Energy and the Built Environment
CRP 470.004 /570.004

Christian E. Casillas

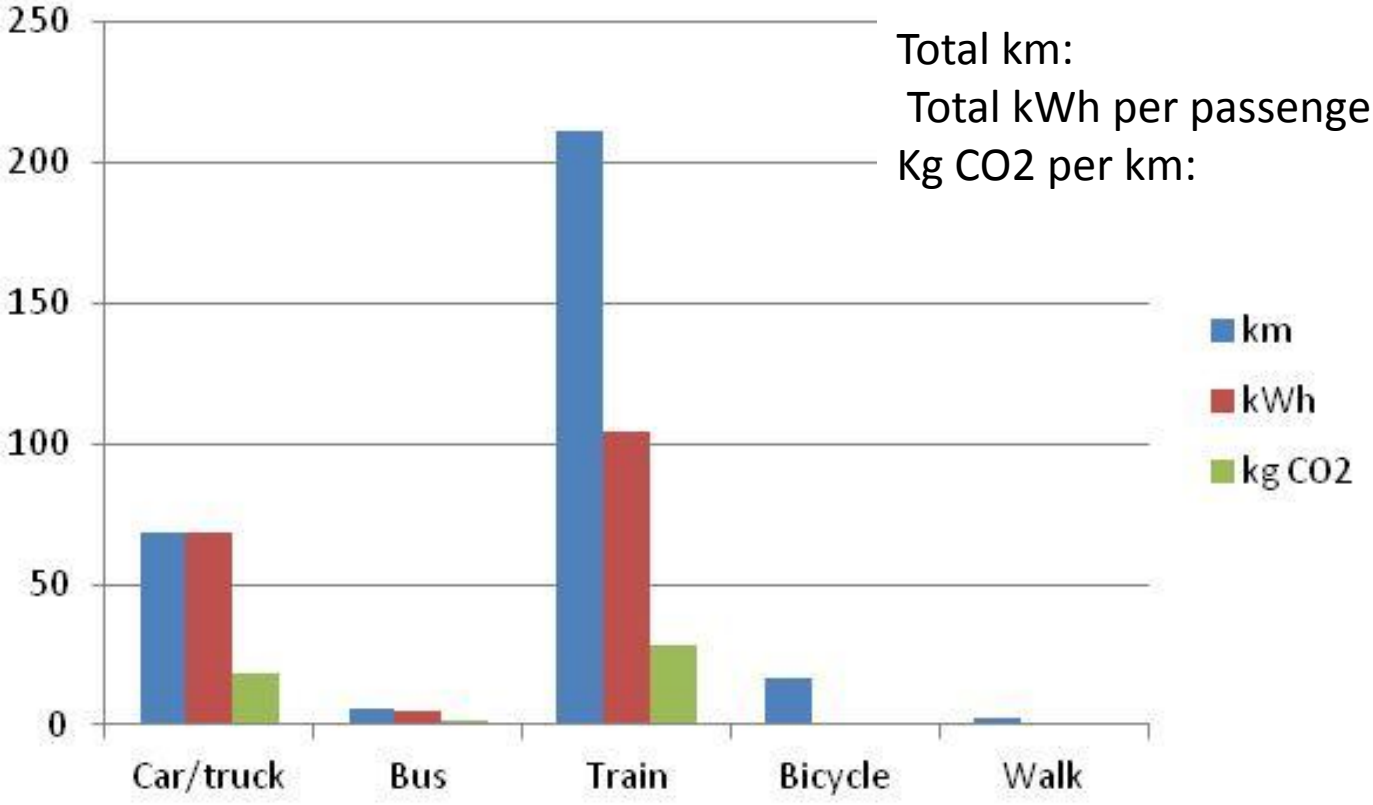
Lecture 10

Buildings and energy efficiency

Upcoming Events

- Today – Building and Efficiency guests at 1:30 pm
  - Olivia Terado: http://2030palette.org/
  - Ed Mazria, Architecture 2030
- Wed 4/1 – Efficiency
  - *Hans Frederick Barsun* University Facilities Engineer - discussion of campus demand, power plant economics, and efficiency
    - PPD - Utilities Conference Room 124, at 12 pm
  - Ingrid Kelley, former CRP Master's student, architect and energy expert.

