Carbon Budgets and Your Carbon Legacy

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Defining Carbon Debt, Footprint, Budget, and Legacy

“Definitions”

Carbon Debt	**What we’ve already emitted**
Carbon Footprint	**What we’re currently emitting**
Carbon Budget	**Limit on cumulative global emissions**
Carbon Legacy	**What we’ll emit in our lifetime**

Scope

Carbon Debt	**National, (Technology)**
Carbon Footprint	**Individual, (Process, Product)**
Carbon Budget	**Global → Individual**
Carbon Legacy	**Individual**

Some Questions

- What is the global carbon budget / U.S. share?
- How might this be translated to individual carbon budgets?
- What are the impacts of a small set of key life decisions on your carbon legacy?
  - E.g., Housing location, housing type, family size, vehicle choice, dietary choice

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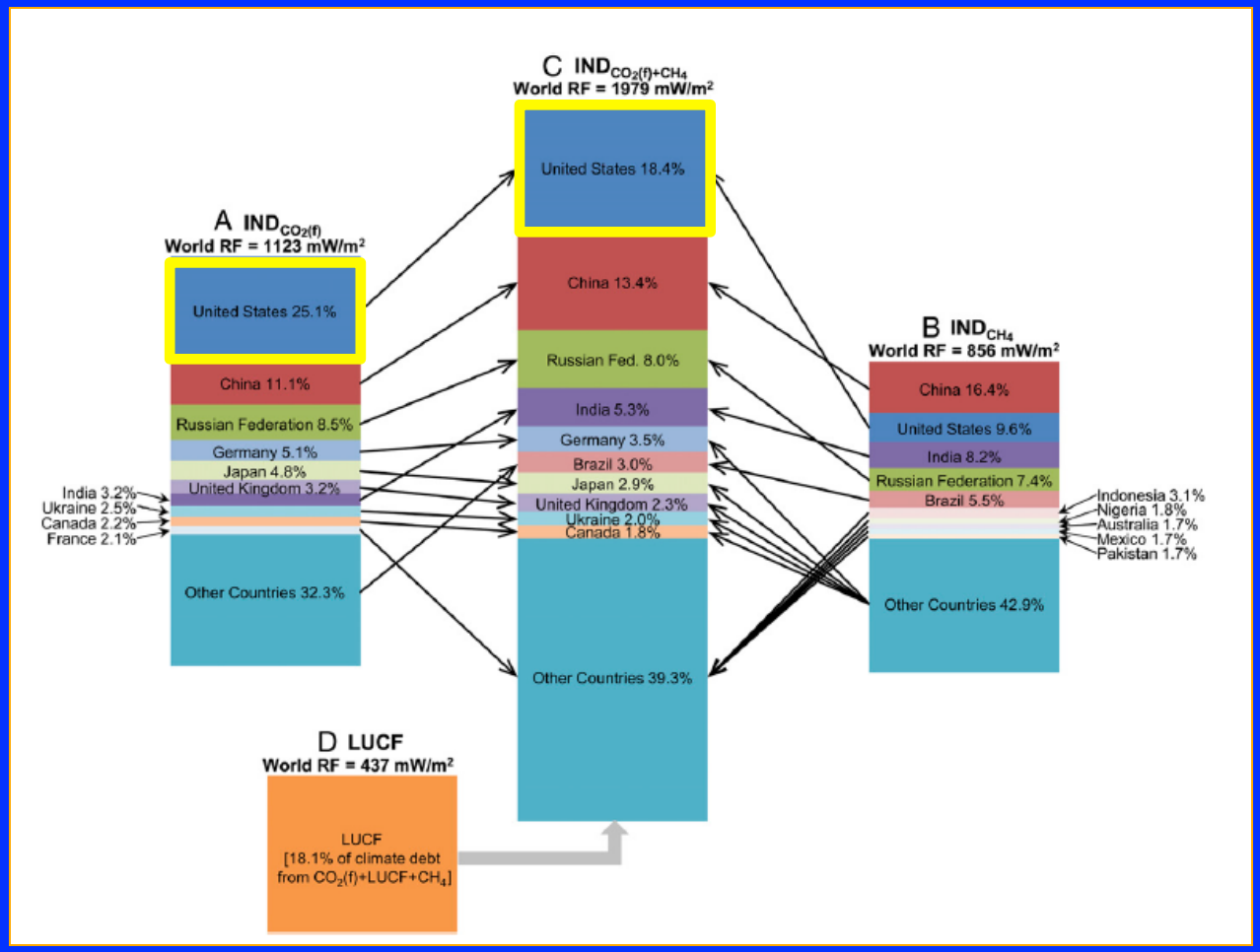
Carbon Debt – Historical Cumulative CO_2, CH_4 by Country



CO_2 and CH_4 Post 1950:

U.S. 25% of CO_2 debt
U.S. 18% of CO_2, CH_4 debt

K. Smith, PNAS (2013)

"Nations should pay back the (natural) debt in the same proportion as it was borrowed."

Key Issues: Timescales, Land use change uncertainty, Lack of official data pre 1950, …
➔ Very difficult to get consensus

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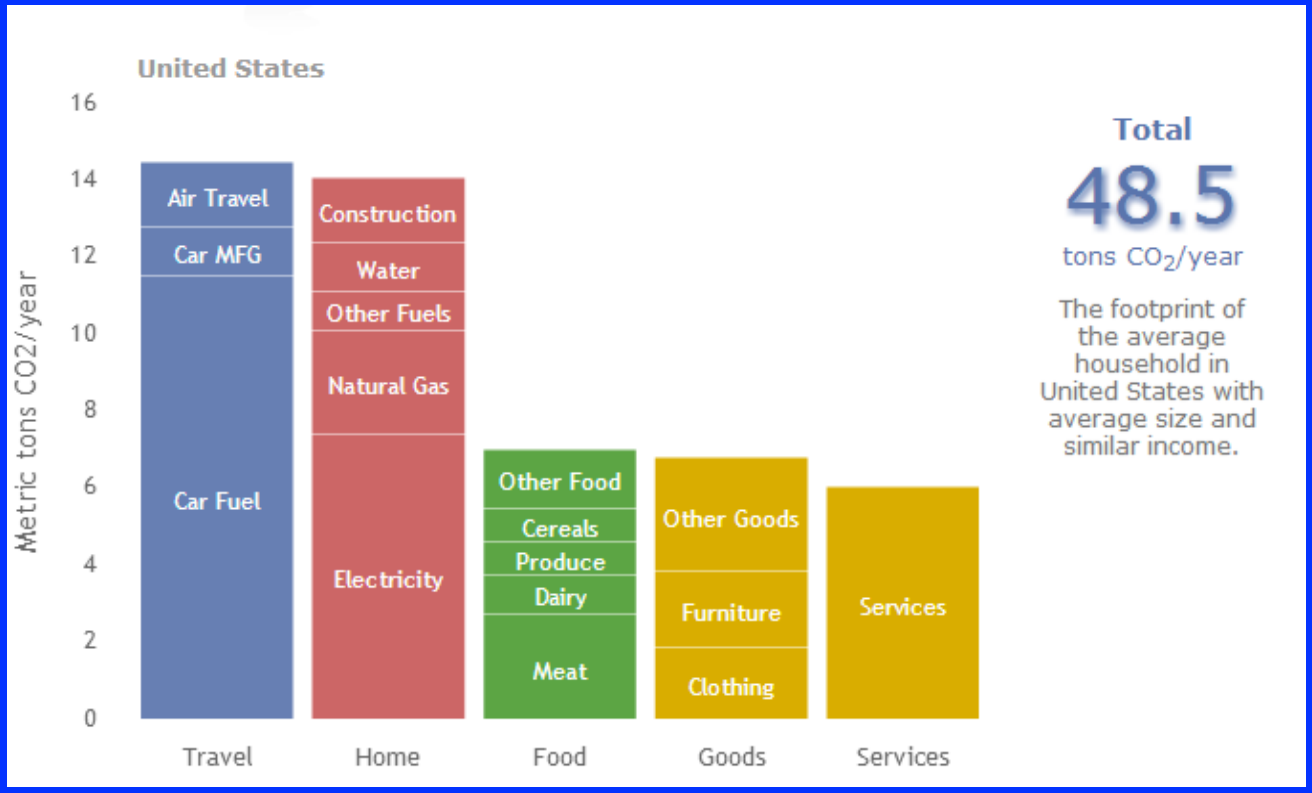
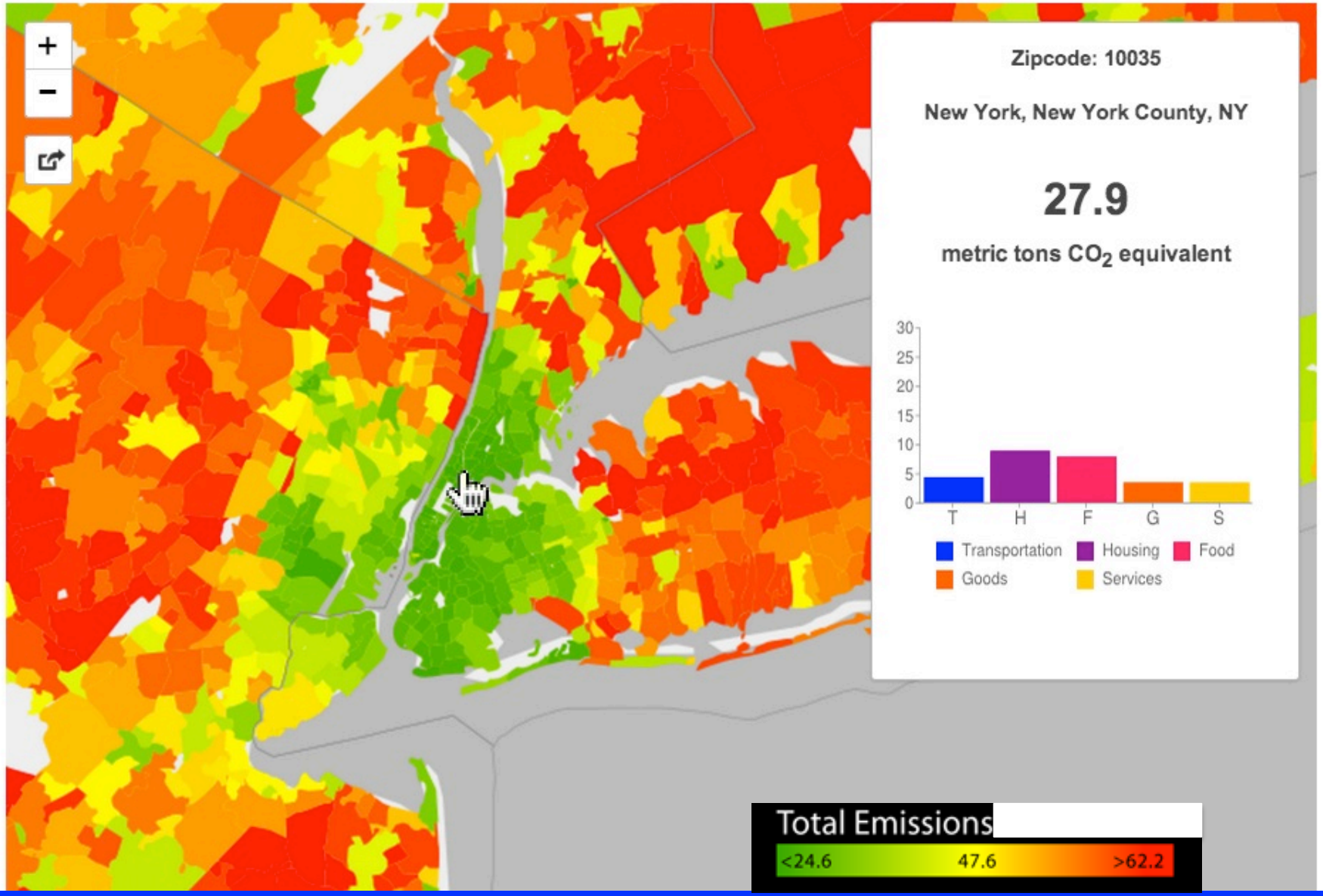
Carbon Footprint



