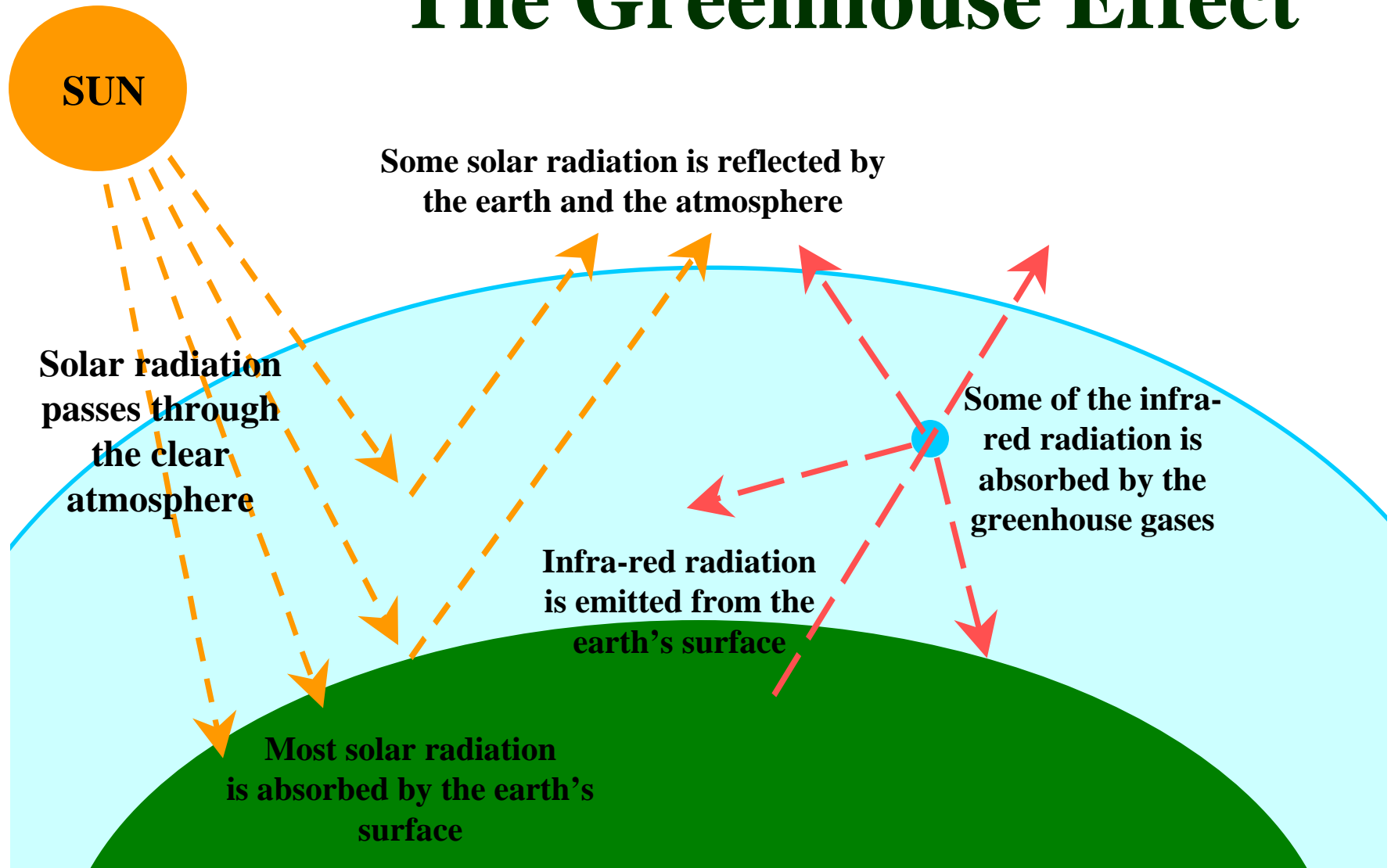


Greenhouse Gas Impacts from Home Space Heating



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The Greenhouse Effect



Greenhouse Gases

Gas	Global Warming Potential	1995 U.S. Emissions (million metric tons)	Atmospheric Lifetime (years)
Carbon Dioxide (CO₂)	1	5297	50-200
Methane (CH₄)	21	31	12
Nitrous Oxide (N₂O)	310	0.5	120
Hydrocarbons and Minor Gases (CFC-11, CFC-12, CFC-113, HCFC-22, HFCs, PFCs, SF ₆ , Methylchloroform)	most >1200	0.2	varies ¹

