistance to preschool children and pregnant women in 44 poorest countries	4
Reproductive health and family planning	17
Universal basic health care	33
Closing the condom gap	3
Total	**77**
Earth Restoration Goals	
Planting trees to reduce flooding and conserve soil	6
Planting trees to sequester carbon	20
Protecting topsoil on cropland	24
Restoring rangelands	9
Restoring fisheries	13
Protecting biological diversity	31
Stabilizing water tables	10
Total	**113**
Grand Total	**190**

Sources: United Nations and many others. See book Plan B 3.0 for details.

Societal Costs:

e.g. War vs. Social & Environmental Rescue

Table 13-3. Military Budgets by Country & for the World in 2006 compared with "Plan B" Annual Expenditures Needed to Meet Social Goals and to Restore the Earth Budget

Country	Budget (billion dollars)
United States	560
United Kingdom	59
France	53
China	50
Japan	44
Germany	37
Russia	35
Italy	30
Saudi Arabia	29
India	24
All others	314
Total World Military Expenditure	**1,235**

"Plan B" Annual Expenditures Needed to Meet Social Goals and to Restore the Earth Budget
190

Sources: SIPRI Military Expenditure Database, June 2007; www.armscontrolcenter.org, 9-14-07. See book Plan B 3.0 for details.

7

To go beyond economic analysis, ask 4 questions:

1. How well does the device (design) use energy to accomplish its task?
2. Is the device (design) appropriate for the task?
3. Is the type of energy used appropriate?
4. Is the energy embedded (used in manufacturing) in the device (design) appropriate?

…and you can ask the same questions about CO_2 emissions as well!

8

Answer question #1
(Is the device efficient?)

First Law of Efficiency

$$\text{Efficiency} = \frac{\text{Useful Energy}}{\text{Potential Energy}}$$

Also called
Coefficient of Productivity (COP)

Most devices waste energy and their 1st Law efficiency is <100%

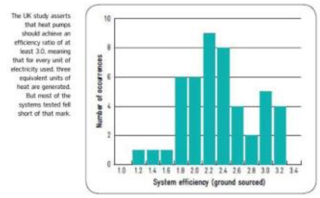
…exception solar DHW in Florida…

Solar COPS rated 'tops'

No, this isn't solar powered law enforcement! In a recent study of the average system efficiency, or coefficient of performance (COP)* of various water heating systems, solar came out on top. The one year monitoring program conducted by the Florida Solar Energy Center gave solar domestic hot water systems an average COP of 2.5, followed by heat pumps (COP of 1.5), wasdte heat recovery units (COP of 1.1), and "energy-saving" conventional water heaters (COP of 0.8). A summary of the study can be obtained by writing FSEC, 300 State Rd. 401, Cape Canaveral, Florida 32920.

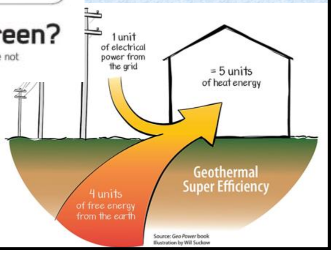
$$* \text{COP} = \frac{\text{Hot water energy out}}{\text{Electric energy in}}$$

9



Are Heat Pumps Green?

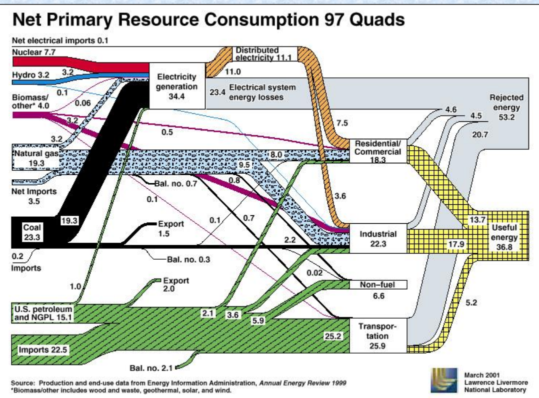
A study suggests that 80% of heat pumps installed are not performing well. Who should take the heat?



