Show Me The Money (and Carbon)

WHERE IS THE CARBON?

→HVAC (AC=electricity; heating=electricity or natural gas) – ~30-50 % of building emissions

→hot water heating (electric or natural gas) – ~5-10% of emissions

→lighting and plug load (electric) – ~20-30% of emissions in commercial space

→transportation (gasoline) – 30% of emissions

Sources: https://www.epa.gov/sites/production/files/2017-02/documents/2017_executive_summary.pdf (electricity generation + transportation) (Table ES-6, page 24 and Chapter 3 page 16);

NOTE: These numbers represent the breakdown of emissions for the average American. Please note that many of you will be engaging with partners in the commercial sector. Depending on the sector, these estimates may be wildly different for your partner's operations. But almost every partner will have large amounts of emissions arising from these various sources, even if their footprints are weighted slightly differently.

NATURAL GAS

- Applications: cooking, heating water, HVAC heating
- Cost in Georgia:
    - Residential: 0.967 (dollars/therm)
    - Commercial: 0.749 (dollars/therm)
    - Source: https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm
- Carbon emissions: 11.7 lbs CO2/therm
    - Source: https://www.eia.gov/environment/emissions/co2_vol_mass.php

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ELECTRICITY

- Applications: air conditioning, lighting, manufacturing
- Cost in Georgia: 11 cents/kWh for residential
    - Source: Georgia Power

- Carbon emissions:
  - 0.98 lb CO_2 per 1 kWh
  - Source: Dr. M Berry, Georgia Power
- Extra Resource:
  - Average price in cents/kWH for every electric company in all states for 2015
  - Source: https://www.eia.gov/electricity/sales_revenue_price/pdf/table6.pdf (Also includes all States)

Example Calculations: Changing out incandescent bulbs for LED bulbs

Scenario 1: 80 incandescent bulbs (no change)

i. Lights: http://www.homedepot.com/p/GE-50-100-150-Watt-Incandescent-A21-3-Way-Long-Life-Soft-White-Light-Bulb-2-Pack-50-150LL-HTP2-6/202954247

ii. Incandescent lights are on for 6 hours a day

iii. Lifetime of incandescent lights: 1.2 years (438 days)

iv. 150 Watts/fixture

v. 80 fixtures total

vi. Carbon emitted using fluorescent lights

$$\frac{6\ hours}{day}\ x\ \frac{150\ Watts}{fixture}\ x\ 80\ fixtures = \frac{72\ kWh}{day}\ x\ \frac{365\ days}{year}$$
$$= \frac{26280\ kWh}{year}\ x\ \frac{1.222\ lbsCO_2e}{kWh} = 32{,}114.2\ \frac{lbs\ CO_2e}{year}\ \ for\ 80\ fixtures$$

$\frac{72\ kWh}{day}\ x\ \frac{1.222\ lbsCO_2e}{kWh} = \frac{87.984\ lbsCO_2e}{day}\ x\ 438\ days = 38{,}537\ lbsCO_2e$ (over lifetime of bulb)

vii. Cost to operate incandescent lights

$$\frac{72\ kWh}{day} x \frac{9.62\ cents}{kWh} = \frac{692.64\ cents}{day} x \frac{1\ dollar}{100\ cents} = \frac{6.93\ dollars}{day} x \frac{365\ days}{year} = \$2{,}529.45\ per\ year$$

a. $\frac{dollars}{day} x\ 438\ days = \$3{,}035.34$ (over lifetime of bulb)

Scenario 2: Replace 80 incandescent bulbs with LED bulbs

viii. LED bulbs are 10 Watts per fixture

ix. http://www.homedepot.com/p/EcoSmart-60W-Equivalent-Soft-White-A19-Basic-Non-Dimmable-LED-Light-Bulb-8-Pack-5cSA800STQ101/206836838

x. Carbon emitted replacing with 80 LED bulbs

$$\frac{9\ hours}{day} x \frac{10\ Watts}{fixture} x\ 80\ fixtures = \frac{7.2\ kWh}{day} x \frac{365\ days}{year} = \frac{2628\ kWh}{year} x \frac{1.222 lbsCO_2e}{kWh} = 3{,}211.42\ \frac{lbs\ CO_2e}{year}\ for\ 80\ fixtures$$