- E.g., Cool California Carbon Calculator
- Snapshot in time + impact of changes (less driving, lower income, smaller house)
- But does not provide analysis of potential lifetime cumulative carbon (carbon legacy)

coolclimate.berkeley.edu/maps

Average Annual Household Carbon Footprint



source: CoolClimate Maps: coolclimate.berkeley.edu/maps

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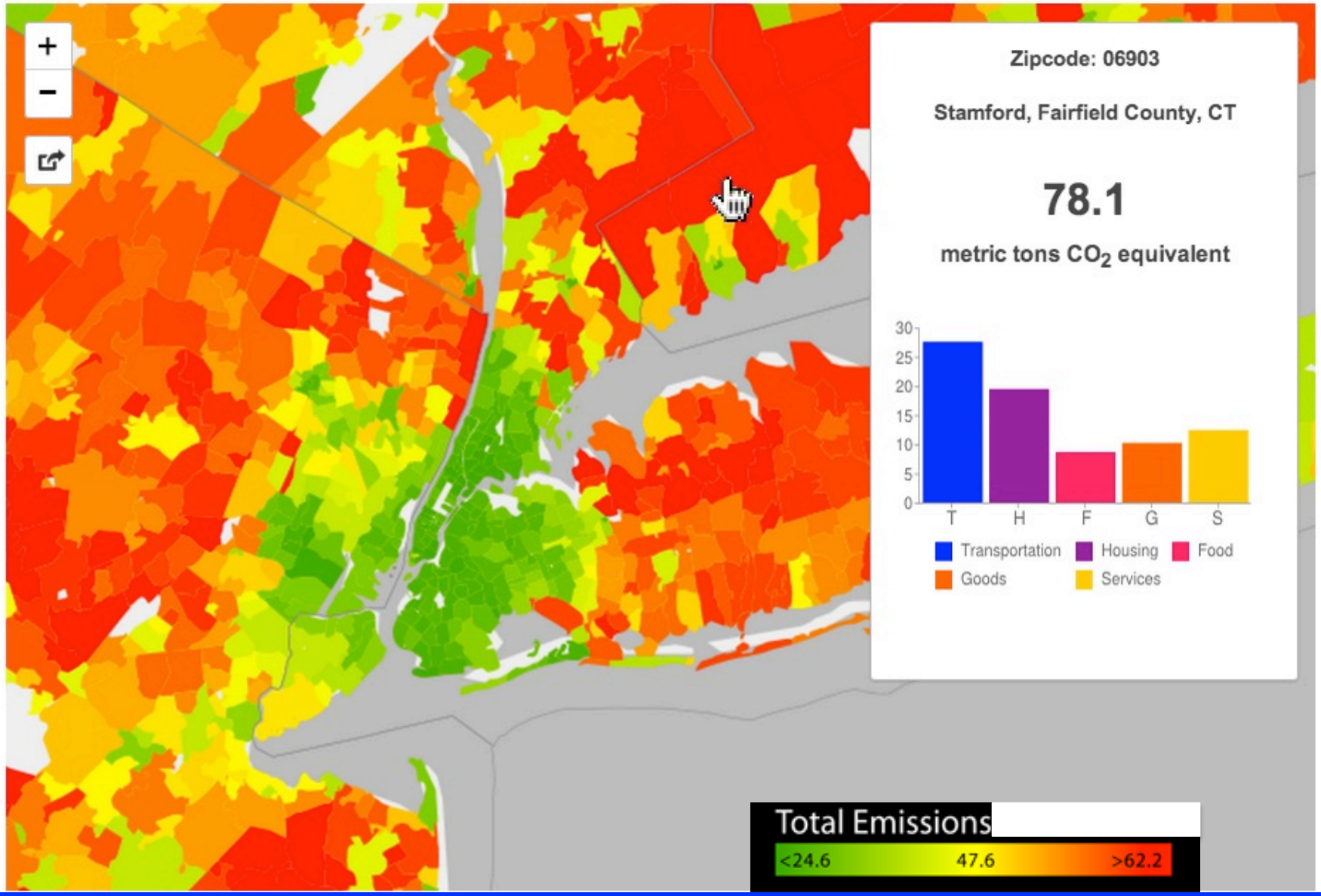

