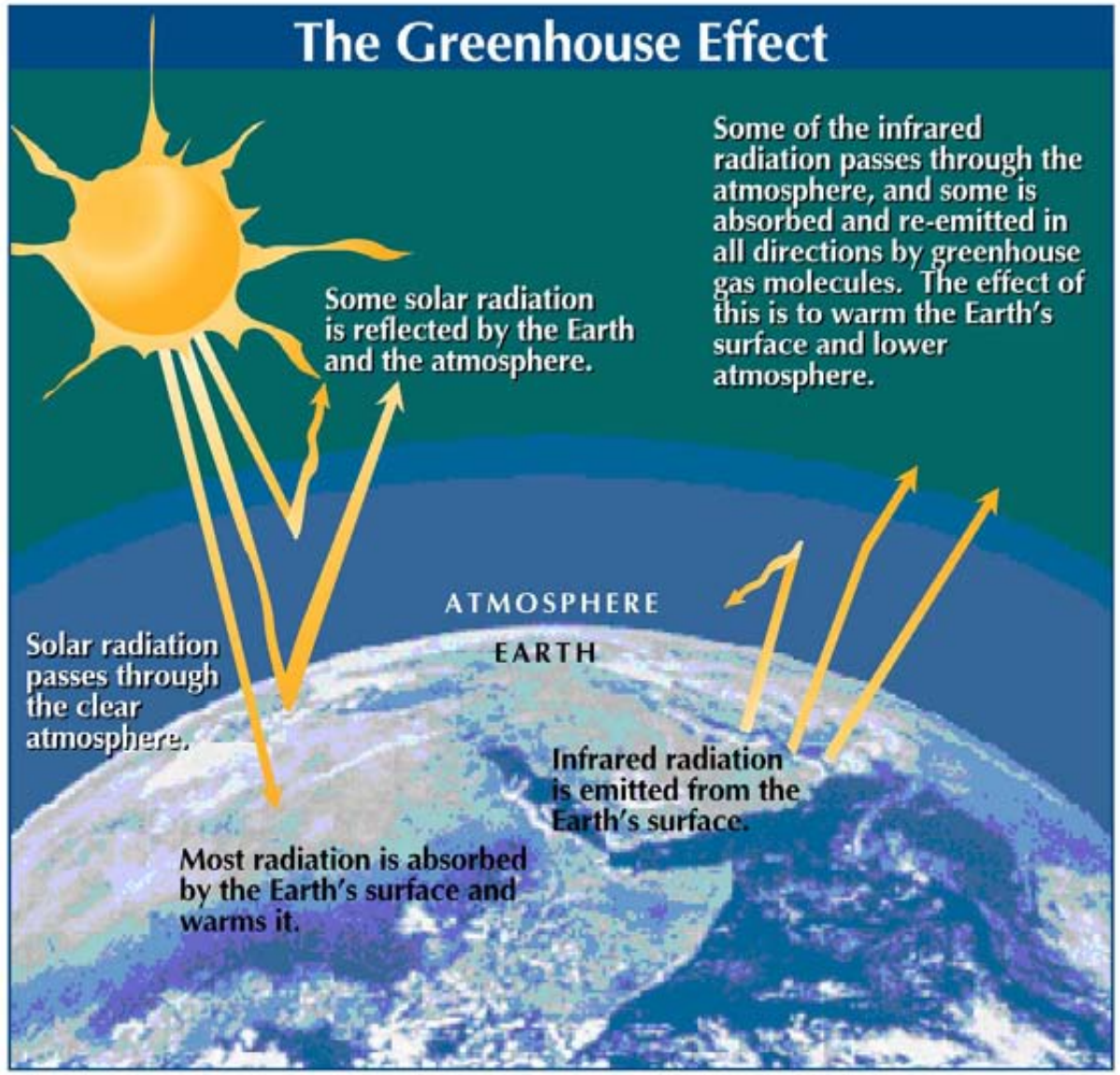
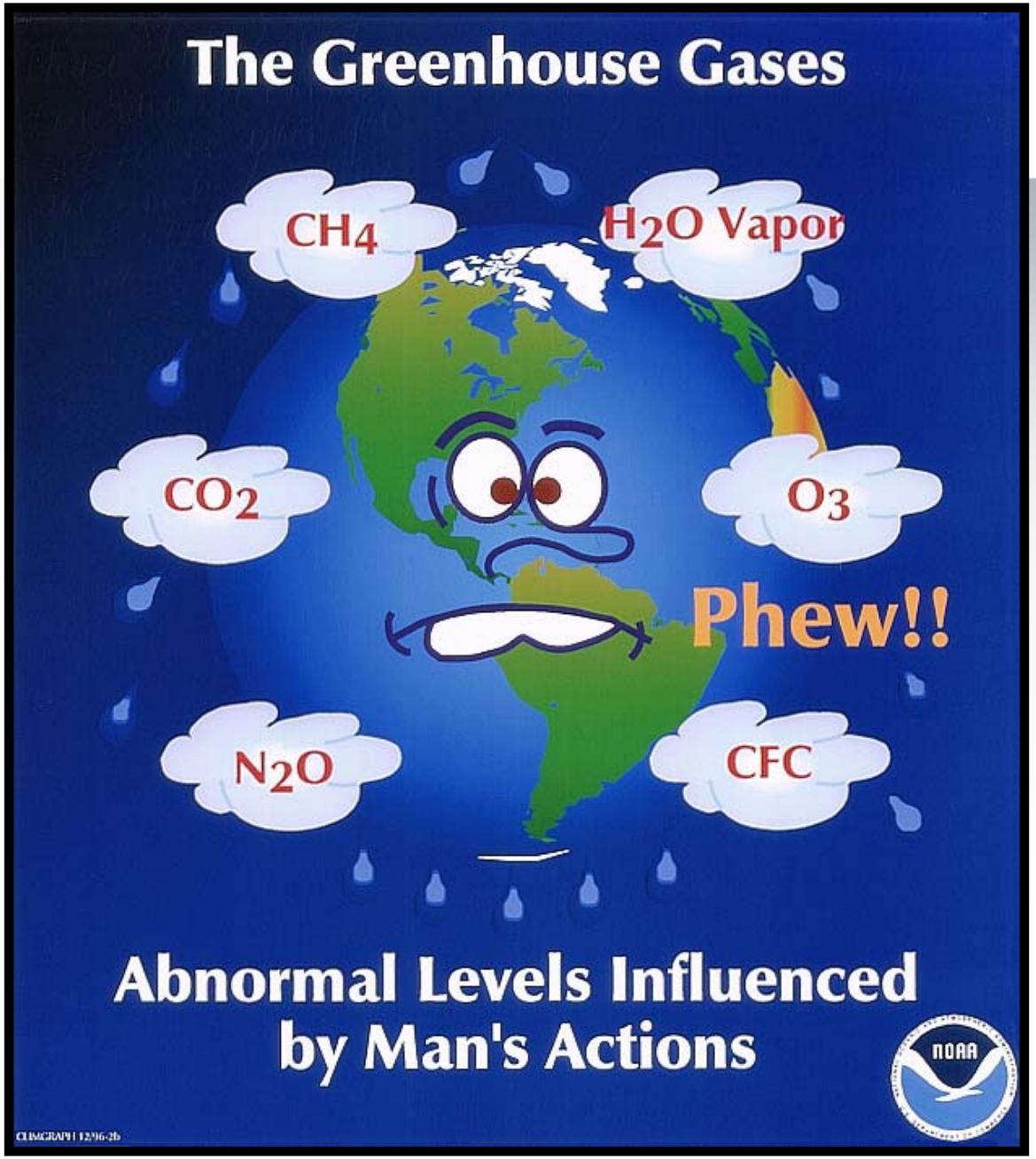
Climate Change 101

Ben Machol
U.S. Environmental Protection Agency, Region 9
June 23, 2009

Outline

- Climate Change Impacts (video)
- Greenhouse Gases
- Energy and Energy Consumption
- Life Cycle Assessment
- What Can You Do?


The Greenhouse Effect
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and lower atmosphere.
Some solar radiation is reflected by the Earth and the atmosphere.
ATMOSPHERE
EARTH
Solar radiation passes through the clear atmosphere.
Infrared radiation is emitted from the Earth's surface.
Most radiation is absorbed by the Earth's surface and warms it.



NOAA Slides by Forecast Systems Laboratory.

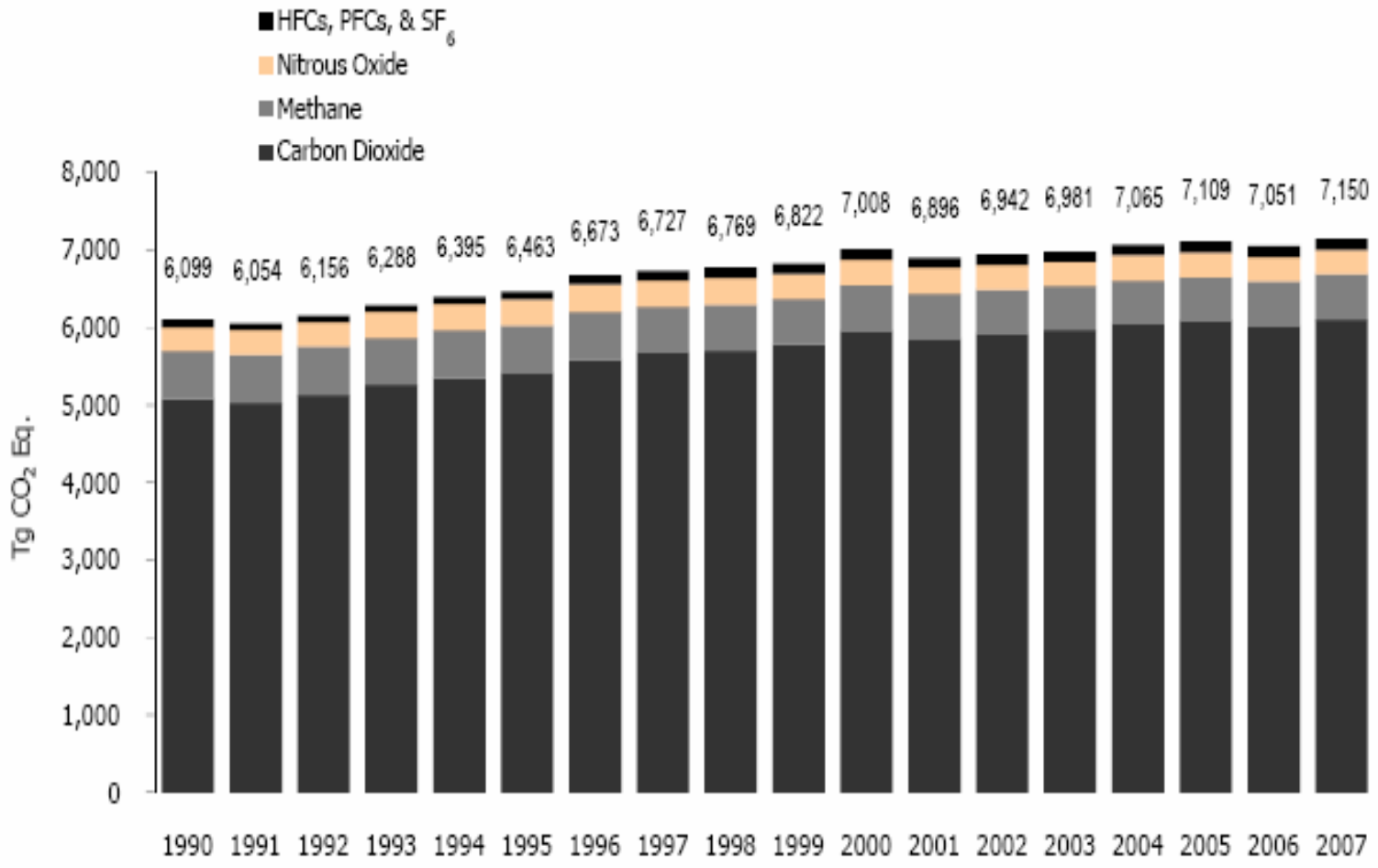
How Strong Are the Greenhouse Gases?

