Greenhouse Gas Emissions from Aviation and Marine Fuel Use

Gail Bruss

And

Wiley Barbour

Introduction

What this session will cover:

- The process and the assumptions used to derive the 1998 potential Carbon Dioxide (CO_2) emissions from United States aviation and marine fuel usage and the portion attributed to bunker fuel
- Specifically the portion of military aviation and marine International Bunker Fuel as first reported in 1998
  - *Inventory of United States GHG Emissions and Sink, 1990-1998 EPA 236-R-00-001*

Background

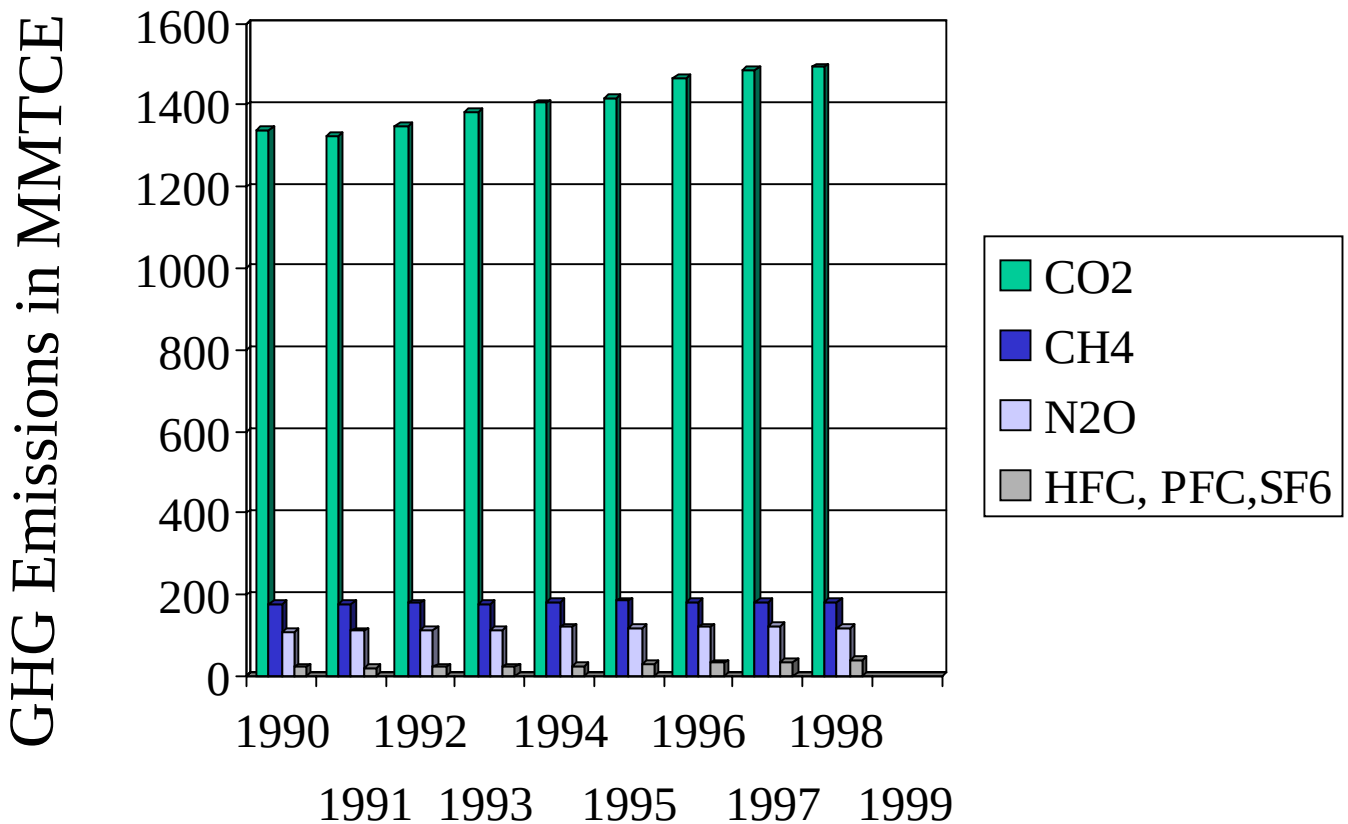
In 1992 the Framework Convention on Climate Change (FCCC) was adopted.

- Article 4 of the FCCC includes the commitment of the Parties to prepare national greenhouse gas (GHG) inventories

