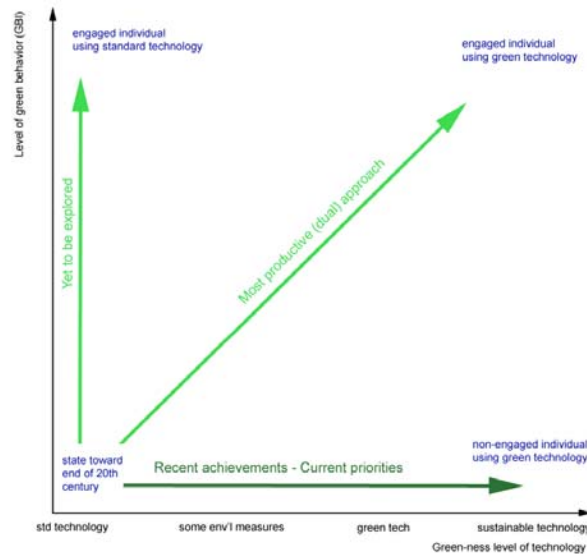# GREEN

BEHAVIOR

(*Homo ecologicus*)

It is one thing to have a "green" building.

It is quite another to have "green" people using it.

What constitutes green behavior?

What incentives exist to incite people

to adopt a green behavior?

ENGS 44 Sustainable Design
Benoit Cushman-Roisin
9 May 2019

Vertical axis is a measure of the extent to which occupants of the building engaged in environmentally conscious behavior.

Level of green behavior (GBI)

engaged individual using standard technology

engaged individual using green technology

Yet to be explored

Most productive (dual) approach

state toward end of 20th century

Recent achievements - Current priorities

non-engaged individual using green technology

std technology   some env'l measures   green tech   sustainable technology

Green-ness level of technology

Progression along the horizontal axis may be:
No green feature – low-hanging fruits only – green processes – green products
– green infrastructure – combination of the latter – 100% sustainable

Green buildings turning out to be not-so-green in parts because of people!

Over the past few years, companies and government agencies have been investing more and more in "green" buildings. These high-tech, low-impact, resource-efficient buildings come equipped with technology that can make them 50% more efficient than their "non-green" peers.

Unfortunately in many cases, these green buildings are not living up to their green performance ratings. A 2008 study by the New Buildings Institute of LEED buildings found that less than half of LEED certified buildings were able to achieve ENERGY STAR ratings above 75%, and nearly a quarter of LEED buildings were performing worse than the U.S. building average!

One reason that some green buildings are not achieving high environmental performance is because employees, tenants, and visitors are not doing their part to leverage green building technology, or to help the building with its conservation goals.

There are a number of strategies to incentivize employees to do their part to go green. These strategies generally fall in the following categories:
Awareness, Automation, Incentives, and Peer Pressure.

Source: www.dailyenergyreport.com/ 2011 article "How to incentivize employees to go green at the office"
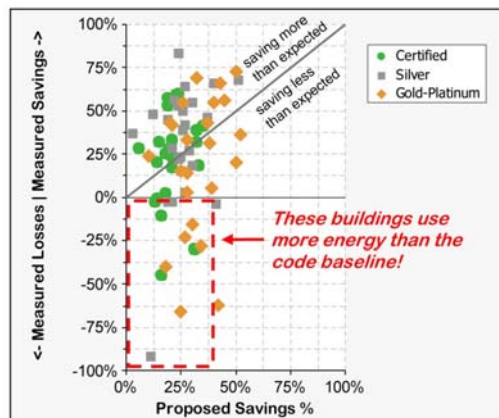

Figure ES- 5: Measured versus Proposed Savings Percentages

Energy Performance of LEED Buildings   NBI / USGBC

https://newbuildings.org/wp-content/uploads/2015/11/Energy_Performance_of_LEED-NC_Buildings-Final_3-4-08b1.pdf

Let us get started with what elements constitute green behavior.

