

# APTI Course 427

## Combustion Source Evaluation

# Administrative

- Post-test similar to pretest, open notes
- Daily schedule
  - Three 90 minute sessions
  - Two 15 minute breaks
- Presentation follows Student Manual
- Read ahead for each day

# APTI Course 427

## Combustion Source Evaluation

### Chapter 1: Overview

# Chapter Overview

- Significance of Combustion Sources
- Carbon and Energy
- Fuels
- Air Pollution
- Overview of Combustion Sources

# Significance of Combustion Sources

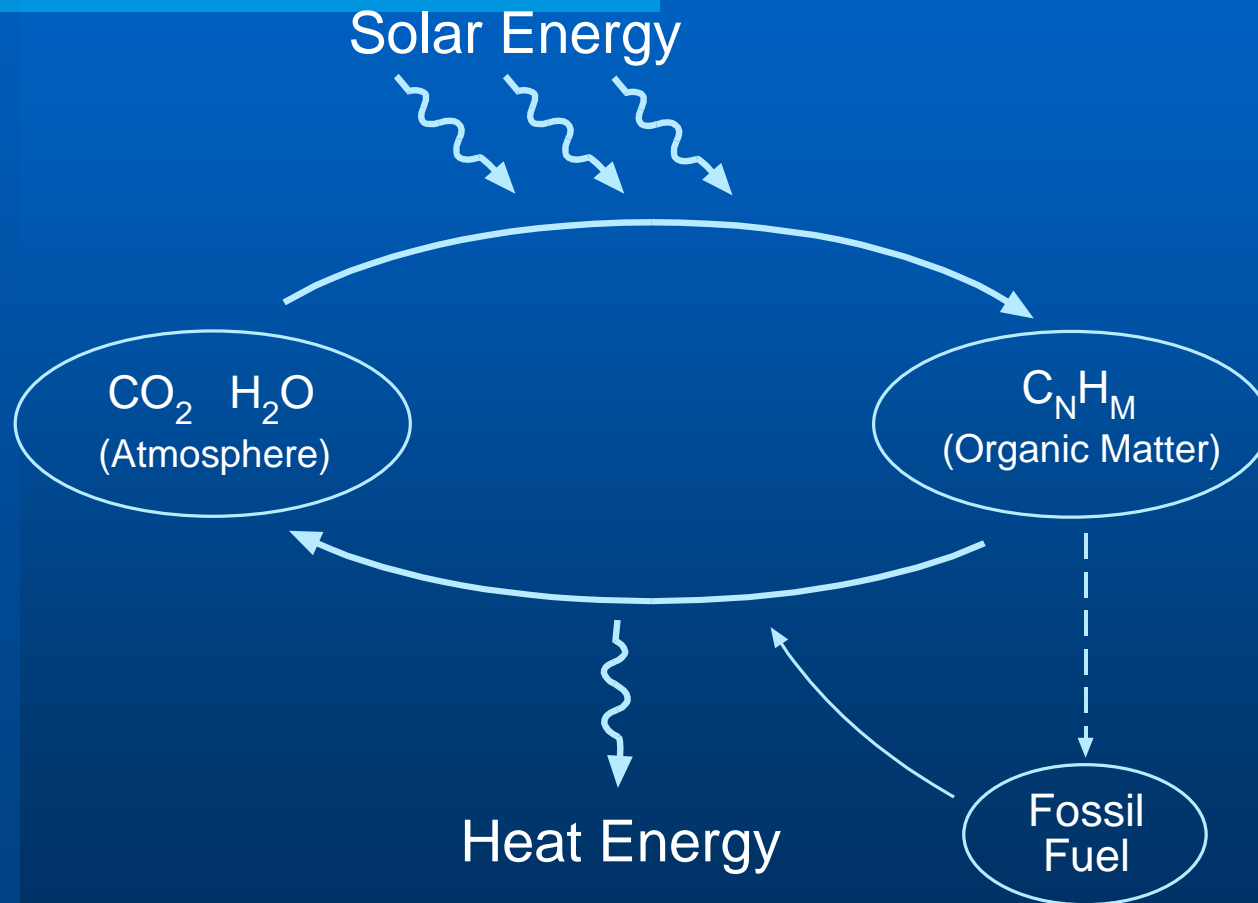
**Table 1-1. Examples of Sources and Fuels**