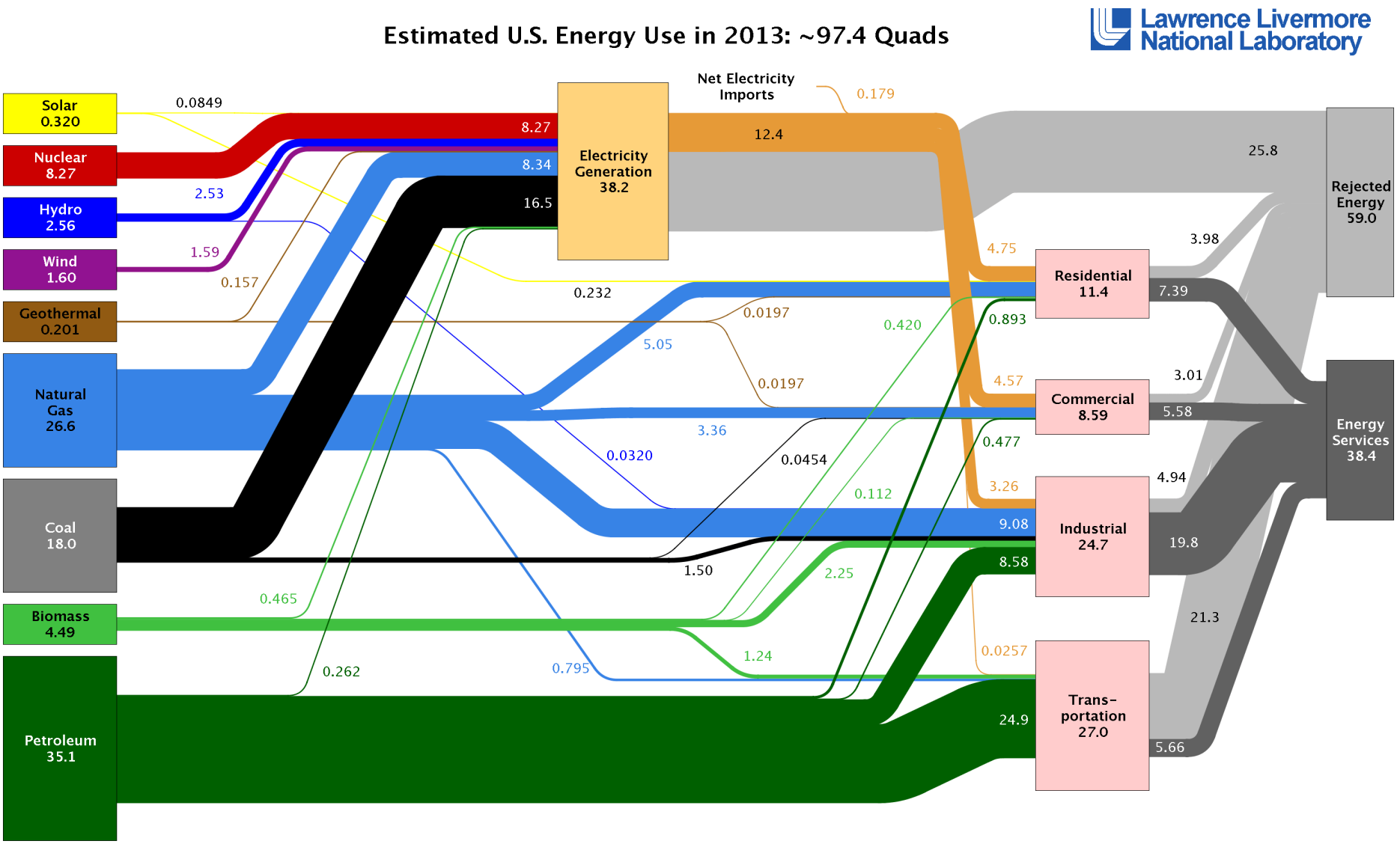
My 7 day transport and use emissions



Total km:	302
Total kWh per passenger-km:	0.68
Kg CO2 per km:	0.16

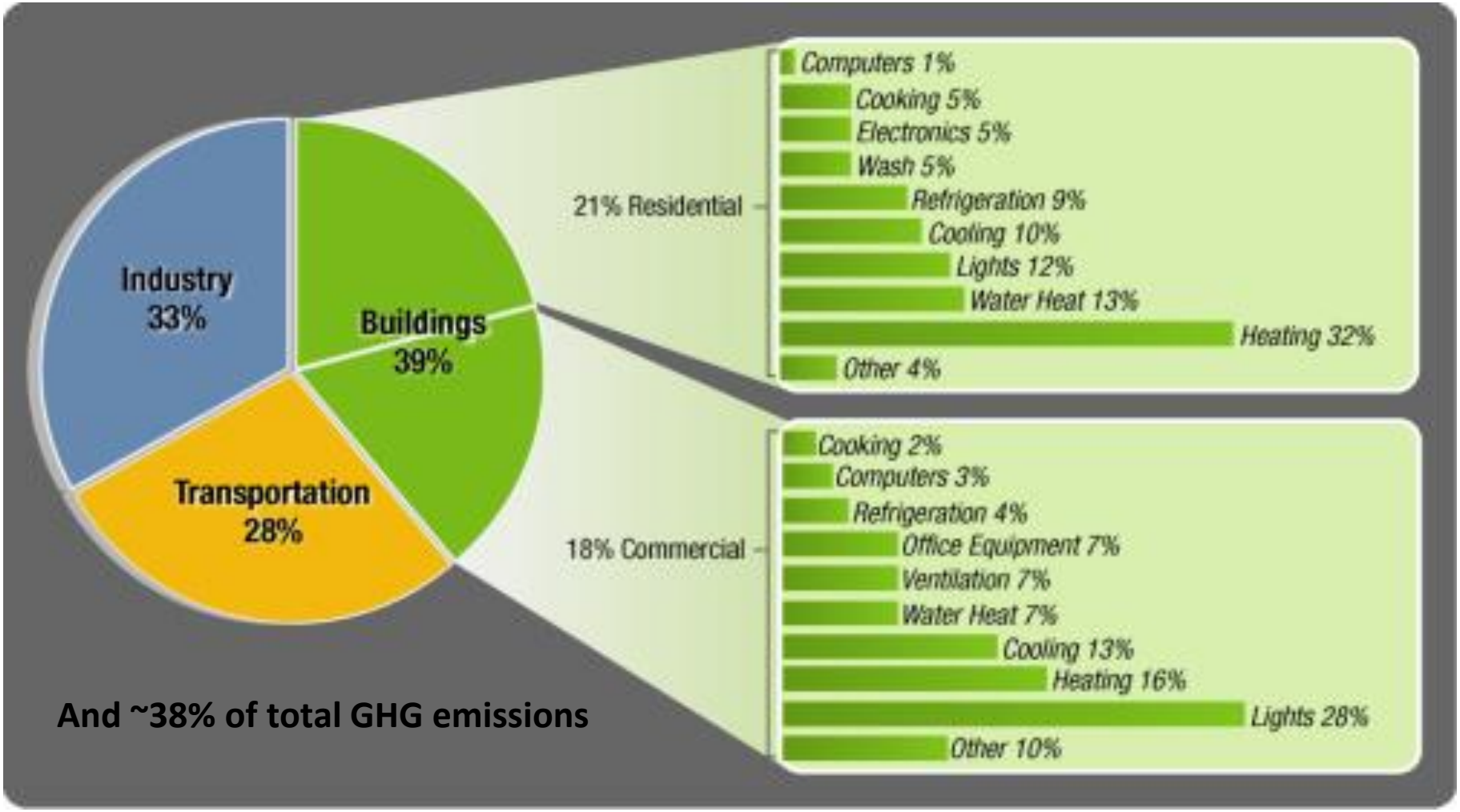
Energy intensity is equivalent to riding solo in a car that gets 31 mpg.
Emissions are equivalent to a gasoline car with 35 mpg

Sankey Diagram of US energy use



Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

US energy use in buildings



http://newscenter.lbl.gov/2009/06/02/working-toward-the-very-low-energy-consumption-building-of-the-future/