Two things: Do good things – Avoid bad things

Green things to do are:
- Turn lights off when leaving a room
- Use daylight whenever possible
- Use staircase, not elevator
- Recycle paper, *etc*.
- Eat low-carbon footprint types of food (= little to no red meat)
- Reuse cups, plates and utensils
- Dry clothes outside on a line, not with an electrical dryer
- Purchase energy-star appliances
- Walk, bike to work, take public transportation, car-pool
- Draw close window curtains after sunset
- Live near places you most often go to.

Environmentally damaging things to avoid are:
- Let the water run when brushing teeth
- Leave computers and peripherals 'on' overnight
- Open windows when it feels a little too hot
- Drink water from individual plastic bottles
- Water and fertilize lawn
- Live in a huge house.

Also, to the extent possible:
- Know your building and act accordingly.
  (*Ex*. Don't cut shading trees to create a view.)

Gas-guzzler Hummer with an environmental license plate!

Anything else?

Green Behavior – From examples to principles

What are attributes of "green" personal behavior?

The basic element is the development of good habits, such as
water conservation
driving less and driving wisely
turning lights off
closing night curtains
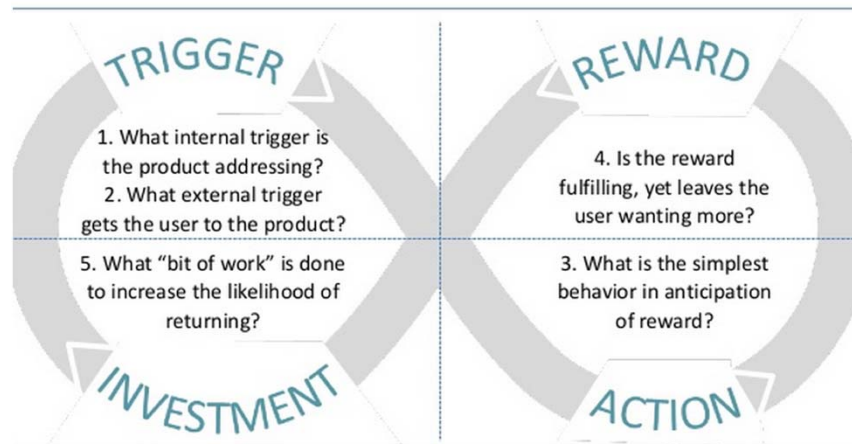paying attention to labels when shopping
minimization of waste generation
→ generally being aware of one's impacts.

Green behavior is influenced by:

- The context: definition depends on technology being used
  (residence building, working environment, driving a vehicle)
- The educational level of the person
- The level of awareness of the person
- The perception of risk (fear of the new, fear of consequences).
- The degree of self motivation (desire to be a good steward of natural resources or not).

Motivation is relatively independent of how green is the technology being used.

To learn about forming a good, green habit,
we can consider what gets customers hooked on new products.

TRIGGER
1. What internal trigger is the product addressing?
2. What external trigger gets the user to the product?

REWARD
4. Is the reward fulfilling, yet leaves the user wanting more?

INVESTMENT
5. What "bit of work" is done to increase the likelihood of returning?

ACTION
3. What is the simplest behavior in anticipation of reward?

Hooked: How to Build Habit-Forming Products book by Nir Eyal, 2014

Research in the context of Behavioral Economics has further revealed that

- People most often make decisions based on approximate rules of thumb,
  and rarely by rational analysis (Cognitive biases & Heuristics).

- People's actions are affected by the way the information is presented to them
  (Framing).

(*Source*: Shefrin, Hersh - "Beyond Greed and Fear: Understanding Behavioral Finance and the Psychology of Investing" Oxford University Press, 2002.)

Who then is an "*Homo ecologicus*"?

A compact definition is still very difficult to formulate.

While the professor continues speaking,
ask yourself this question:

"What encourages **me** to act in green ways?"

A useful criterion to determine whether
an action with ecological impact is a good one:

According to Aldo Leopold (author of A Sand County Almanac, 1949),

- **Right** if action contributes to *integrity*,
  stability, or
  aesthetics of the ecosystem

- **Wrong** otherwise.

