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Introduction

- A non-profit organization founded in October 2016
- Promoting metrics and quantitative thinking to bridge the gap between science and climate action
- Facts, not advocacy...

Outline

- **Carbon ‘illiteracy’**
- A science – based standard
- Progress towards 40%X2030 and 80%X2050

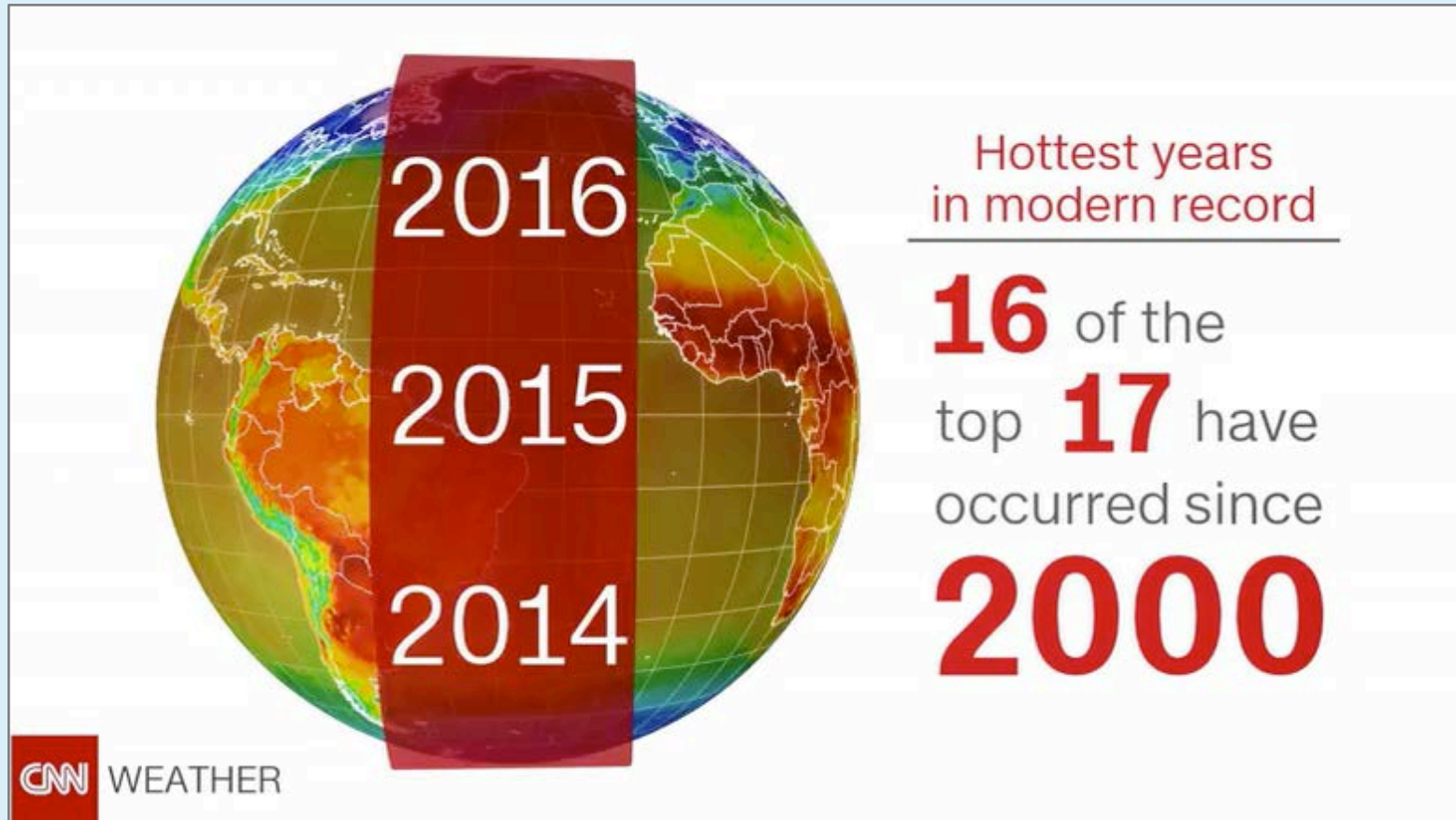
Background: In 2011 HelioFocus Installed 800kW Solar in Inner Mongolia, China



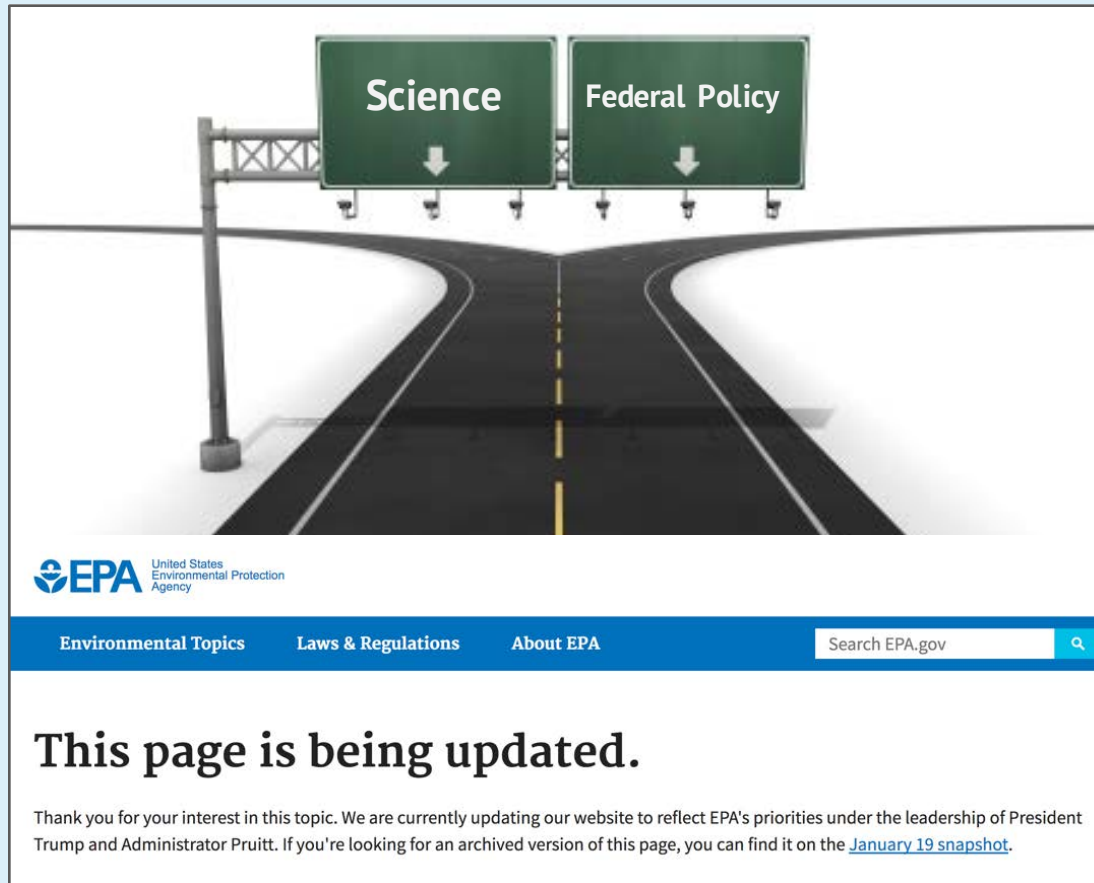
Each Solar Concentrator Contained 60 tons of Steel, Produced using Coal



Likely 2018 Presentation: “17 of the Last 18 Years were the Hottest on Record”