Global energy use in buildings

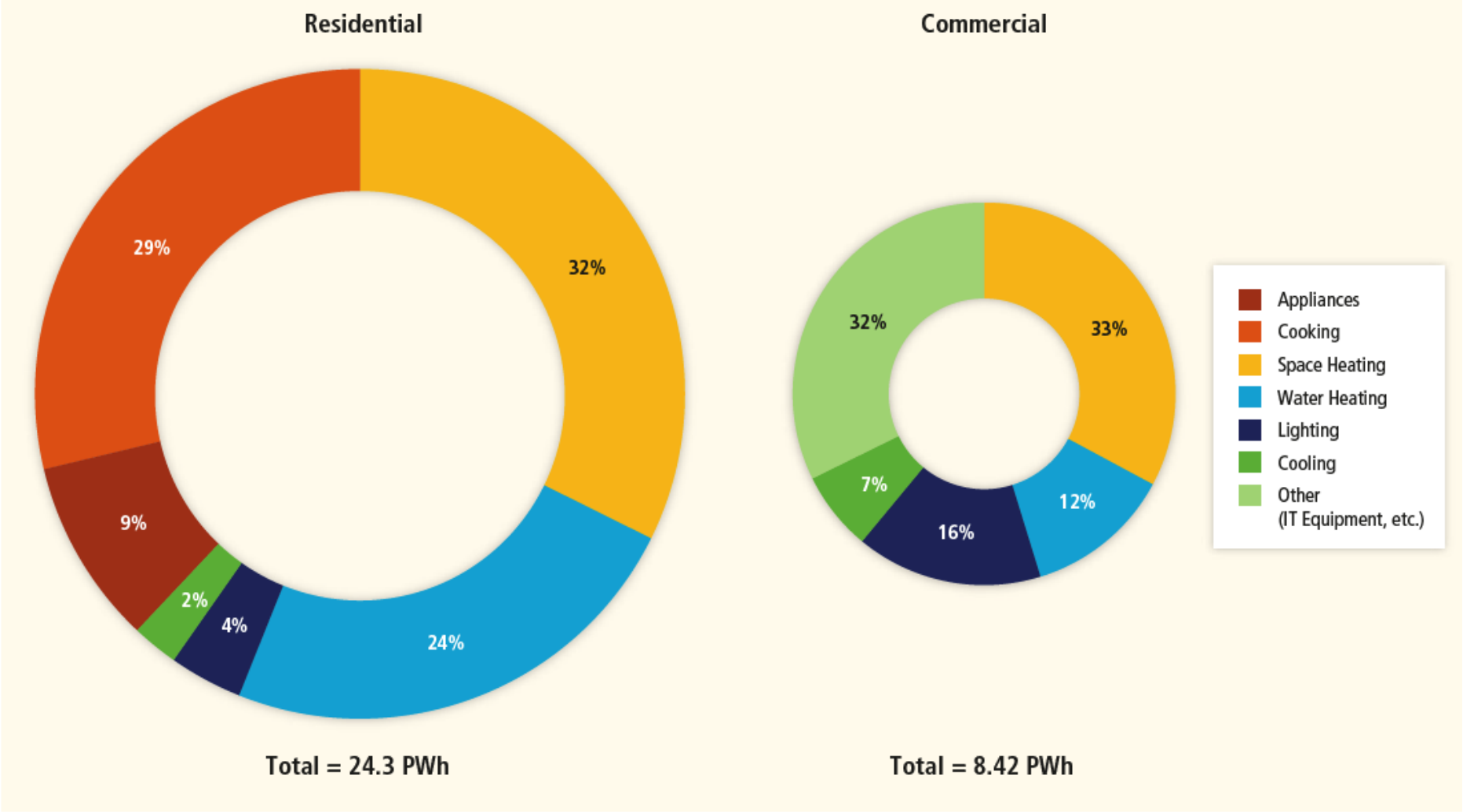
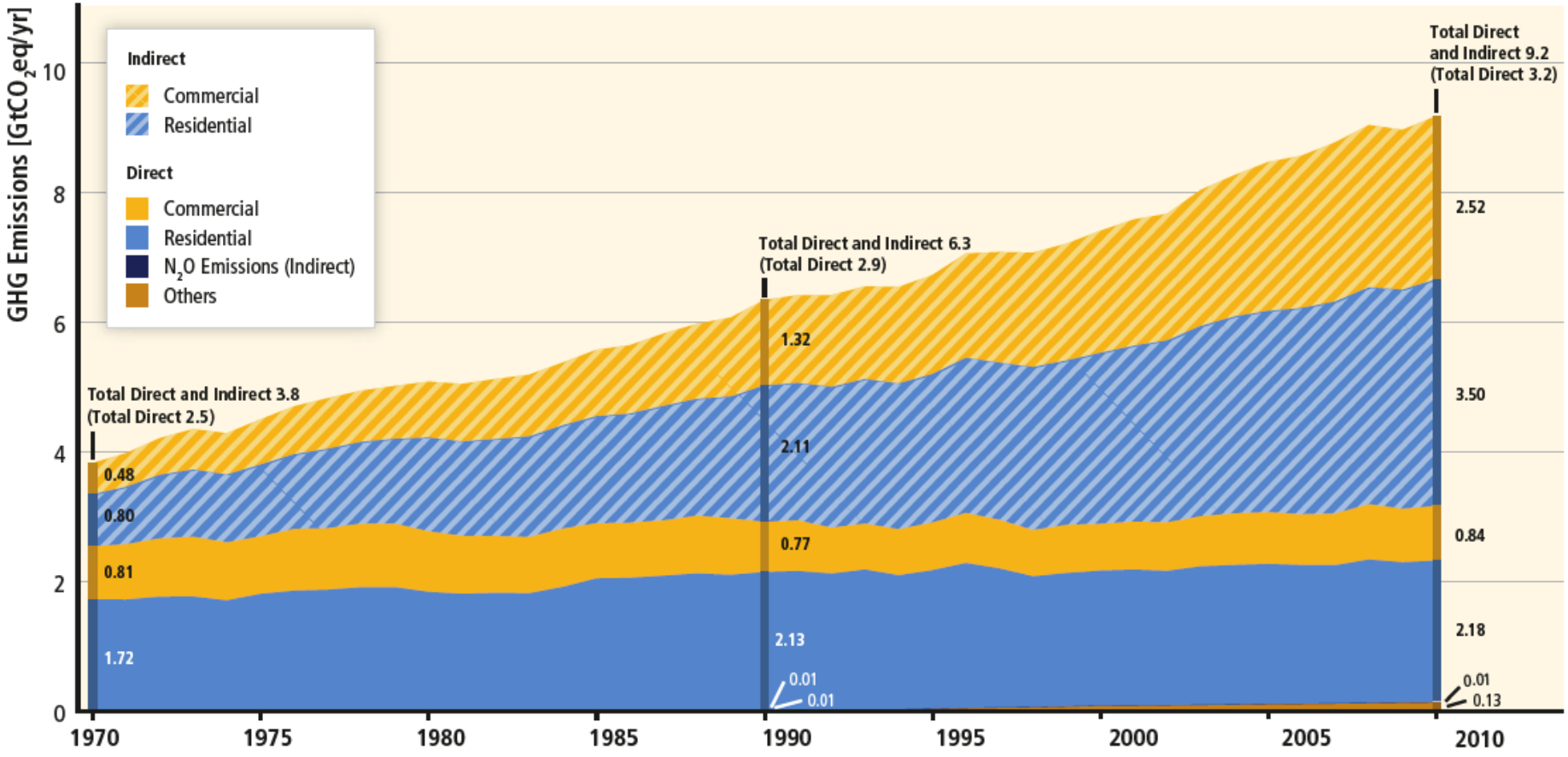


Figure 9.4 | World building final energy consumption by end-use in 2010. Source: IEA (2013).