¹ CFC-11 50 years
 CFC-12 102 years

Carbon Equivalents =
Mass of Greenhouse Gas × GWP × 12/44

- GWP is the Global Warming Potential
- 12/44 is the ratio of carbon mass to total mass in a carbon dioxide molecule

Energy Directly Consumed by Source for Residential Space Heating in the United States

	Electricity	Natural Gas	Fuel Oil	Kerosene	LPG	Wood	Coal
Households	37.1 Million	52.6 Million	10.7 Million	3.6 Million	5.6 Million	20.4 Million	0.2 Million
Total Energy Consumed	119 Billion KWH	3570 Billion Cubic Feet	6.51 Billion Gallons	0.34 Billion Gallons	3.25 Billion Gallons	27.4 Million Cords	3 Million Short Tons
Total Energy Consumed (Quads)	0.41¹	3.67	0.90	0.05	0.30	0.55	0.06
Percent of Total	6.9%	61.8%	15.1%	0.8%	5.1%	9.2%	1.0%

¹ 1.22 quad of energy is consumed by power plants to produce the 0.41 quads of electricity consumed in residences for space heating.

Energy Consumed by Primary Source for Residential Space Heating in the United States

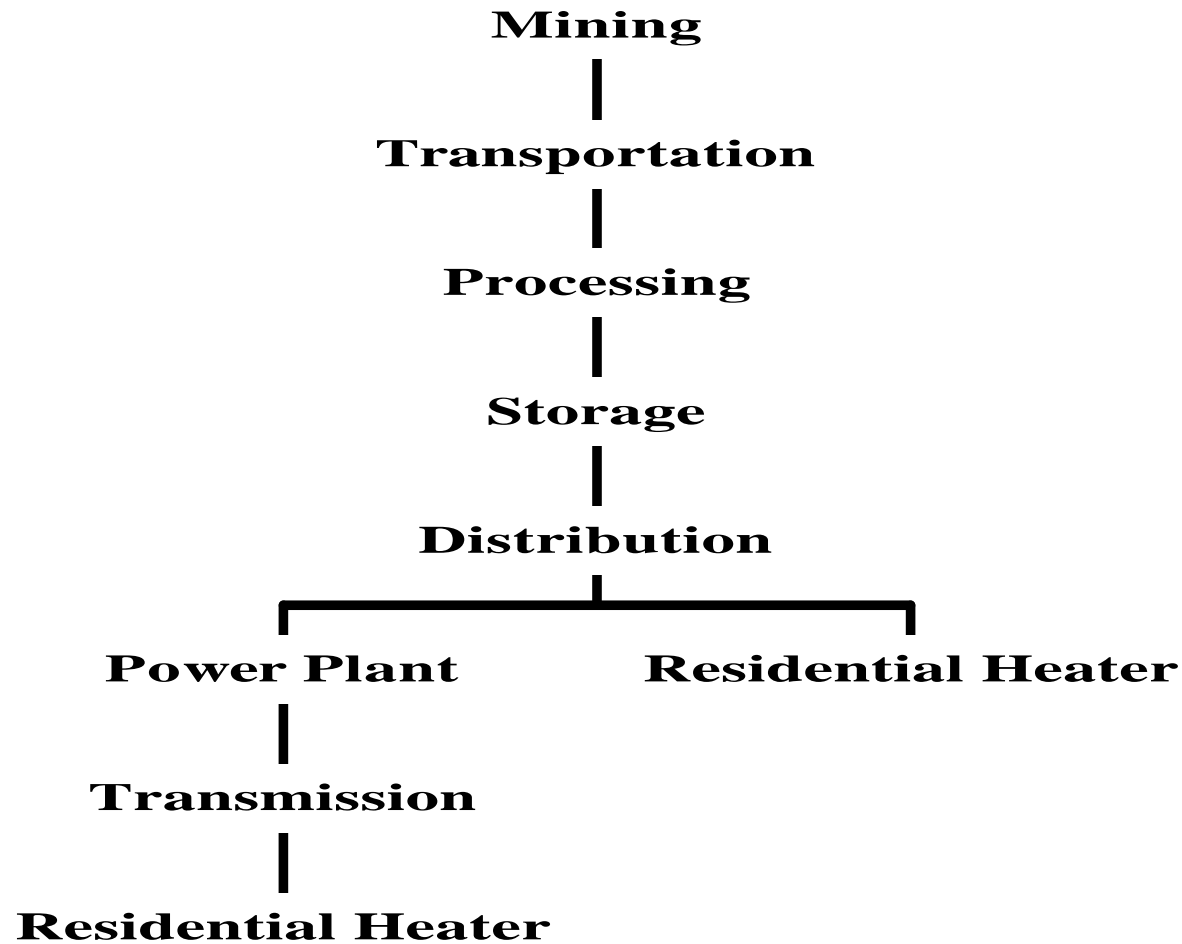
	Coal	Natural Gas	Petroleum ¹	Wood	Nuclear	Other ²
Total Energy Consumed (Quads)	0.62	3.78	1.29	0.55	0.26	0.13
Percent of Total	9.5%	57.0%	19.4%	8.3%	3.9%	2.0%