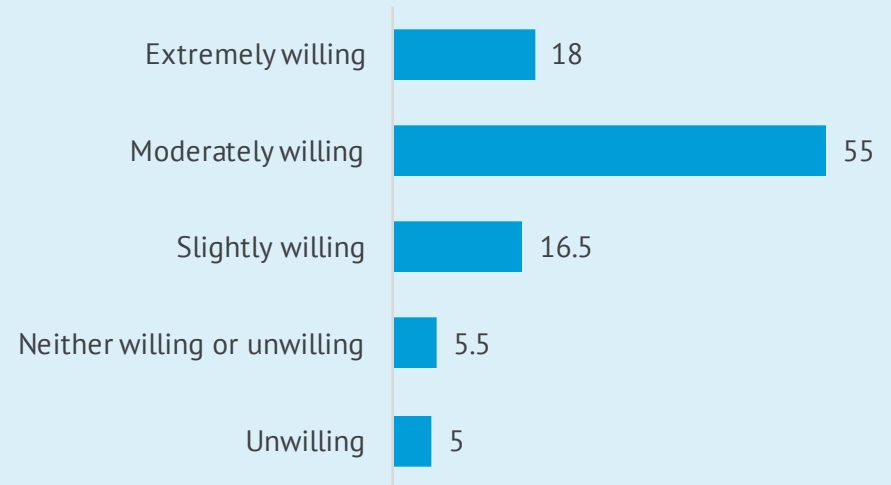
The Paris Agreement – The Federal Government is Likely to Step Out



Consumers, Investors, Companies and Local Governments Want to Act

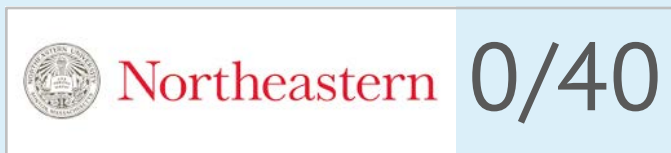
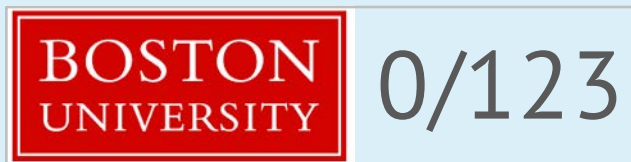
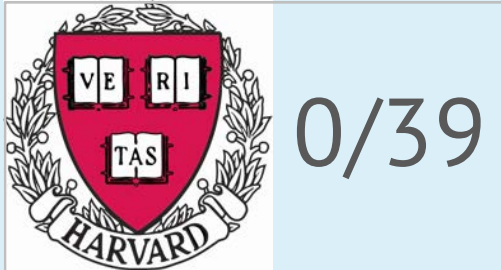


Willingness to change lifestyle to reduce carbon footprint (%)

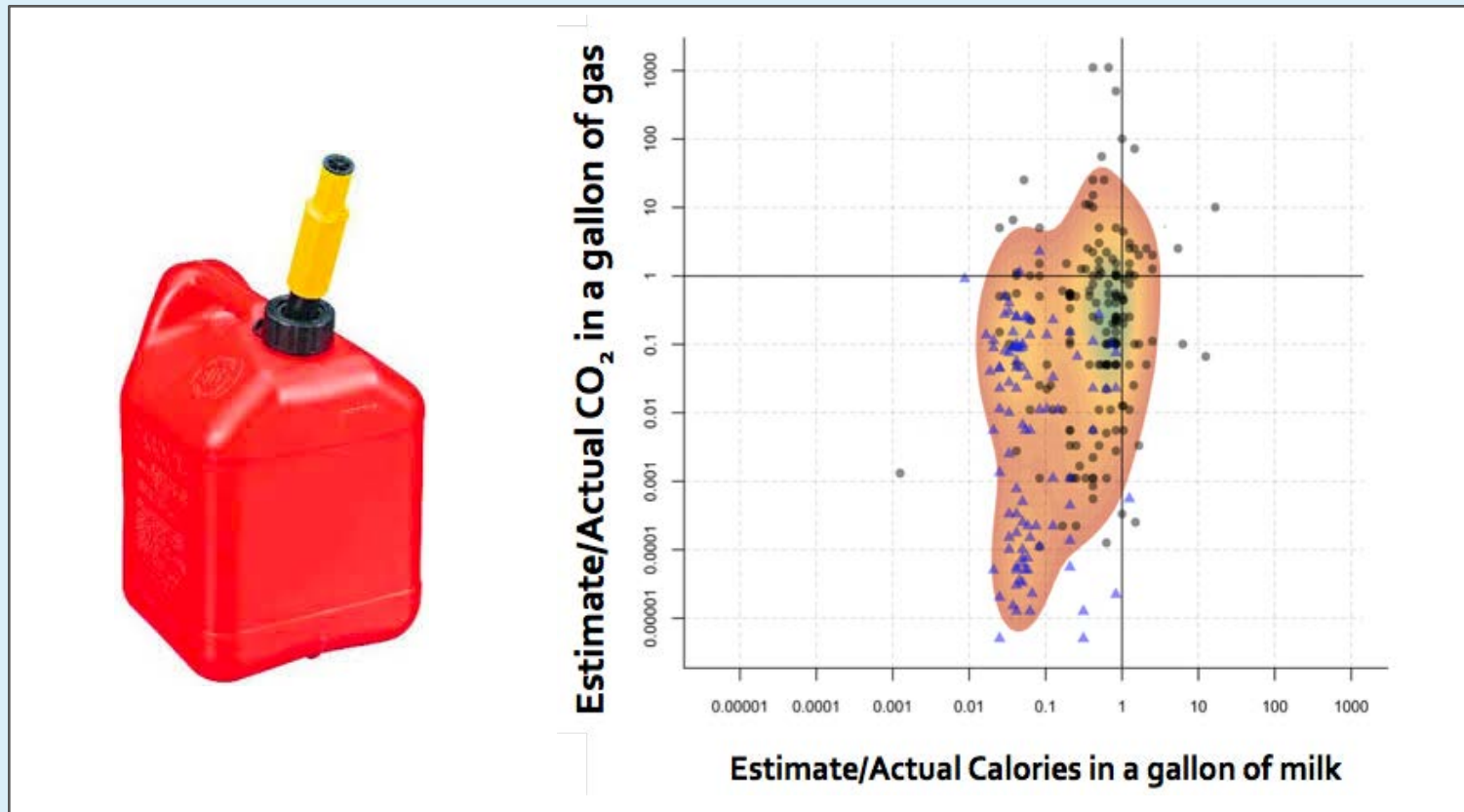


Email and Facebook survey of 118 people made for Greenometry by Northeastern students

Carbon 'Illiteracy': People Cannot Estimate or Calculate Carbon Footprint



People Cannot Even Estimate the Carbon Footprint of a Gallon of Gasoline



Source: Shen, Grinstein, Kodra, Sheldon and Zik (Manuscript)

A Good Metric Enables Both Estimations and Accurate, Standard Measurements

- Examples: money, distance, temperature, time...
- Commonality: quantitative intuition / estimations, “knowing without calculating”
- Required: consistency + practice