Source: IPCC, AR5, Buildings 2014

Global GHG Emissions from buildings



Source: IPCC, AR5, Buildings 2014

Energy consumption by US household type

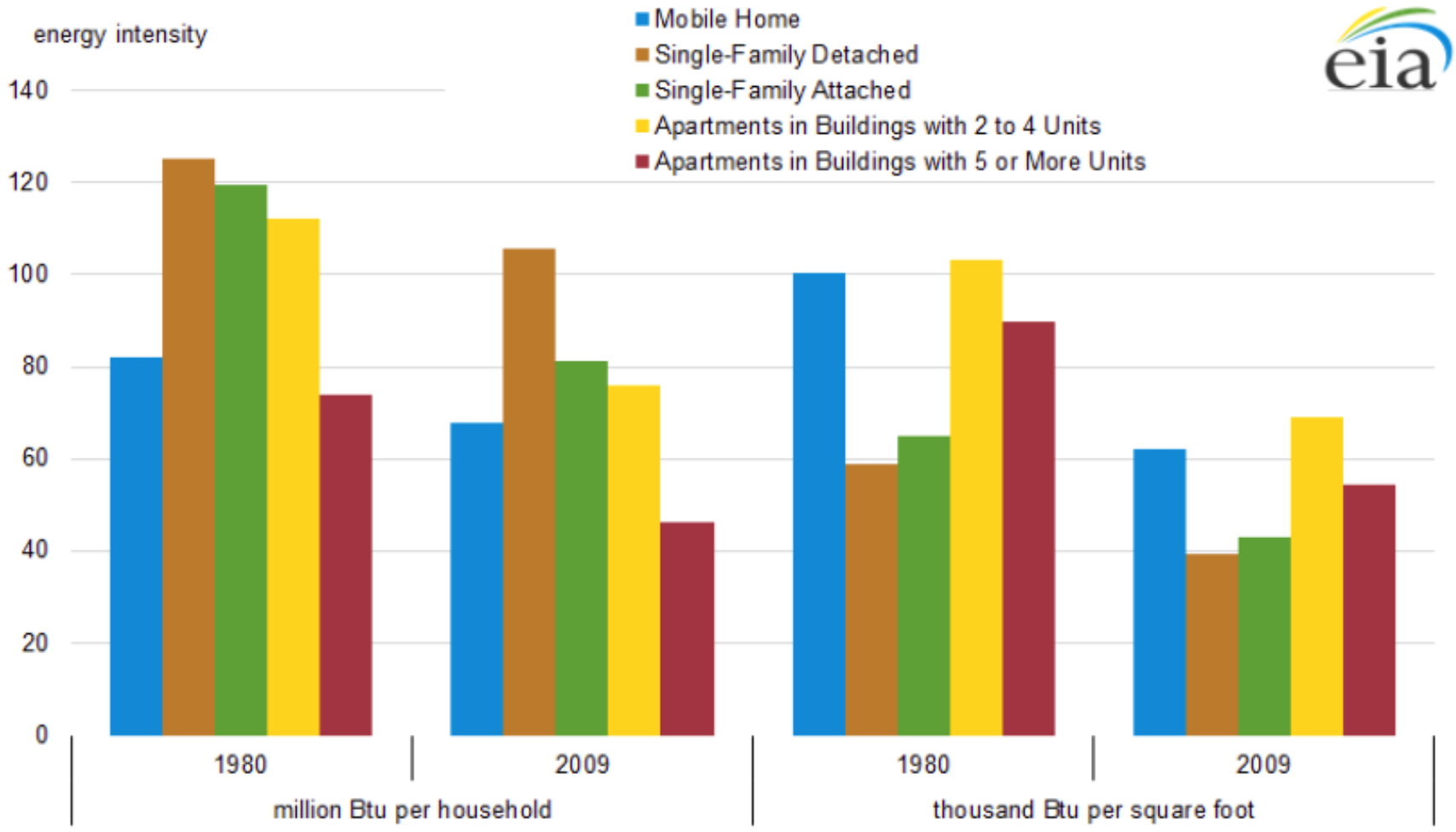
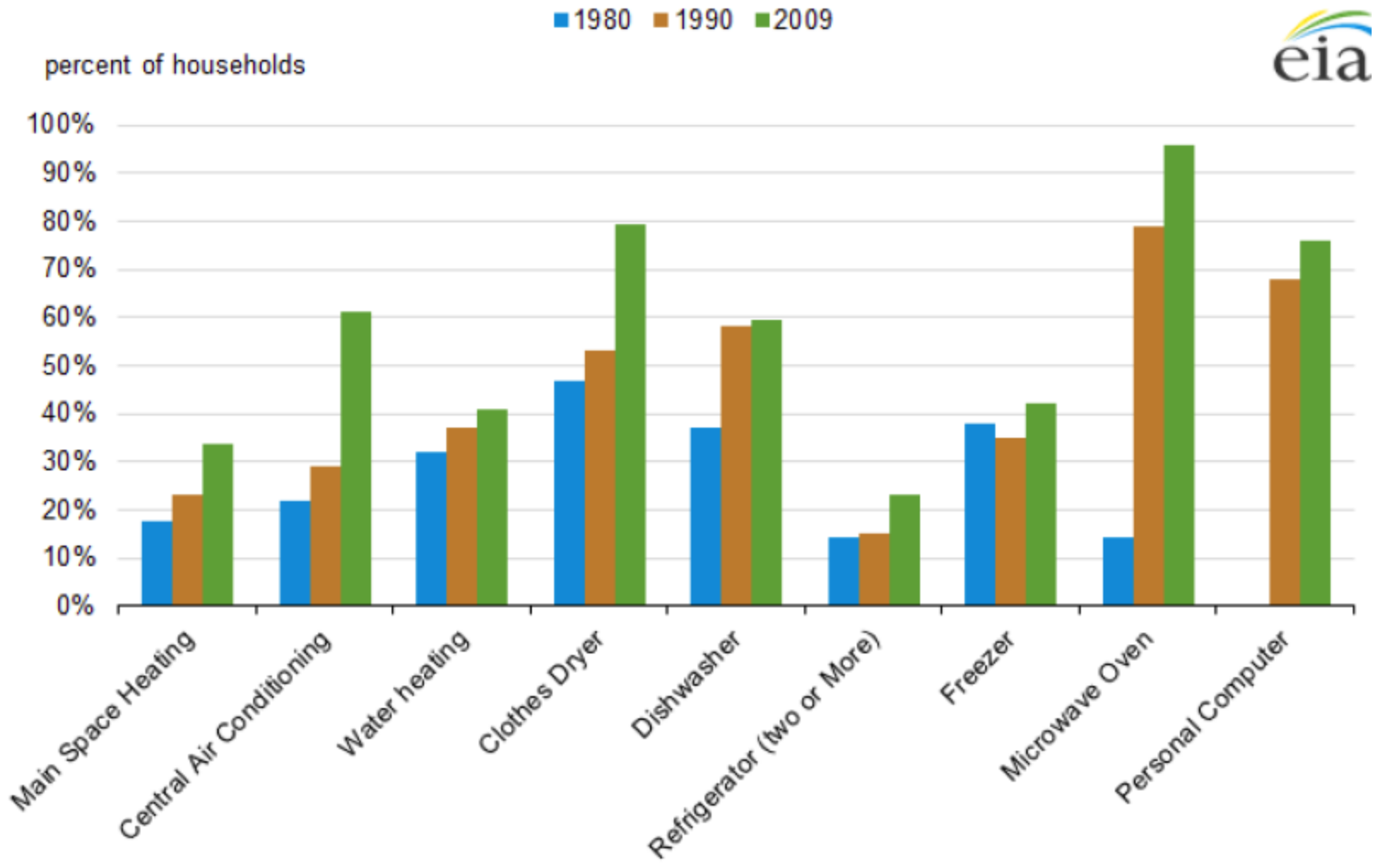