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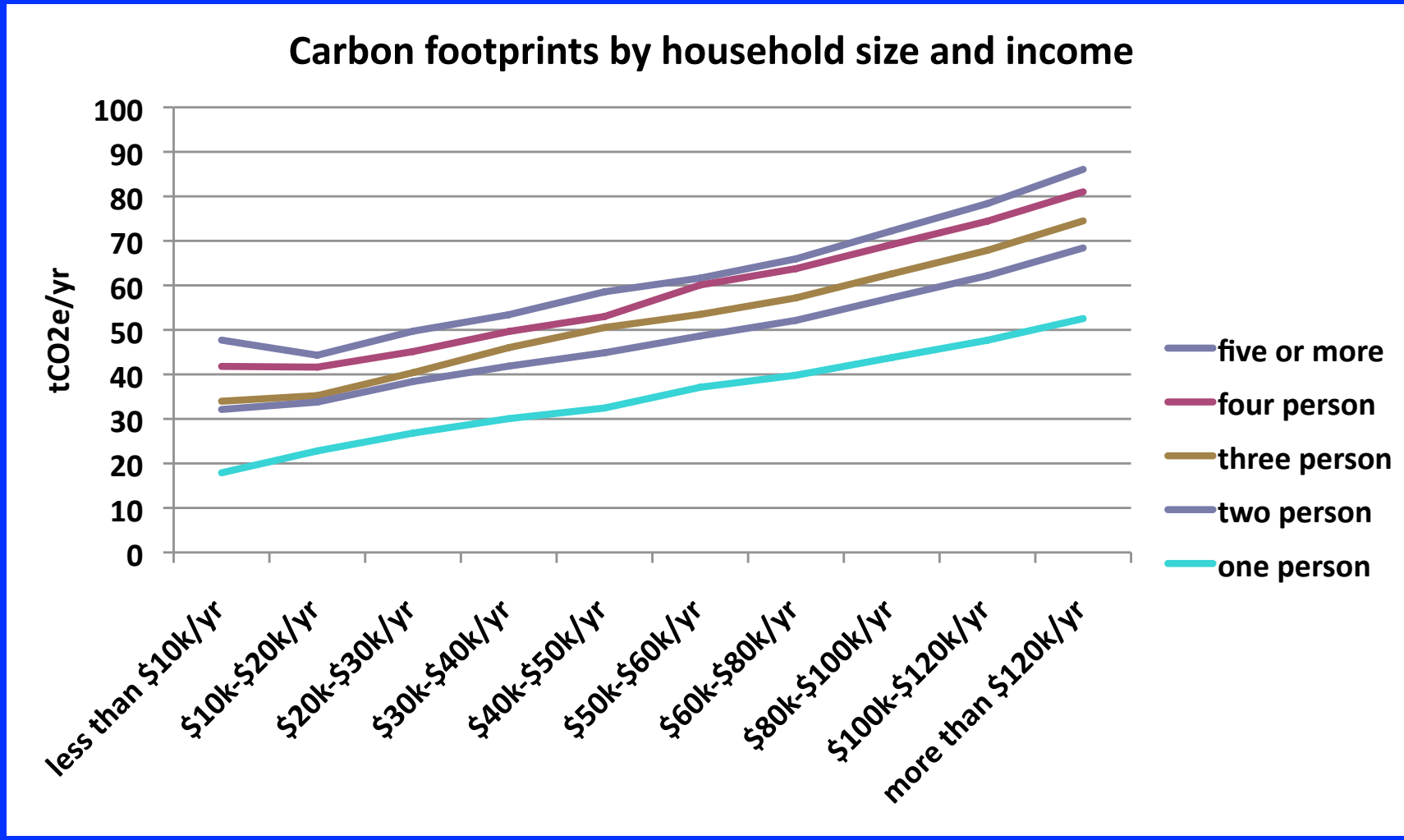
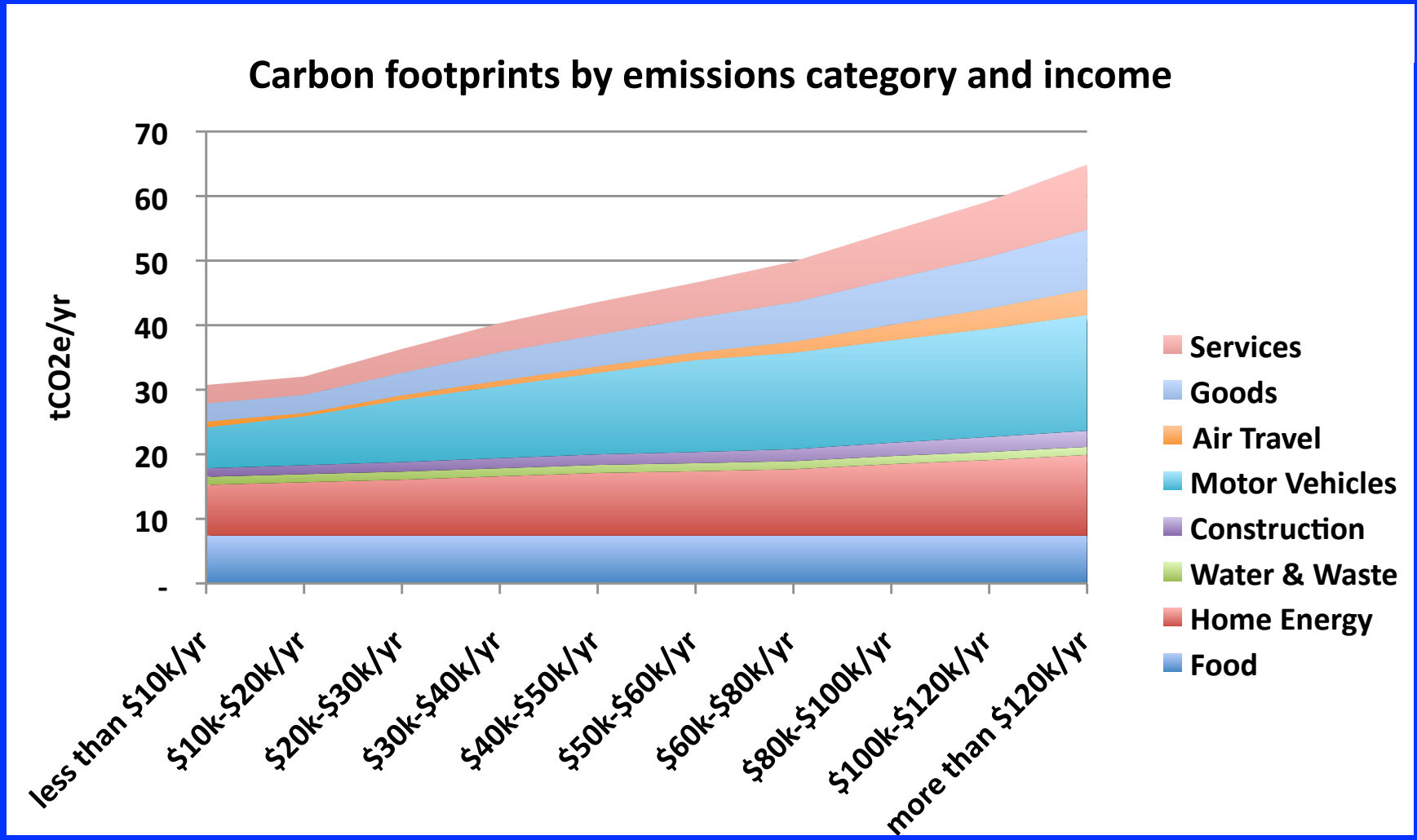


Jones, C.M. and Kammen, D.M. Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities. *Environ. Sci. Technol.*, 2011, 45 (9) pp 4088-4095



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Carbon Budget

- The IPCC issued a global carbon budget for the first time (Nov.'13):

  < 790 Gtons of carbon to keep warming < 2°C vs. pre-industrial temp*

- About 32% of budget remains

* 66% confidence

Carbon Budget

- **Why: "Policy targets based on limiting cumulative emissions likely to be more robust than emission-rate or concentration targets."**

  M. Allen, Nature, 2009

- **Net Emissions need to be at zero when the budget is expended**

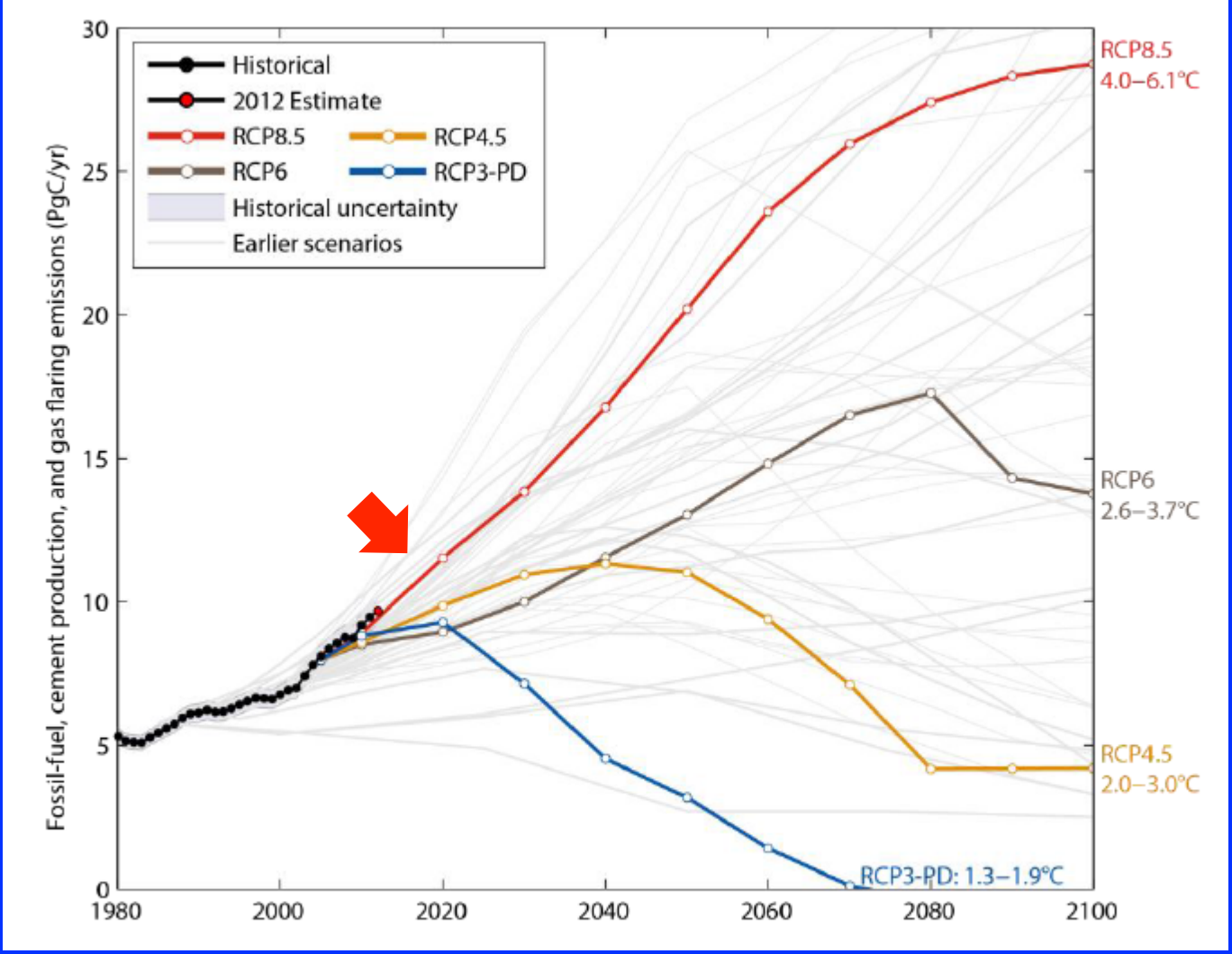
Carbon Budget

- There are no such things as an "allowable CO2 emissions." There are only "damaging CO2 emissions" or "dangerous CO2 emissions."