…ground-source heat pumps…

10

Here potential energy is 97 quads; useful is 36.8; +38% 1st Law efficiency



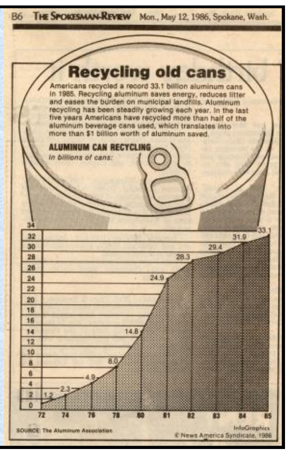
11

Answer question #2
(What's the best device?)

Second Law of Efficiency

<u>This Device</u>
Best Device

The best device is 100% efficient by 2nd Law definition.


B6 THE SPOKESMAN-REVIEW Mon., May 12, 1986, Spokane, Wash.

Recycling old cans

Americans recycled a record 33.1 billion aluminum cans in 1985. Recycling aluminum saves energy, reduces litter and eases the burden on municipal landfills. Aluminum recycling has been steadily growing each year. In the last five years Americans have recycled more than half of the aluminum beverage cans used, which translates into more than $1 billion worth of aluminum saved.

ALUMINUM CAN RECYCLING
In billions of cans:

72	74	76	78	80	81	82	83	84	85
1.2	2.3	4.9	8.0	14.8	24.9	28.3	29.4	31.9	33.1

SOURCE: The Aluminum Association

InfoGraphics
© News America Syndicate, 1986

12

Intelligent Use of Daylight in Genzyme Headquarters

Compare efficiency of all possible lighting systems holistically…
here daylight vs. electric light…

13

Comparison of Water Heaters and Important Metrics

High-Efficiency Water Heater Type	Energy Savings Vs. Minimum Standards	Best Climates	Expected Energy Savings Over Equipment Lifetime	Expected Lifetime	Major Advantages
High-Efficiency Storage (Tank) (Oil, Gas, Electric)	10%–20%	Any	Up to $500	8–10 Years	Lowest first cost
Demand (Tankless) Using Gas or Electric	45%–60%	Any	Up to $1,800	20 Years	Unlimited supply of hot water
Heat Pump	65% (compared to electric resistance)	Mild-Hot	Up to $900	10 Years	Most efficient electric fuel option
Solar with Electric Back-Up	70%–90%	Mild-Hot	Up to $2,200	20 Years	Largest energy savings using a renewable energy source

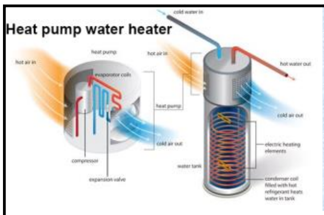
First-Hour Rating (FHR). FHR measures how much hot water will be available during the busiest hour of the day. A large tank does not necessarily translate to a higher FHR. The recovery rating is important as it indicates the water heater's ability to replenish hot water as it is drawn from the tank.

Efficiency. The water heater's efficiency is measured as an Energy Factor (EF), which is usually listed beside the EnergyGuide label: the higher the number, the more energy efficient the water heater.

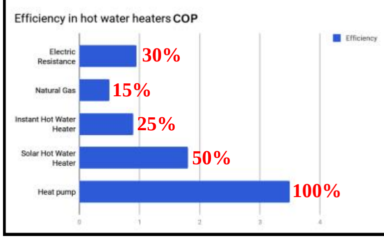
So, if these are all the options for high-efficiency water heaters, Solar with Electric Back-Up has a 2nd law efficiency of 100%.

14

Heat pump water heater



1st Law (COP) vs. 2nd Law vs. $ bottom line



15

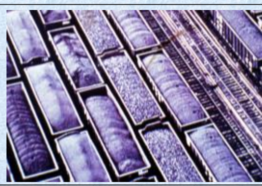
Answer question #3
(Is the energy source appropriate?)

Match Task to Fuel

High Grade Energy
for High Grade Tasks
Low Grade Energy
for Low Grade Tasks

"You don't want to cut butter with a chainsaw…"

16

Low Grade Fuels	High Grade Fuels
	
The sun (no C) Bio-fuels (low C) The wind (no C) Hydro (no C)	Fossil fuels (high C) Uranium (no C)

17

Other (subjective) questions on energy sources:

- Is it appropriate to burn wood while it pollutes the air?
- Is it appropriate to use nuclear power when it threatens the health of future generations?
- Is it appropriate to burn coal while it is unhealthy to mine? …and it causes acid rain? …and produces vast amounts of greenhouse gas emissions?