Figure 9. Penetration of selected electrical appliances in U.S. households, 1980, 1990, and



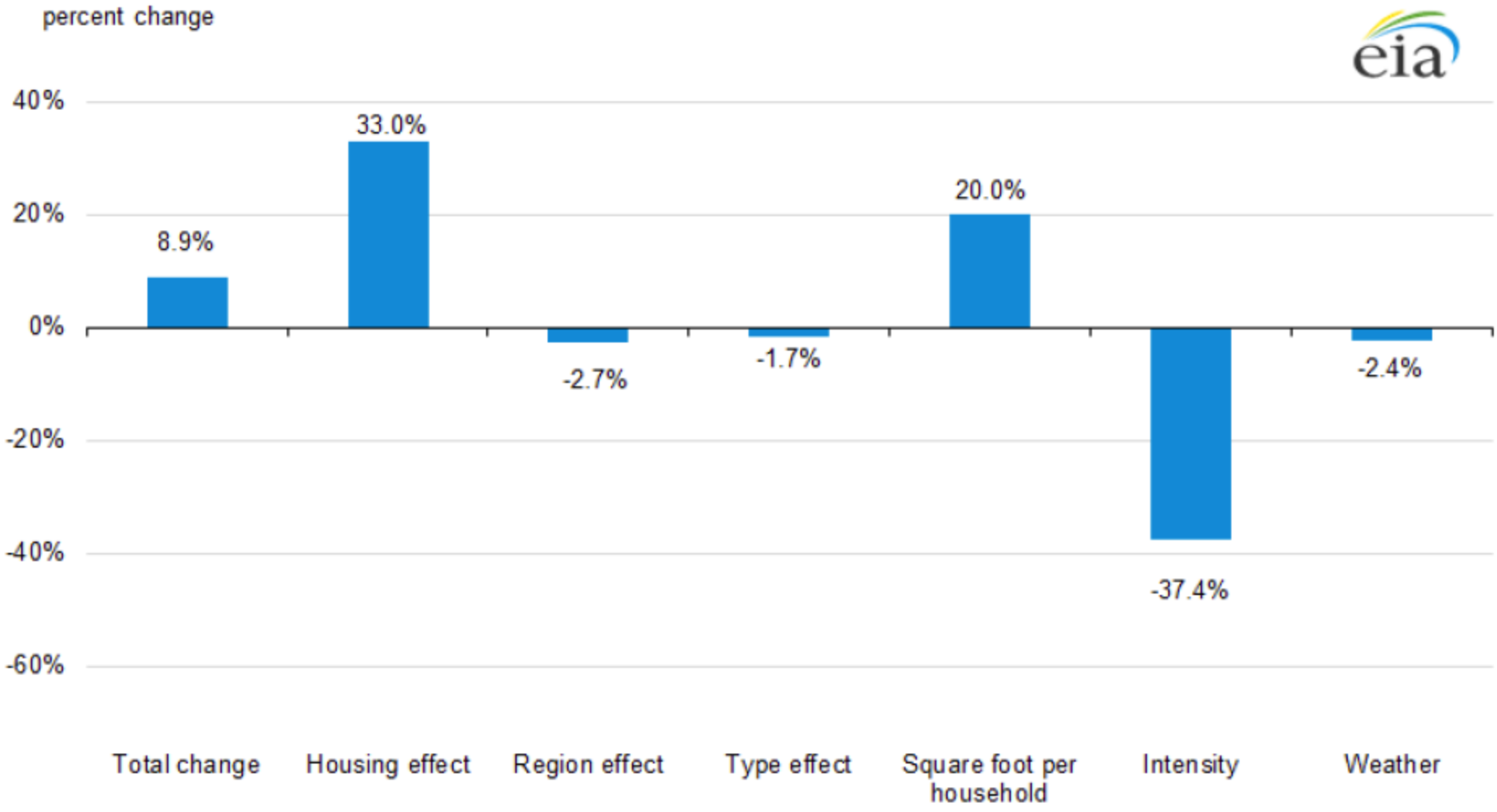
Sources: Hojjati and Wade (2012) and U.S. Energy Information Administration, Residential Energy Consumption Surveys, 1980, 1990, and 2009.

Energy expenditures by income

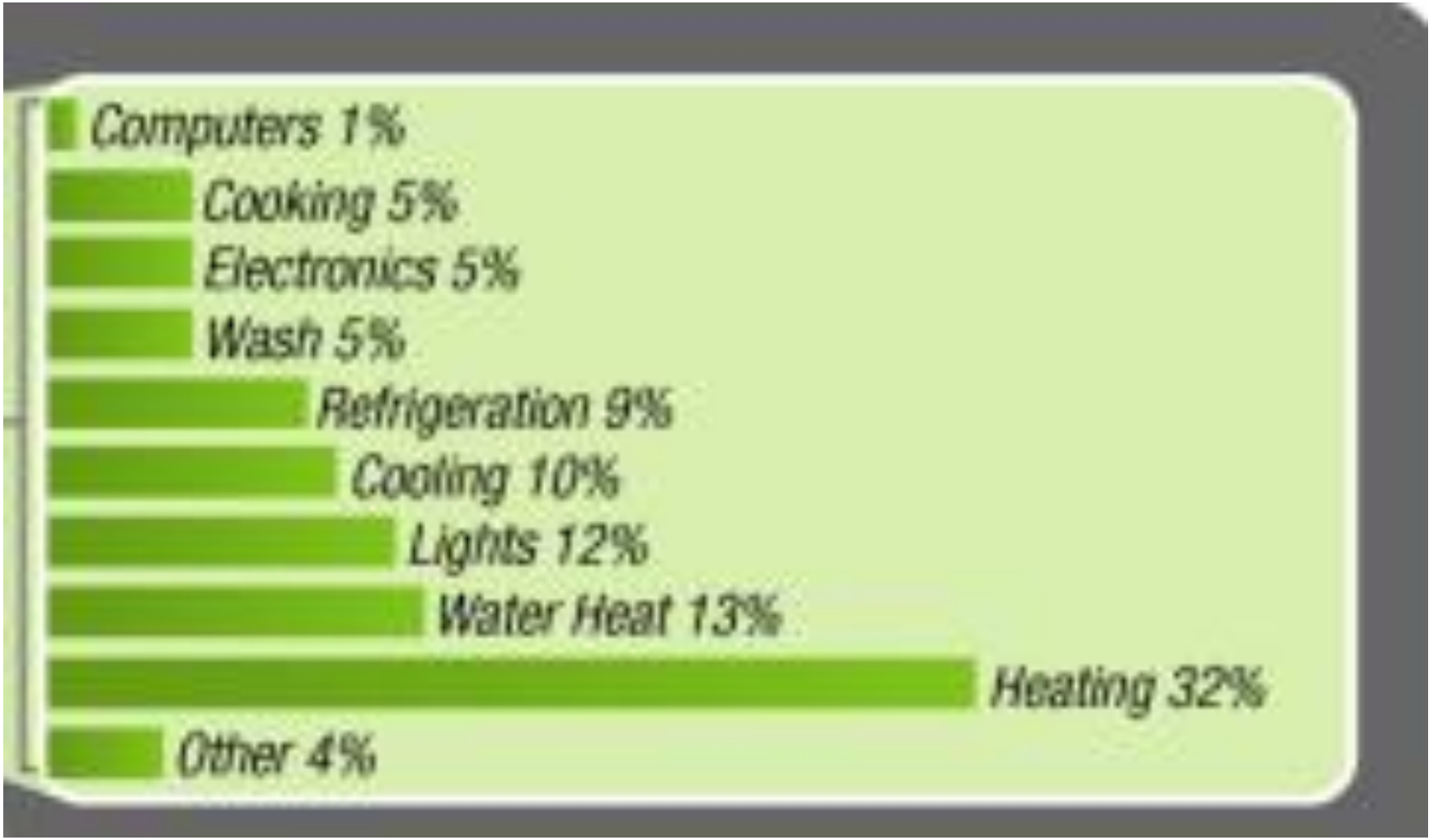
2.3.15 2005 Households and Energy Expenditures, by Income Level ($2010)