  K. Caldeira, 2013

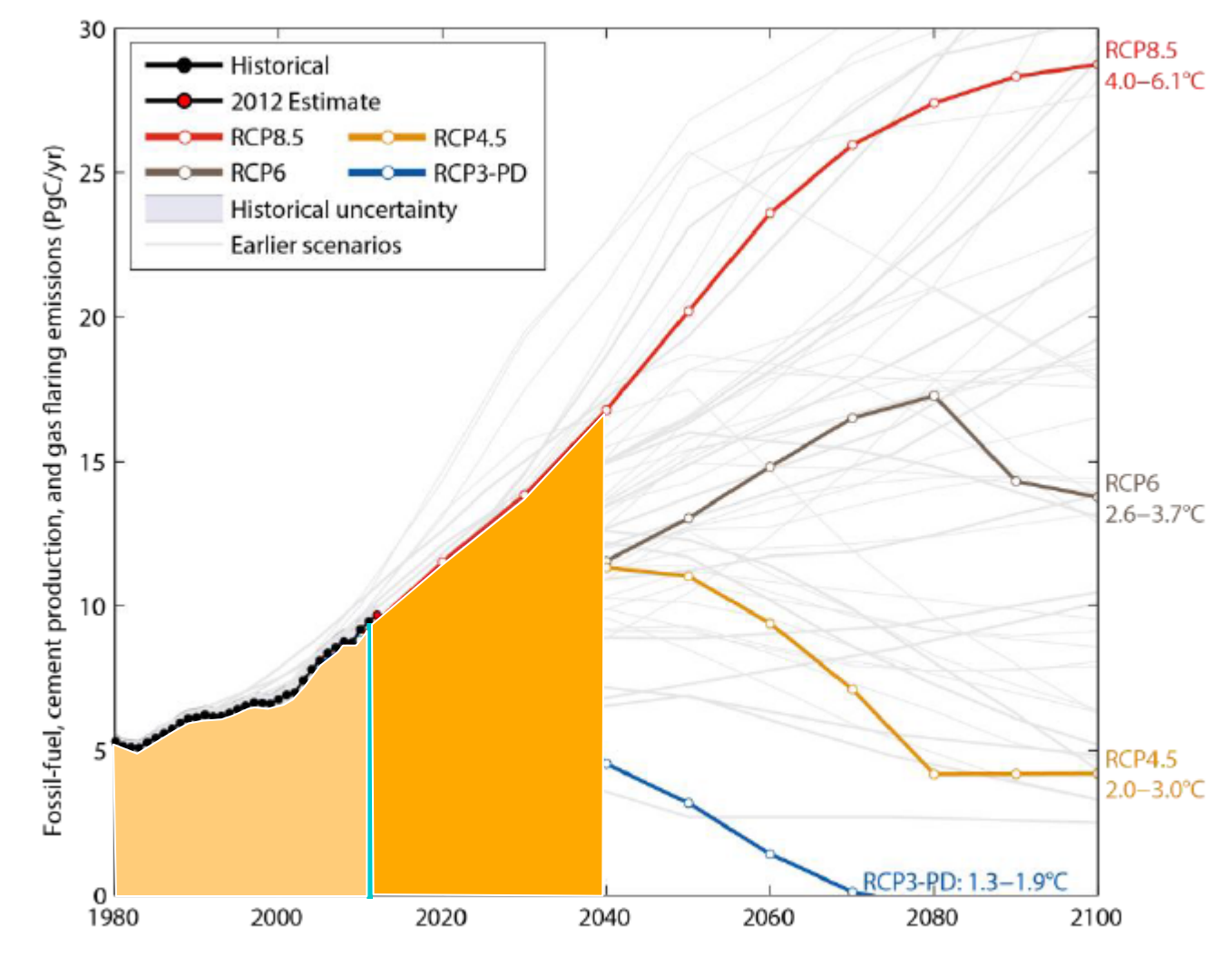
- The Carbon budget concept needs to be taken into account in climate targets e.g., multi-year targets