A Sand County
ALMANAC
AND SKETCHES HERE AND THERE
By ALDO LEOPOLD
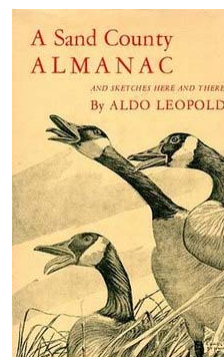
One reason to act green is
to be environmentally aware and
to be desiring to act locally to minimize one's
footprint on the planet.

Tasha Cotter

So, let us see what highly motivated students have been doing.

Dartmouth's Sustainable Living Center
Outcome of students living in North Hall in 2008-09

Fact:
Electricity consumption dropped by 58%
between 2007-08 when "regular" students lived in North Hall
and 2008-09 when "green" students started to live in North Hall

North Hall
on the Dartmouth campus
home of the SLC
A very non-green building
serving as residence to
very green students!

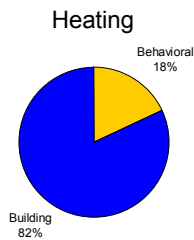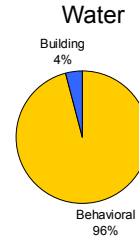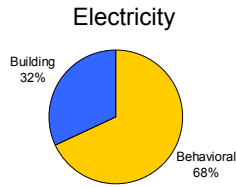By which means was this accomplished?
Mostly:
- Air drying of clothes
  (*i.e.* prohibition against use of electric dryer)
- Turning off unnecessary lights
- Not leaving computers and peripherals on.

Source:
Sustainable Living Center
Dartmouth College

Dartmouth's Sustainable Living Center
Outcome of students living in North Hall in 2008-09

Considering how much of the various contributions to electricity consumption, water usage and heating is under the control of the North Hall's residents

Electricity
- Building 32%
- Behavioral 68%

Water
- Building 4%
- Behavioral 96%

Heating
- Behavioral 18%
- Building 82%

Source:
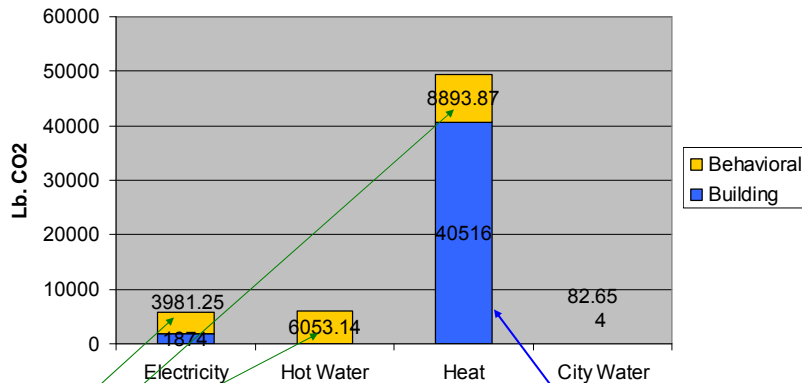Hannah Dreissigacker's Honors Thesis, Spring 2009 Dartmouth College

Conclusion:
Residents can have a major impact on water consumption, a significant impact on electricity consumption but can only make a small impact on building heating need.

North Hall, Dartmouth College
Carbon Emissions by Source and Type

Lb. CO2

- Electricity: 3981.25 / 1874
- Hot Water: 6053.14
- Heat: 8893.87 / 40516
- City Water: 82.654

Legend:
- Behavioral
- Building

advocates green behavior on the part of building users

advocates for a good thermal envelope and, generally, a green building

Figure 11. Environmental impact of an office building by building systems over 50 years of service life (II).

Seppo Junnila (2004)

HVAC = Heating, Ventilation, Air Conditioning

Consequently, the overall greenness of some activity may be more or less sensitive to the behavior of the people engaging in this activity, compared to its sensitivity to the greenness of the technology employed.

Case of greenness more sensitive to human behavior than technology.

Example: Hot-water use for which environmental gain can be better achieved by behavior modification (*ex*. shorter showers) than by green technology (*ex*. low-flow shower head).

Case of greenness more sensitive to technology than human behavior.