Household Income	Households (10^6)		Energy Expenditures by Household	Energy Expenditures by Household Member	Mean Individual Energy Burden (1)
Less than $10,000	9.9	9%	1,497	778	24%
$10,000 to $14,999	8.5	8%	1,568	757	13%
$15,000 to $19,999	8.4	8%	1,602	731	9%
$20,000 to $29,999	15.1	14%	1,753	715	7%
$30,000 to $39,999	13.6	12%	1,852	707	5%
$40,000 to $49,999	11.0	10%	1,995	750	4%
$50,000 to $74,999	19.8	18%	2,129	771	3%
$75,000 to $99,999	10.6	10%	2,431	847	3%
$100,000 or more	14.2	13%	2,774	909	3%
Total	**111.1**	100%			**7%**

Figure 10. Decomposition of change in total energy consumption, 1980-2009



How can we reduce our use?

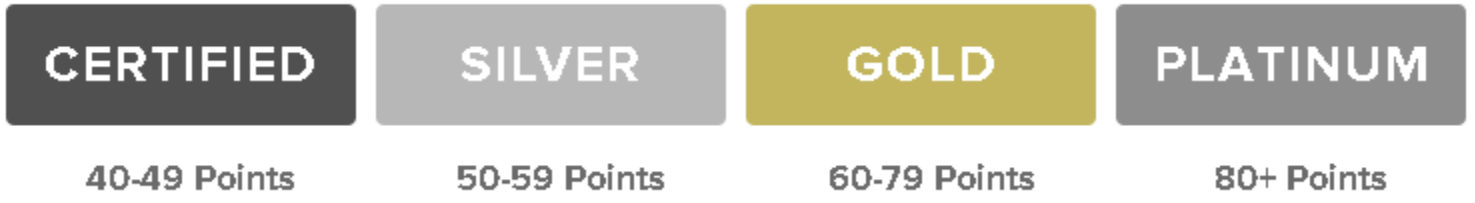


Energy Star

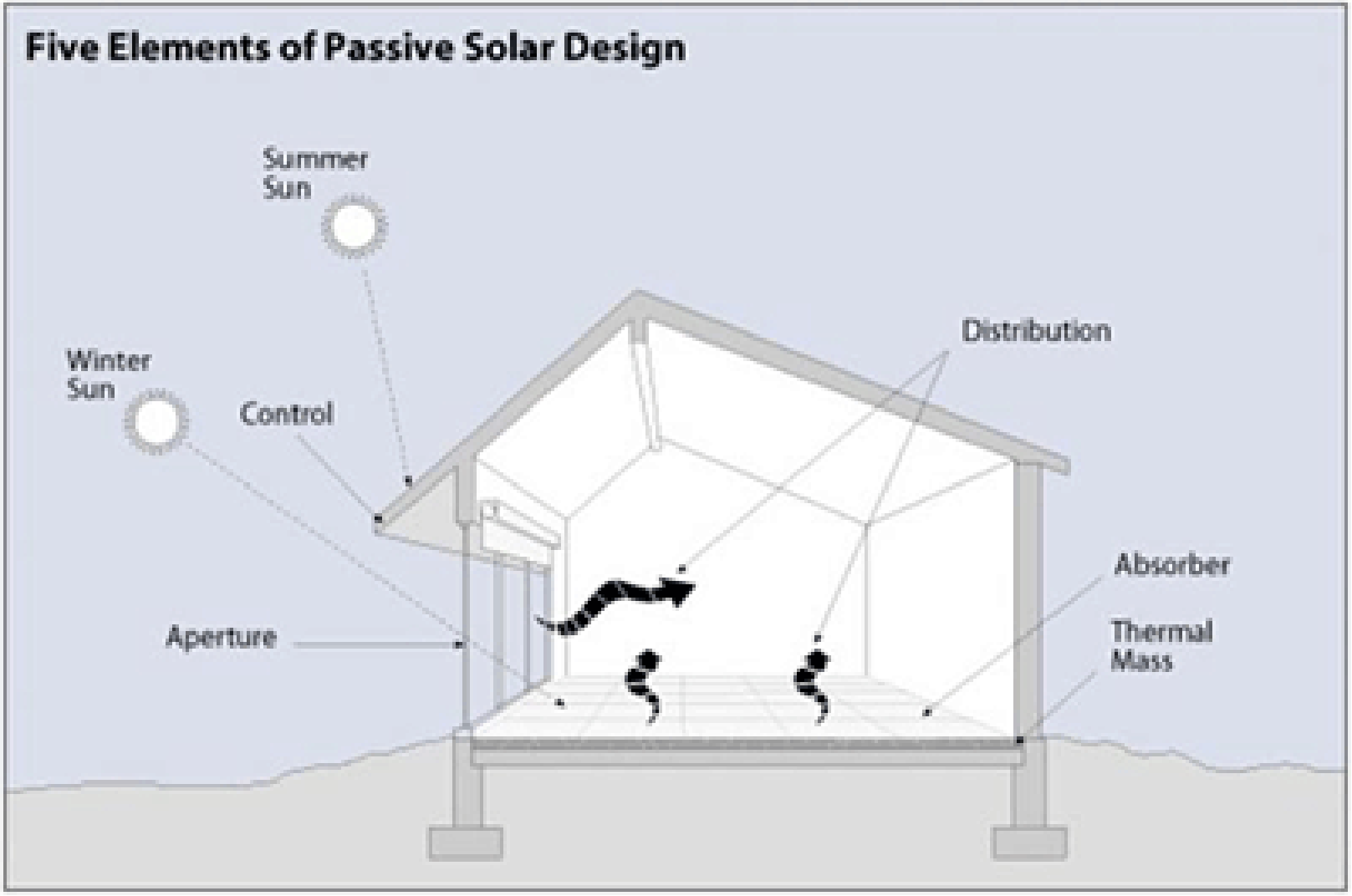
- An international performance standard for appliances and buildings
- Developed by DOE and EPA in 1992
- To be eligible for ENERGY STAR certification, a commercial building must earn an ENERGY STAR score of 75 or higher, indicating that it performs better than at least 75 percent of similar buildings nationwide.