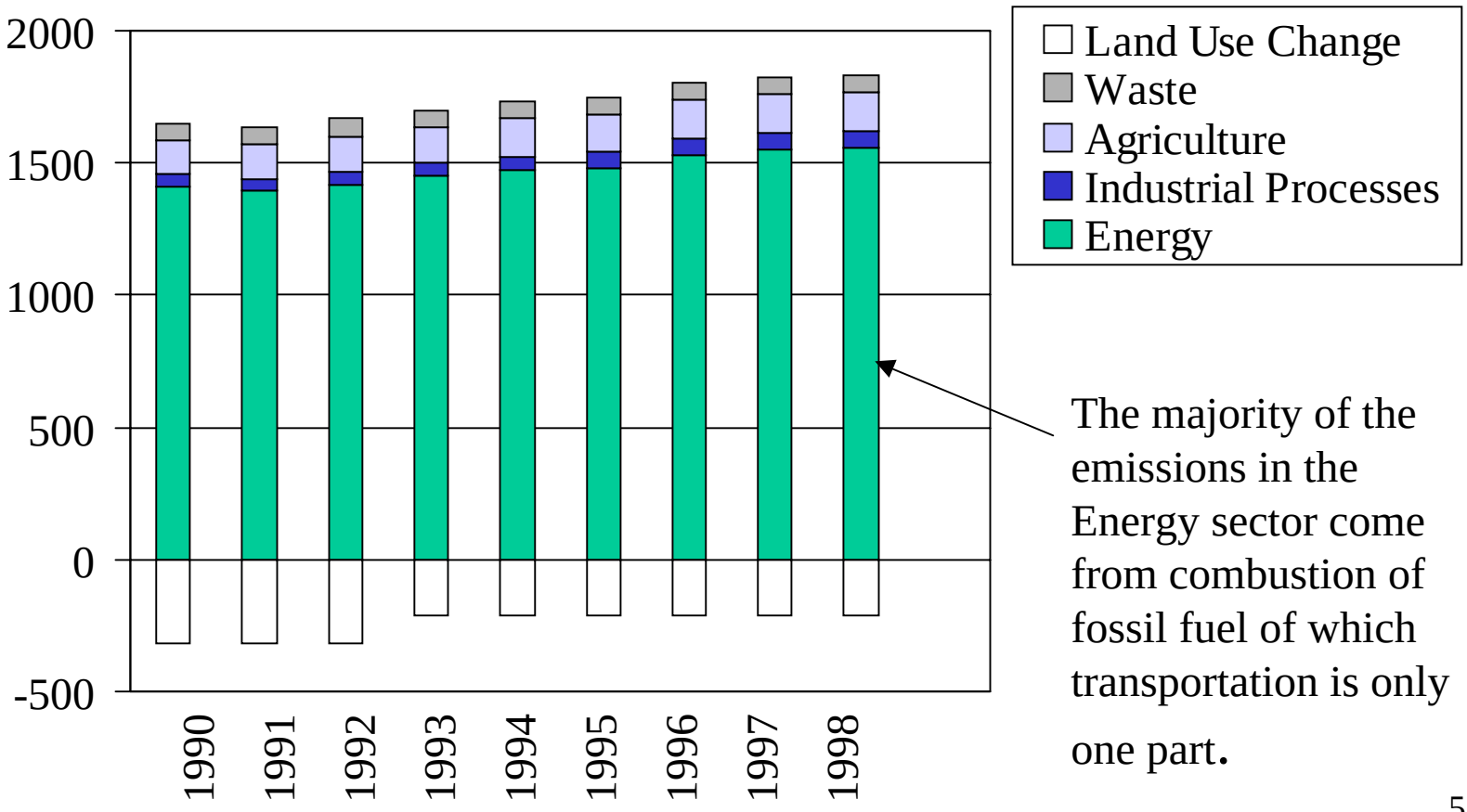
U.S. has done inventory work for the last 10 years. First published a nation GHG inventory in 1994