Emergency vehicles leave the entrance to Massey Energy's Upper Big Branch coal mine in Montcoal, W.Va., on Monday after an explosion at the underground mine.

APR. 6, 2010

Blast kills 12 in coal mine

10 missing in West Virginia

By Lawrence Messina

Deadly mining disasters in the United States

The nation's single deadliest mining disaster was in 1907, when 362 were killed in an explosion near Monongah, W.Va. Here's a list of some recent fatal mine disasters in the United States:

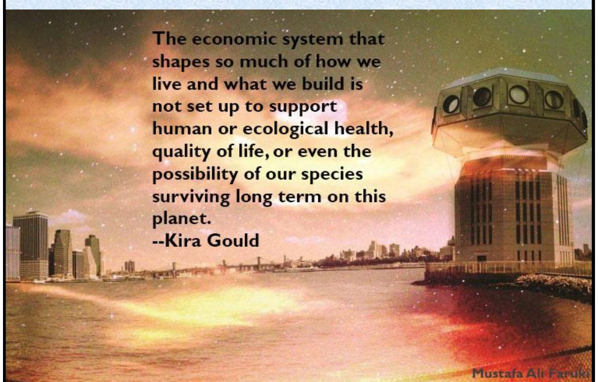
2007: Six miners, three rescuers killed in collapses at the Crandall Canyon mine in Emery County, Utah, owned by a subsidiary of Murray Energy.
2006: 12 killed in a methane explosion at the Sago Mine in West Virginia owned by International Coal Group.
2006: Five killed in an explosion at the Kentucky Darby No. 1 Mine in Harlan County, Ky.
2001: 13 killed in explosions at a Jim Walter Resources Inc. mine in Brookwood, Ala.
1992: Eight killed in an explosion at a Southmountain Coal Co. mine in Norton, Va.
1989: 10 killed in an explosion at a Pyro Mining Co. mine in Wheatcroft, Ky.
1986: Five killed when a coal pile collapses at Consolidation Coal Co.'s mine in Fairview, W.Va.
1984: 27 killed by a fire at Emery Mining Corp.'s mine in Orangeville, Utah.

Source: AP archives, federal mining safety statistics.

18

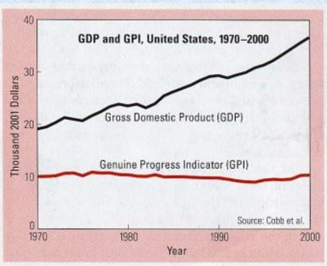
When will Congress consider environmental costs?

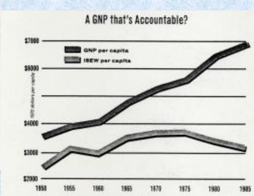
19



20

Answering question #3 suggests there is an alternative to GNP





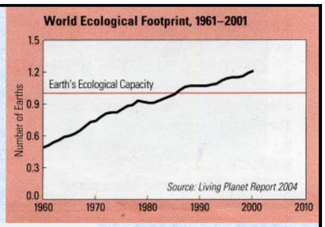
Calculated across 35 years, each line depicts estimates of an average American's share of prosperity. The top line shows Gross National Product per capita. The bottom line shows Herman Daly's "Index of Sustainable Economic Welfare." While the GNP suggests that prosperity has increased almost relentlessly since the 1950s, the ISEW gives a much bleaker picture, because it blends in quality-of-life measurements.

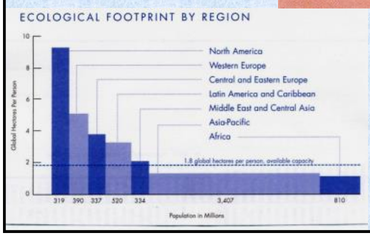
… that considers quality of life…

(Bhutan tries to measure GNH!)