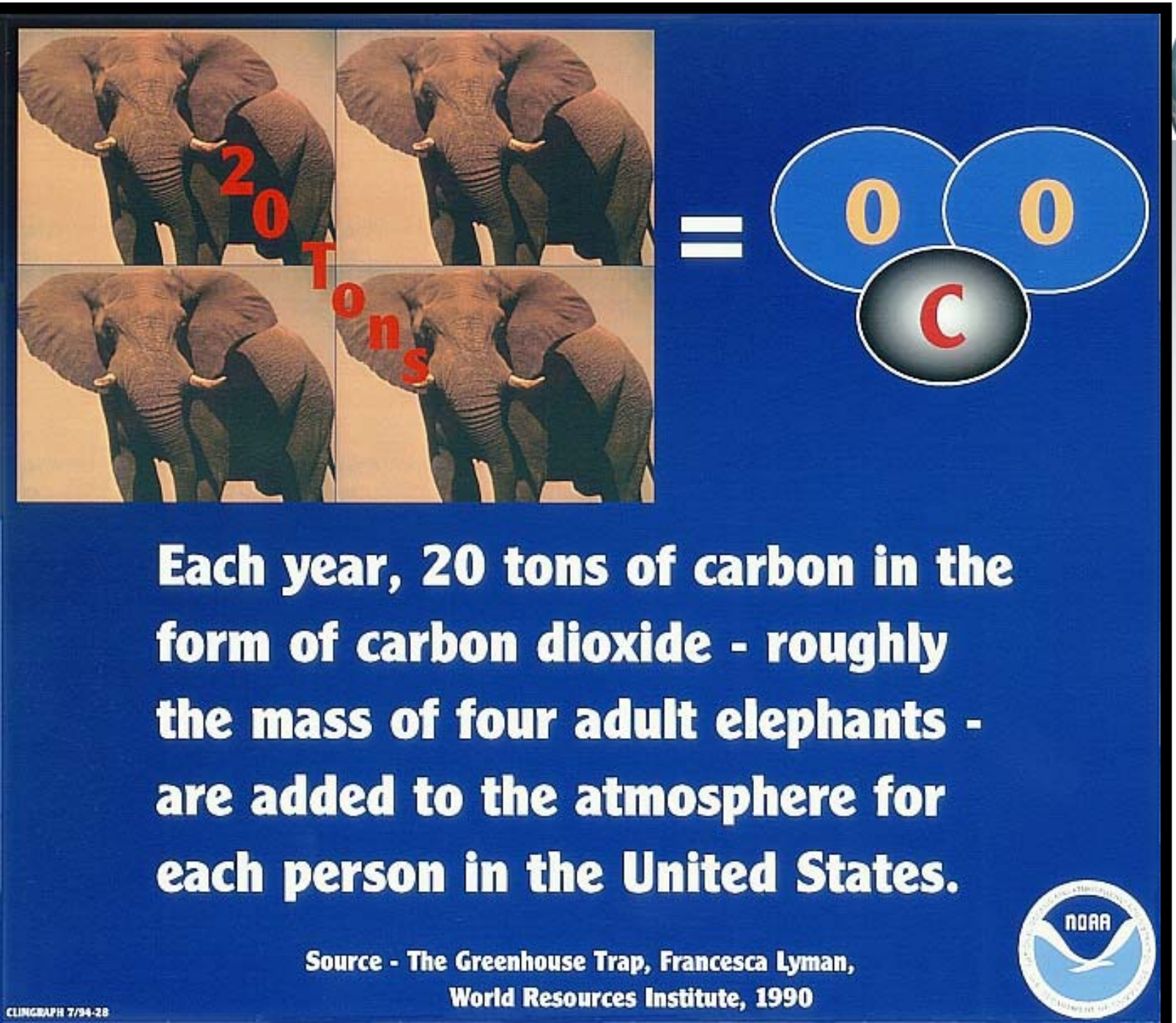
CO_2 Equivalency (Warming Potential)

- Carbon Dioxide, CO2 **1 x CO_2 , ≈ 100 year life**
- Methane, CH4 **23x CO_2 ,12 year life**
- Nitrous Oxide, N2O **296x CO_2, 114 year life**
- High Global Warming Potential Gases (Fluorinated Gases)
  - Hydrofluorocarbons, HFCs **Up to 12,000x CO_2**
  - Perfluorocarbons, PFCs **Up to 11,900x CO_2**
  - Sulfur Hexafluoride, SF6 **22,200x CO_2**

3,200 year life!!

U.S. Greenhouse Gases – By Gas




20 Tons
=
O
O
C
Each year, 20 tons of carbon in the form of carbon dioxide - roughly the mass of four adult elephants - are added to the atmosphere for each person in the United States.
Source - The Greenhouse Trap, Francesca Lyman, World Resources Institute, 1990
NOAA
CLINGRAPH 7/94-28

U.S. Greenhouse Gases – By Economic Sector

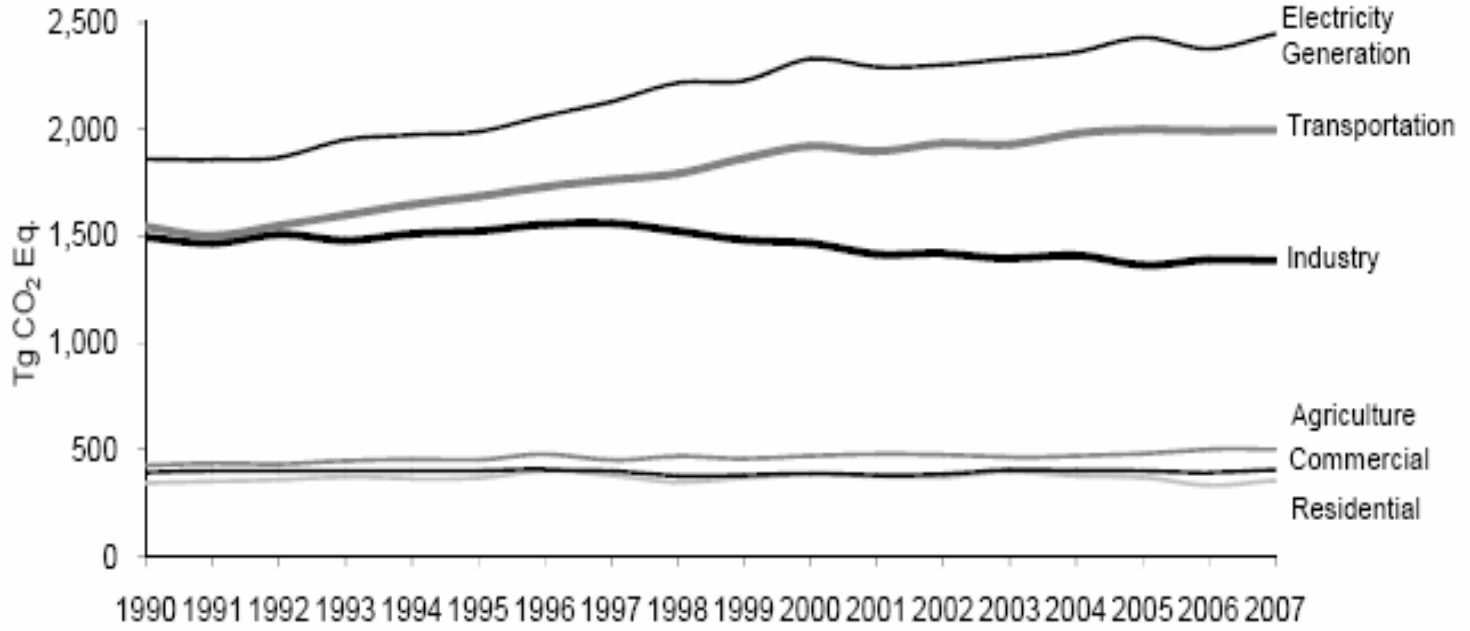
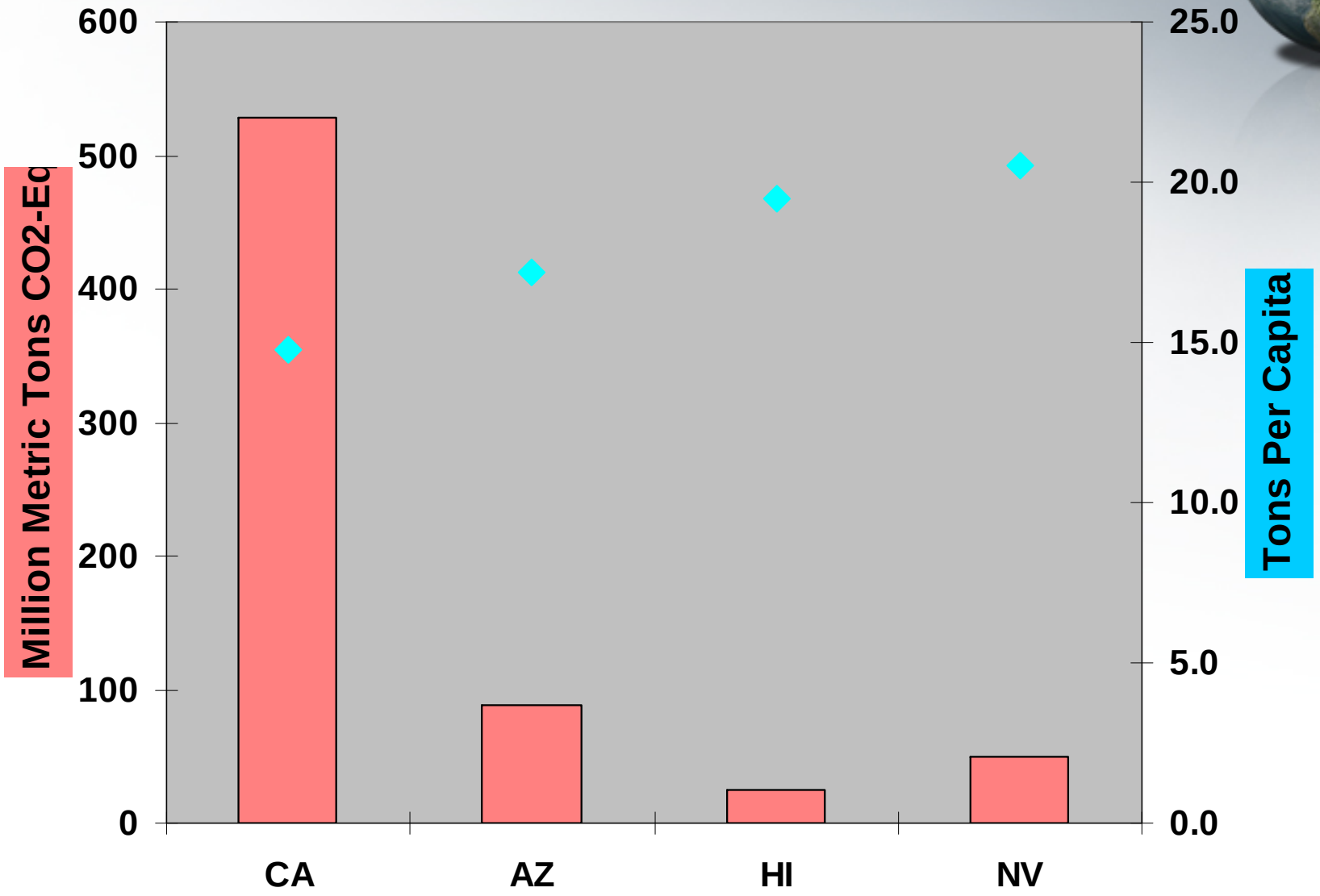