Example: Space heating, for which environmental gain can be better achieved by greener technology (*ex*. better thermal envelope of building & renewable source for heating fuel) than by behavior modification (*ex*. closing night curtains).

At a more basic level, people make an unconscious decision about their environmental impacts by choosing where they live.

Living in an older, compact, European-style city reduces people's footprint on Planet Earth.

Typical city characteristics:
- Dense housing
  → common walls → energy savings
  → smaller living quarters → further energy savings,
- Public transportation & Pedestrian friendly,
- Short distances for road traffic.

**Conclusion:
Good policy is
to induce people
to live
in compact cities**
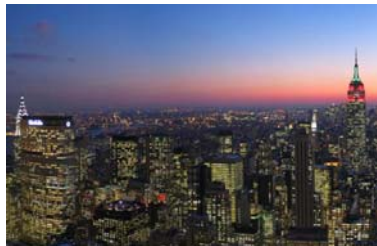
In 2005, carbon dioxide equivalent emissions in New York City were approximately 58×10^6 metric tons (about 1% of US total).

On a per-capita basis, the carbon footprint is **less than a third** of the average in the US.

Setting the stage – Greenness by default

Employees are busy people and often act with least effort.

So, an approach is to make the green thing more convenient and the impacting thing more arduous.

Examples:

- Set printer to double single-sided printing.
- Move waste basket away from desk down the hallway
  and place recycling bins near the desk.
- Place air-blowing hand dryers closer to the bathroom sink
  than the paper dispenser.
- Have the staircase in the middle of the building in plain view,
  while the elevator is in a corner of the building.

*Rule*: If the environmental choice is easier, employees will go for it.

One might call this "Involuntary Greenness" or "Greenness by Default".

http://www.dailyenergyreport.com/how-to-incentivize-employees-to-go-green-at-the-office/

Relatively few people are highly motivated on their own.

Society can usefully be divided into the following categories:

1. The innovators are trailblazers at the frontier, motivated to do something positive. They go out of their way to explore new ways of behaving, learn the hard way what works and what does not. They are testing new grounds and new ways.

2. The early adopters like what they see, get convinced easily, and are eager to show that they "get it". Their involvement spreads the word and market share.

acting based on environmental concerns

3. The early majority consist of people who jump on the band wagon because it is "the thing to do" and because green things have become cheaper.

4. The late majority people feel pressure to act like others. They fear being left behind.

acting under peer pressure

5. The laggards are hopeless reactionaries. They don't want to change their ways.

not acting

Laggards 16%	Late Majority 34%	Early Majority 34%	Early Adopters 13.5%	Innovators 2.5%
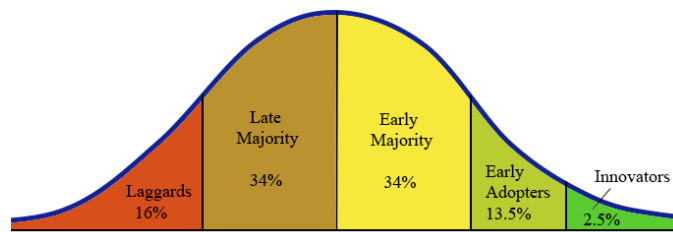
Everett Rogers Technology Adoption Lifecycle Model

Awareness

Often building occupants are not aware of the impact of their actions.

One powerful way to build awareness of resource use is to contextualize an employee's actions in environmental or economic terms.

Example: By not turning off my computer at night for a year, I produce 500 lbs of greenhouse gas emissions and cost my company $40.

Another option is a visual display. One leading media company collected water bottles from their sets for a week and then displayed these water bottles outside the building – enough to fill up a 10'x10x'10' bin!

The limitation of this approach is that displays may be dramatic but insufficiently individualized.
Also, after a while, people cease to notice. It's just there…

A trash temple!
(in Rotterdam,
The Netherlands)

http://inhabitat.com/

http://www.dailyenergyreport.com/how-to-incentivize-employees-to-go-green-at-the-office/

Incentives

These come in essentially two types:

- Incentives with negative feedback (punishment of bad behavior)
- Incentives with positive feedback (encouragement of good behavior).