- Large undertaking
- Estimates from all sectors of the economy

U.S. GHG Emissions 1990 -1998

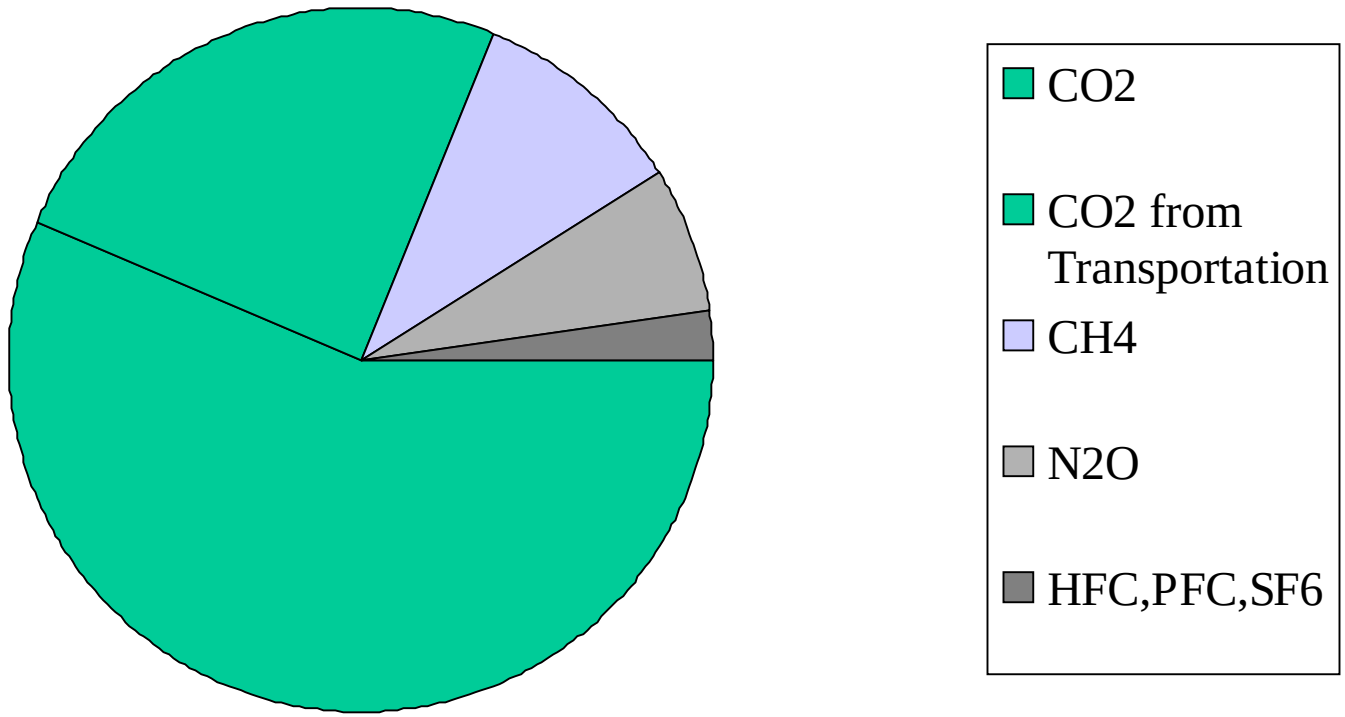


U.S. GHG Emissions and Sinks by IPCC Sector

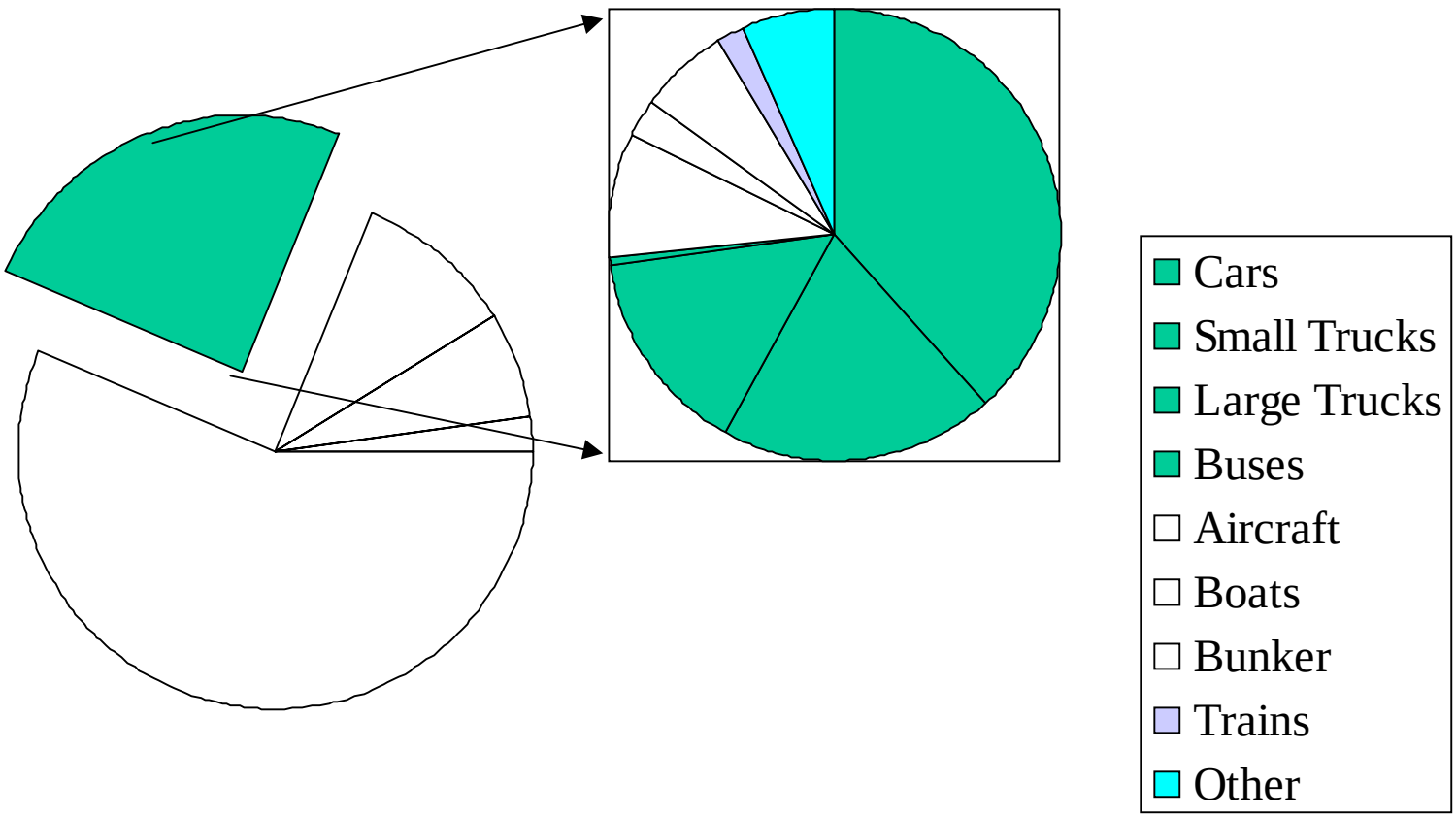


The majority of the emissions in the Energy sector come from combustion of fossil fuel of which transportation is only one part.