21

… and considers global and future trends …





22

2005 World Environmental Sustainability Rankings

ESI Rankings

Top 10	Score	Bottom 10	Score
Finland	75.1	Yemen	37.3
Norway	73.4	Kuwait	36.6
Uruguay	71.8	Trinidad & Tobago	36.3
Sweden	71.7	Sudan	35.9
Iceland	70.8	Haiti	34.8
Canada	64.4	Uzbekistan	34.4
Switzerland	63.7	Iraq	33.6
Guyana	62.9	Turkmenistan	33.1
Argentina	62.7	Taiwan	32.7
Austria	62.7	North Korea	29.2

Carbon-Neutral Wallbridge Mill, Toronto

23

Adam Lewis Center, Oberlin College

William McDonough

24

TABLE 1: SUMMARY OF CALCULATIONS ON MONETARY AND ENVIRONMENTAL PAYBACK

Currency	Initial Costs	Total Revenues	Payback Time	Revenue / Cost Ratio
Secondary Energy	369 MWh	1,194 – 1,753 MWh	7.3 yrs (Feb. 2008)	3.2 – 4.8
CO2	409,800 lbs	2,582,000 – 3,791,000 lbs	3.7 yrs (July 2004)	6.3 – 9.3
Money simple	$385,788	$59,700 -- $87,700	Never	0.15 – 0.23
Money w/externalities	$391,000 -- $492,000	$68,100 -- $1,032,500	16.8 yrs (Aug 2017)	0.18 – 2.68
Money w/green tags	N/A	$83,600 -- $227,900	Never	0.22 – 0.59

"PAYBACK AND CURRENCIES OF ENERGY, CARBON DIOXIDE AND MONEY FOR A 60 KW PHOTOVOLTAIC ARRAY,"
Michael E. Murray and John E. Petersen
Oberlin College, Lewis Center for Environmental Studies

25

…cost analysis in dollars or carbon…

15.5g CO_2 per dry vs. 4.4g of CO_2 per dry*

* LCC study commissioned by Dyson in 2011

26

Answer question #4
(Was the energy use in making the device appropriate?)

Embodied Energy

Consider:

- Btus in manufacture
- Btus in fuel extraction/creation
- Btus in delivery of device
- Btus in delivery of fuel

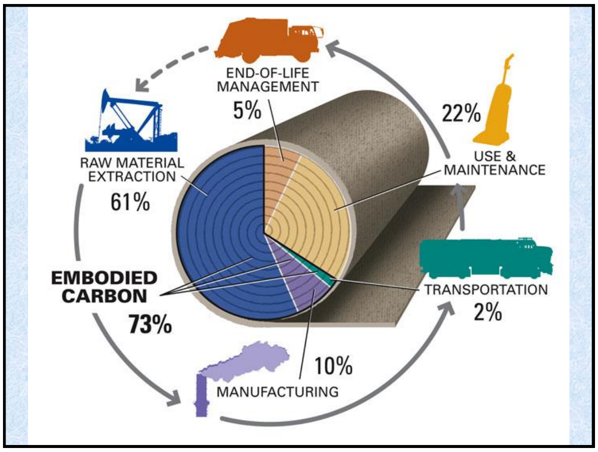
Also, was the CO_2 produced in making the device appropriate?

27

TABLE 1.4 Total Energy Embodiment in Selected Building Materials per Unit of Material at Job Site

Material	*Unit*	*Total Embodied Energy (Btu/unit) at Job Site*
Wood products		
Lumber	Board foot	7,600–9,800
Shingles		7,300
Flooring		10,300–14,300
Mouldings		17,900
Glu-lam		16,700
⅜-in. plywood (softwood)	Square foot	5,000–5,800
Paints	Gallon	437,000–508,500
Asphalt roofing		
Rolls	Square foot	7,800–11,000
Shingles		25,600–29,700
Mineral-surface insulating board siding		67,500
Glass		
Flat glass: double strength	Square foot	15,430
Flat glass: tempered		72,600
Plate and float glass, ⅛ to ¼-in. thick		48,000
Laminated plate glass, ¼-in. and over		212,500
Stone and clay products		
Common brick	Per brick	14,300
Ceramic glazed brick		33,413
Quarry tile	Square foot	51,000
Ceramic mosaic tile and accessories, glazed		63,600–68,700
Concrete block	Per block	31,800
Ready-mix concrete	Cubic yard	2,594,300
Gypsum board-⅜ in.	Square foot	5,300
Mineral wool insulation, 4½-in. thick	Square foot	8,300

28



29

Environmental Building News

THE LEADING SOURCE FOR ENVIRONMENTALLY RESPONSIBLE DESIGN & CONSTRUCTION

What's an EPD? Environmental Product Declaration FAQs

CEUs are available for reading all the short pieces on EPDs. Click here to learn more and take the quiz.