Common examples, unrelated to green behavior:

- Negative:
    a fine for speeding
    a high tax to discourage a certain activity
    a buzzing red light to embarrass the wrongdoer

- Positive:
    a monetary reward
    employee-of-the-month parking space
    a pleasurable consequence of some sort

Examples of positive green incentives

- Exposure to the science and numbers

- Exposure to nature during childhood

- Positive slogans, such as "Think Globally – Act Locally"
    or, printed on toilet paper: "Remember I come from a tree."
    See also: https://brandongaille.com/112-catchy-environmental-awareness-campaign-slogans/

- Emotional response to an iconic issue (*ex*. Chinese panda, polar bear)

- Peer pressure ("My neighbors / co-workers are doing it.")
        → From innovators to early adopters to greater segment of population

- Personal rewards:
        Positive financial incentive, such as a rebate or savings
        Better health – Increased happiness
        Feeling good about doing good

- Rewards at level of the community (*ex*. fresh air, clean water for all)

- Metering: Information in people's face at point where action takes place
        (*ex*. shower-meter)

- Public policy by means of laws encouraging green behavior

Not all of these work equally well. Which one do you think are more effective?

© Arne Naevra (Norway)

Examples of positive green incentives – cont'd

● Give rewards.
In Illinois, USA, the firm Christopher B. Burke Engineering
- offers a monthly free breakfast to all employees who come to work by bicycle;
- pays employees $0.75 for every mile commuted to work by bike;
- Provides discounts at a local bike shop for parts & service;
- has quarterly giveaways of bicycle gear, and, once a year, gives a free bicycle to
the employee who rode the most miles. (http://cbbel.com/bike-to-work/)

● Organize a competition in which the greenest team is the winner.

Tips:
    Variety and fun are required for this to work. Otherwise fatigue sets in.
    Better if one can tap on an existing rivalry (ex. Dartmouth *vs*. Yale)

Examples of negative green incentives
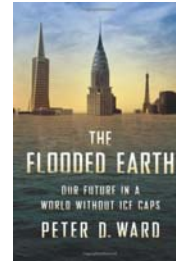
- Fear of doom – alarmist information
    Ex. Al Gore's Inconvenient Truth

- Negative or guilt-laden slogans such as
    "Modern technology owes ecology an apology."
    "When you refuse to reuse it's our Earth you abuse."

- Taxation and fees for un-green behavior
    Ex. Carbon tax
    *Ex. "*Gas-guzzler tax" on fuel-inefficient vehicles in Massachusetts
    Ex. Bring your own or pay steeply for your grocery bag(s) in Europe

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The power of peer pressure

A study involved placards in hotel bathrooms that urge guests to reuse towels.

Over a three-month period, researchers tested two different placards in a 190-room, mid-price chain hotel. One card was headlined "*Help Save the Environment*" and urged visitors to "show your respect for nature" by reusing towels. The second read, "*Join Your Fellow Guests in Helping to Save the Environment*". The management noted that 75% of guests participated in the towel-reuse program.

The guests who were exposed to the peer pressure – the fact that so many of their fellow travelers were doing it – were 25% more likely to reuse towels.

A follow-up study found that tweaking the wording on the placard so it was specific to the guest's room (as in: nearly 75% of guests who stayed here in Room 331 reused their towels) yielded even better compliance.

Stephanie Simon, *Wall Street Journal*, 18 October 2010

A similar story…

financial argument   scientific argument   moral argument

Another study involved public-service messages hung on the doorknobs of several hundred middle-class homes in San Marcos, California. All urged residents to use fans instead of air conditioning, but they gave different reasons for doing so.

- Some residents learned they could save $54 a month on their electricity bill.
- Others, that they could prevent the release of 262 pounds (= 120 kg)
  of greenhouse gases per month.
- A third group was told it was the socially responsible thing to do.
- The fourth group was informed that 77% of their neighbors already used fans
   instead of air conditioning, a decision described as "your community's popular choice!"

social argument

Meter readings found that those presented with the social argument (= peer-pressure) reduced their energy consumption by 10% compared with a control group.
No other group reduced energy use by more than 3% compared with the control group.