U.S. GHG Emissions 1998 Only



U.S. GHG Emissions
1998 Only



Aviation Bunker Fuel Calculations

Aviation transportation

- Tier I approach: The quantity of fuel purchased and delivered within the United States provides an accurate estimate of the national CO_2 emissions.

Start with the total jet fuel consumption

- Determine International Bunker Fuel
- Three components of Bunker Fuel:
  1) Fuel used by U.S. flag carriers on international flights
  2) Fuel purchased by foreign flag carriers while at United States airports
  3) International flights by the United States Military

Aviation Bunker Fuel Data Source

Commercial International Bunkers

- The Bureau of Transportation Statistics (BTS) produces a monthly report (Form 41) entitled “Fuel Cost and Consumption”
- BTS data is supplied in gallons. The data must be converted to heat content units: MMBtu/gallon.
- Let’s look at a sample calculation

1998 Sample Calculation

U.S. Flag Commercial International Bunkers

Heat content jet fuel = (5.67 MMBtu/Barrel)(Barrel/42 gallons) = 0.135 MMBtu/gallon

Calculation:

(4,725,250,123 gallons used in round trip international flights)(0.135 MMBtu) = 637,908,767 MMBtu

(637,908,767 MMBtu)(1Tbtu/1,000,000 MMBtu) = 637.9 TBtu

½ International Jet Fuel consumption (outbound flight only) = 319 TBtu (rounded)

(Inbound leg of round trip flights assumed to have purchased fuel at overseas airport.)

1998 Sample Calculation

Foreign Flag Commercial International Bunkers

Total expenditure Foreign Flag carriers at U.S. airports = $7,107 Million
Percentage of total expenditure spent for fuel and oil = 24%
($7,107 x$10^6$)(0.24) = $1,706,000,000 Million spent on fuel
Fuel cost (cent/gal) = $0.5435
($1,706,000,000)/($0.5435) = 3,138,914,443 gallons fuel
(3,138,914,443 gallons)(0.135 MMBtu/gallon) = 423,753,449 MMBtu
(423,753,449 MMBtu)/1,000,000 MMBtu/TBtu = 424 TBtu

Bunker fuel sold to Foreign Flag Carriers (424 TBtu)

Military Bunkers

Determine International Bunker Fuel

- Three components of aviation bunker fuel:
  1) Fuel used by domestic flag carriers on international flights
  2) Fuel purchased by foreign flag carriers while at United States airports
  3) International flights by the United States military
- Now let's look at the military aviation bunker fuels

1998 Sample Calculation Military Aviation Bunker Fuel

Data on fuel delivered to the military within the United States is provided from unpublished data by the Defense Energy Support Center under the Defense Logistics Agency

Heat content jet fuel = (5.67 MMBtu/Barrel)(Barrel/42 gallons) = 0.135 MMBtu/gallon

$(501.67 \times 10^6$ gallons)(0.135 MMBtu) = 67,725,450 MMBtu

(67,725,450 MMBtu)(1Tbtu/1,000,000 MMBtu)

= 68 TBtu Military bunker fuel (rounded)