LEED – Leadership in Energy & Environmental

- LEED is a design tool and not a performance measurement tool
- set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighborhoods.



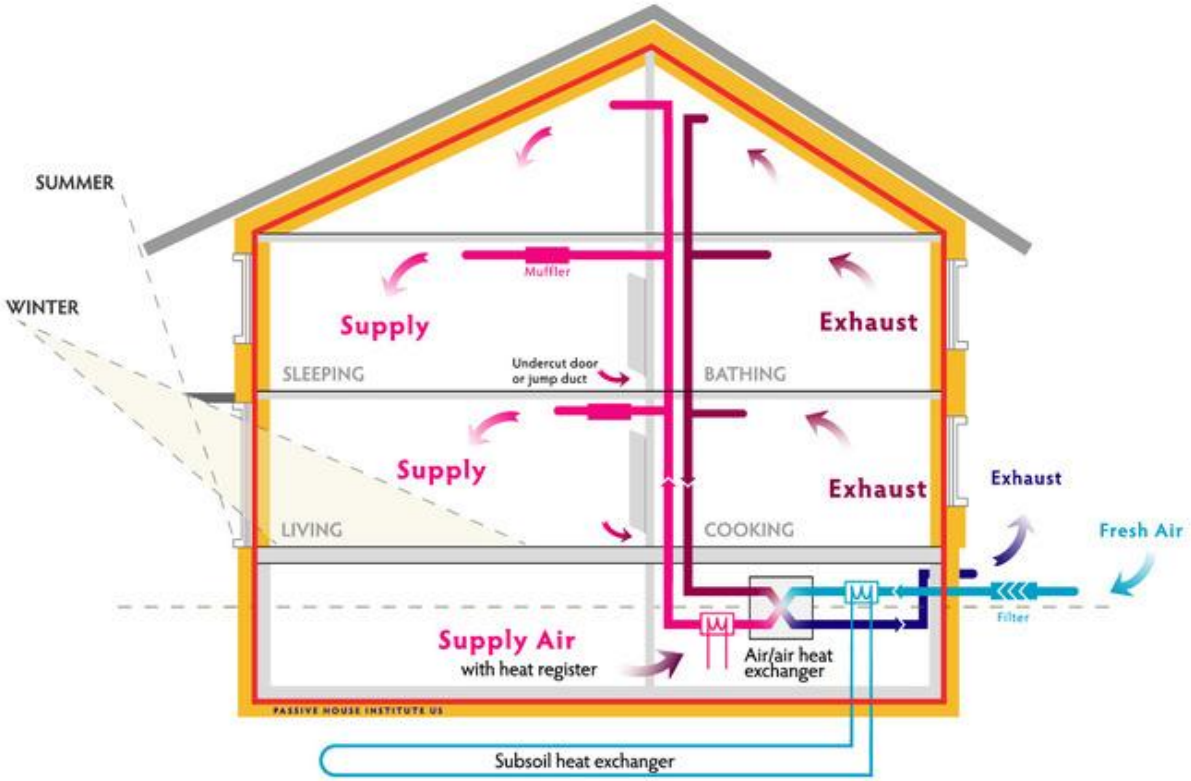
Passive Solar



Passive House Design

1. It employs continuous insulation through its entire envelope without any thermal bridging.
2. The building envelope is extremely airtight, preventing infiltration of outside air and loss of conditioned air.
3. It employs high-performance windows (typically triple-paned) and doors
4. It uses some form of balanced heat- and moisture-recovery ventilation and uses a minimal space conditioning system.
5. Solar gain is managed to exploit the sun's energy for heating purposes and to minimize it in cooling seasons.

Passive House Design



- The building must be designed to have an annual heating demand of not more than 15 kWh/m² per year (4746 BTU/ft² per year) and 15 kWh/m² per year in cooling.
- Total primary energy (source energy for electricity, etc.) consumption (primary energy for heating, hot water and electricity) must not be more than 120 kWh/m² per year (37900 btu/ft² per year)

Sufficiency….

150 – 300 square feet

Policy Tools (IPCC)

1. Regulatory measures
2. Information instruments
3. Direct market intervention
   - Public procurements
4. Economic instruments
   - (tradable permits/taxes)
5. Voluntary agreements
6. Advice and Leadership

Green Design Features

Building Massing

North/South orientation for optimal solar control

Deep recessed openings and windows provide shading

Setbacks for overhanging studios and critique bridge were set by the winter solstice altitude angle to maximize winter sun and minimize summer sun

Light

Sun louvers/light shelves control direct sun to minimize heat gain and glare. The light shelves reflect sun onto the interior ceilings for indirect light.

High performance glazing: low-e solar ban 60 glazing used in combination with fritted glass on the east and west elevations to control heat gain.

Water

A green roof terrace is located on the southeast corner of the second level.

Roof drains directed to storage tanks provide irrigation water for the green roof planting beds