We answer FAQs on EPDs, which allow manufacturers to disclose a product's carbon footprint and other impacts.

By Brent Ehrlich and Paula Melton

Though intended to promote material transparency, environmental product declarations (EPDs) are complex documents that can be anything but clear (see The Product Transparency Movement: Peeking Behind the Corporate Veil) to most architects and other building professionals.

We've put together this FAQ to introduce the basics.

To learn how to get key information from an EPD quickly, also see our short video primer, provided by international expert Frances Yang, S.E., of Arup.

Like nutritional labels, EPDs strive to summarize ingredients that are difficult to quantify.

Photo: FoodFacts

What is an EPD?

An EPD consists of life-cycle assessment information summarized and repackaged into a shorter, more accessible document.

It is formally known as a "Type III Environmental Product Declaration."

August 2015
Volume 24, Number 8

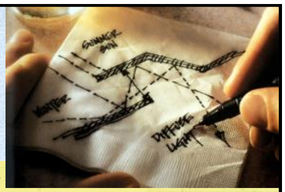
Get the PDF

By downloading this digital content, you agree to BuildingGreen's terms and conditions of use.

Article Contents

30

Basic economics…



Pretend you're an architect

Sometimes clients say 'I wanna save energy'

They always say 'I wanna make a profit.'
or 'I wanna stay inside my budget.'

Sales – Expenses = Profit

Or is it that simple?

31

A new building is a big expense…

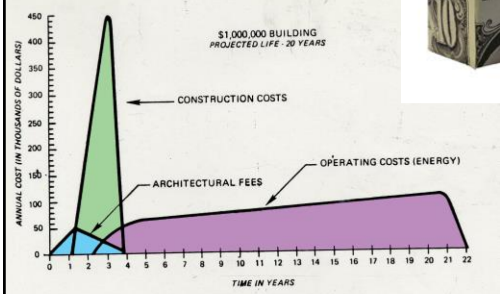


Figure 5-1. Stages of Life Cycle Cost

32

…and architects can't deliver buildings more efficiently…

Technology Viewed as Increasing Efficiency But Not Fulfillment in Profession

% of firms responding that they "strongly agree" or "somewhat agree" with statement on the impact of technology

Made staff more efficient	86%
Made firm more profitable	60%
Improved relationships with clients	59%
Improved the quality of our designs	42%
Reduced the number of errors in designs/contracts	31%
Made architecture a more fulfilling profession	27%

Technology: good for efficiency; mixed for everything else

This month we asked firms to assess the impact of technology on their practice. While almost all firms in our panel (86 percent) agreed that technology has made their staff more efficient, there was less of a consensus on the other impacts of technology.

Over half of firms agreed that technology had made them more profitable and had improved client relationships. Firms were mixed on whether technology had improved the overall quality of their designs. Firms disagreed that technology had reduced the number of errors in designs, and that technology has made architecture a more fulfilling profession. There were some differences in responses by size of firm. Smaller firms were more likely to agree that technology has made their firm more profitable. Larger firms were more likely to agree that technology had improved the quality of designs.