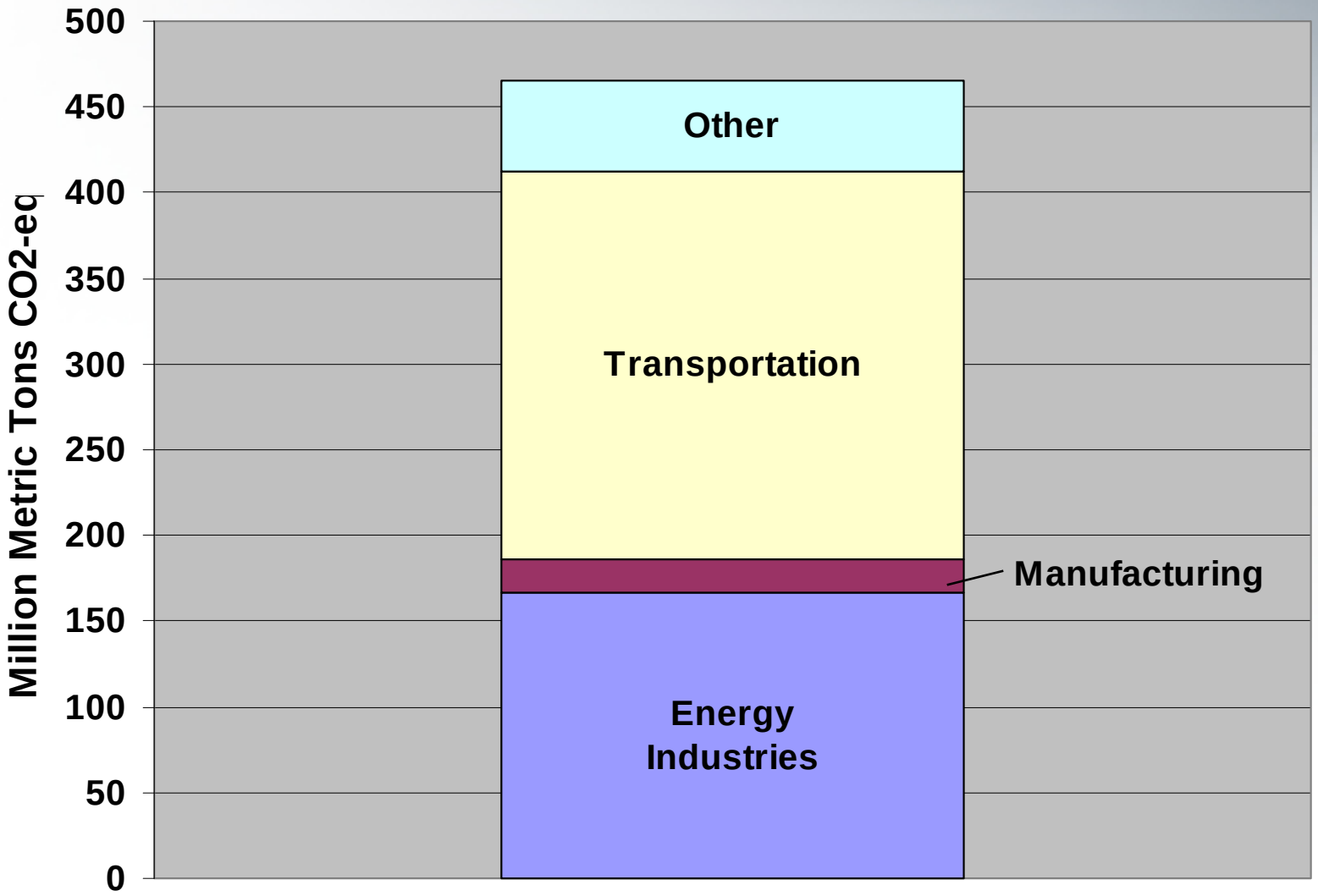
Figure 2-12: Emissions Allocated to Economic Sectors

Note: Does not include U.S. Territories.

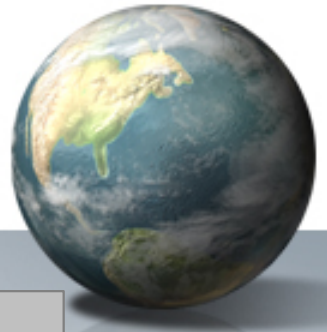
EPA Region 9 GHG Emissions

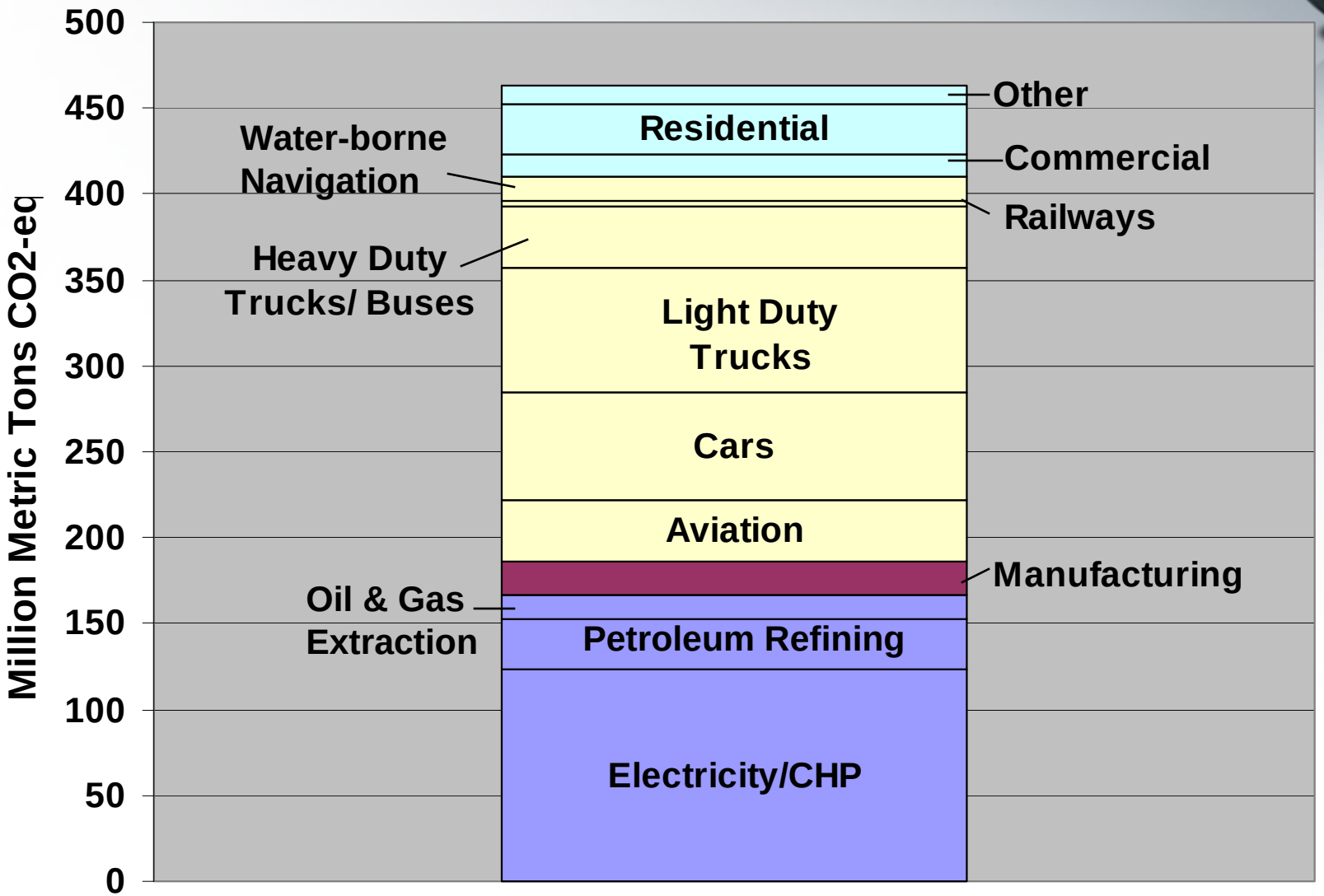


California GHG Emissions – Energy Sector

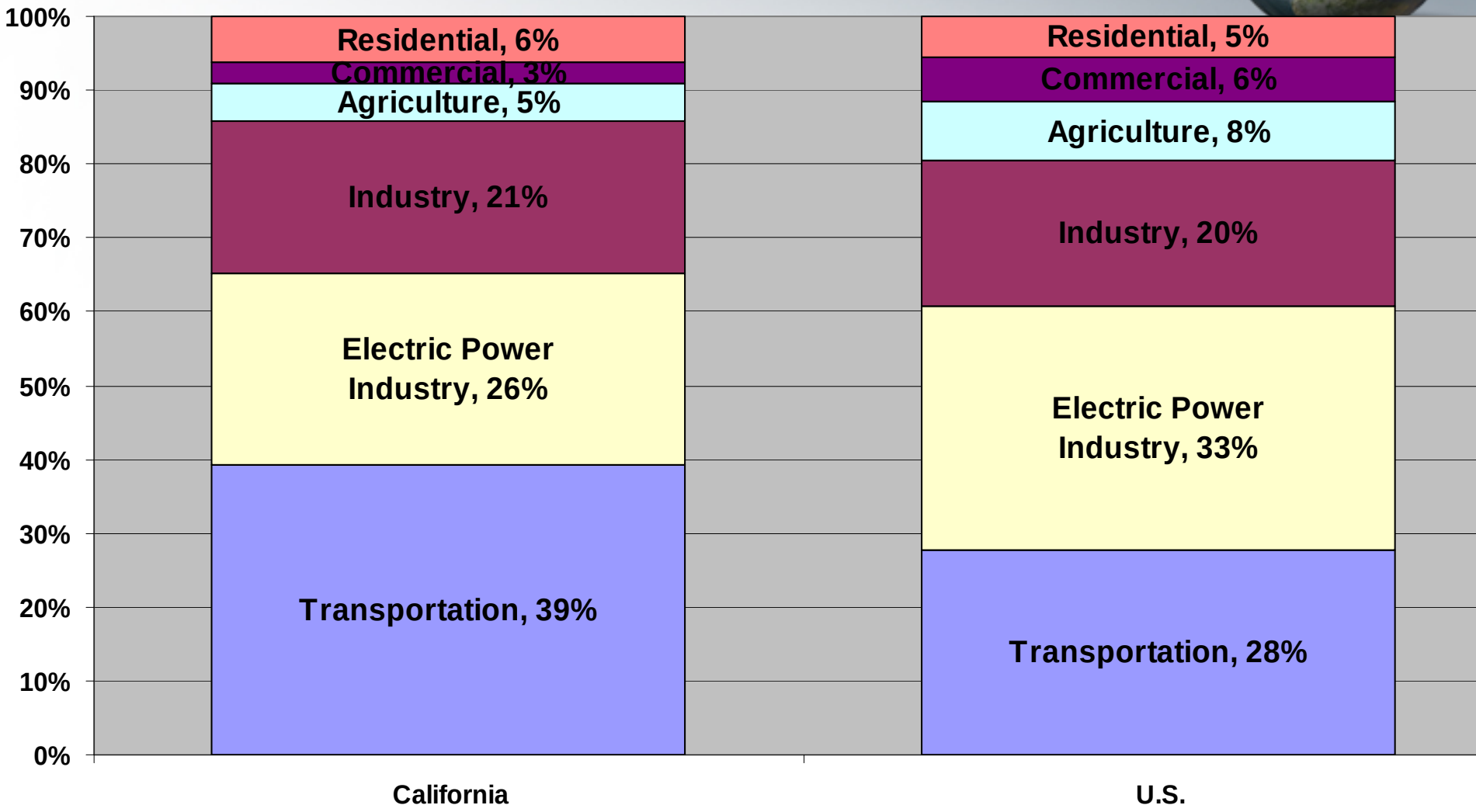


California GHG Emissions





Proportional Emissions - California vs. U.S.