Current Global Emissions Path

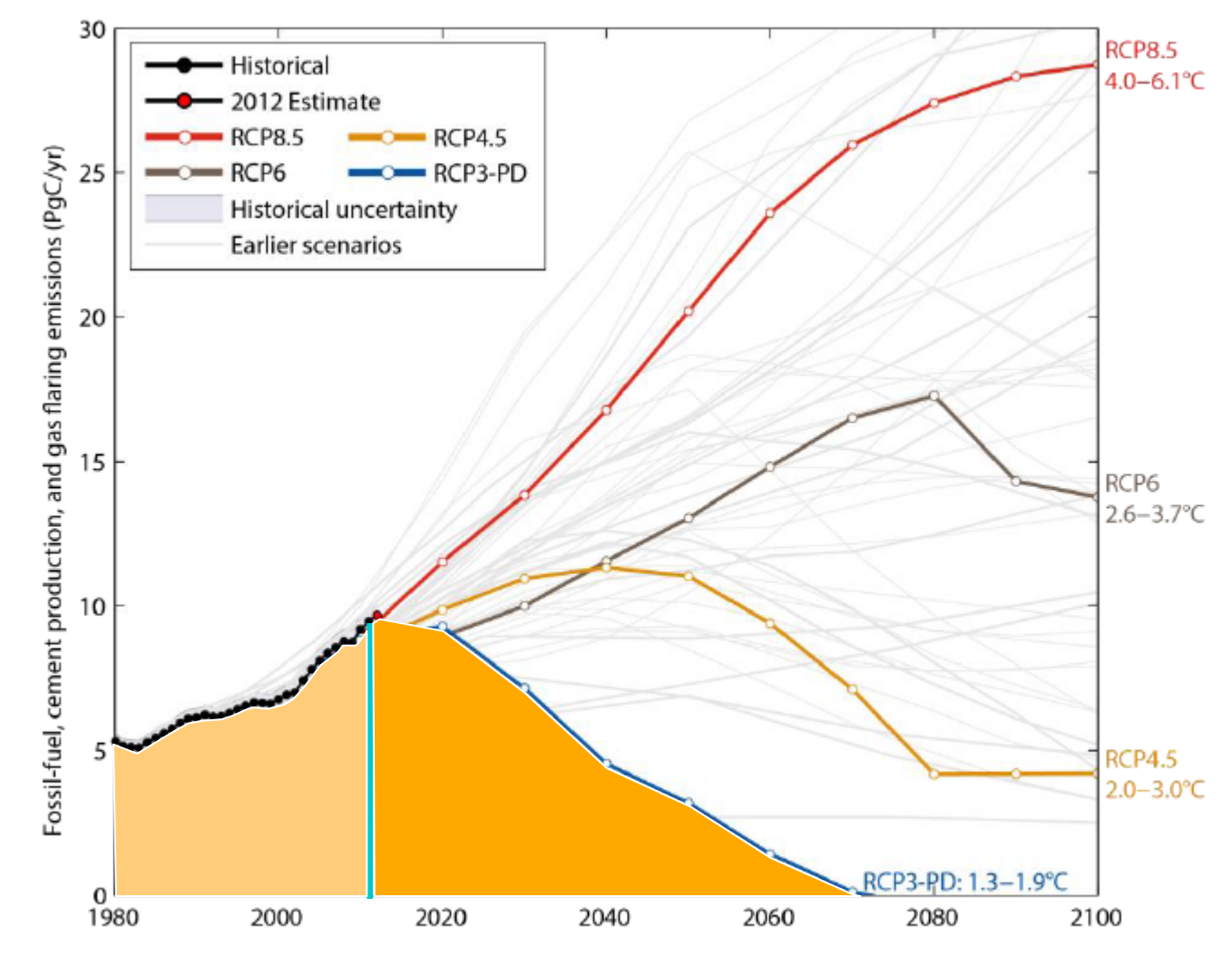


G.P. Peters, Nature Climate Change, 2013

Carbon Budget Exceeded by 2040 on Current Path



Large and Sustained Mitigation required to keep below 2°C

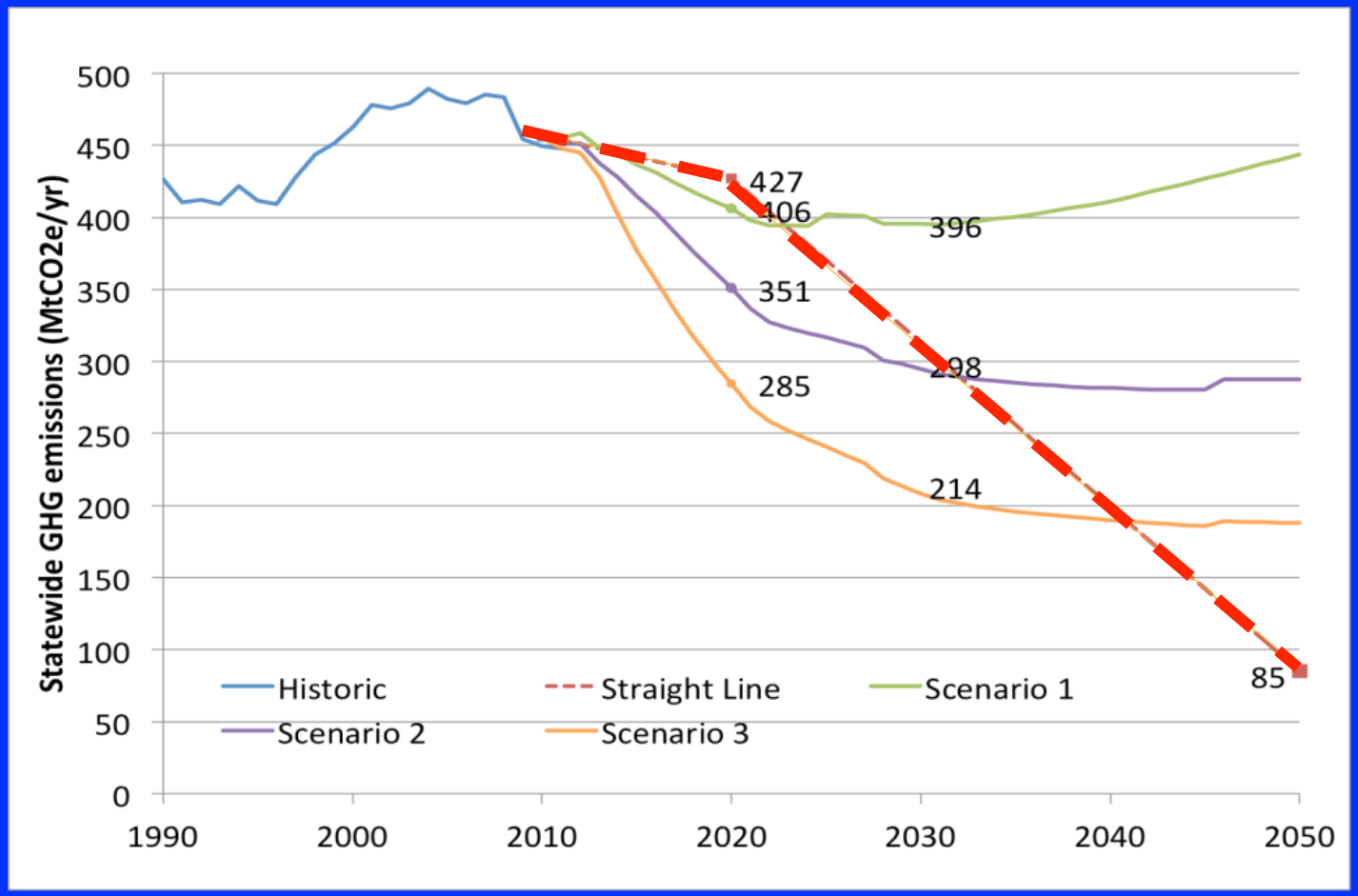


U.S. Carbon Budget

- U.S. Population weighted share: 41 Gtons CO_2
- For a 50 year timespan ➔
  - 3 tons CO_2 per adult per year
  - 150 tons CO_2 per adult over 50 years

- At current emissions rate, U.S. exceeds its budget in < 10 years
  - ~ 26 tons CO_2 per adult per year
  - ~ 1250- 1000 tons CO_2 per adult over 50 years

California Greenhouse Gas Targets: Meet 1990 level by 2020; 80% below 1990 by 2050



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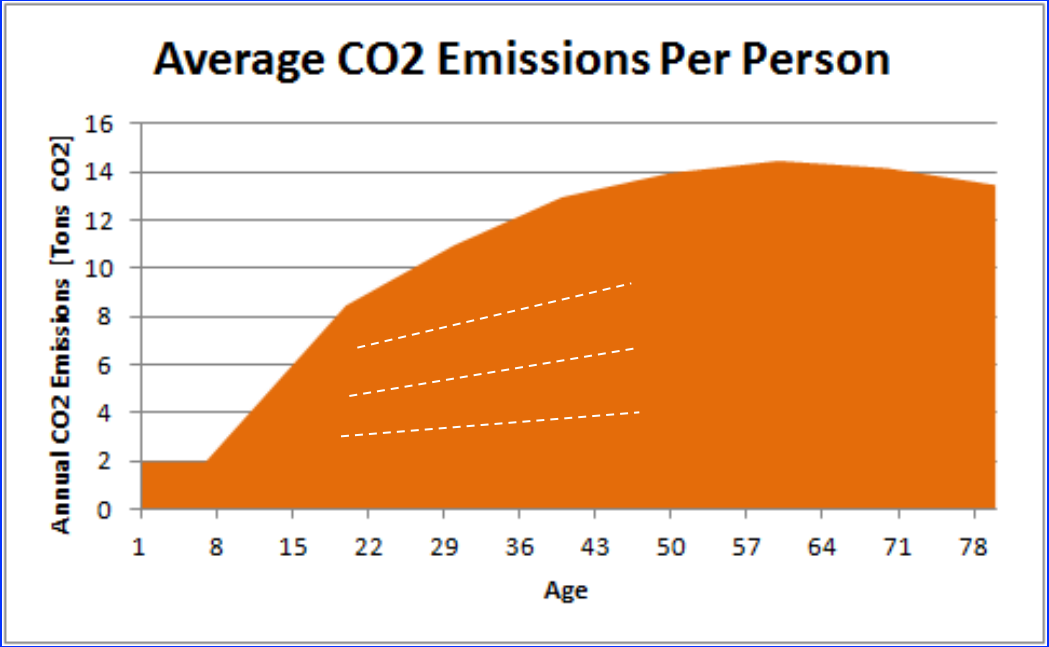
Carbon Legacy



E. Zagheni, Demography (2013)

What factors drive carbon legacy?

- Where you live
- Income
- Family size
- Driving Patterns, …

Carbon Legacy Factors

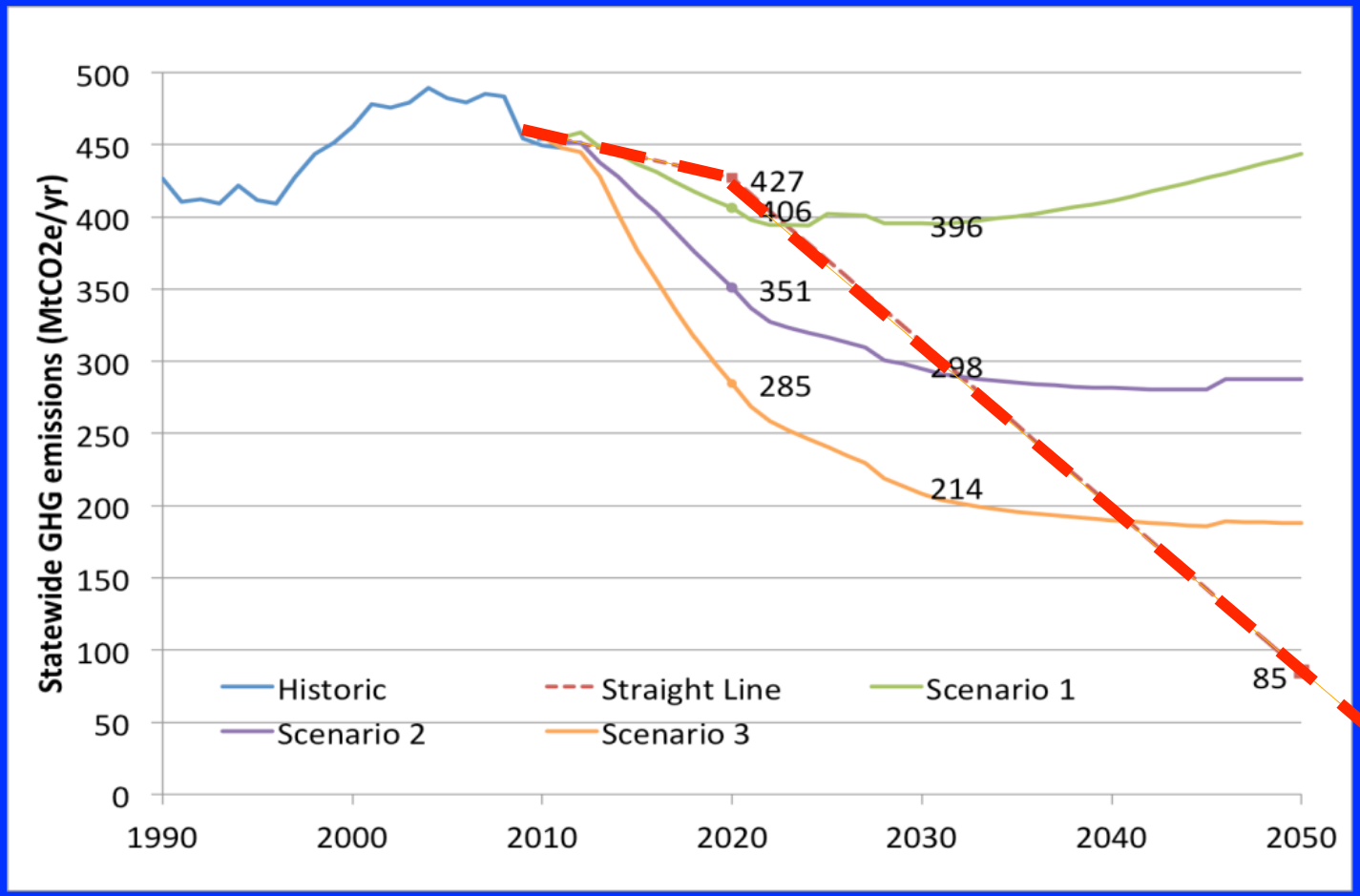
$$\sum_{\text{Lifetime Years}} \sum_{\substack{\text{All travel, Home energy,} \\ \text{Goods and Services}}} \text{Usage}_i \times \text{Energy}_i \times \text{Carbon Intensity}_i$$