—AIA poll

33

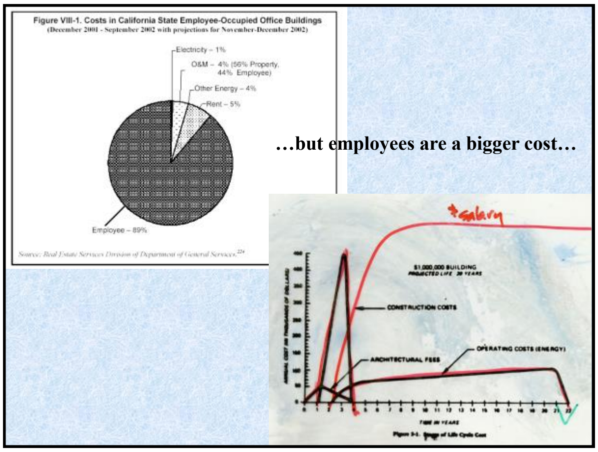
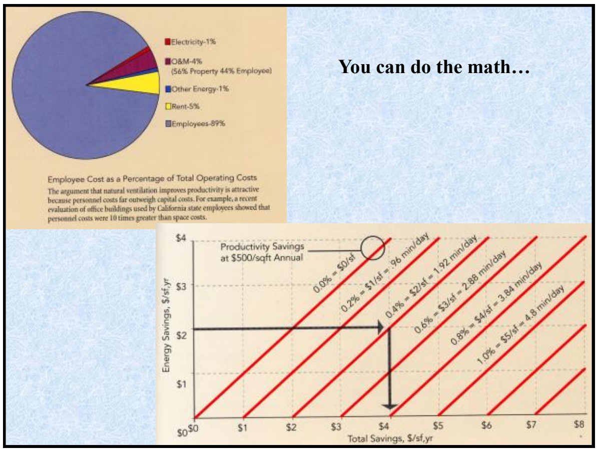
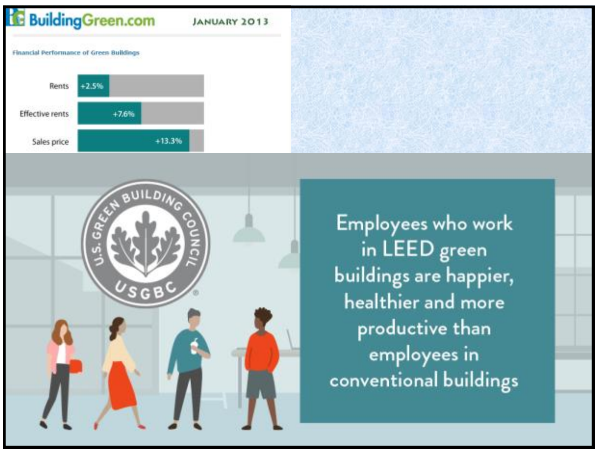


Figure VIII-1. Costs in California State Employee-Occupied Office Buildings
(December 2001 - September 2002 with projections for November-December 2002)
Electricity – 1%
O&M – 4% (56% Property, 44% Employee)
Other Energy – 4%
Rent – 5%
Employee – 89%
Source: Real Estate Services Division of Department of General Services.
…but employees are a bigger cost…
$salary
$1,000,000 BUILDING
PROJECTED LIFE 20 YEARS
CONSTRUCTION COSTS
ARCHITECTURAL FEES
OPERATING COSTS (ENERGY)
TIME IN YEARS

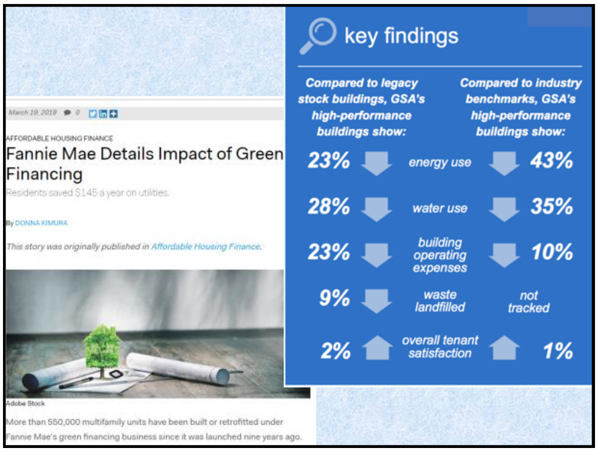
34


Electricity-1%
O&M-4% (56% Property 44% Employee)
Other Energy-1%
Rent-5%
Employees-89%
Employee Cost as a Percentage of Total Operating Costs
The argument that natural ventilation improves productivity is attractive because personnel costs far outweigh capital costs. For example, a recent evaluation of office buildings used by California state employees showed that personnel costs were 10 times greater than space costs.
You can do the math…
Productivity Savings at $500/sqft Annual
0.0% = $0/sf
0.2% = $1/sf = .96 min/day
0.4% = $2/sf = 1.92 min/day
0.6% = $3/sf = 2.88 min/day
0.8% = $4/sf = 3.84 min/day
1.0% = $5/sf = 4.8 min/day
Energy Savings, $/sf,yr
Total Savings, $/sf,yr
$0 $1 $2 $3 $4 $5 $6 $7 $8

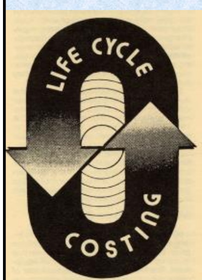
35


BuildingGreen.com
JANUARY 2013
Financial Performance of Green Buildings
Rents +2.5%
Effective rents +7.6%
Sales price +13.3%
U.S. GREEN BUILDING COUNCIL
USGBC
Employees who work in LEED green buildings are happier, healthier and more productive than employees in conventional buildings

36



37



A tool for understanding the long-term dynamics of building and operating costs…

Life Cycle Costing (LCC)

Best to compare "standard" building with "green" building….