300% Difference Between Carbon Footprint Calculators using the Same Data



Available online at www.sciencedirect.com



Environmental Impact Assessment Review 28 (2008) 106–115

Environmental
Impact
Assessment
Review

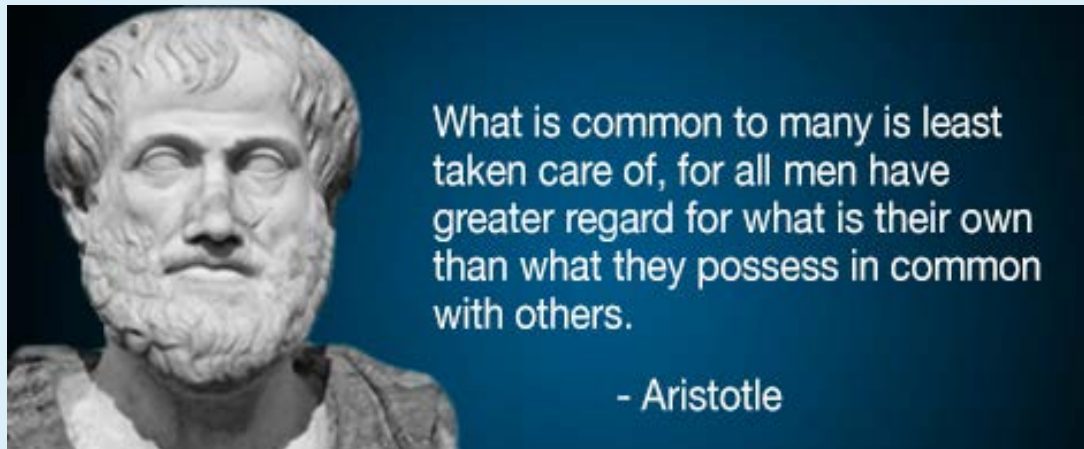
www.elsevier.com/locate/eiar

A comparison of carbon calculators

J. Paul Padgett ^{a,*}, Anne C. Steinemann ^b, James H. Clarke ^a, Michael P. Vandenberg ^a

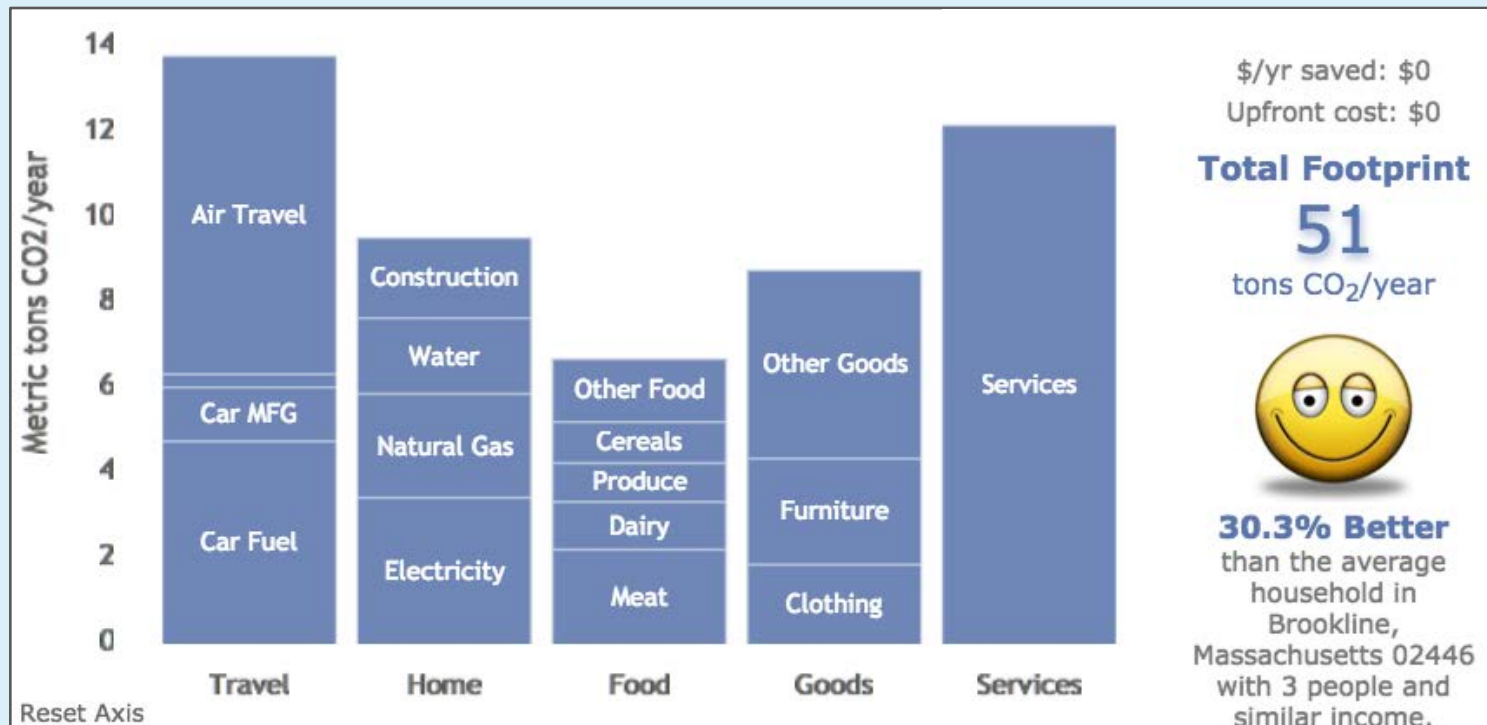
Weak Incentive to Practice Carbon Footprinting - Hopefully Changing

- Collective consequences
- No personal measurement
- Not readily accessible.



Can My Household Meet the Paris Goals?