$\frac{7.2\ kWh}{day}\ x\ \frac{1.222\ lbsCO_2e}{kWh} = \frac{8.79\ lbsCO_2e}{day}\ x\ 3332\ days = 29{,}316.3\ lbsCO_2e$ (over lifetime of bulb)

xi. Lifetime of LED Bulbs: 9.13 years (3332 days)

xii. Cost to operate LED lights:

$\frac{7.2\ kWh}{day} x \frac{9.62\ cents}{kWh} = \frac{69.26\ cents}{day} x \frac{1\ dollar}{100\ cents} = \frac{0.6926\ dollars}{day} x \frac{365\ days}{year} =$
$\$252.81\ (for\ one\ year)$

$\frac{0.6926\ dollars}{day} x\ 3332\ days = \$2{,}307.88$ (over lifetime of bulb)

Difference between Scenario 1 (no change) and Scenario 2 (LED bulb)

A. Carbon

Carbon emissions of incandescent bulbs (x 7): 38,537 x 7 = 269,759 lbs CO_2e

B. Cost (including total lifetime savings and ROI/Payback period)

1. Cost of installation/labor: $150

2. Lifetime of bulbs: Incandescent bulbs need to be purchased ~ 7 times to keep up with lifetime of LED bulbs: $3,035.34 x 7 = $21,247.40

3. Purchasing cost of LED bulbs: ($12 for pack of 8 → $120.00)

$$\$120 + \$150 = \$270$$
$$\frac{(\$270 + 15{,}393.80)}{\$5583.80\ (total\ savings)} = 2.8\ years\ for\ Return\ on\ Investment$$

Total Savings: $21,247 – ($270 + 15,393.80) = $5,583.80 over lifetime of bulbs (includes installation/purchasing cost)

Total Carbon Savings: 269,759 – 29,316 = 240,443 lbs CO_2 not emitted

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GASOLINE

- Applications: transportation
- Cost in Georgia:
  - 2.22 dollars/gallon
  - Source: http://www.georgiagasprices.com/prices_nationally.aspx
- Carbon emissions:
  - 19.64 lbs of CO_2 from burning one gallon of gasoline
  - Source: https://www.eia.gov/tools/faqs/faq.php?id=307&t=11, https://www.eia.gov/environment/emissions/co2_vol_mass.php, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/PublicTransportationsRoleInRespondingToClimateChange2010.pdf

Example: Compare 1 year of driving to 1 year of biking or public transport

Scenario 1: Drive 13,500 miles per year or 37 miles per day (average American, https://www.fhwa.dot.gov/ohim/onh00/bar8.htm)

$$\frac{13500\ miles}{year}\ x\ \frac{0.964\ lbs\ CO_2e}{1\ mile} = 13{,}014\ \frac{lbs\ CO_2e}{year}$$

*Using a car that gets 20 miles per gallon, 12 gallons

$\frac{37\ miles}{day}\ x\ \frac{gallon}{20\ miles}\ x\ \frac{365\ days}{year} = 675.25\ \frac{gallons}{year}\ x\ \frac{\$2.22}{gallon} = \$1{,}499.06$ spent per year on gasoline

Scenario 2: Replace driving (Scenario 1) with biking

- Costs: Invest in bike for $500

Total Savings (Biking): $1,499.06 - $500 (bike cost to purchase) = $999.06 saved in one year

Total Carbon Savings: 25,650 lbs CO_2 not emitted during one year

Scenario 3: Replace driving (Scenario 1) with Public Transportation (MARTA) for 3500 miles a year

- 0.245 lbs CO_2/passenger mile
- Source: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/PublicTransportationsRoleInRespondingToClimateChange2010.pdf
- Fare price: 30-day pass at $95

$$\frac{3500\ miles}{year}\ x\ \frac{0.245\ lbs\ CO_2e}{1\ mile} = 857.5\ \frac{lbs\ CO_2e}{year}$$

$\$95\ x\ 12\ months = \$1{,}140.00$ on MARTA fare

Total Savings (MARTA): $1,499.06 - $1140 = $359.06 saved in one year

Total Carbon Savings: 13,014 – 857.5 = 12,156.5 lbs CO_2 not emitted during one year