Materials

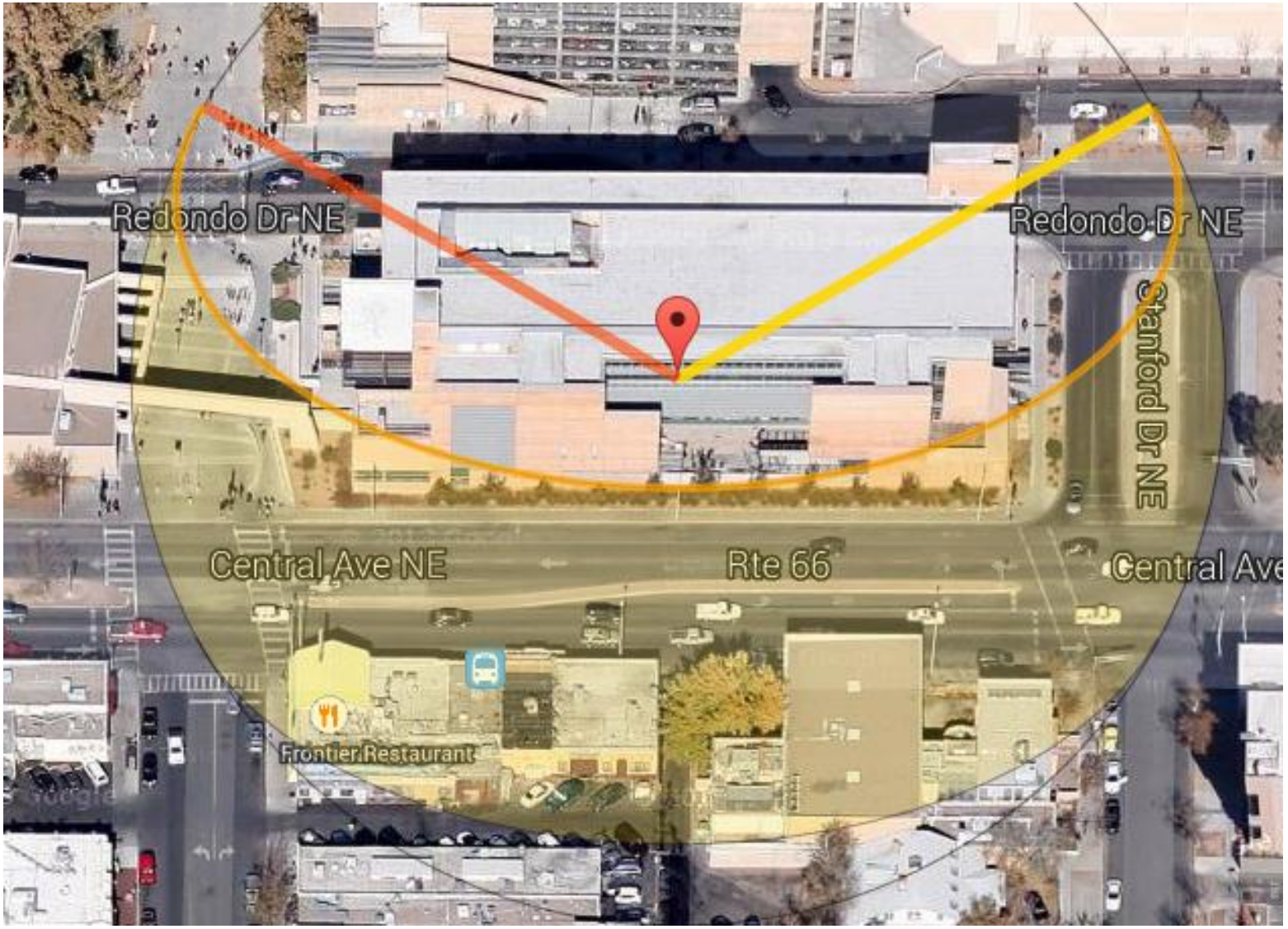
Recycled materials include steel and homasote for pin up walls.

Local/regionally purchased materials include concrete and courtyard sandstone pavers.

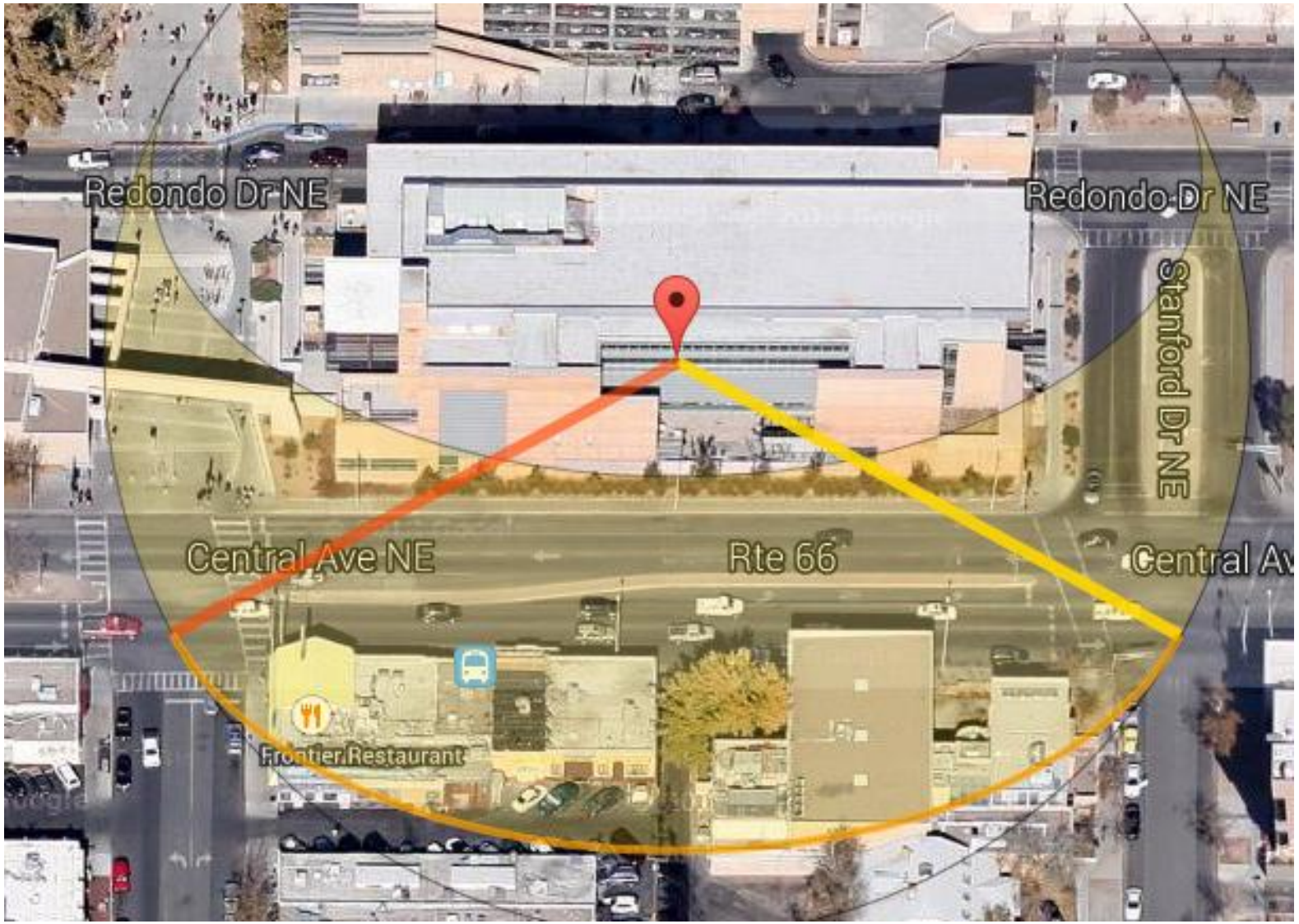
Mechanical System

Energy management computer control system used throughout, and monitored from UNM central processor.

Pearl Hall, Summer Solstice



Pearl Hall, Winter Solstice



Other topics

- What policies have you seen that seem effective?
- How do they impact your behavior?
- Other aspects of buildings that you'd like to discuss?