Reduce footprint from 50 to 30 tons CO₂ / year by 2030 and to 10 by 2050

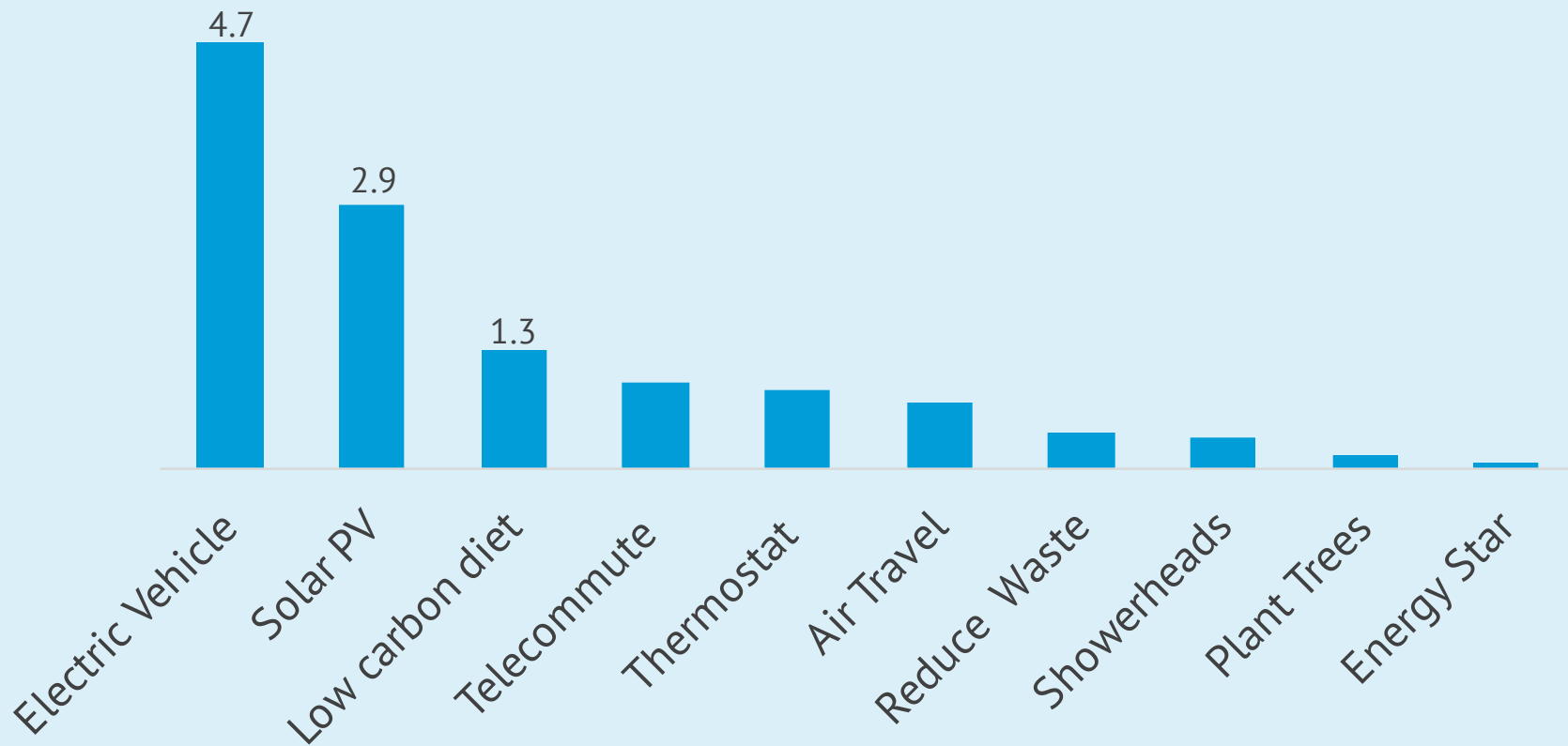


<http://coolclimate.berkeley.edu/calculator>

'Action Plan': The Top 10 Activities Reduce about 13 tons CO₂ per year

Tons CO₂ / year

70% of the reduction are the Top 3 activities



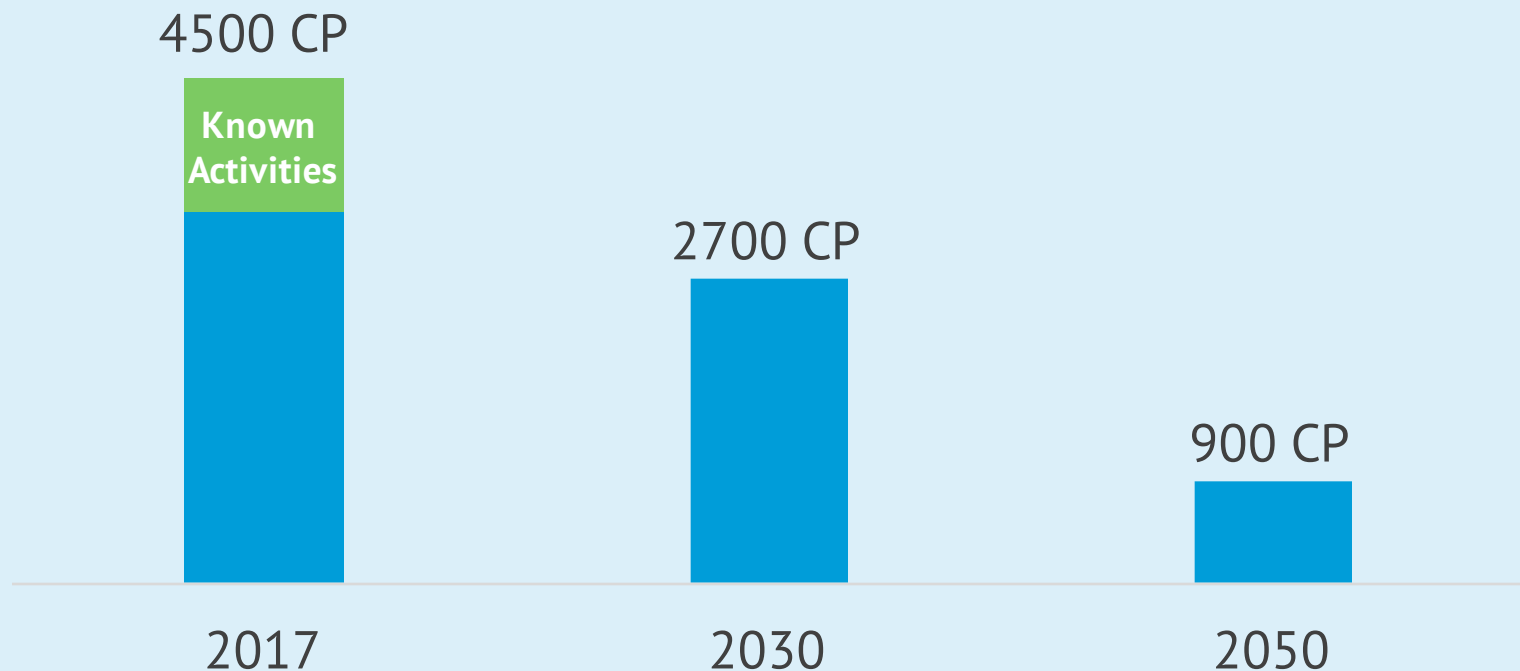
Need a Simple Frontend (10,000 steps) Powered by a Robust Backend



Personal Role in Keeping the Planet Below 2°C: Save Climate Points

1 Climate Point (CP) = 10 gram CO₂

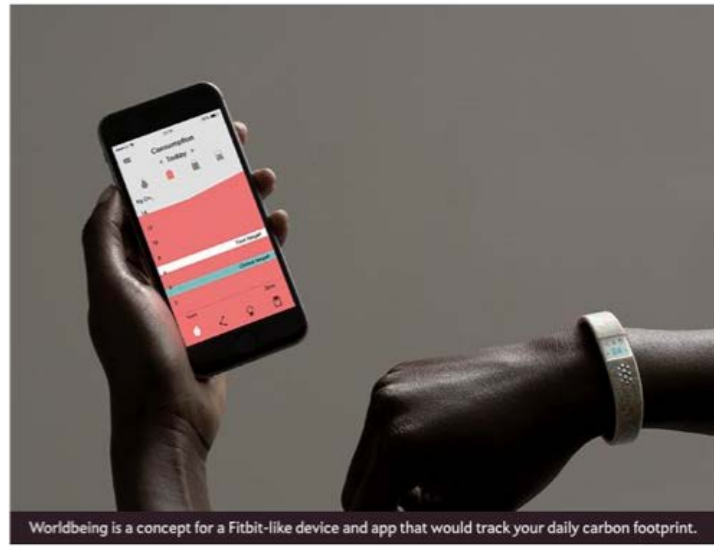
Household of three; 50 tons per year ~ 4,500 CP per person per day