Source Type	Principal Fuels
Steam-electric power plant	Bituminous coal, subbituminous coal, residual oil, natural gas (fossil fuels)
Waste-to-energy steam power plant	Wood, municipal solid waste, misc.
Factory boiler	Gas, No. 2 oil, No. 6 oil, site specific waste
Combustion turbine power plant	Natural gas or distillate oil
Cement kiln	Fossil fuels, tires, used oil, hazardous waste
Residential or commercial furnace	Natural gas or No. 2 oil
Trucks, cars & railroad engines	Gasoline or diesel fuel
Incinerators	Natural gas, fumes, organic liquid and solids

# Carbon and Energy

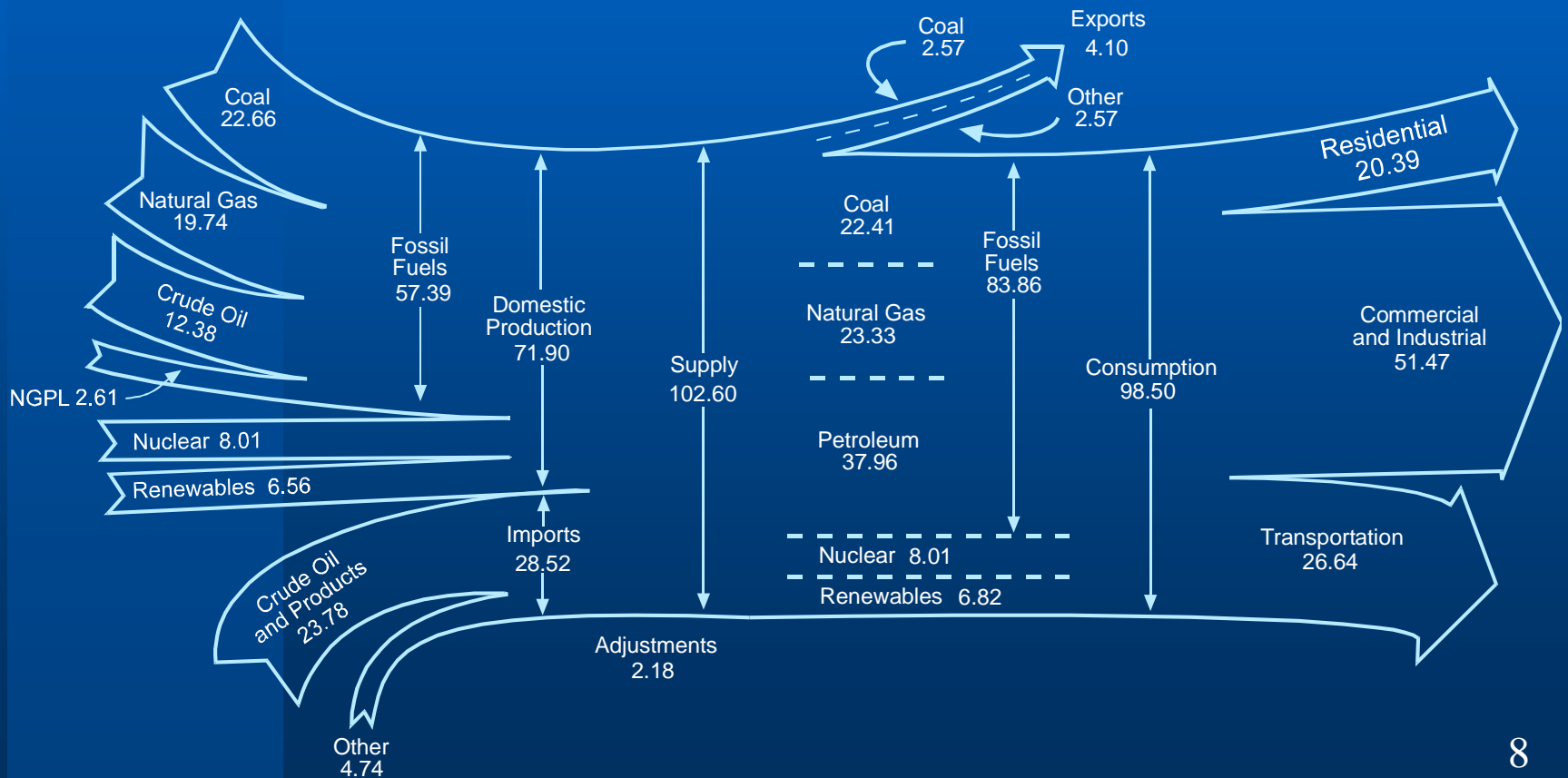
- All common fuels are hydrocarbons.
- Energy is derived from the oxidation of carbon and hydrogen.