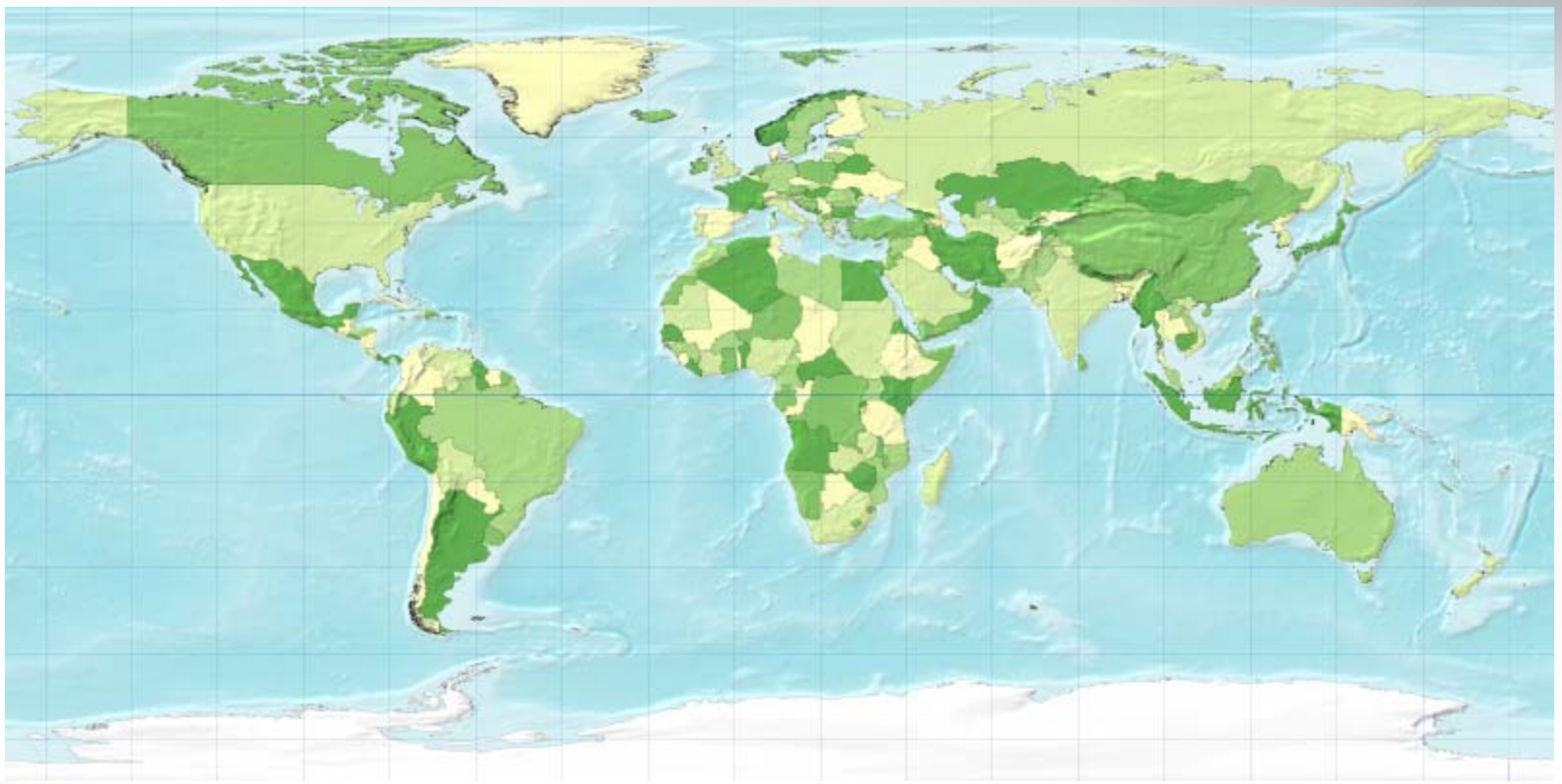
National GHG Emissions

Table 2-14: U.S Greenhouse Gas Emissions by Economic Sector and Gas with Electricity-Related Emissions Distributed (Tg CO_2 Eq.) and Percent of Total in 2007

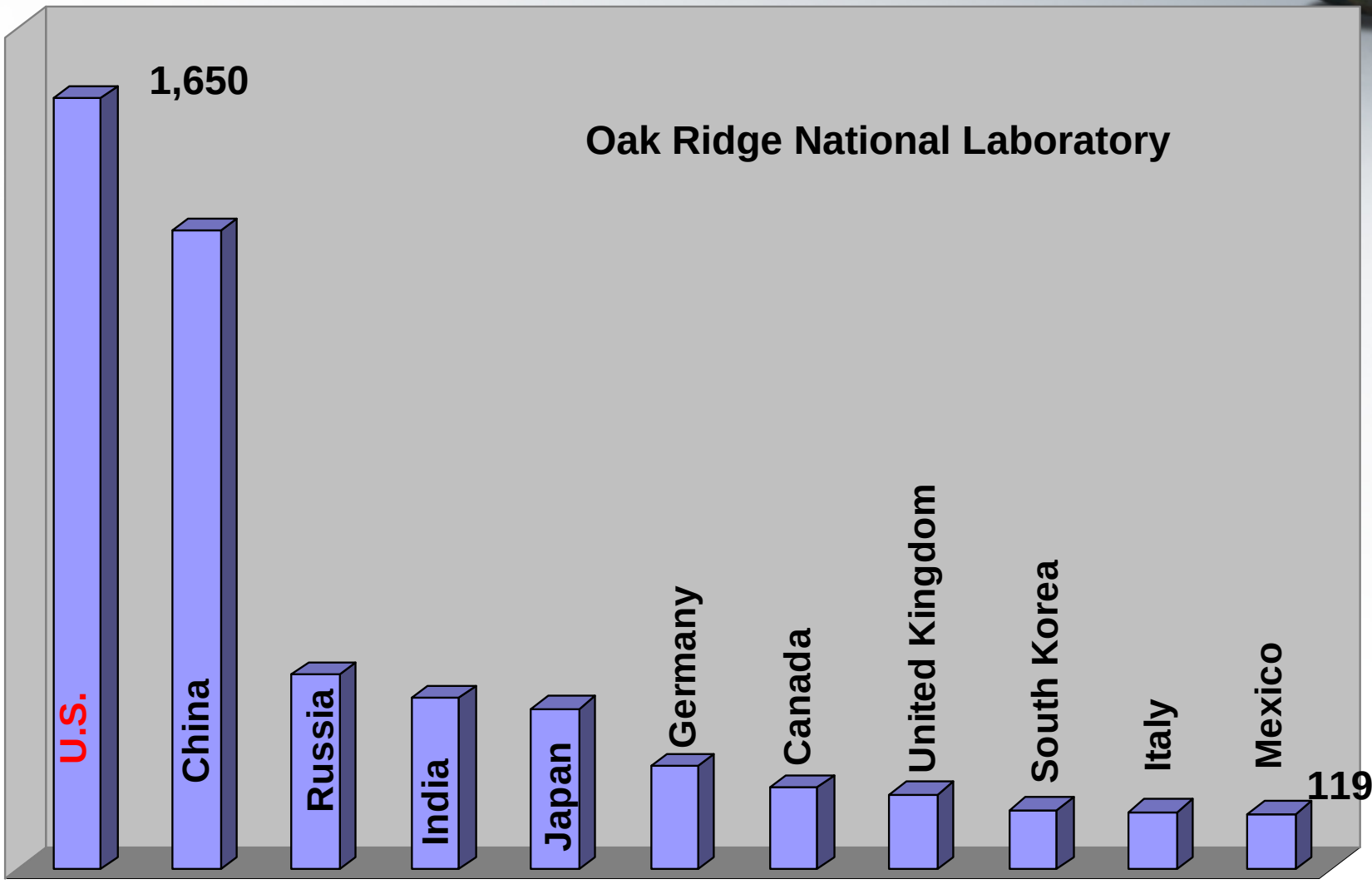
Sector/Gas	1990	1995	2000	2005	2006	2007	Percent[a]
Industry	**2,166.5**	**2,219.8**	**2,235.5**	**2,081.2**	**2,082.3**	**2,081.2**	**29.1%**
Direct Emissions	1,496.0	1,524.5	1,467.5	1,364.9	1,388.4	1,386.3	19.4%
CO_2	1,097.9	1,141.7	1,118.3	1,070.1	1,095.8	1,086.4	15.2%
CH_4	291.1	277.8	262.5	230.4	230.2	229.1	3.2%
N_2O	43.6	48.4	37.2	33.1	32.8	36.2	0.5%
HFCs, PFCs, and SF_6	63.3	56.6	49.6	31.3	29.6	34.7	0.5%
Electricity-Related	670.6	695.3	767.9	716.3	693.8	694.9	9.7%
CO_2	657.6	684.4	759.3	708.8	686.7	688.0	9.6%
Agriculture	**459.2**	**489.7**	**503.2**	**511.7**	**530.0**	**530.1**	**7.4%**
Direct Emissions	428.5	453.7	470.2	482.6	502.9	502.8	7.0%
CO_2	38.9	44.4	47.2	55.3	57.3	56.9	0.8%
CH_4	176.1	192.6	201.3	199.8	218.2	219.2	3.1%
N_2O	213.5	216.7	221.7	227.5	227.4	226.7	3.2%
Electricity-Related	30.6	36.0	33.0	29.0	27.0	27.3	0.4%
CO_2	30.0	35.5	32.6	28.7	26.8	27.0	0.4%
CH_4	+	+	+	+	+	+	+
N_2O	0.1	0.2	0.1	0.1	0.1	0.1	+
SF_6	0.4	0.4	0.2	0.2	0.2	0.1	+
U.S. Territories	**34.1**	**41.1**	**47.3**	**60.5**	**62.3**	**57.7**	**0.8%**
Total	**6,098.7**	**6,463.3**	**7,008.2**	**7,108.6**	**7,051.1**	**7,150.1**	**100.0%**

[40] Emissions were not distributed to U.S. territories, since the electricity generation sector only includes emissions related to the generation of electricity in the 50 states and the District of Columbia.