Example:

$$\sum_{\text{Lifetime Years}} \text{Annual Miles driven} * \frac{\text{Gallon Gas}}{\text{Mile}} \times \frac{CO_2}{\text{Gallon Gas}}$$

vary over time and policy/technology dependent

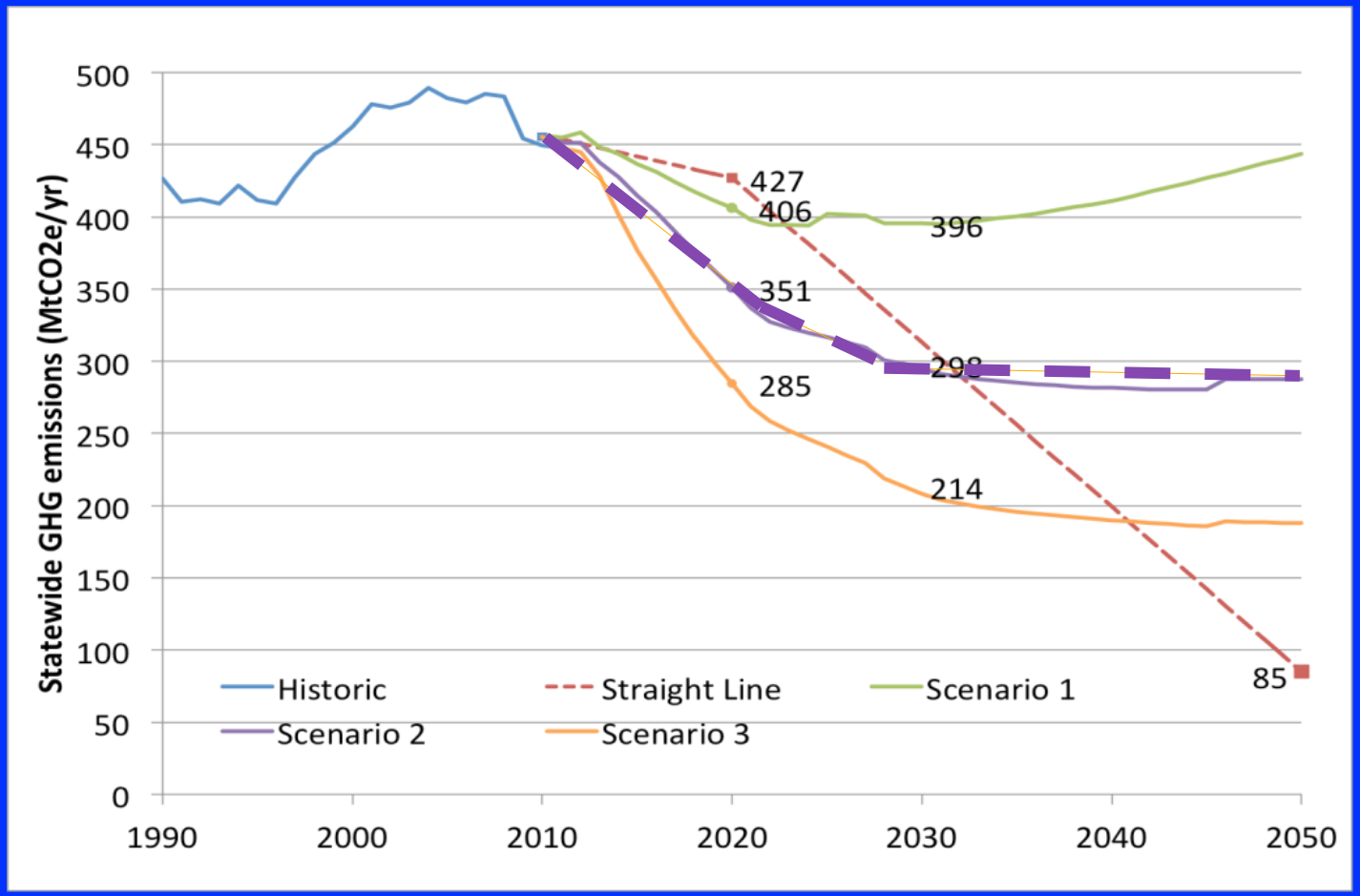
California Scenarios - 1



Meet 2050 Target and Net Zero CO2 Emissions within 50 years of today (2063)

Wei, ERL 2013; Greenblatt, CCST 2012; Williams, Science 2012

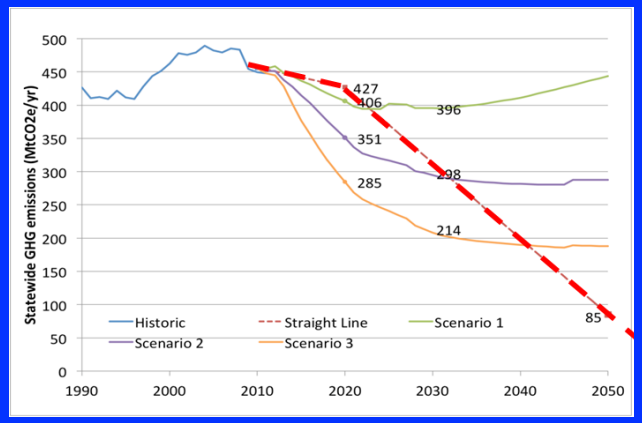
California Scenarios - 2



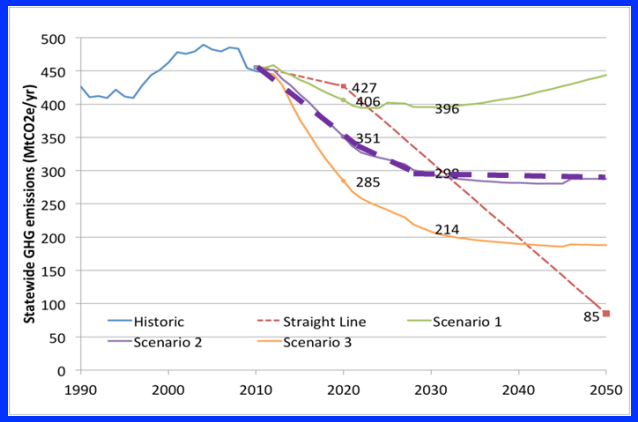
Scenario 2: "Existing Policies + Additional Uncommitted Policies"

(Greenblatt, ARB 2013)

California Scenarios



1. State targets met in 2050 and carbon neutrality within 50 years (2063)
   - ~300 tons CO2 per adult over 50 years
     - About 2X the U.S. budget

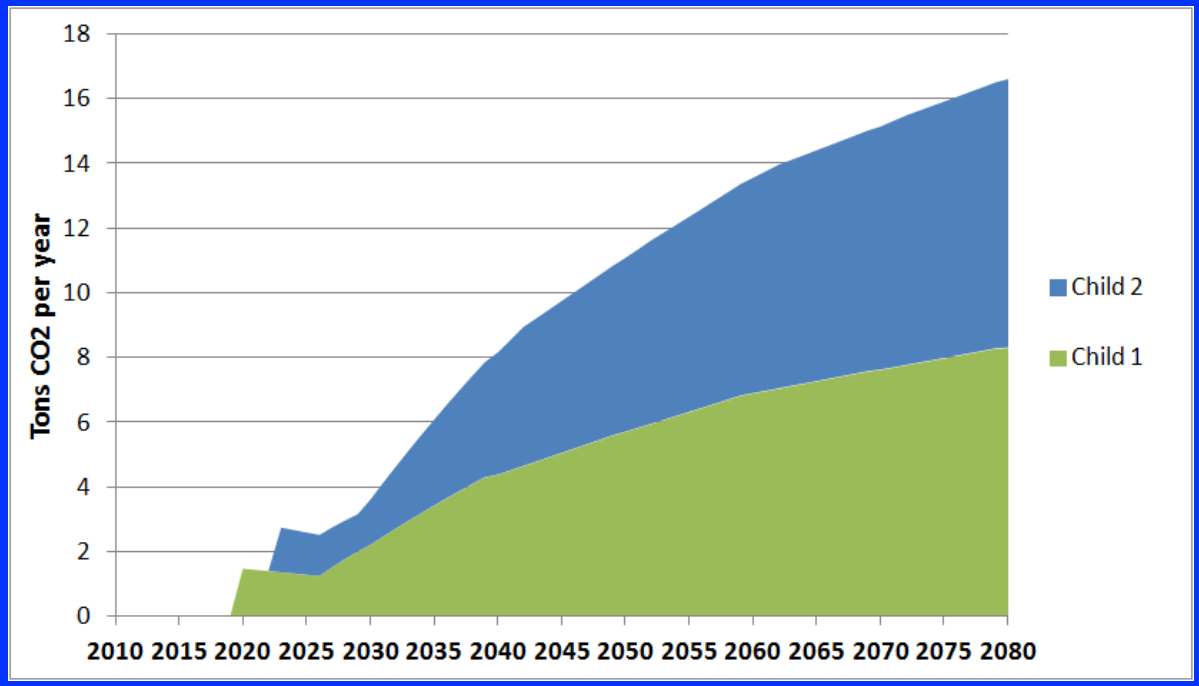


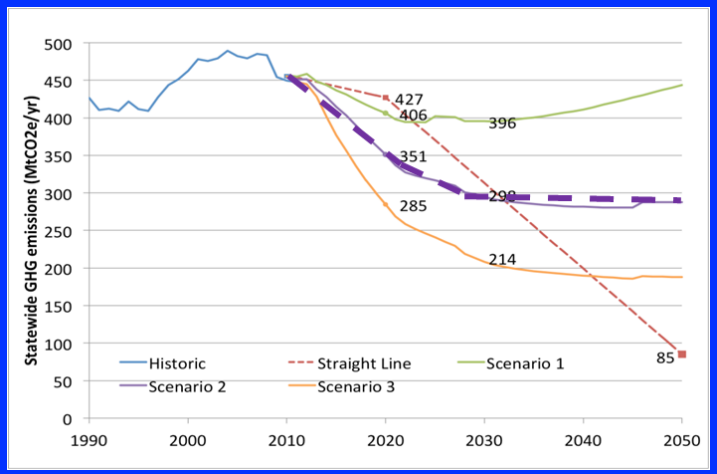
2. "Scenario 2"
   - ~400 tons CO2 per adult over 50 years
     - 2.7X the U.S. budget but still emitting in 50 years!