# Energy and Carbon Cycle



# Energy Production/Consumption

Energy Flow, 2000  
(Quadrillion Btu)





# Fuels (outline)

- Fuel Characteristics
- Carbon Emissions

# Fuel vs Combustor Design

- Fuel characteristics affect combustor design
- Some sources operate on several fuels
- The many aspects of source design depend on fuel type

# Fuel Characteristics

**Table 1-2. Fuel Characteristics**

Fuel	Chief Characteristic
Natural Gas	Mostly $\text{CH}_4$ (methane) - usually burns clean
LPG	Mostly $\text{C}_3\text{H}_8$ (propane) - higher density than $\text{CH}_4$
Light Oil (No. 2, Diesel)	Few contaminants - a mixture averaging $\text{CH}_2$
Heavy Oil (No. 4, No. 6, residual)	Black (close kin to tar), not readily pumped or burned when cold, sulfur and other contaminants
Coal (bituminous, anthracite, lignite)	Contaminated with sulfur, ash, rock & water. Composition - C to CH
Wood	Moderate ash, water content is high & variable. Typical composition - $\text{CH}_2\text{O}$

# Fuel Characteristics (cont.)

Table 1-2. Fuel Characteristics

Fuel	Chief Characteristic
Waste Oil	Distillate oil with some contaminants
Refinery gas, producer gas, coke oven gas	Gas mixtures with inerts plus some contaminants
Landfill gas, sewage treatment gases	Mostly CH <sub>4</sub> & CO <sub>2</sub> with smelly contaminants
Solid wastes	Contaminated with almost anything

# Fuel Choices

- A source will use the least expensive fuel
  - that's practical & permitted
    - Limited by existing equipment?
    - Environmental restrictions?
- Clean fuels are expensive
- Trade off between expensive fuel & expensive equipment & permits

# Carbon Emissions

Table 1-3. Carbon Emissions (10 <sup>6</sup> tons)		
Sector	Total Carbon	Electric*
Transportation	496	1
Industrial	481	180
Residential	290	193
Commercial	243	183

\*Electric is part of the total.

# Air Pollution (outline)

- Origin
- Emission rates
- Types of pollutants
- Emission controls

# Origin

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- Direct
- Indirect
- Dilution, transport, ambient impacts



# Determining Emission Rates

- Estimating - rate is proportional to
  - Amount of fuel burned
  - Fuel contaminant content
- AP-42
  - ?? Applicability & reliability ??

# Emission Rates Units

Common measurement units:

- lb/hour or tons/year
- ppm or lb/ft<sup>3</sup> (corrected)
- lb/mmBTU
- lb/ton of product

# Types of Pollutants

1. Products of incomplete combustion or PIC (CO, carbon, organic species)
2. Emissions formed from fuel contaminants (SO<sub>x</sub>, particulates, etc.)
3. Nitrogen oxides (NO<sub>x</sub>)

# Emission Control

<i>Source</i>	<i>Pollutant</i>	<i>Uncontrolled</i>	<i>Controlled</i>
Natural gas furnace	NOx	0.1 to 0.5	.02 to .02
No. 6 oil fired boiler	NOx Particulates SO <sub>2</sub>	0.45 0.10± 2.50	0.25 0.05± <1.00
Pulverized coal boiler	NOx Particulates SO <sub>2</sub>	0.80 10.00 4.50	0.40 <0.05 <1.50
Wood fired boiler	Particulates	2.50	0.1 to 0.6
Diesel Engine	NOx Particulate – PM10 CO	3.2 0.05 – 1.0 0.85	1.9
Combustion Turbine	NOx	0.50	0.035