Progress in the Frontend. But... Need to Fix Carbon 'Illiteracy' and the Backend

A Fitbit-Like Wearable That Tracks Your Carbon Footprint

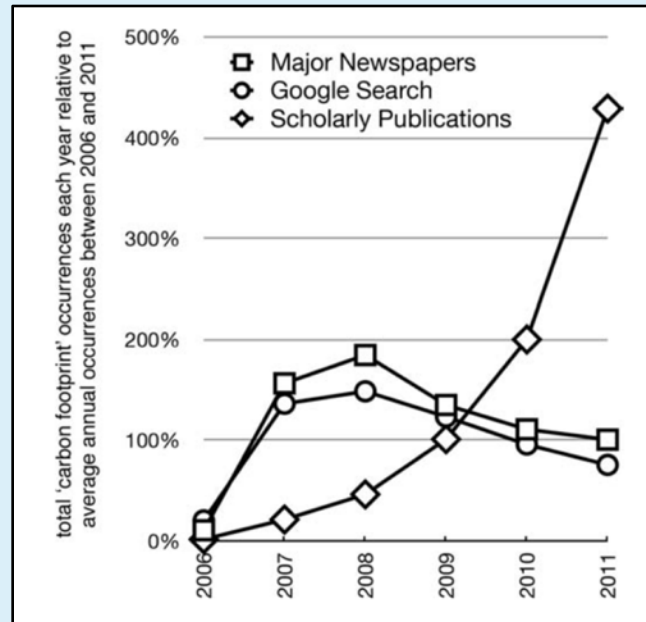
By Kristin Hohenadel



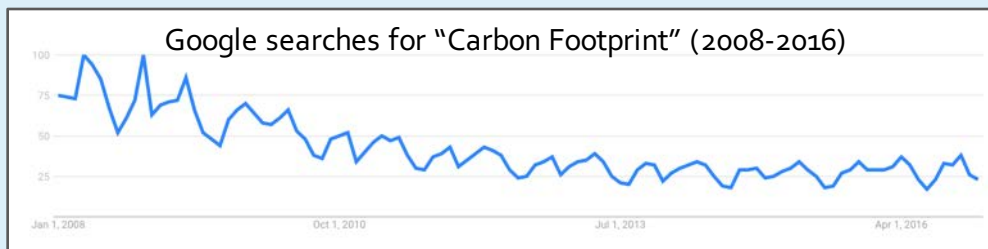
Worldbeing is a concept for a Fitbit-like device and app that would track your daily carbon footprint.

Courtesy of Layer

The Backend Exists! It has a Name: We can Solve Carbon Illiteracy with Science



Source: James Morton Turner; *Global Environmental Politics*



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The Conversion Challenge: Data and the Reverse Problem

$$\text{Impact}(CO_2) = \text{Consumption (measured unit)} \times \text{Conversion} \left(\frac{CO_2}{\text{measured unit}} \right)$$



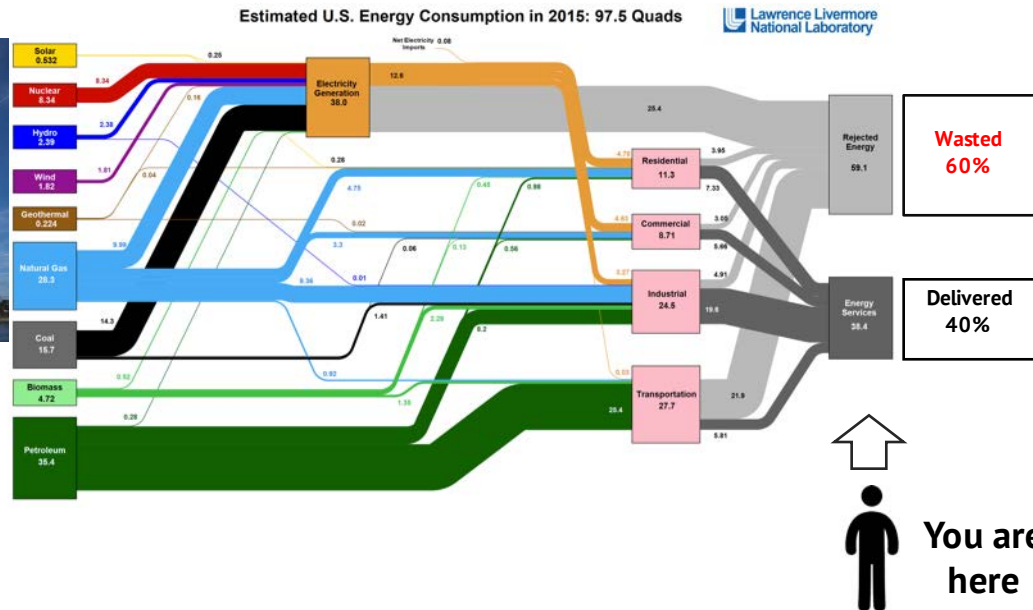
Image: Al Gore's TED talk

Conversion of Electricity to Carbon Footprint, Mix of Multiple Resources

$$\text{Electricity Impact}(CO_2) = \text{Consumption (kWh)} \times \text{Conversion} \left(\frac{CO_2}{kWh} \right)$$



Your impact is
determined here



Progress in Consumption Data, But Not in Calculating the Conversion Factors

Conversion (kgCO₂/kWh)

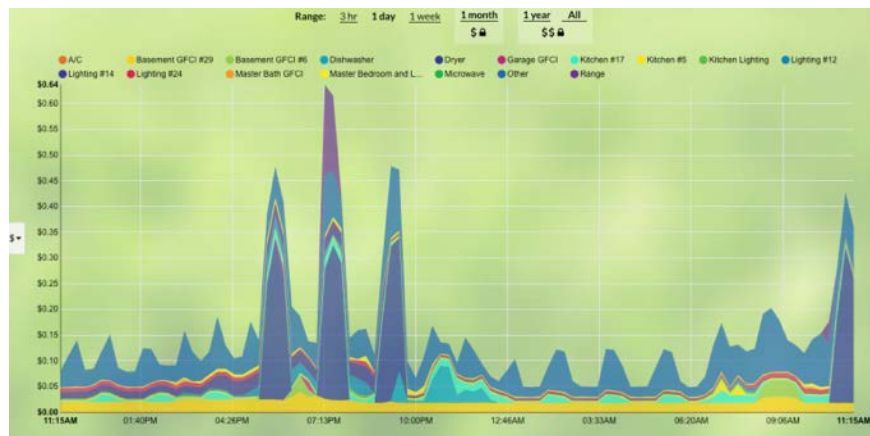
Annual average; 3 years delay;
24 Regions (eGRID)



Source: EPA

Consumption Data (kWh)

Real time



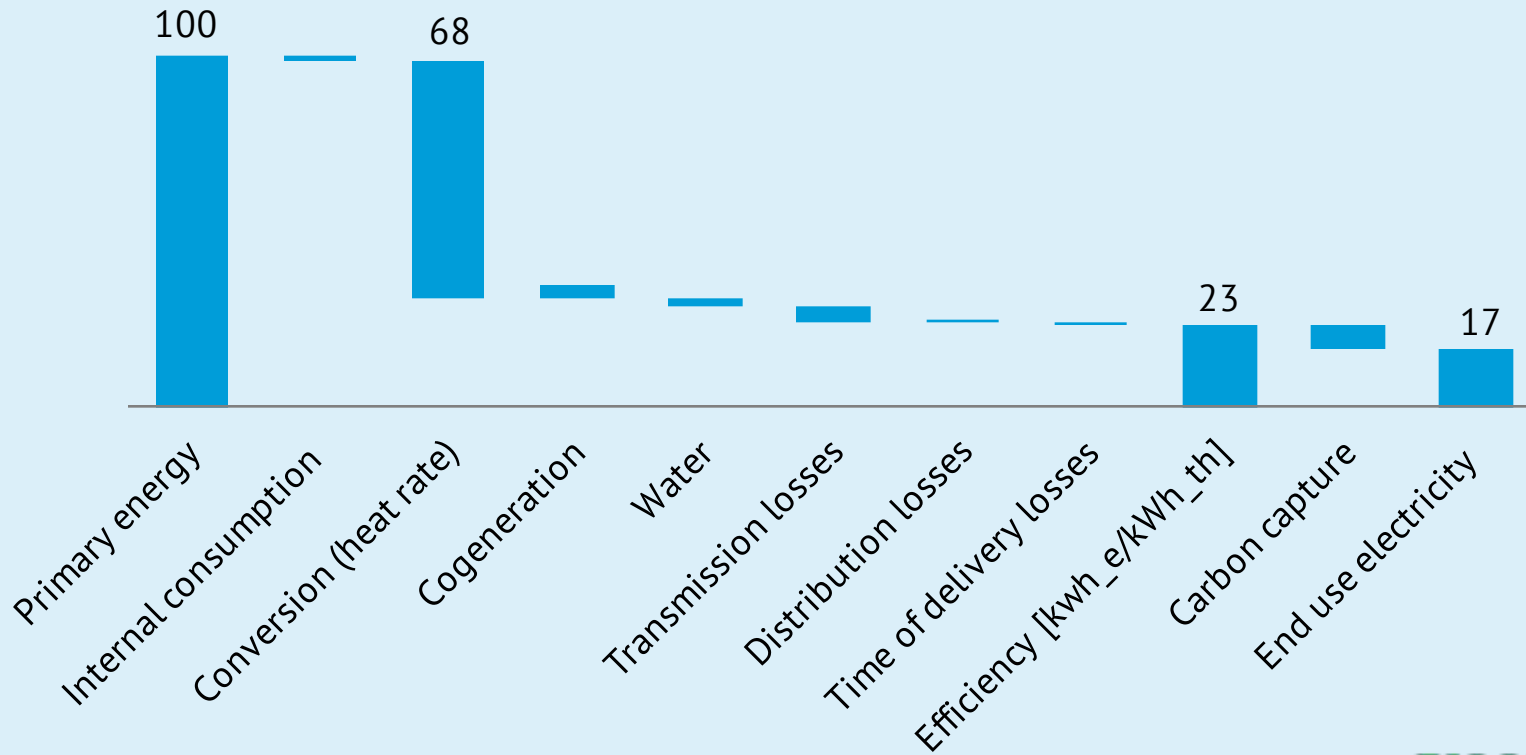
The Conversion is the Weighted Average of Power Plant Emission and Grid Mix