California Scenarios – Family Size

Each child ~ 480 tons CO_2 over 80 yr Lifetime
~ 240 tons CO_2 per parent

Each child ~50 tons CO_2 First 21 years
~ 25 tons CO_2 per parent



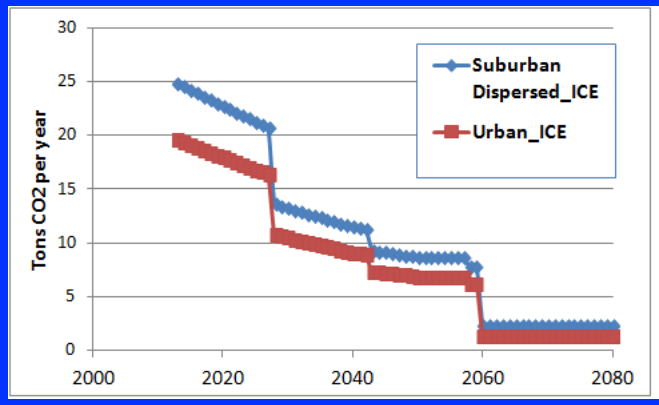


Scenario 2, "Existing Policies + Additional Uncommitted Policies"

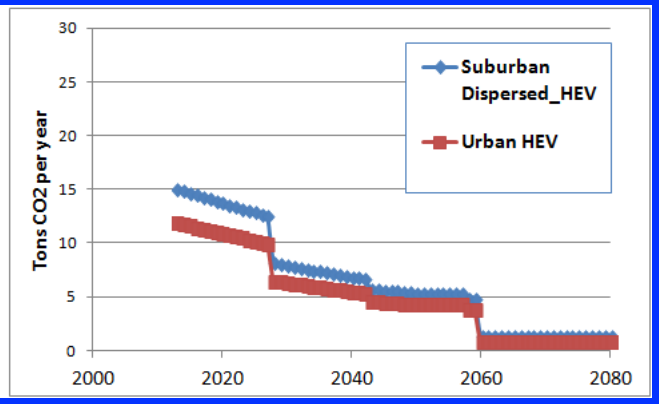
Greenblatt, ARB 2013

California Scenarios – Personal Vehicles, Bay Area

Location Effect

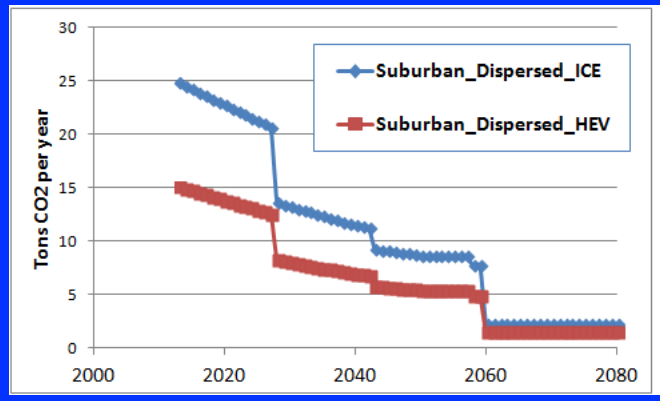


148 tons CO2 saved, 50 yrs
~ 74 tons CO2 per adult

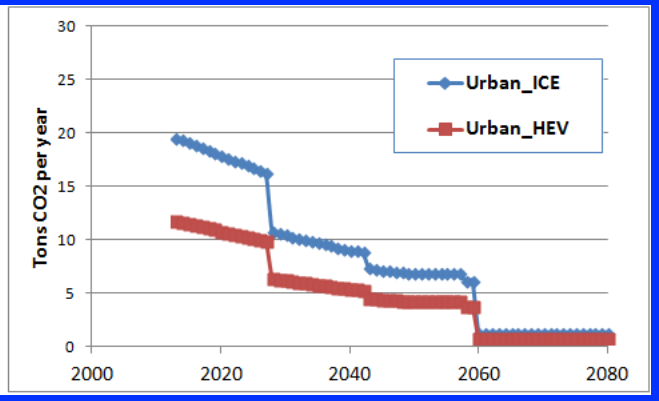


90 tons CO2 saved, 50 yrs
~ 45 tons CO2 per adult

Vehicle-Type Impact



268 tons CO2 saved, 50 yrs
~ 134 tons CO2 per adult



210 tons CO2 saved, 50 yrs
~ 105 tons CO2 per adult

Median income, Multi-worker, Multi-vehicle household (Brazil, Purvis, MTC BASSTEG Travel Survey, 2000; Greenblatt, ARB 2013, Scenario 2 MPG and biofuels)

California Scenarios – Personal Vehicles, Bay Area

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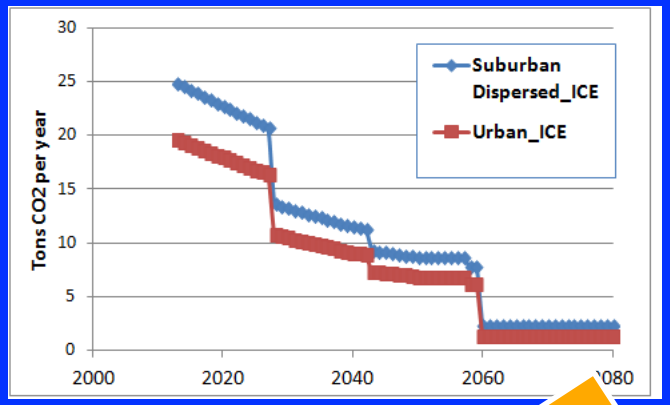

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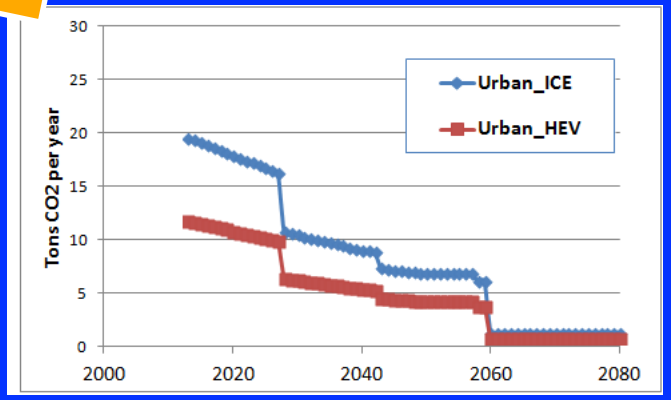


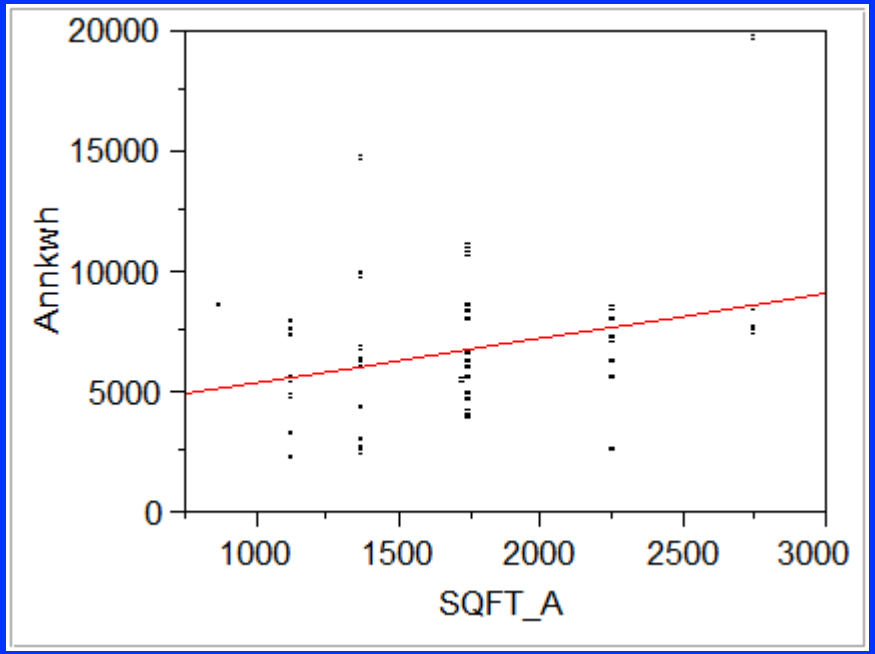
357 tons CO2 saved, 50 yrs
~ 179 tons CO2 per adult

Median income, Multi-worker, Multi-vehicle household (Brazil, Purvis, MTC BASSTEG Travel Survey, 2000; Greenblatt, ARB 2013, Scenario 2 biofuels)

Housing Size Impact

- Correlation of energy use with single family housing size is very poor
  - Controlling for multiple factors (Income, family size and composition, climate zone, housing age)
  - Driven by many other factors (including behavior)