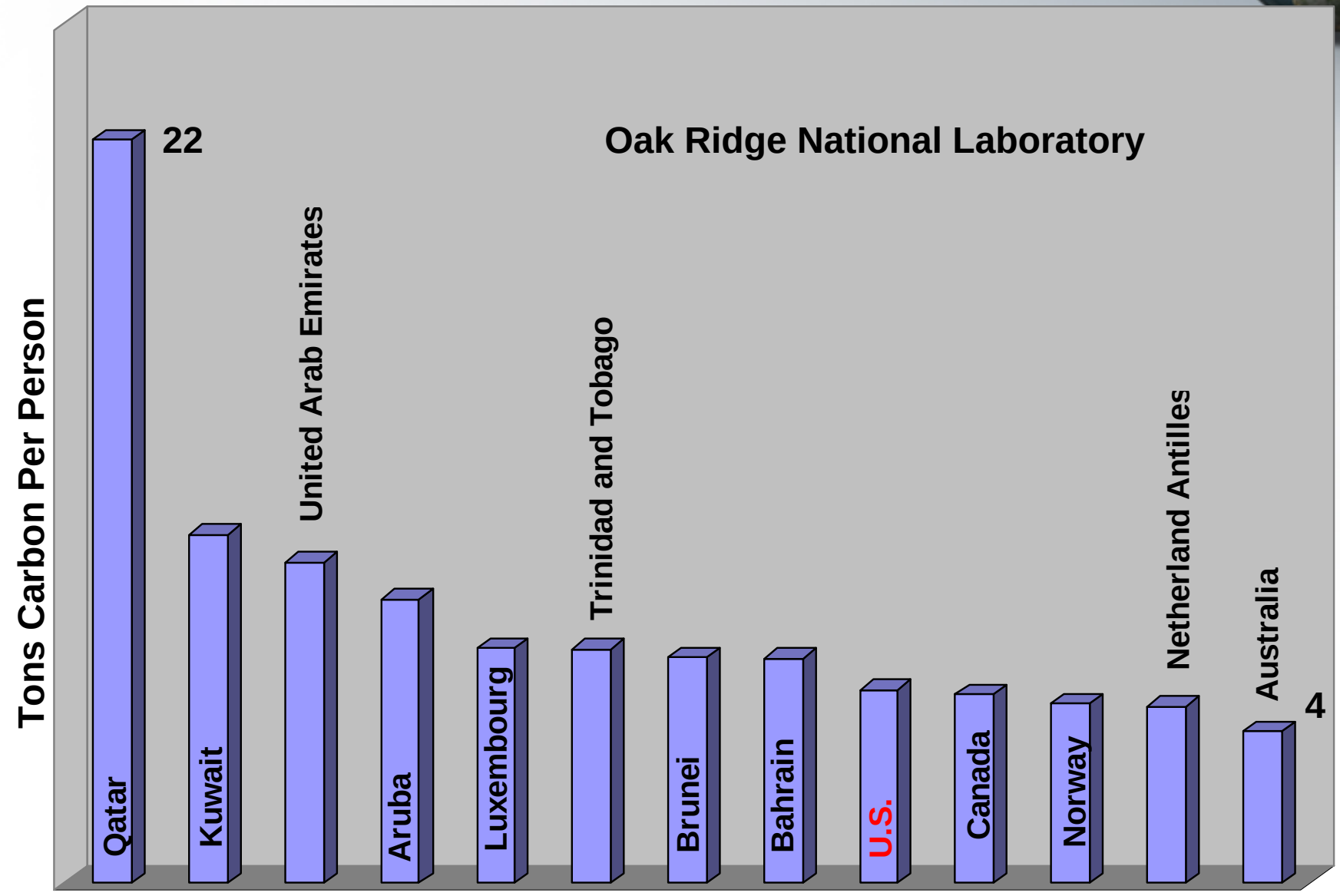
International Emissions



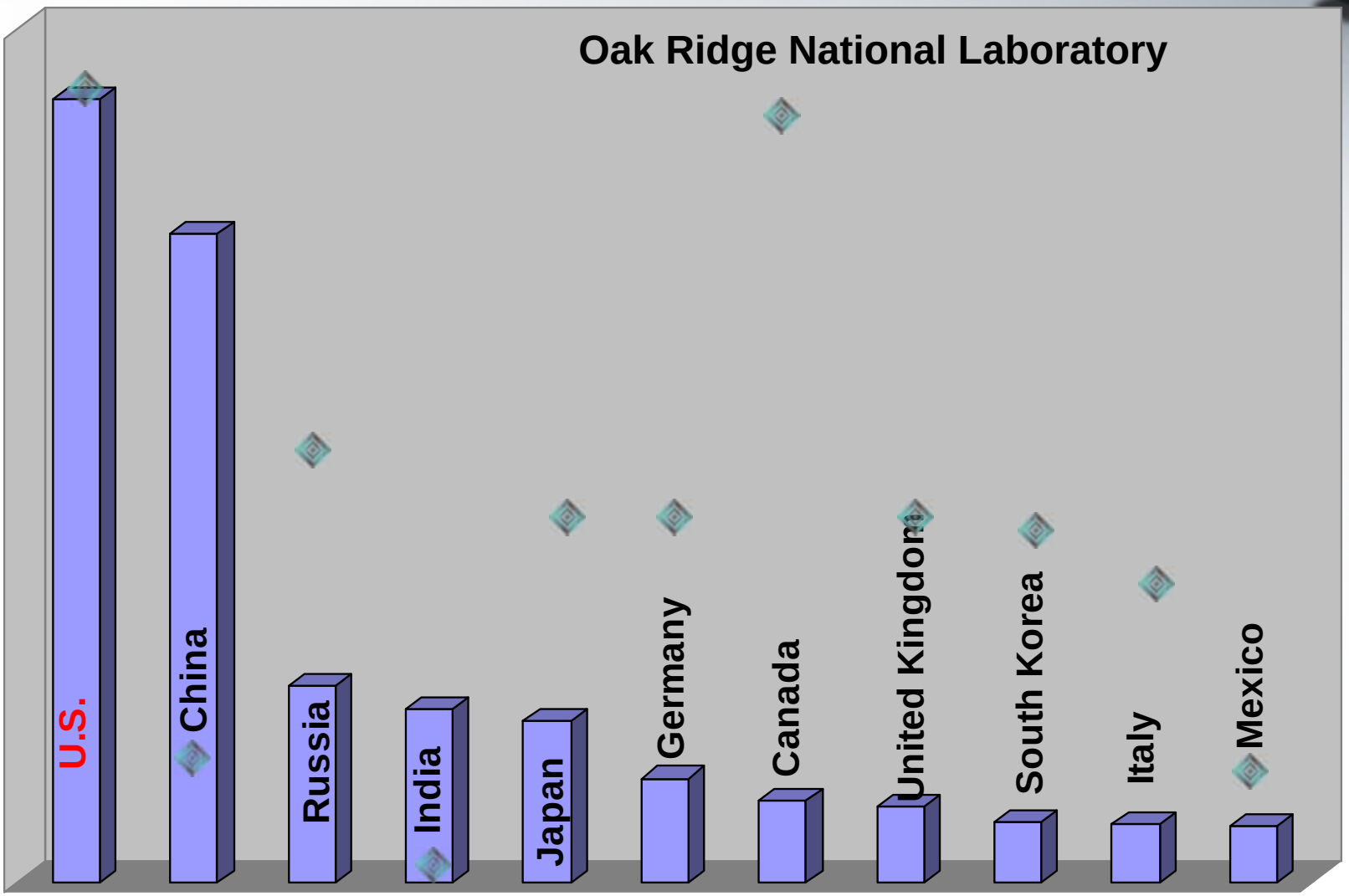
Top Emitters
by Country



Per Capita Emissions
by Country



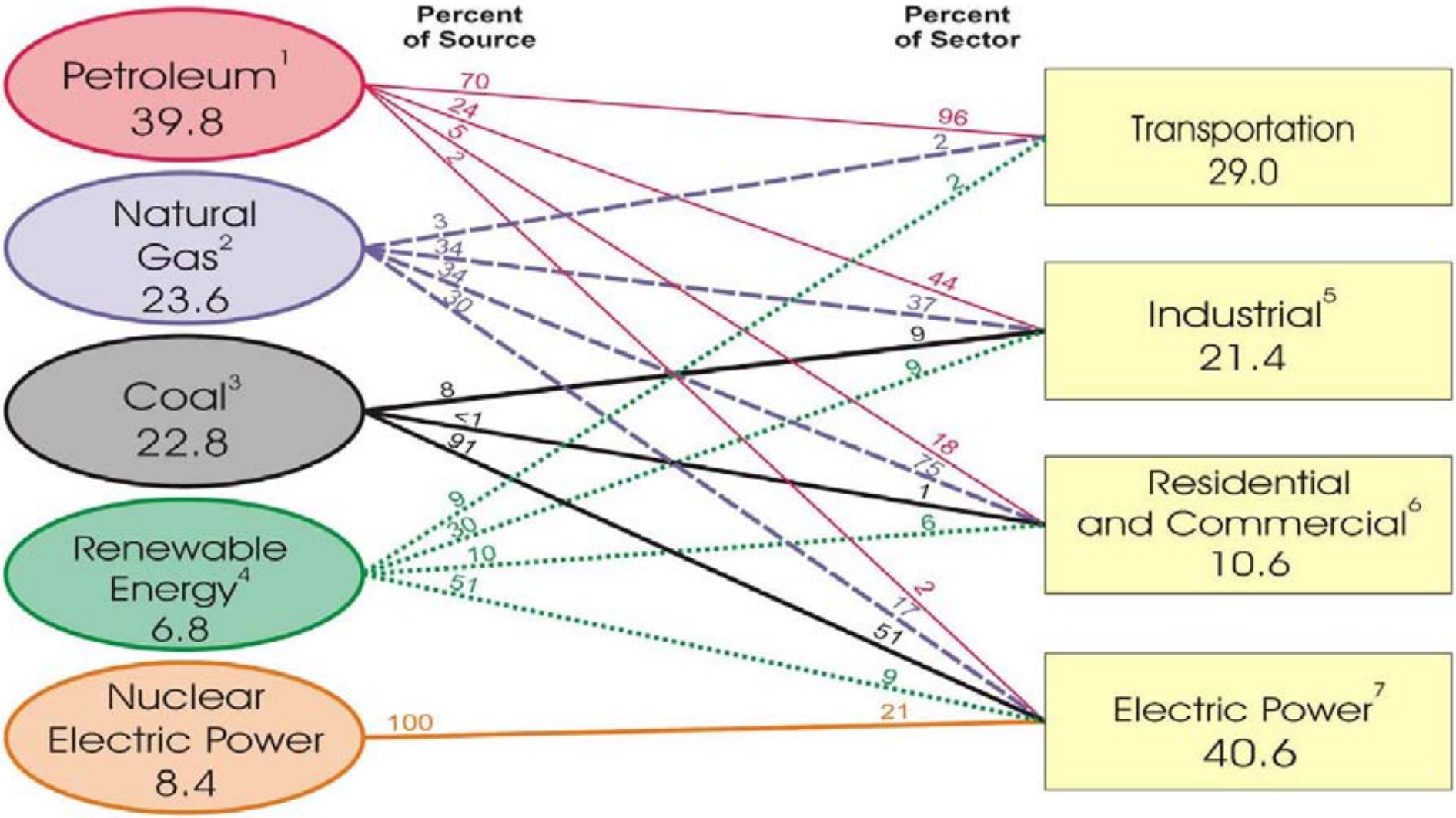
Total + Per Capita Emissions
by Country



Energy and Energy Consumption

U.S. Primary Energy Consumption by Source and Sector, 2007

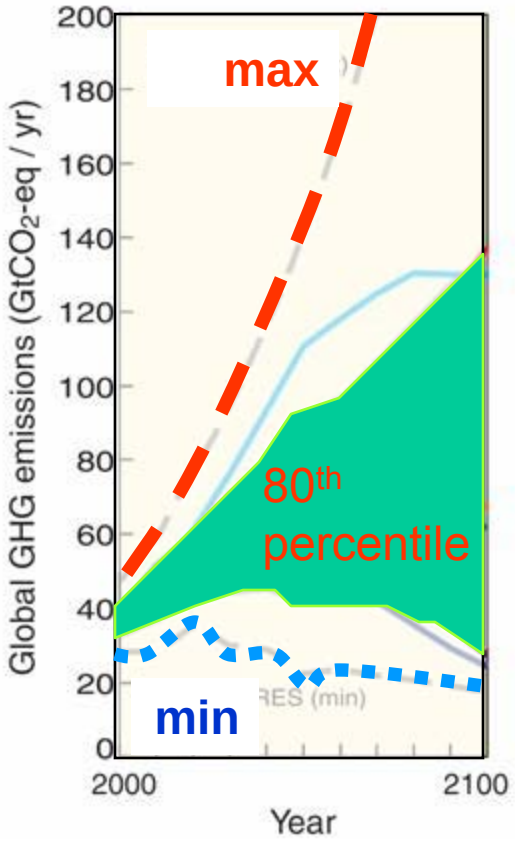
(Quadrillion Btu)