¹ The petroleum category includes heavy and light oils, kerosene, LPG and petroleum coke.

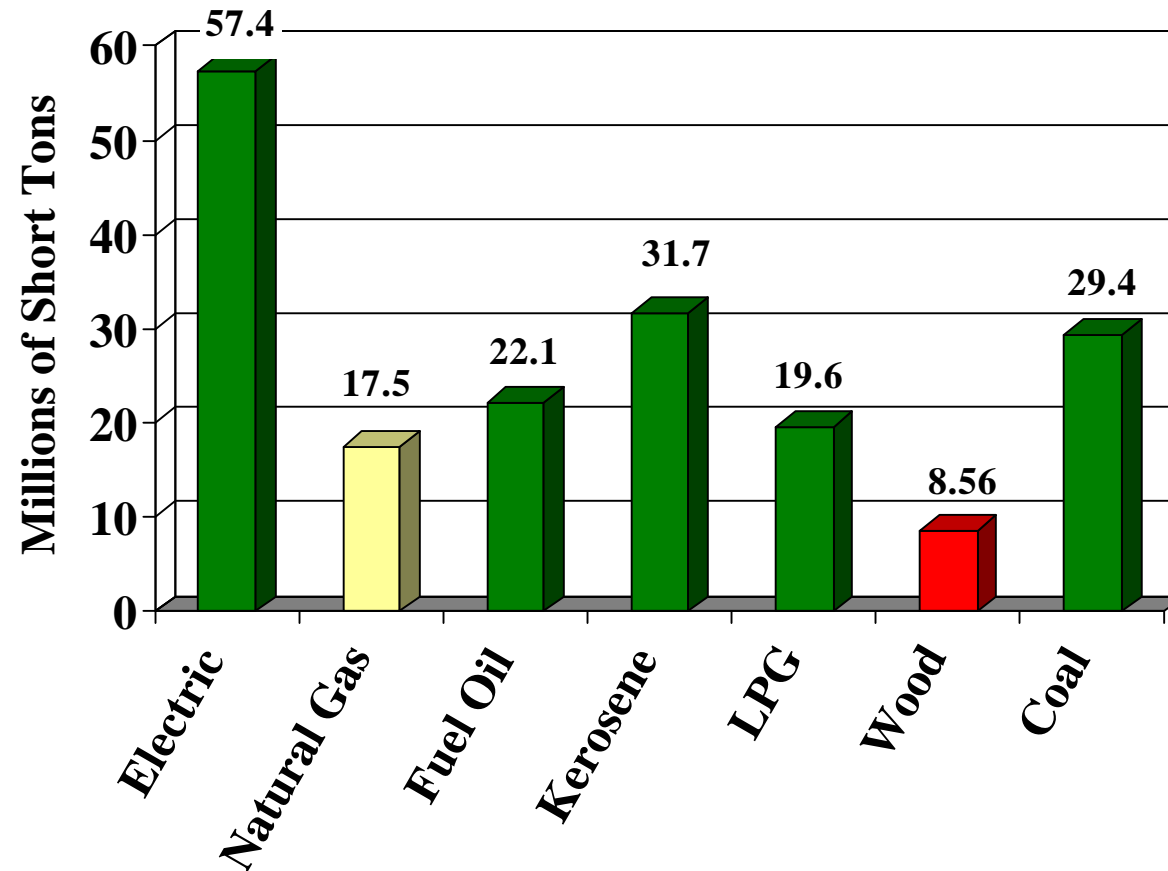
² Hydroelectricity makes up the majority of the “other” category.