Annual Electricity Consumption vs. Single Family Home Size



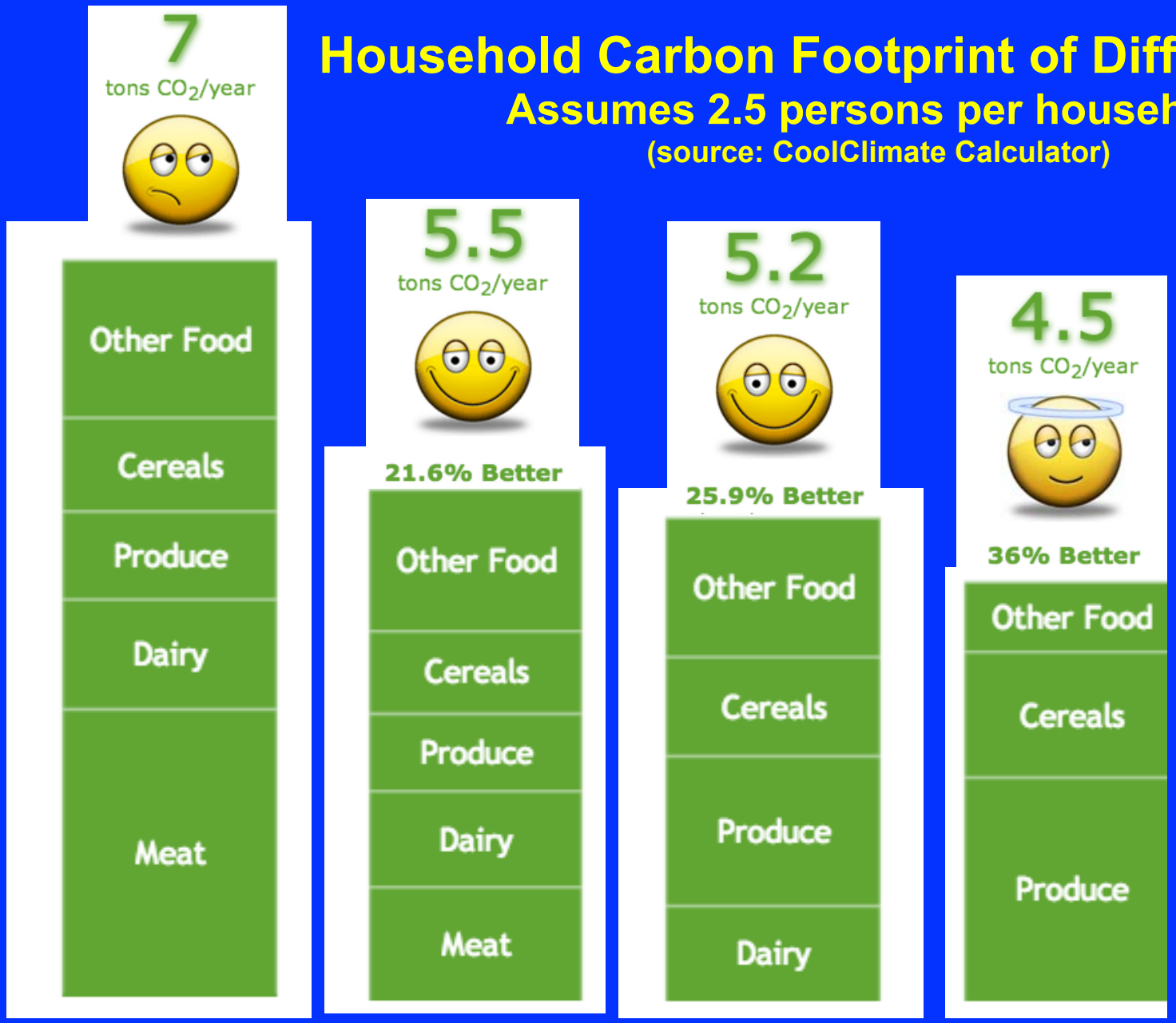
Bay Area, Single Family homes, 2 adults, 1 child, $87.5k annual income

California Residential Appliance Saturation Survey (RASS), CEC/KEMA, 2003

Household Carbon Footprint of Different Diets

Assumes 2.5 persons per household

(source: CoolClimate Calculator)



Max Savings
~1 ton CO_2
Per person
Per year

or
< 50 tons
CO_2/ 50 years

Conclusions

- A carbon budget of ~ 150 tons CO_2 per adult over next 50 years is derived from the IPCC global budget and U.S. pop.-weighted share
- Cumulative carbon is an important concept to frame carbon reduction activities and decisions
  - Dependent upon individual actions/choices + future energy system trajectory set by policies/markets
- Preliminary assessment of "key life decisions" suggest vehicle technology type, housing location, and family size are among the important factors for your carbon legacy

Thank You

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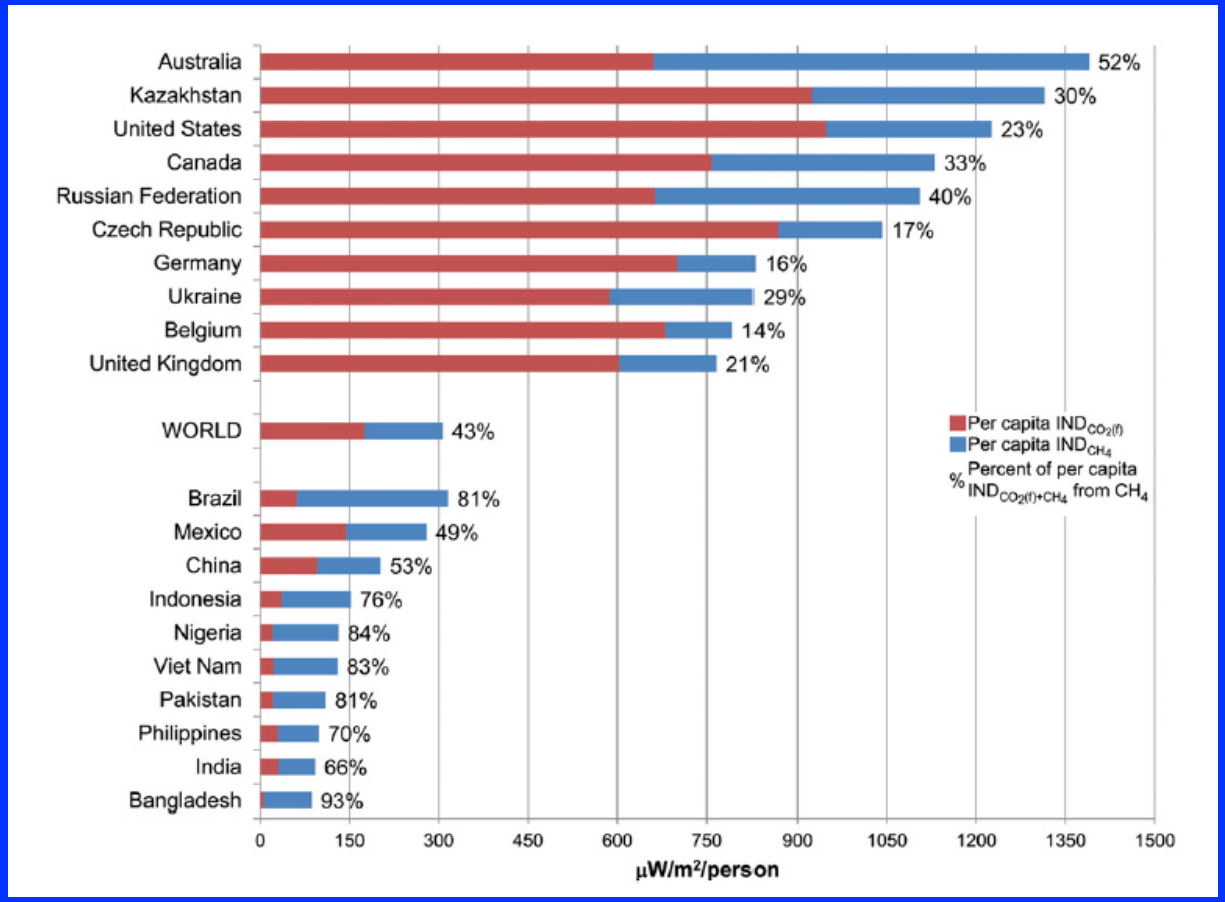
Backup Slides

Notes

- NB – average VMT by cohort; have overlapping distributions

Carbon Debt - Cumulative CO2, CH4 Per Capita by Country - SKIP



CO_2 (red) and CH_4 (blue) Post 1950

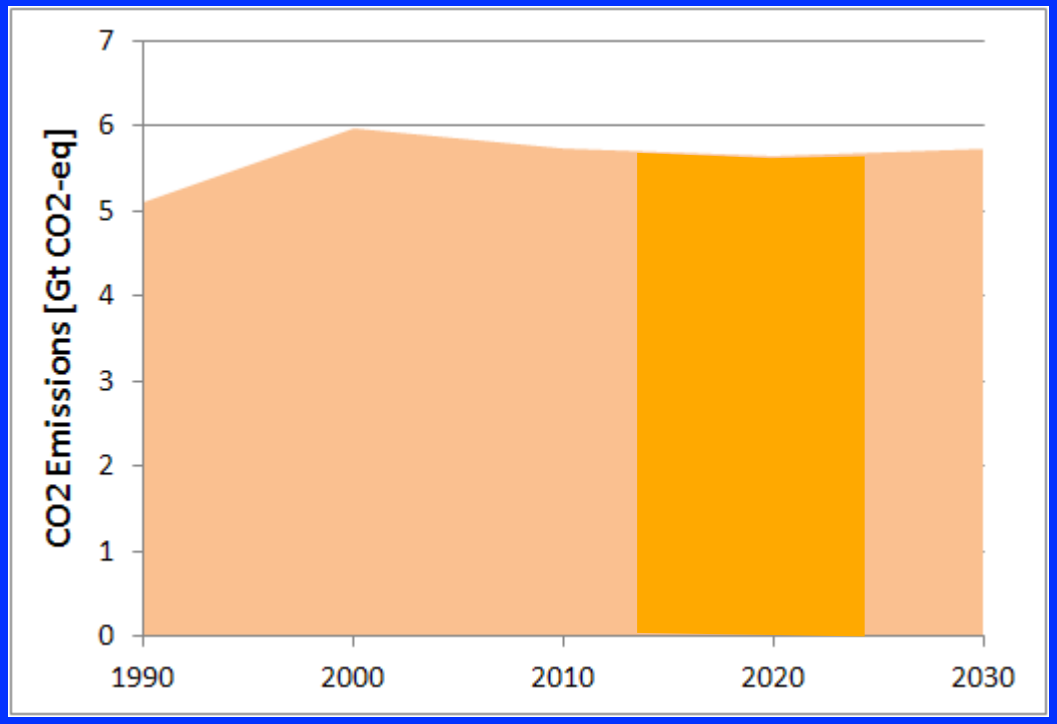
U.S. Per cap CO_2, CH_4 debt: 6X China 13X India

K. Smith, PNAS (2013)

Including Methane shifts "accountability" distribution

Methane possibly lower hanging fruit – waste management, fossil fuel system leakage

U.S. Carbon Budget Exceeded in less than 10 years with BAU



DOE/EIA 2013