1998 Sample Calculation

Reported in Table 2-33 of the U.S. National Inventory

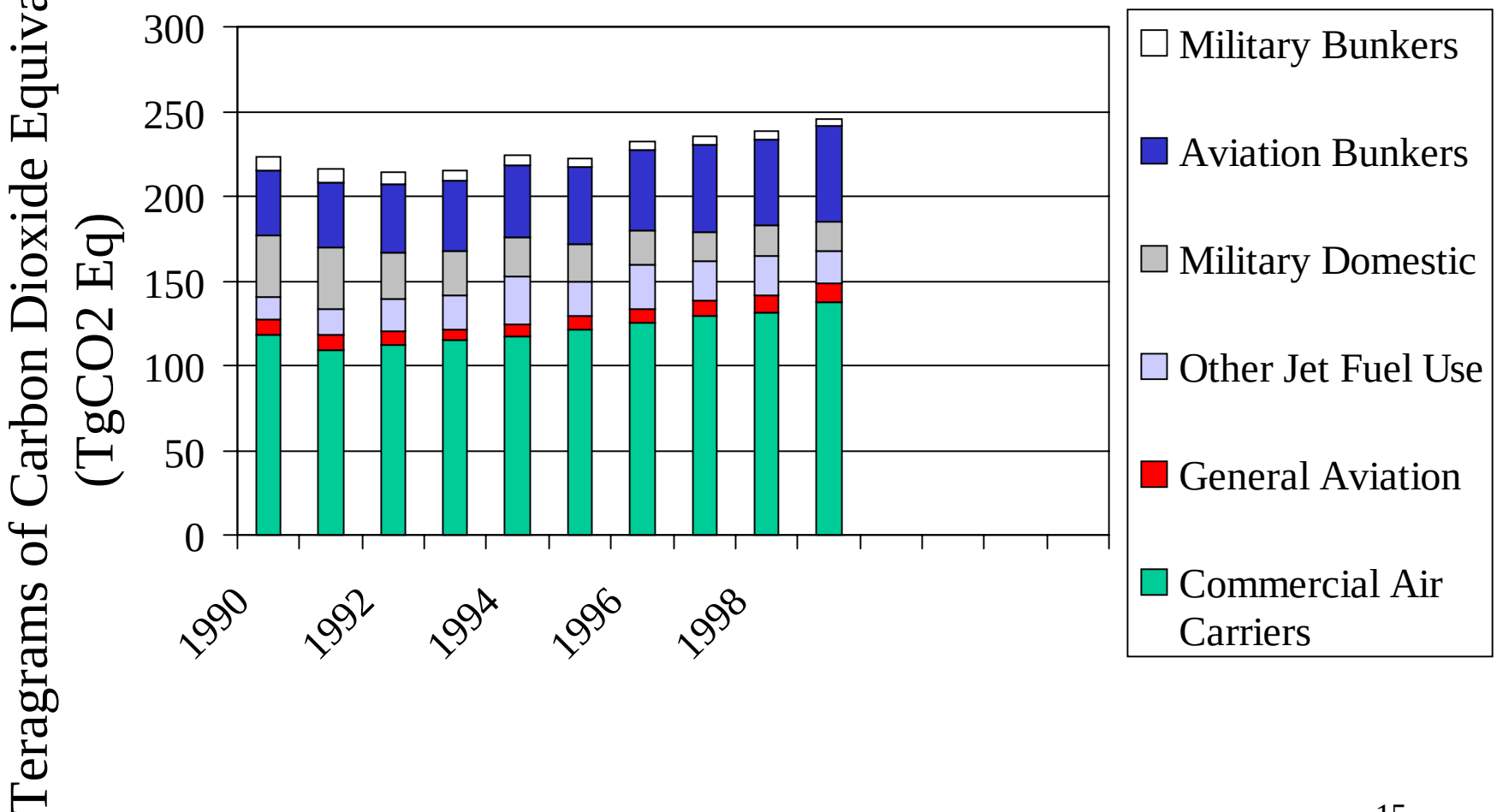
Domestic Flag International bunker fuel (319 TBtu)
+ Bunker fuel sold to Foreign Flag Carriers (424 TBtu)
+ Military Bunker fuel (68 TBtu)

International Bunker Jet Fuel Use = 811 TBtu

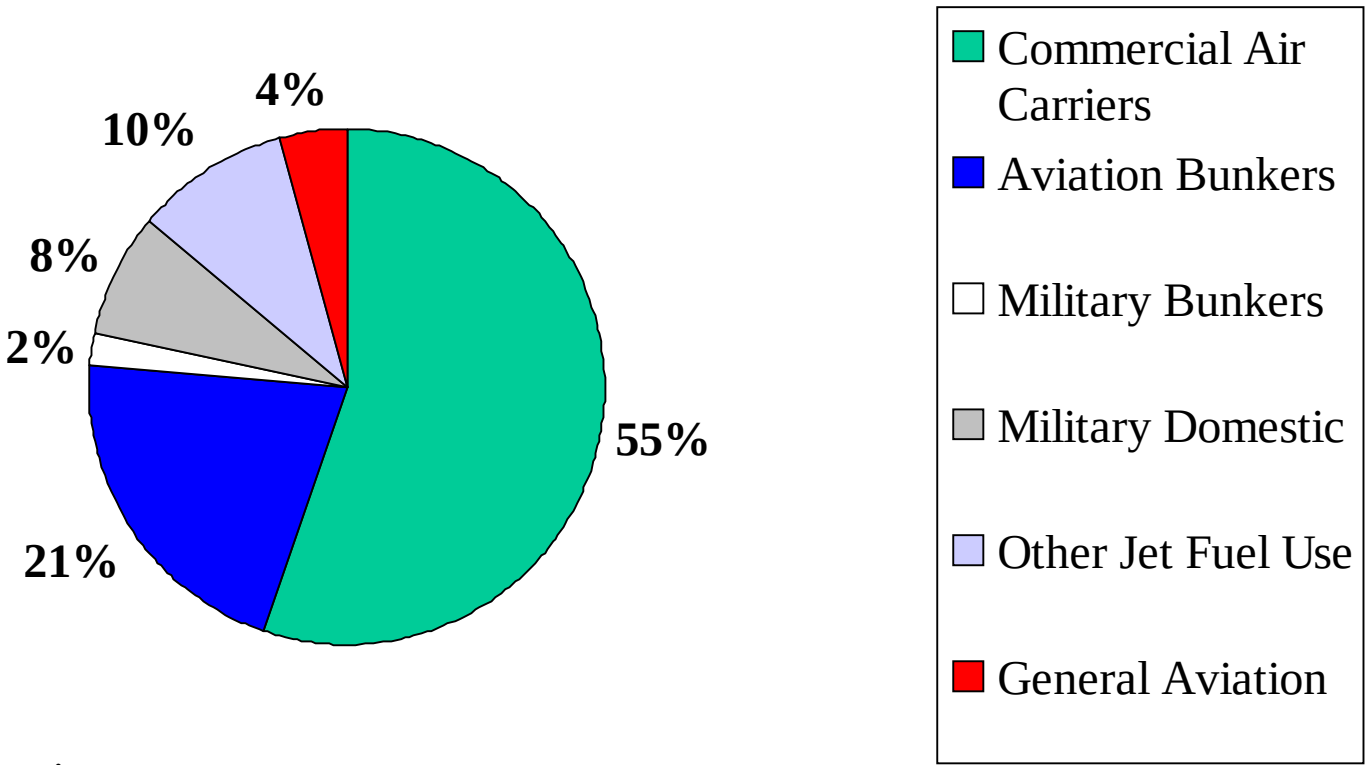
Now multiply fuel use by carbon content of fuel and assumed oxidation fraction:

International Aviation Bunker Fuel CO2 Emissions =
(811Btu/1000)(19.33MMTCE/Tbtu)(0.99) = 15.5 MMTCE

Carbon Dioxide Emissions from Aviation Transport by Mode



Aviation Fuel Breakout by Mode – 1998 only



77% Domestic

23% Bunker

Marine Bunker Fuel Calculations

Marine transportation Tier I approach:

The quantity of fuel purchased and delivered within the United States provides an accurate estimate of the national CO_2 emissions.

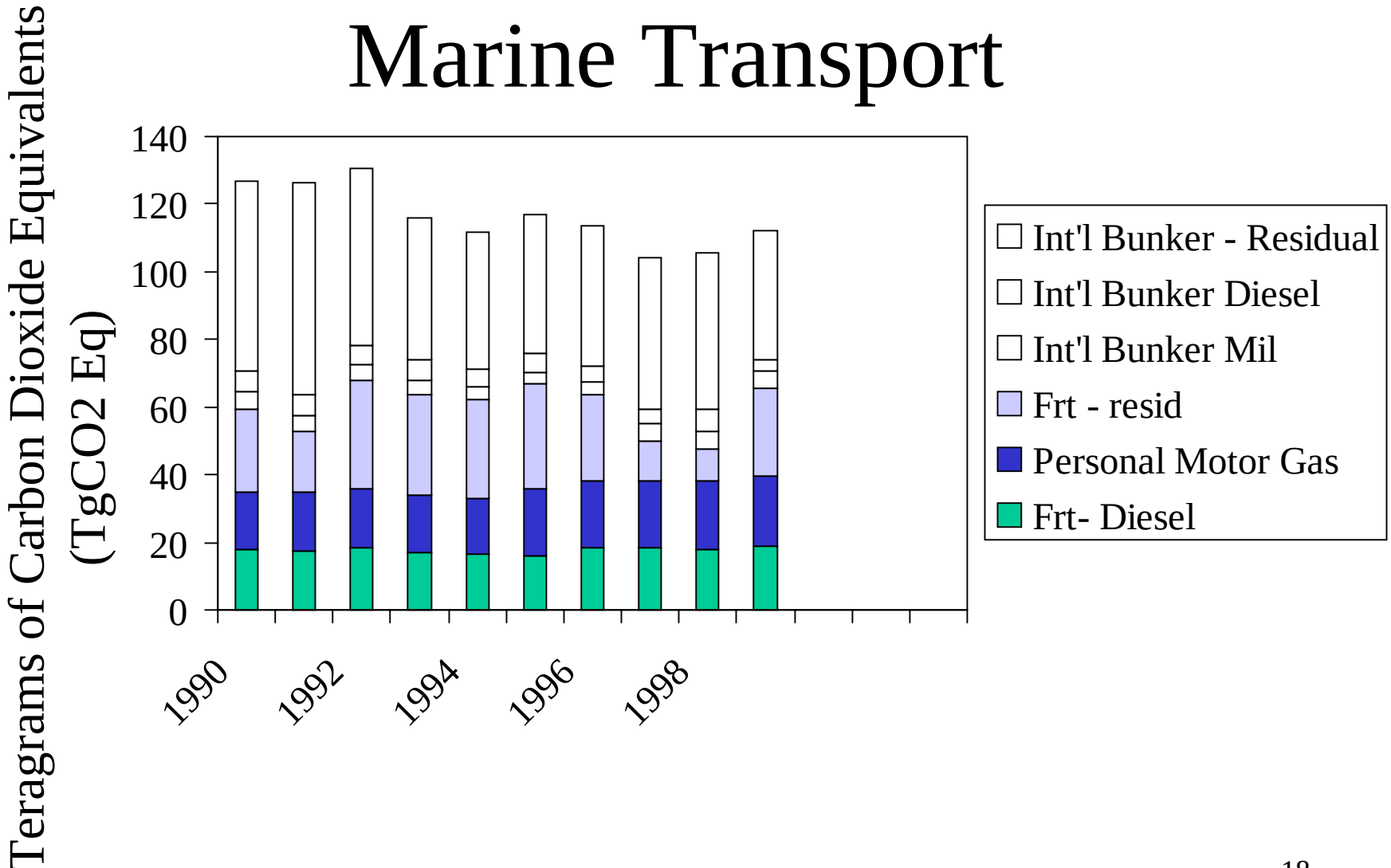
Ocean-going ships use two primary types of fuel:

Diesel and Residual fuel oil

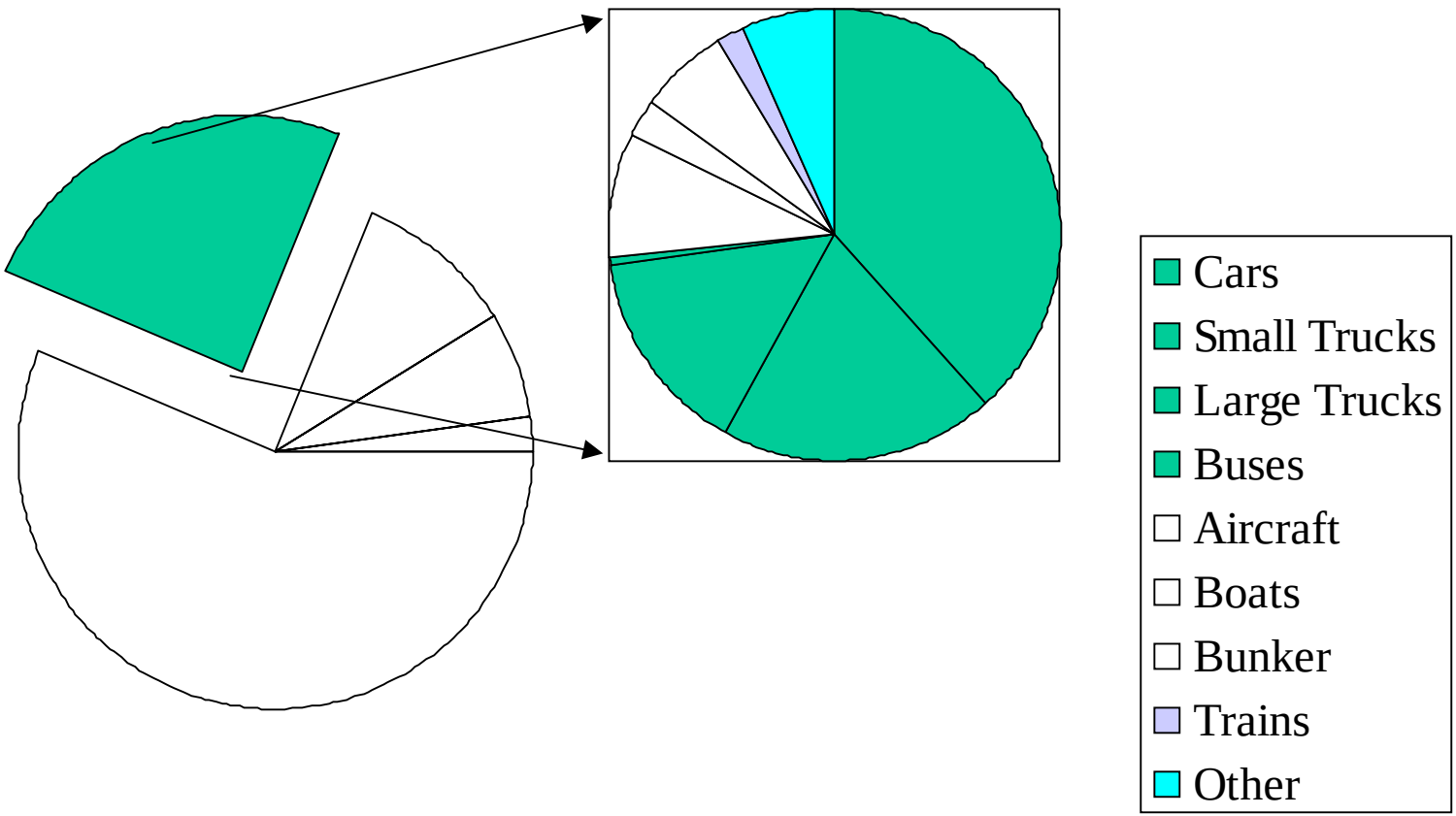
Three components of Bunker Fuel:

1) Fuel used by domestic flag carriers on international voyages
2) Fuel purchased by foreign flag carriers while at United States ports
3) International deployments by the United States Military

Carbon Dioxide Emissions from Marine Transport



U.S. GHG Emissions
1998 Only



Marine Bunker Fuel

Commercial International Bunkers

- Assumed all the residual fuel oil is used by vessels.
- We could not assume all diesel was used at sea.
- The U.S. Department of Commerce from Foreign Trade Division, Bureau of the Census Provided the data in a report titled: Report of Bunker Fuel Oil Laden on Vessels Cleared for Foreign Countries (Form –563)

1998 Sample Calculation

Commercial International Bunkers

Distillate Fuel (627,282,000 gallons distillate fuel)(0.1387 MMBtu/gallon) =
93,904,115,540.57 MMBtu
(87,004,013.4 MMBtu)(1TBtu/ 1,000,000 MMBtu) =
87.00 TBtu