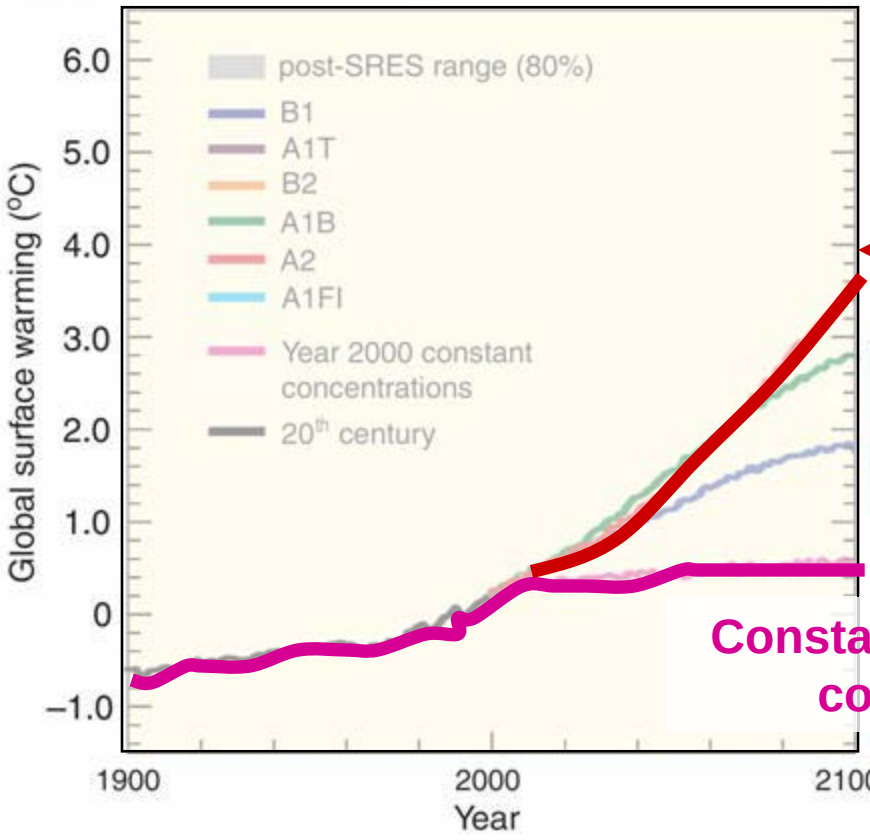


Source: Energy Information Administration, *Annual Energy Review 2007*

Scenarios: GHG and °C

Scenarios for GHG emissions from 2000 to 2100 (in the absence of additional climate policies) and projections of surface temperatures





mid-range estimate of the worst case scenario

~ 3.5 °C

Constant 2000 GHG concentrations

Source: Intergovernmental Panel on Climate Change, 2007

Necessary Emission Reductions

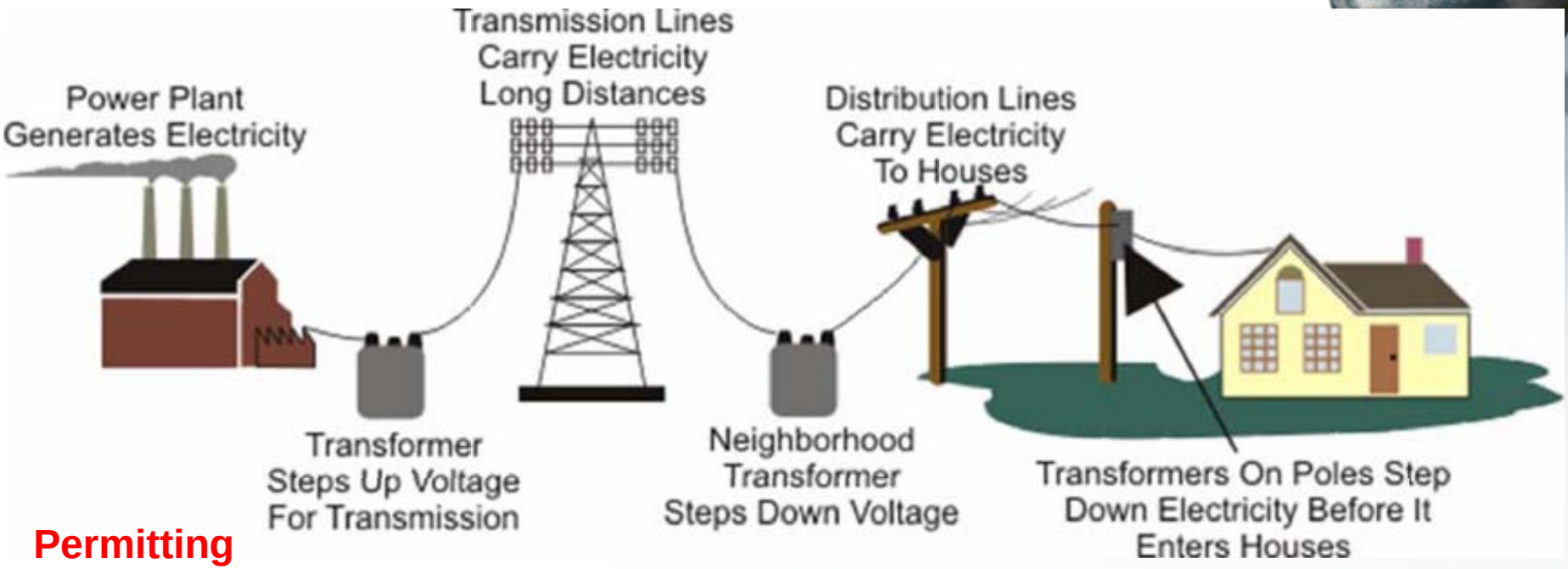
CO_2-eq Levels in Atmosphere (ppm)	Average Global Temperature Increase (°C)	% Change in 2050 Compared to 2000 Emissions
445 – 490	2.0 – 2.4	-85 to -50
535 – 590	2.8 – 3.2	-30 to +5
855 – 1130	4.9 – 6.1	+90 to +140

Source: Intergovernmental Panel on Climate Change, 2007

Impacts Beyond Greenhouse Gas Emissions

- Air: Electricity is Source of
  - 67% of U.S. SO2 Emissions
  - 23% of U.S. NOx Emissions
- Water: Electricity Consumes 3 Billion Gallons Per Day
- Land: 470,000 Petroleum Releases From Underground Storage Tanks

Electricity Systems



Permitting
Enforcement
Standards
TRI

NEPA Reviews (Federal Land)
Toxics (PCBs in Transformers)

??