Coal is not 'Dirty' nor 'Clean'. It has a High Conversion Ratio from CO_{2-e} to Electricity

Conversion ratio 0.8 kg CO_{2-e}/kWh_e (80 CP / kWh_e)

The detailed exergy breakdown enables rating innovation



Multiple Factors Effect the Conversion of Ratio of Solar PV

- Grid at manufacturing site
- Embodied energy (LCEA)
- Water consumption
- Carbon residue time
- Transportation and installation
- Land use and albedo effects
- Technology (photons to electrons)
- Local radiation
- Marginal electricity replaced

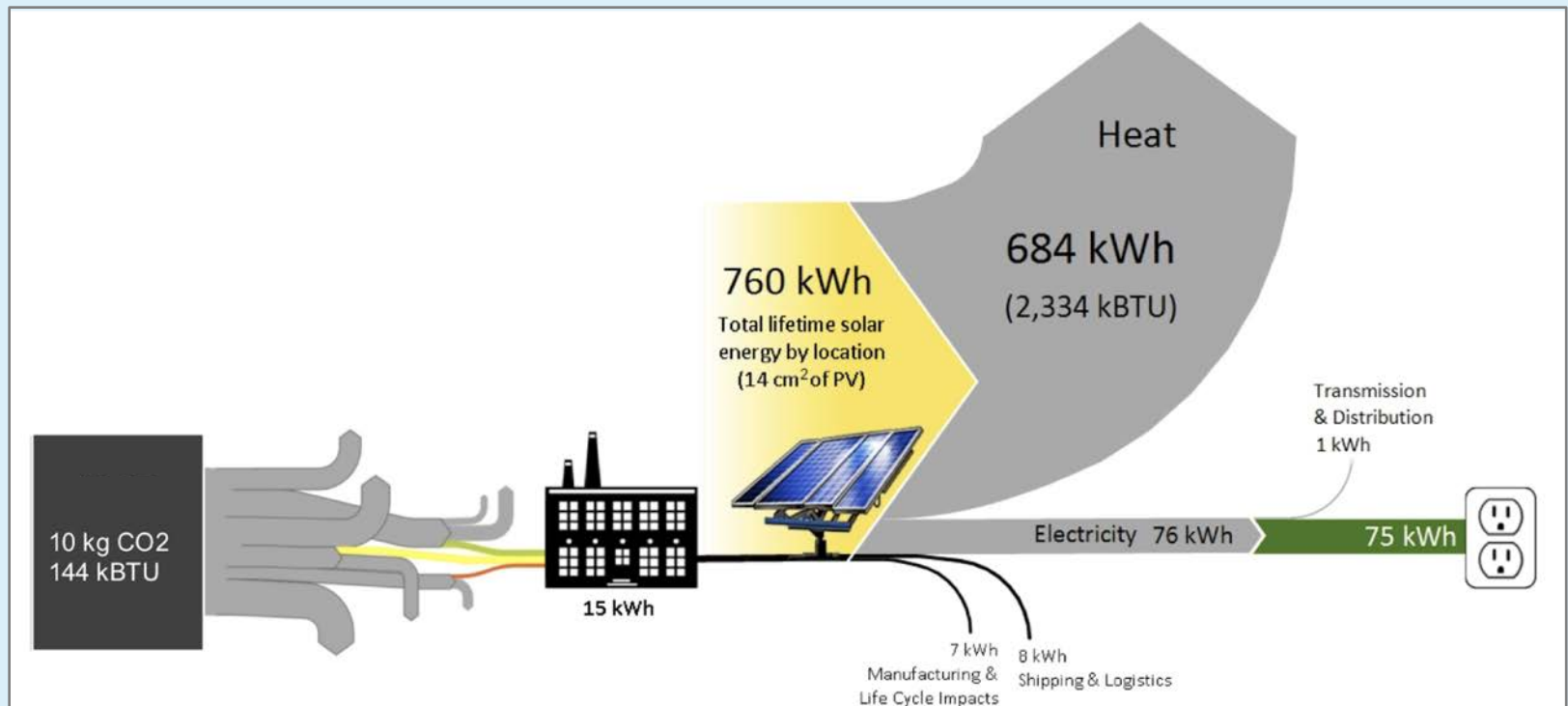
Solar Panels Besides the Mass Pike in Framingham



Jessica Costa / WBUR

Solar is not 'Clean'. It has a Conversion Ratio 5-15 Times Cleaner than Coal

Conversion ratio 0.13 kg CO₂/kWh_e (13 CP / kWh_e)