Residual Fuel (3,973,566,000 gallons residual fuel)(0.1497 MMBtu/gallon) = 594,842,830.2 MMBtu
(594,842,830.2 MMBtu)(1TBtu/1,000,000 MMBtu) = 594.8 TBtu

Military Bunkers

Determine International Bunker Fuel

- Three components of Bunker Fuel:
  - 1) Fuel used by domestic flag carriers on international voyages
  - 2) Fuel purchased by foreign flag carriers while at United States ports
  - 3) International deployments by the United States Military
- Now let’s look at the Military Marine Bunker Fuels

Military International Bunker Fuels

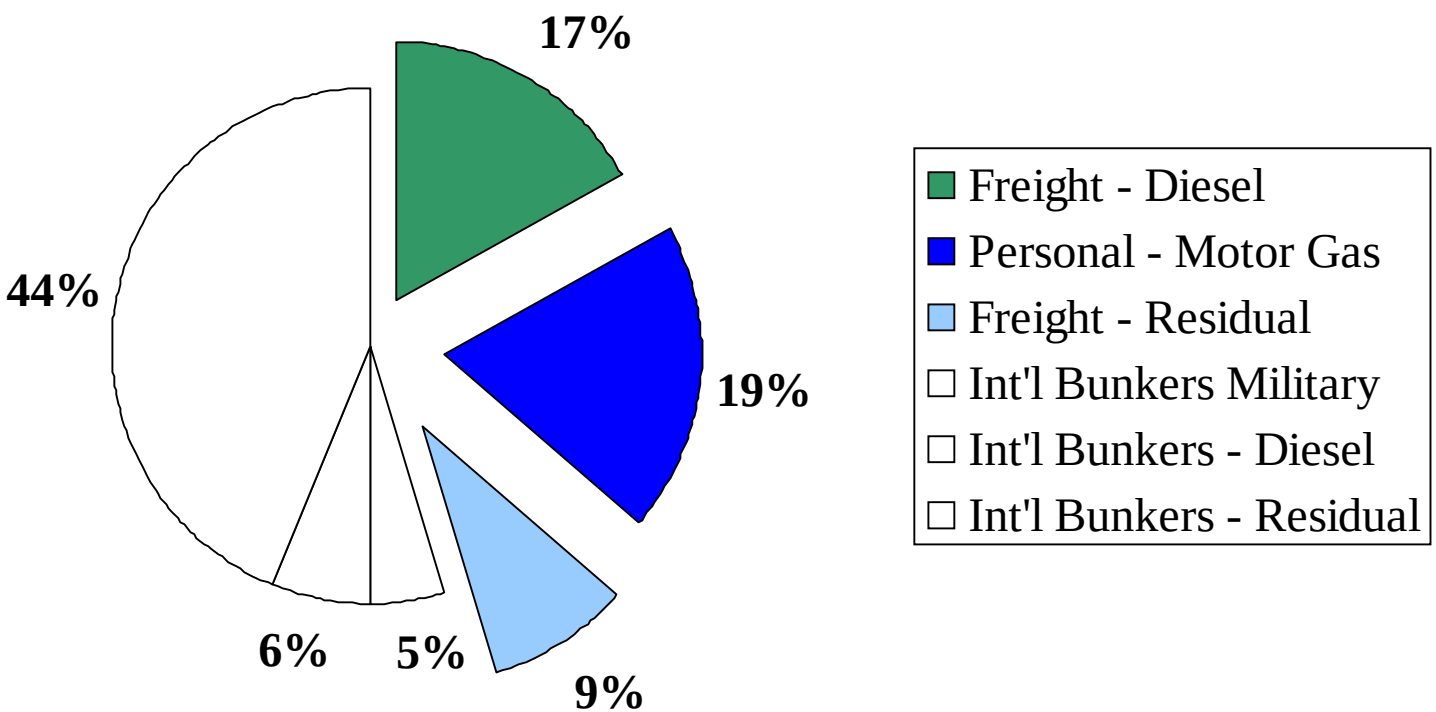
Heat content marine fuel = (31,880,000 gallons Navy MGO*)(0.1387 MMBtu/gallon) = 4,421,756 MMBtu MGO
(4,421,756 MMBtu)/(1TBtu/1,000,000 MMBtu) = 4.42 TBtu

(474,230,000 gallons Navy F76*)(0.1387 MMBtu) = 65,775,701 MMBtu
(65,775,701 MMBtu)(1TBtu/1,000,000 MMBtu) = 65.78 Tbtu

Military Marine Distillate Bunker fuel = 70.2 TBtu

*Navy MGO and F76 are distillate fuels.

Breakout of Marine Transport Fuel – 1998



55% International
45% Domestic

Conclusion

Total U.S. CO2 from Fossil Fuel Combustion in 1998 was 1,468.2 MMTCE

- International Aviation Bunker Fuel =
  - 15.5 MMTCE (about 1% of total CO2)
- International Marine Bunker Fuel =
  - 15.8 MMTCE (about 1% of total CO2)

CONTACT

- Gail Bruss, Office of the Chief of Naval Operations, (703) 602-7871, Bruss.Gail@hq.navy.mil

- Wiley Barbour, Environmental Protection Agency, (202) 564-3999, Barbour.Wiley@epamail.epa.gov