Example Energy Trajectory

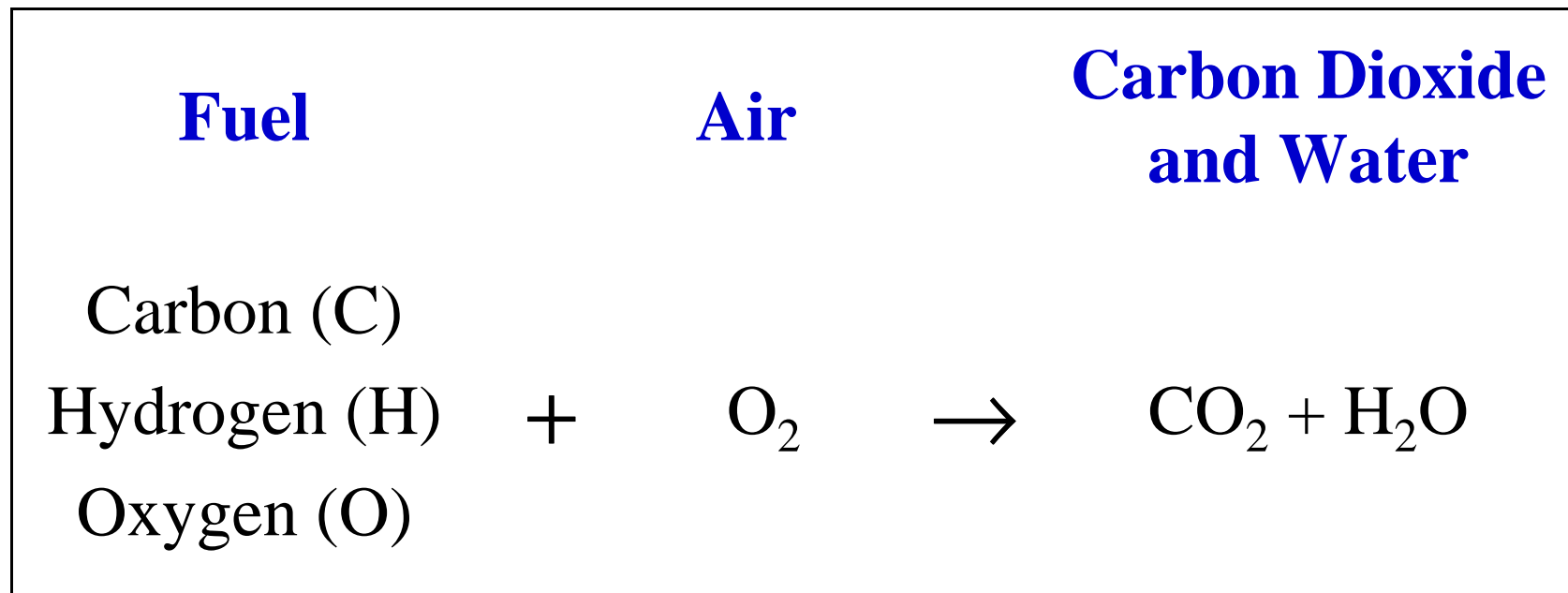
coal used for residential space heating



Carbon Equivalents of Greenhouse Gases per Quad of Heat Delivered



Carbon Dioxide Emissions



RWC and Direct Natural Gas Space Heating have the Lowest Greenhouse Gas Impacts

- Natural gas has relatively few and efficient intermediate steps in its energy trajectory as compared to other fossil fuels
- Carbon dioxide credit for RWC since the harvesting of mature trees for fuel is using a modern carbon source and their replacement with more rapidly growing, younger trees provides an effective CO₂ offset for RWC
- RWC has a simple energy trajectory and high Energy Return On Investment (EROI)

Relative Contribution to Greenhouse Gas Impacts by Gas Type for Natural Gas Heating

Gas	% Impact*
Carbon Dioxide	88.4 %
Methane	11.4 %