A Similar Approach Applied to Hydroelectric and Nuclear



Energy

Available online 1 April 2015

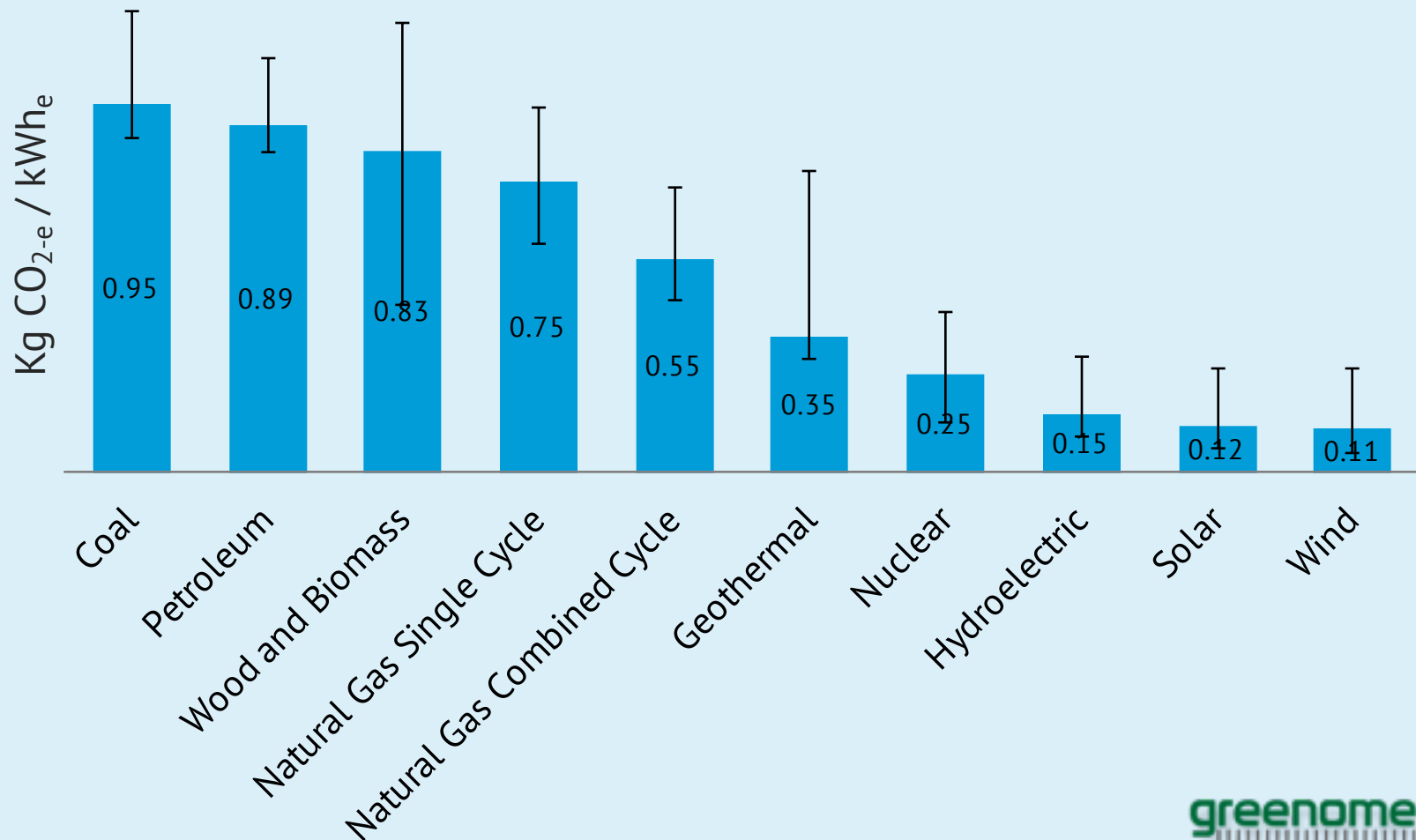
In Press, Corrected Proof — Note to users



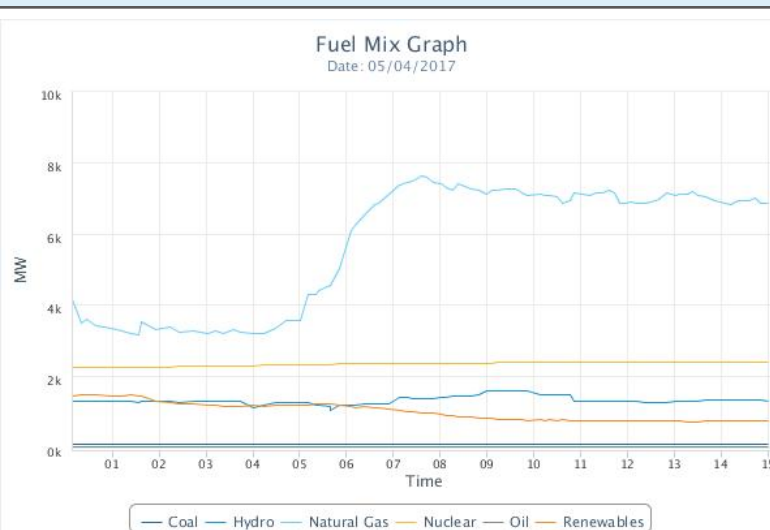
Beyond carbon: Quantifying environmental externalities as energy for hydroelectric and nuclear power

Seth Sheldon^a,  , Saeed Hadian^b,  , Ory Zik^a,  

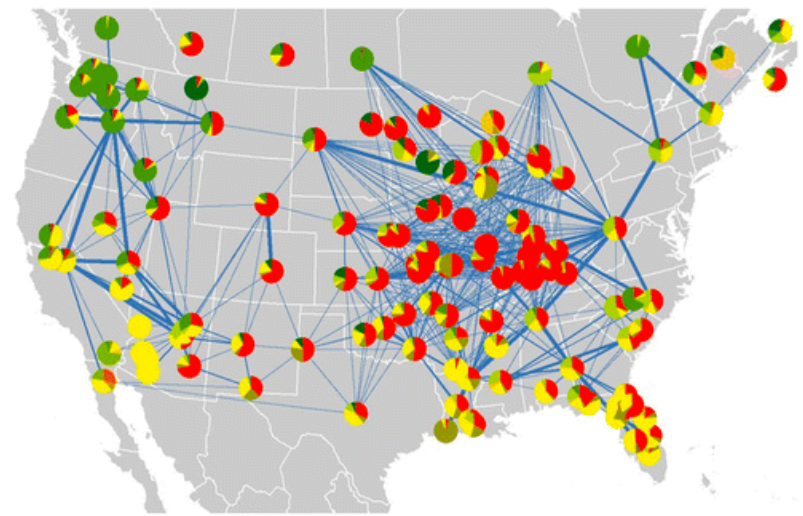
The Conversion Factors for Electricity Sources Using LCA+Exergy



The Grid Mix Can be Analyzed in Hourly Intervals, Including Inter-Utility Transfers



<https://www.iso-ne.com/isoexpress/web/charts>



E. Kodra, S. Sheldon, R. Dolan, O. Zik Environ. Sci. Technol., 2015, 49 (22), pp 13692–13698

The Information is Shared Through a Public API



Greenometry API (beta)
<http://www.greenometry.org/api/>

We Need Science-Based Conversion Factors as a Fundamental Platform

- Carbon footprint cannot be measured. It has to be calculated
- We have to do it together: collaborate to embed science into the conversion factors

$$CP = \sum_R \iint \text{cloud} CF_R(x, t) * C_R(x, t) dx dt$$

CF_R = Conversion; C_R = Consumption

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Electric Vehicles: Can Know the MPG & Climate Points in Real Time

421 Wh/mi

34 mpg (U.S. Average)