Other Categories of Emissions Reductions

FOOD/DIET

- Cost (Retail Rates)
- Carbon emissions:
  - Beef: 6.61 lb CO_2e per serving
    - 26.44 lb CO_2e per pound of beef
  - Pork: 1.72 lb CO_2e
    - 6.88 lb CO_2e per pound of pork
  - Poultry: 1.26 lb CO_2e
    - 5.04 lbs CO_2e per pound of poultry
  - Milk: 0.72 lb CO_2e per 8 ounces
    - 1.44 lb CO_2e per pound of milk
    - Average weight of 1 gallon of milk = 8.6 pounds
    - 12.384 lb CO_2e per one gallon of milk bought
    - Source: University of Michigan, Center for Sustainable Systems Fact Sheets: Carbon Footprint; Heller, M. C. and Keoleian, G. A. (2015), Greenhouse Gas Emission Estimates of U.S. Dietary Choices and Food Loss. Journal of Industrial Ecology, 19: 391–401. doi: 10.1111/jiec.12174

Example Calculations: Decreasing Meat and Dairy in an Adult Food Diet

Scenario 1: (standard diet) 2 lbs of beef, 2 lbs of chicken, 0.5 gallons of milk per week

$$\frac{26.44\ lbs\ CO_2e}{1\ lb\ Beef}x\ 2\ lbs = 52.88\ lbs\ CO_2\ e$$

$$\frac{5.04\ lbs\ CO_2e}{1\ lb\ Chicken}x\ 2\ lbs = 10.08\ lbs\ CO_2\ e$$

$$\frac{12.384\ lbs\ CO_2e}{1\ gallon\ of\ milk}x\ 0.5\ gallons\ = 6.192\ lbs\ CO_2\ e$$

Total CO_2e per week = 69.152 lbs CO_2

Total for one year = 3,595.9 lbs CO_2

$$\frac{\$\ 7.277}{1\ lb\ Beef}x\ 2\ lbs = \$14.54$$

$$\frac{\$\ 3.289}{1\ lb\ Chicken}x\ 2\ lbs = \$6.58$$

$$\frac{\$\ 3.259}{1\ gallon\ Milk}x\ 0.5\ gallons = \$1.63$$

Total spent for one week = $22.79

Total spent for one year = $1,184.95

Scenario 2: Replace red meat from scenario 1 with chicken, 4 lbs of chicken, no red meat

Total Savings (one year): $1,184.95 - $684.11 = $500.84

Total Carbon Savings (one year): 3595.9 – 1048.32 = 2,547.58 lbs CO_2 per person

- Factors to consider: be wary of using averages of typical American consumption of meat and dairy in their diet; are they a vegetarian? Are they giving up red meat and substituting it with a smaller greenhouse gas emission source like poultry? Or giving up meat and dairy products entirely?

$$\frac{5.04\ lbs\ CO_2e}{1\ lb\ Chicken}x\ 4\ lbs = 20.16\ lbs\ CO_2\ e\ per\ week \rightarrow 1{,}048\ lbs\ CO_2\ e\ per\ year$$

$$\frac{\$\ 3.289}{1\ lb\ Chicken}x\ 4\ lbs = \$13.16\ per\ week \rightarrow \$684.11\ per\ year$$

TREES

- Cost: generally scales with tree maturity; seedlings=$1 on arborday.org up to several hundred dollars for a several-yr-old tree

- Carbon offset potential: 1,000 lbs of CO_2 for each mature tree

  - One acre of mature trees absorbs as much CO_2 as a car driven 26,000 miles. [Source: https://www.arborday.org/trees/treefacts]

Appendix

Energy related Units:

Ccf—equals the volume of 100 cubic feet of natural gas
M—equals one thousand (1,000)
MM—equals one million (1,000,000)
Mcf—equals the volume of 1,000 cubic feet (cf) of natural gas
MMBtu—equals 1,000,000 British thermal units (Btu) (One Btu is the heat required to raise the temperature of one pound of water by one degree Fahrenheit)
Therm—One therm equals 100,000 Btu, or 0.10 MMBtu