# Overview of Combustion Sources

## (outline)

- Overview
- Engines
- Boiler Systems
- Other Combustion Sources

# Overview of Combustion Sources (2)

- Stationary sources account for 1/3 of CO<sub>2</sub>
- Sizes
  - Small sources are manufacturer certified

# Internal Combustion Engines

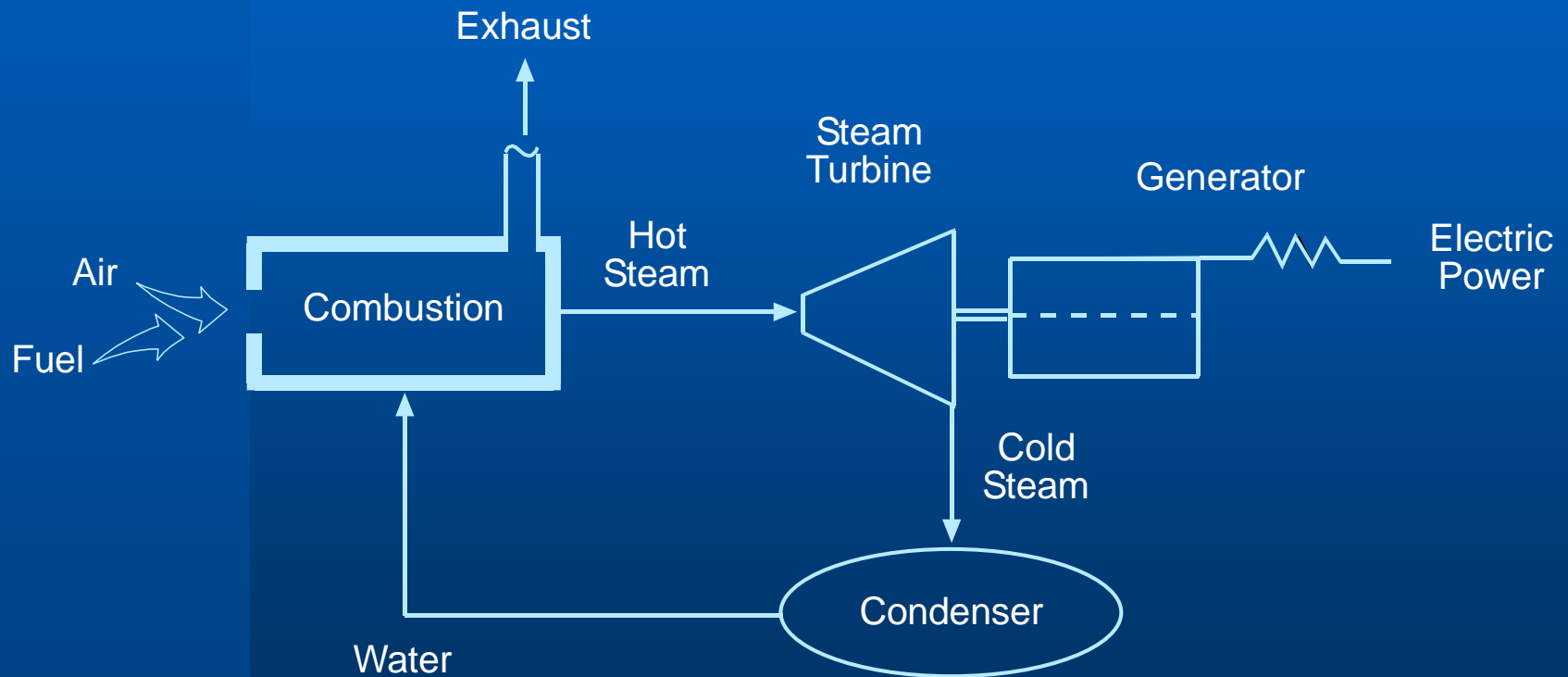
- Two types
  - Reciprocating & combustion turbines
- Uses
- Emissions
  - Clean fuels mean NOx is the main issue
- Basic Configuration
  - Factory built mean they are highly predictable

# Boilers

- Most common stationary combustion source
- Come in all sizes
- Can be configured to burn ANY fuel



# Boiler with Steam Turbine Generator



# Other Combustion Sources

- Cement Kilns
- Solid Waste Incinerators
- Hazardous Waste Incinerators
- Thermal Oxidizers

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