All four of the non-control groups slipped in the long run, conserving less as time went on, but those exposed to peer pressure continued to record the lowest average daily energy use.

Stephanie Simon, *Wall Street Journal*, 18 October 2010

Quote about peer pressure

"Setting an example is not the main means of influencing another, it is the only means."

Albert Einstein

Obstacles and challenges to green behavior

HUMAN
    Cultural environment (North America ↔ Europe) – Traditions
    Affluence – Consumerism – Fashion
    Human resistance to effort
    Human resistance to change
    Human greed – "Tragedy of the Commons"
    Naïveté at beginning
    Fatigue after a while
    Internet society → impatience
    Sense of insignificance
    Complacency (*ex.* LEED building → "good enough")
    Cooperation versus competition
    Distrust and suspicion that env'l agenda has an ulterior motive

ENVIRONMENT
    Everything connected to everything else
        → Possibility of feedbacks (+/–) and rebound effects
            → Complexity, which brings resistance
   Conservation of mass and energy placing limits

"*When one individual's behavior seems insignificant, it's very difficult to get people to change.*" Trae Vassallo, partner at Kleiner Perkins Caufield & Byers

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A sobering note on eating local foods

Life-cycle analysis of energy consumption in food production and transportation has shown:

"Although food is transported long distances in general (1640 km delivery and 6760 km life-cycle supply chain on average), the greenhouse GHG emissions associated with food are dominated by the production phase, contributing 83% of the average U.S. household's 8.1 ton CO_{2e}/year footprint for food consumption.

Transportation as a whole represents only 11% of life-cycle GHG emissions, and final delivery from producer to retail contributes only 4%."
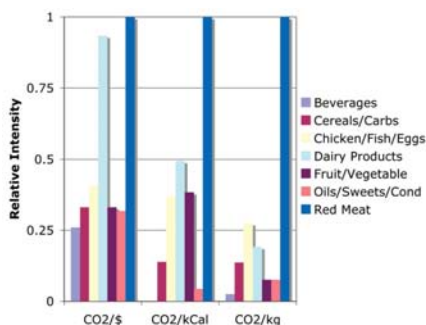
"Different food groups exhibit a large range in GHG-intensity; on average, red meat is around 150% more GHG intensive than chicken or fish.

Thus, a dietary shift can be a more effective means of lowering an average household's food-related climate footprint than buying local."

Source:
C.L. Weber and H.S. Matthews, 2008:
Food-Miles and the relative Climate Impacts
of Food Choices in the United States.
Env. Sci. Tech., Vol. 42, No. 10, pages 3508-3513.

Measuring green behavior

Can green behavior be quantified? Perhaps not, but one may try.

Here is a first attempt – The **Green Behavior Index** (GBI)
Its objective is to provide a numerical value that can be useful to scientific studies.

$$GBI = \frac{\text{Person's allowed eco-footprint for given type of activity}}{\text{Person's actual eco-footprint for that person's behavior}}$$

in which the "activity" is contextual, such as manner of living at home, type of work done in the factory or at the office, mode of transportation, and eating habits.

The allowed eco-footprint (numerator) is to be calculated by dividing an overall allowance deemed sustainable by the number of people concerned, so that the GBI connects the activity being evaluated with its impact on the environment.

Rule:
$GBI = 1$ indicates a behavior that is within allowance and therefore acceptably green;
$GBI > 1$ indicates a behavior that is greener than expected;
$GBI < 1$ indicates a behavior that is less green than it ought to be;
GBI close to zero indicates a behavior that is far from green.

Well, you may object that this is much about human psychology and social sciences, not about environmental science and environmental engineering.

Here are ways in which engineers can contribute.

 - Design sensors at the scale of the individual .

 - Invent meters and other artifacts to bring the measured quantities
   to the individuals in a timely, informative and personal fashion.

 - Redesign components of buildings (ex. staircase, doors, placement
   of switches, *etc.*) to incite green behavior by convenience.

YOUR IDEAS !!!

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