Compare first costs, energy costs, maintenance costs…extra work!!!

38

LCC Formula:

$$S = E - [A + M + R]$$

Where:

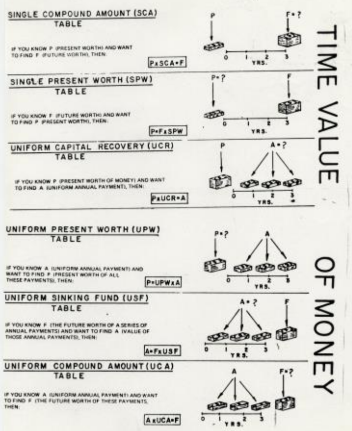
- **S = Net savings (loss) from green architecture**
- **E = Energy cost savings**
- **A = Acquisition and installation costs**
- **M = Maintenance and operating costs**
- **R = Repair and replacement costs**

39

However, money has a value that varies with time!

Conversion of today's dollars to tomorrow's is based on your time preference for money (or your discount rate).

Discount rate is either
- **nominal (interest + inflation)**
- **real (interest only)**



40

The two common ways to evaluate LCC of buildings are:
- **Present value (gives total cost in today's dollars)**
- **Uniform annual value (gives annual costs in today's dollars)**

UCR = Uniform Capital Recovery Formula, $A = P\dfrac{i(1+i)^N}{(1+i)^N - 1}$.

SPW = Single Present Worth Formula, $P = F\dfrac{1}{(1+i)^N}$.

UPW = Uniform Present Worth Formula, $P = A\dfrac{(1+i)^N - 1}{i(1+i)^N}$.

i = Discount rate per period
N = Number of interest periods

41

Present value analysis of electric vs. solar water heater:
(20-year period)

Electric water heater life-cycle cost

$350	= Initial installation cost	
$195	= Present worth of $350 replacement after 10 years (6% real discount rate)	**[$350 x SPW]**
$4669	= Present worth of energy consumed during 20 years with 5% annual fuel escalation rate and 10% nominal discount rate	**[$fuel x UPW]**
$5214	= Total LCC	

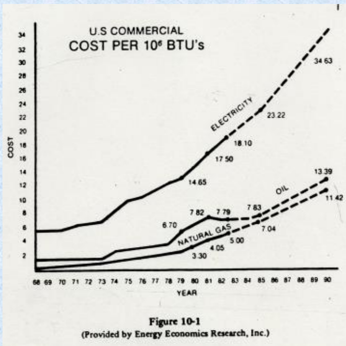
Solar water heater life-cycle cost

$1800	= Initial net installation cost	
$233	= Present worth of $400 to replace tank after 10 years	**[$400 x SPW]**
$344	= Present worth of $30 annual operation and maintenance costs for 20 years	**[$30 x UPW]**
$1401	= Present worth of energy consumed during 20 years, assuming 5% fuel escalation and 10% discount rate	**[$fuel x UPW]**
$3768	= Total LCC	

42

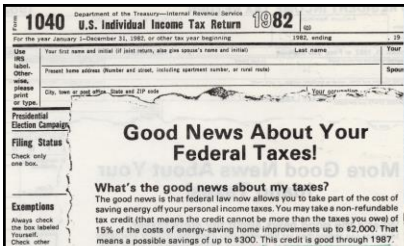
Other cost factors:

- Fuel escalation
- Mortage/loan expense
- Tax credits
- Depreciation allowance

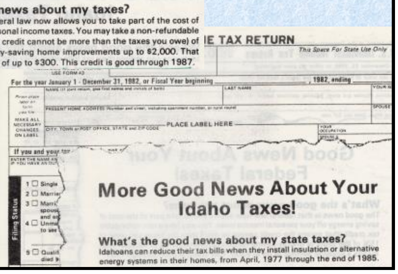


Fuel Price Escalation

43



Long standing tax credits…



44