Traditional Environmental Agency Role

Source: Energy Information Administration

Environmental Opportunities: Promotion of Clean Energy

- Energy Efficiency
- Combined Heat and Power
- Renewable Energy

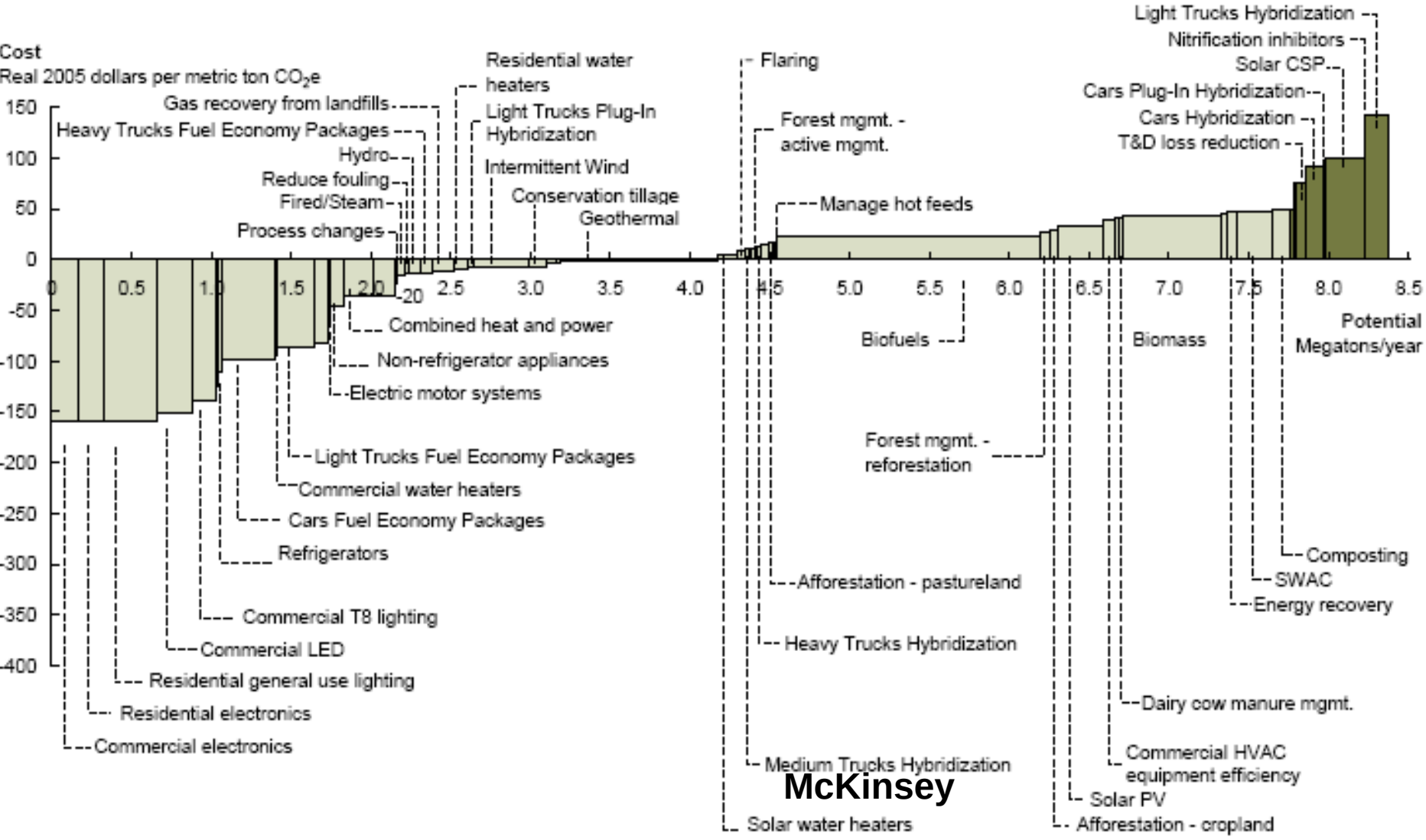
Photo by Eric Vance

Energy Efficiency

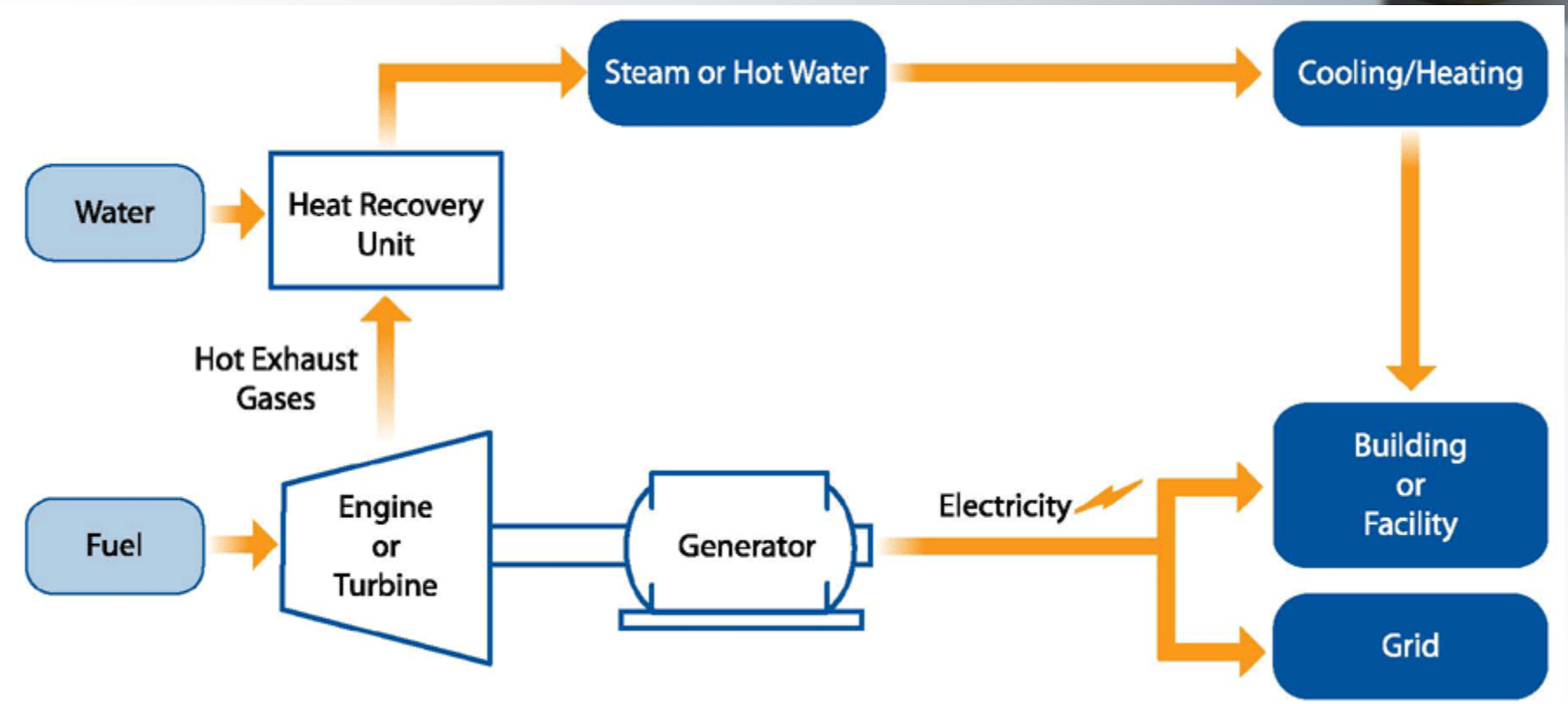
- Residential: Weatherization, Lighting, Appliances, Building Codes
- Commercial: Lighting, Cooling, Building Codes
- Industrial: Pumps, Lighting, Compressed Air

- Programs: EnergyStar, Save Energy Now!, Utilities

Hawaii Cost Abatement Curve



Combined Heat and Power



- Island Hotels
- DoE Grant Now Open: Deployment of CHP, District Energy, and Waste Energy Recovery Systems, www.fedconnect.gov
- EPA: Combined Heat and Power Partnership

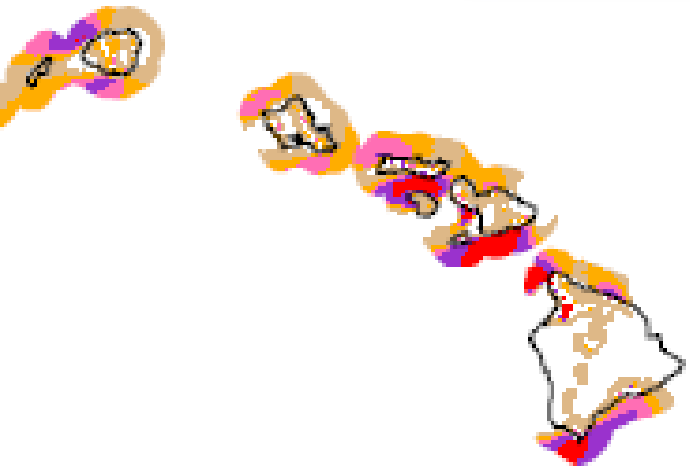
Renewable Energy - Solar

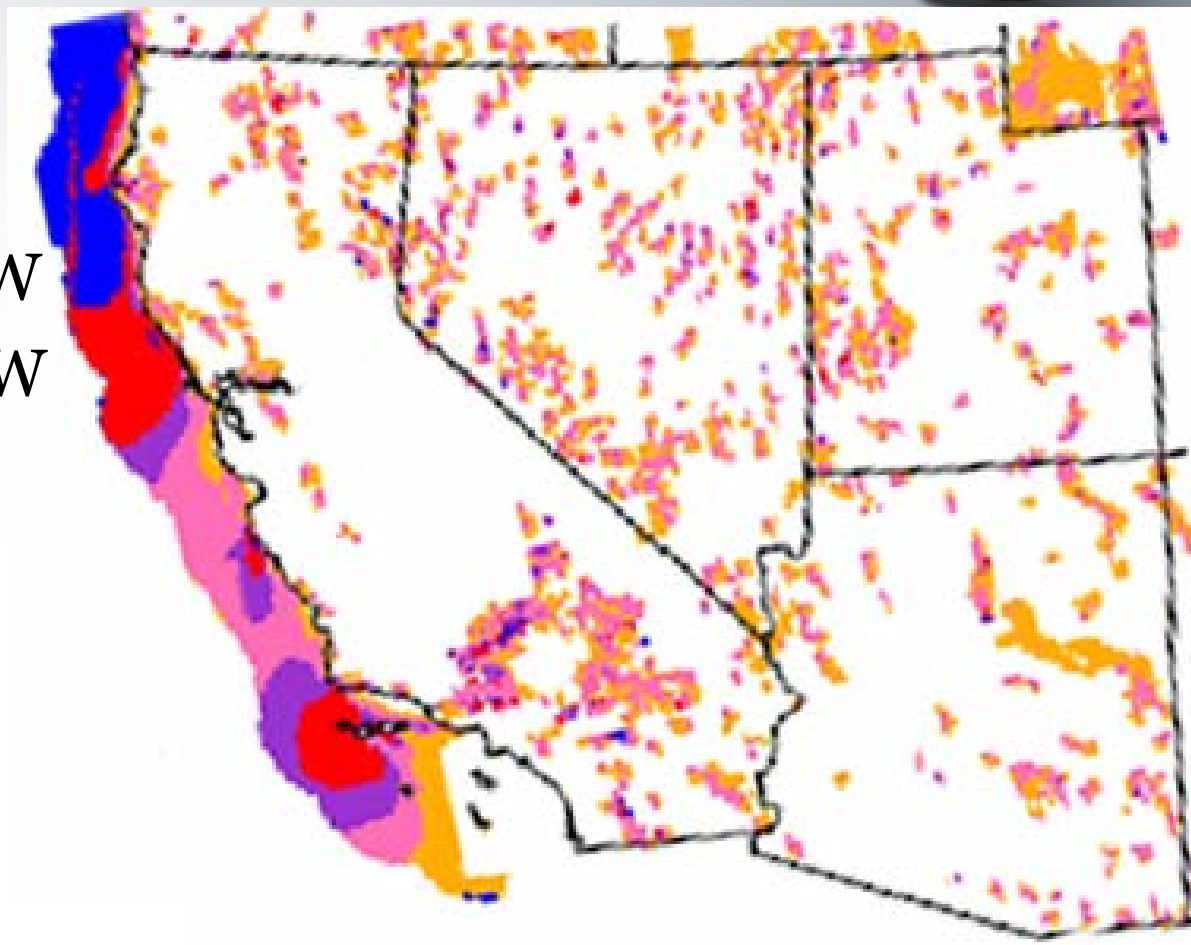
- Utility Scale Solar Thermal
  - Mojave Solar Park 553MW
- Photovoltaic
  - CA Solar Initiative:
    - Smaller Units: Up-Front Rebates (per watt)
    - Larger Units: Production Incentives (per kWh)
  - Federal: 30% Tax Credit
- Solar Heating, Solar Lighting

Source: National Renewable Energy Laboratory

Renewable Energy - Wind

- U.S. 2001: 3,900 MW
- U.S. 2005: 8,700 MW





Source: Department on Energy

Other Clean Energy Opportunities

- Biogas (Dairies, Landfills, Wastewater)
- Biomass (woody material, solid waste)
- Geothermal: 2,300 MW existing
- Wave/Tidal Energy: Study Development

Life Cycle Assessment

Life Cycle Assessment

- **Quantify Total Environmental Impact**
- **Consider production, distribution, use, recycling, treatment, and/or disposal**
- **May include economic and/or environmental cost-benefit analysis**

Life Cycle Inventory of a Shirt

Raw Materials
fertilizer,
energy,
water, pollution

Recycle/Re-use
less pollution
less waste

Disposal
waste,
pollution

Processing
energy, cleaners,
dyes, pollution

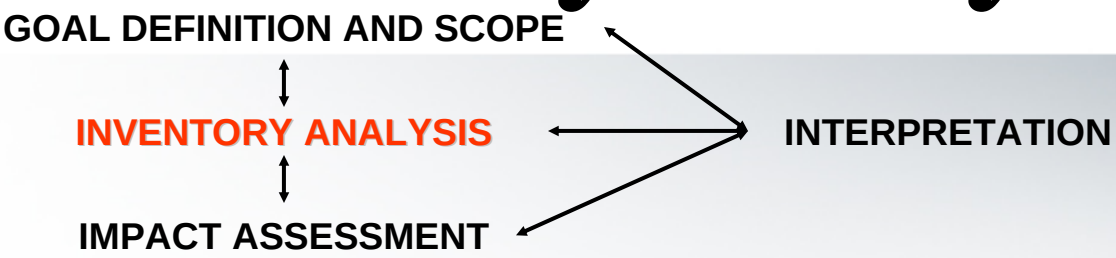
Use
bleach, detergents,
water, pollution