Nitrous Oxide	0.1 %

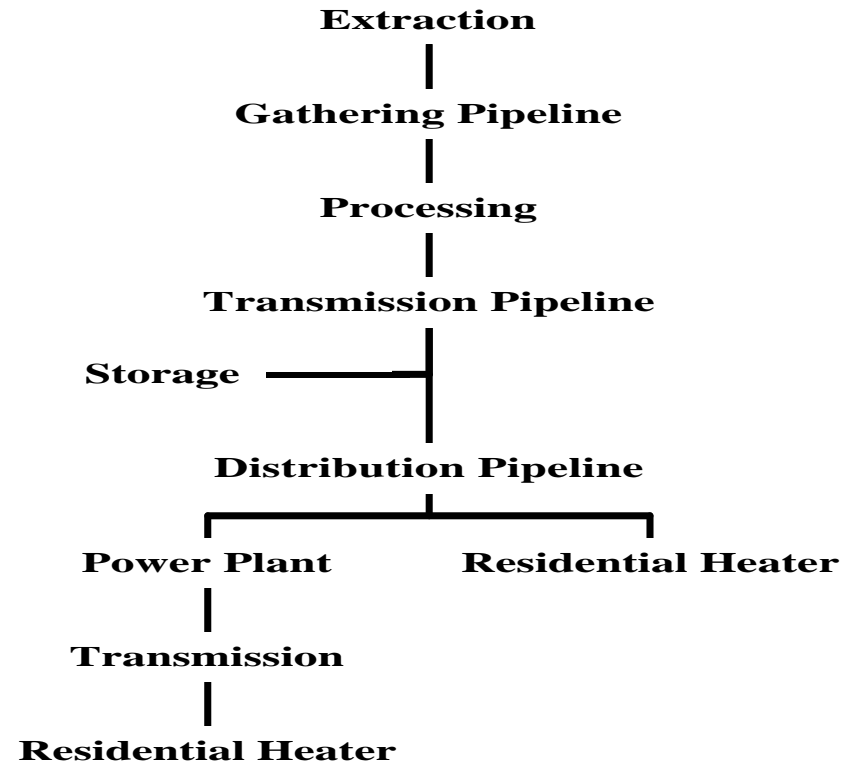
* Expressed as Carbon Equivalents

Methane Emissions for Natural Gas Heating

Typical Composition of Natural Gas

Gas	%
Butane(s)	0.6 %
Carbon Dioxide	0.4 %
Ethane	6.0 %
Methane	81.1 %
Nitrogen	9.2 %
Pentane(s)	0.2 %
Propane	2.1 %
Others	0.4 %

Natural Gas Energy Trajectory



RWC Emission Factors

~ 5g methane per dry kg wood

~ 1700g carbon dioxide per dry kg wood

Reported methane emission factors are extremely variable

Conclusions

- RWC and direct natural gas heating have the lowest greenhouse gas impacts among space heating options
- Simple and efficient energy trajectories
- Carbon sequestration credit fro RWC
- Carbon dioxide effect is greater than methane effect
- Carbon sequestration credit and relative methane concentration still needs to be refined for RWC