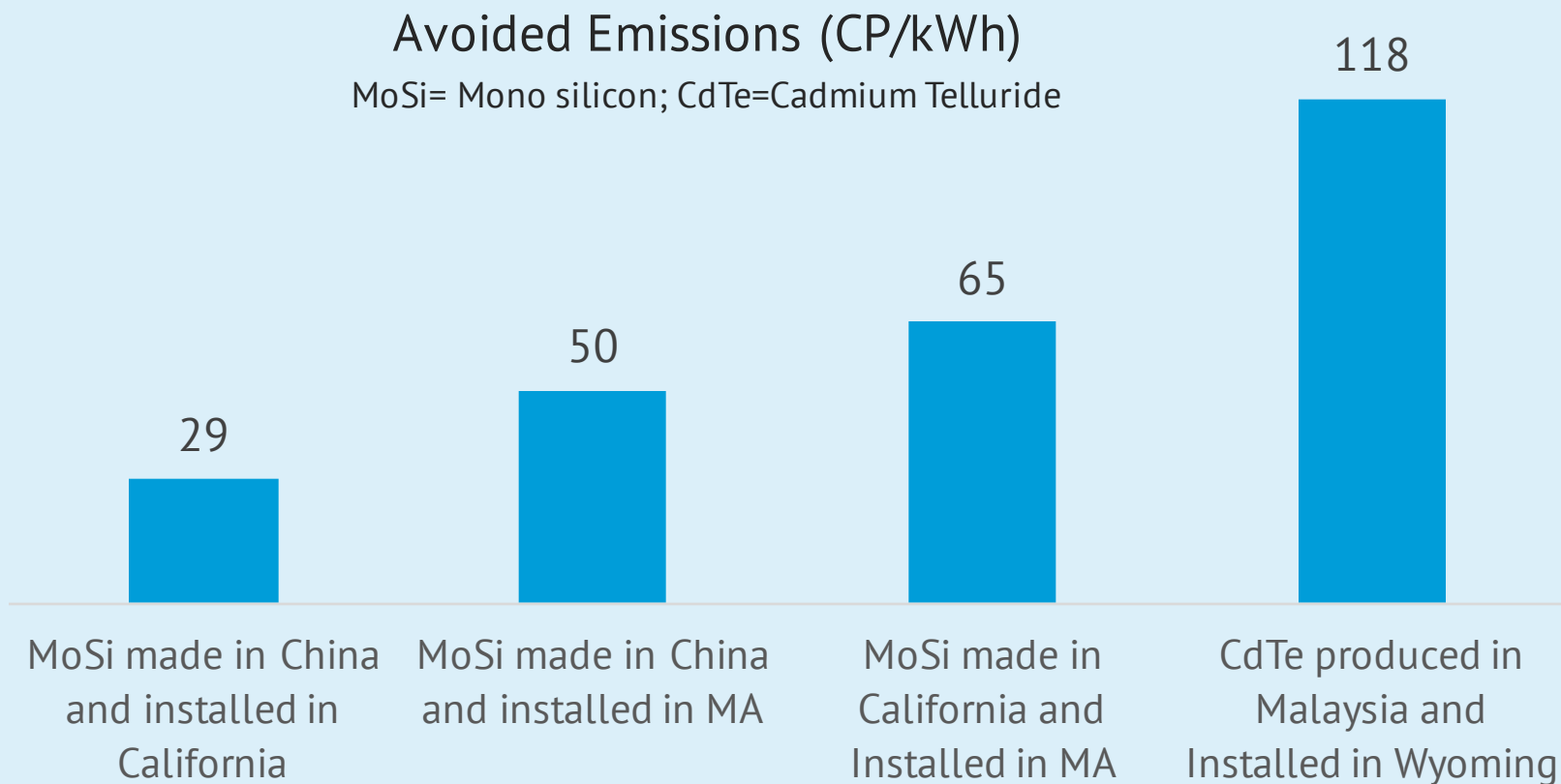
56 mpg (Massachusetts)

182 mpg (Solar in MA)



- A gallon of Gasoline ~ 9 kg of CO₂ ~ 900 CP
- 12 miles per day ~ 190 CP using the grid and 60 CP using solar
- Tesla web application (beta): <http://apps.greenometry.org/tesla/>

Solar PV: The Abated Climate Points Depend on Location and Technology



Diet: Climate Points Displayed Near Calories (Harvard Club, April 17)

greenometry

April 3, 2017

Roasted Beets, Frisée, Crispy Potatoes,
Vermont Goat Cheese with Truffle Vinaigrette

Choice of:

Cedar Plank Roasted Salmon Filet
with a Lemon Peppercorn Rub

Calories 400 (7 oz) Climate Points 700

or

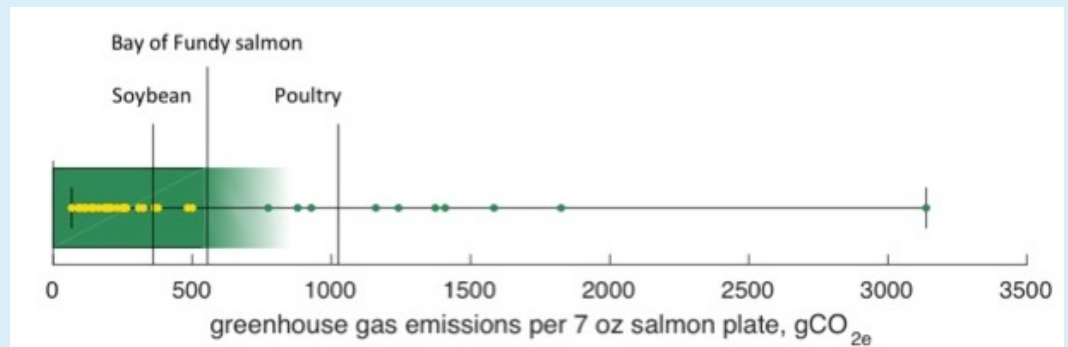
Roasted Eggplant, Grains with Medjool Dates
and Spicy Harissa

Cauliflower Mash, Brussel Sprouts and Baby Peppers

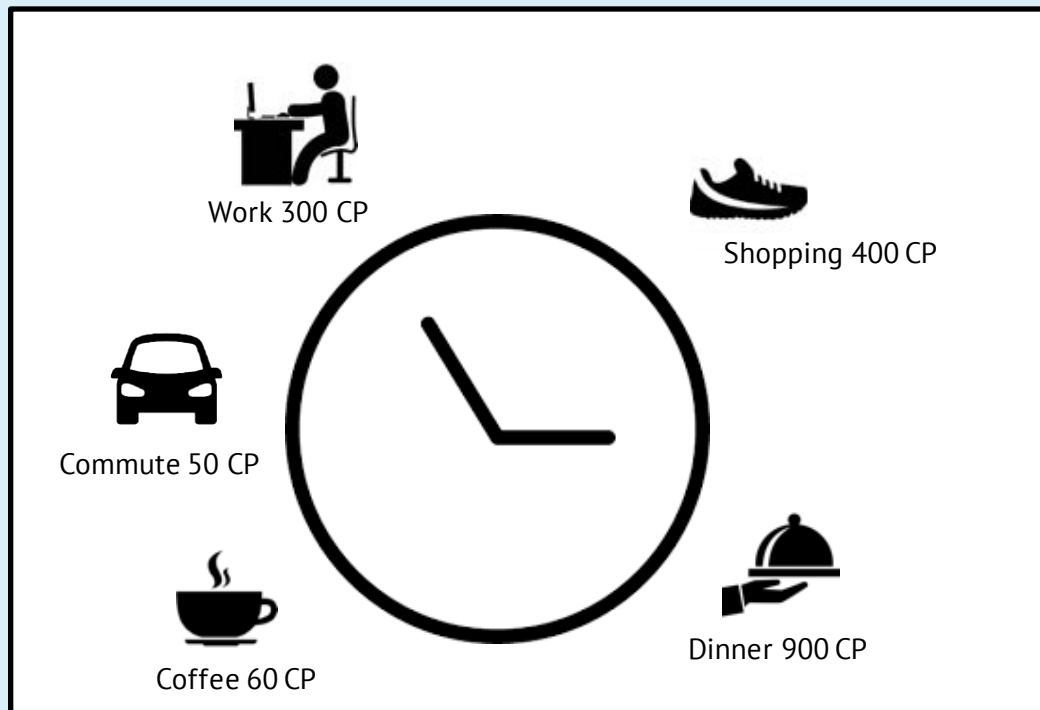
Fresh Berry Tartlett with Mango Sauce

Thank you to our sponsors Mintz, Levin

**"Driving a Low Carbon Economy with Intuitive
and Accurate Metrics"**



A Day in the Life of The Future Consumer: Targeting 40%X2030 and 80%X2050



In Summary

- Quantitative thinking combined with 'science-based standards' can reduce carbon illiteracy, lead to better decisions and enable people to meet the Paris agreement
- What is the role of education?

“I Love Renewables, but I’m Also Pro-Arithmetic” *Sir. David MacKay R.I.P 1965-2014*



CREDIT: GRAHAM TURNER

Thank You!

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