Manufacturing
energy, waste,
pollution

Transportation
energy,
pollution

Packaging
paper, plastic
waste, pollution

Inventory Analysis

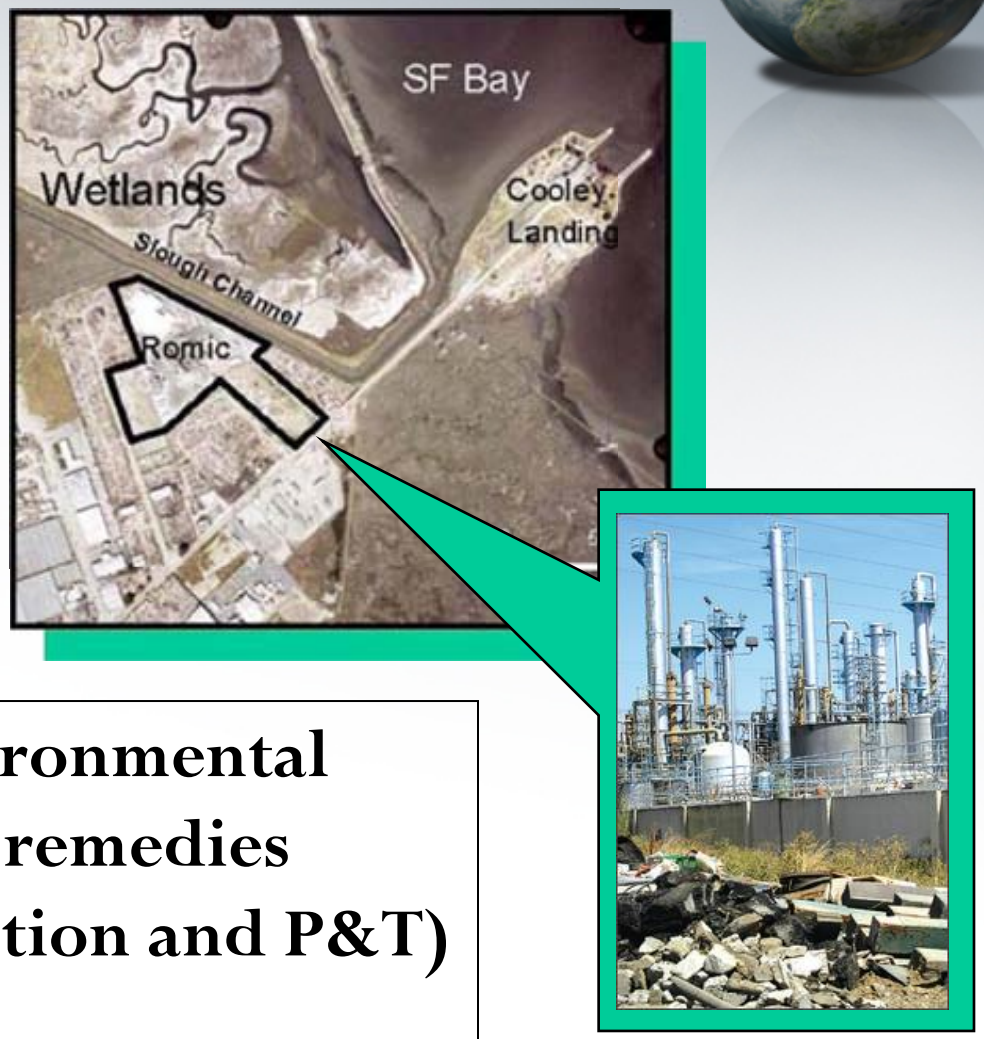


Identify and quantify energy, water and materials usage, and environmental impacts.

- **Inputs - materials, energy, chemicals**
- **Outputs - air and water emissions, solid waste**

LCA Example: Romic East Palo Alto

- 14-acre hazardous waste management facility
- Soil and ground water contaminants are VOCs (such as TCE and PCE)
- Area of contamination to a depth of 80 feet



- LCA to compare the environmental effects of the 3 alternative remedies
  - Hybrid (bioremediation and P&T)
  - Bioremediation
  - Pump and Treat

Detailed Inventory Analysis

Level 2: Transport

Level 1: On Site

Level 3: Manufacture

PVC Pipe Manufacture

Mine

Gravel to site

Operators to Site

Operators to Site

Spent Carbon Regeneration

PVC pipe to Site

Carbon to and from Site

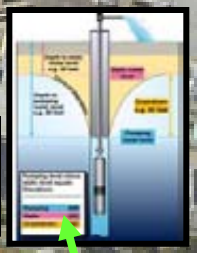
Well Construction

Groundwater Treatment

Drill Cuttings Off Site

Treated Water to Sewage

BioInjections



Groundwater Extraction

Operators and Equipment to Site

Electricity to Site

Cheese Whey to Site

Molasses to Site

Water to Site

Operators to Site

Dairy Farm

Power Plant

Molasses Manufacture

Life Cycle Analysis in Your Daily Life

- How do you choose products and services?
- Example: Not all water is created equal
  - Perrier Bottled Water
  - Fiji Bottled Water
  - Calistoga Bottled Water
  - Tap Water

- Example: PG&E Climate Smart
- Example: printing double sided (R9 reduced CO_2 emissions by194,000 lbs/yr)

What Can You Do?

Saving Energy At Home

- Change Light Bulbs
  - Save $30 Over Lifetime of Each Bulb
  - Uses 75 percent Less Energy
  - Lasts 10 Times Longer

- Look for the Energy Star Logo
  - Appliances
  - Heating and Cooling
  - Water Heaters

  (And Look for Rebates!)

More Savings At Home

- Heat and Cool Smartly
  - Clean Air Filters
  - Keep Equipment Tuned
- Seal and Insulate Your Home
  - Attic/Basement Air Leaks
  - Windows and Doors
  - Air Ducts
- Audit Your Energy Use
  (Home Energy Yardstick: www.energystar.gov)

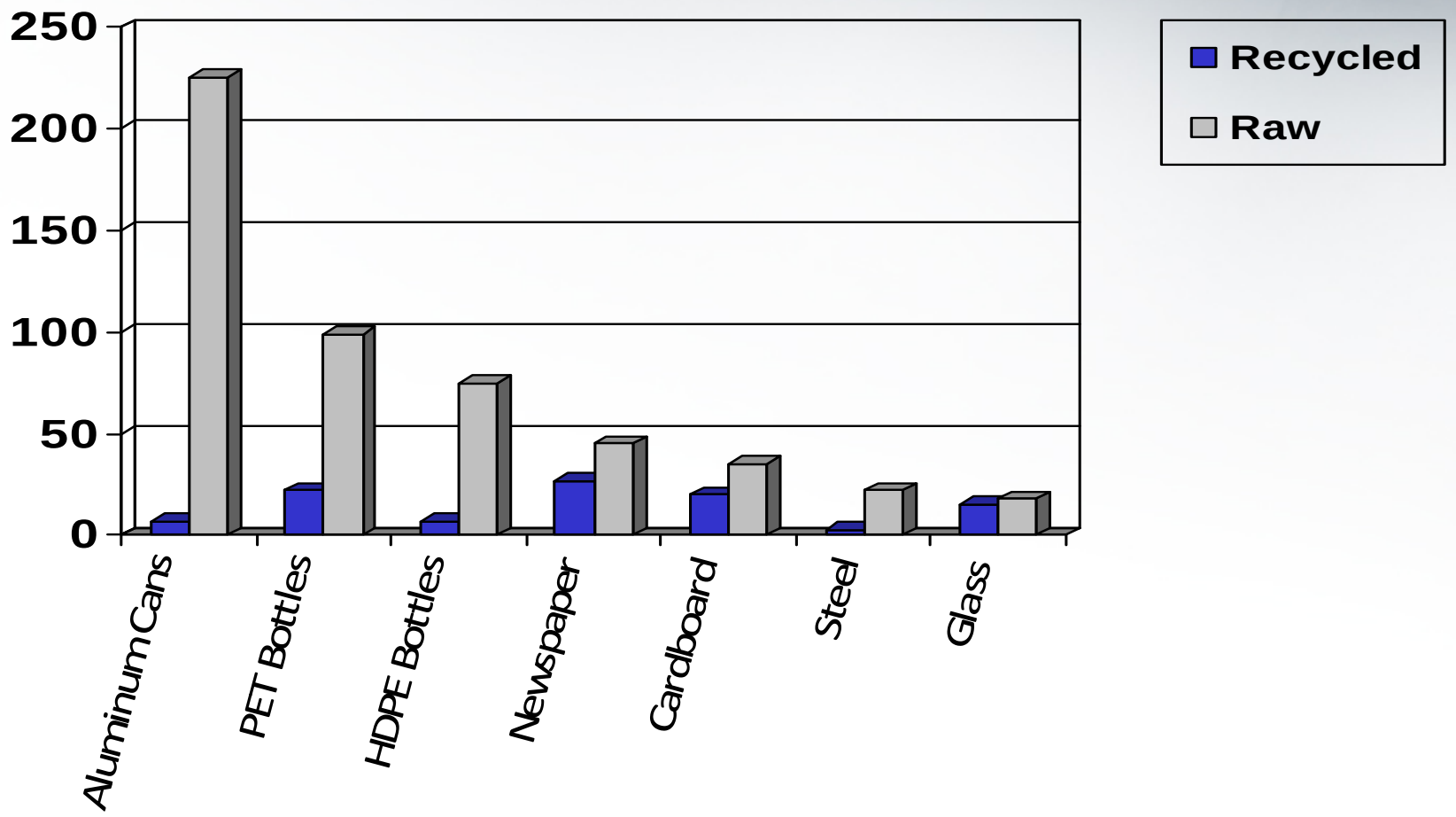
Even More Savings At Home

- Use Water Efficiently
  - Avoid Energy Needed to Move and Treat and Heat Water
  - Faucet Running For 5 Minutes = 60W Bulb On For 14 Hours
  - Look for WaterSense Label

- Recycle

  Using Recycled Materials Avoids Energy Needed to Extract, Transport, and Process Raw Materials

Energy Use: Recycled vs. Raw Content Products (Million BTUs/ ton)



Impacts from the National Recycling Rate

32.5% recycled in 2006

Saving Energy At The Office

- Manage Office Equipment Energy Use
  - Idle & Standby
  - Power Management Features

- Look for the Energy Star Logo
  - Computers
  - Copiers
  - Printers

Saving Energy On The Road

- Buy Smart
  - EPA Clean Vehicle Guide
    http://www.epa.gov/greenvehicles
  - EPA/Department of Energy Fuel Efficiency Guide
    http://www.fueleconomy.gov/
- Drive Smart
  - Avoid Aggressive Driving: 5 – 33% Fuel Savings
  - Observe Speed Limit: 7 – 23% Fuel Savings
  - Reduce Idling (= 0 MPG)

More Savings On The Road

- Vehicle Upkeep
  - Engine – 4% Fuel Savings
  - Tire Inflation – 3% Fuel Savings
- Remove Excess Weight From Vehicle

Challenges

- Lack of detailed U.S. Territories GHG Emissions Data
- Development of Emissions Inventory
- Identify Reduction Areas/Opportunities and Establish Reduction Targets

For More Information

Visit EPA's Climate Change Web site at
http://www.epa.gov/climatechange

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