PART I. THE INFORMED CAR SHOPPER -- CAR COMPARISON

Go to http://www.fueleconomy.gov/feg/

“Find and Compare Cars”

“Compare Side by Side”

Compare these cars, using the “Fuel Economy” tab

<table>
<thead>
<tr>
<th>Type of car</th>
<th>Annual Fuel Cost ($)</th>
<th>Cost ($) to drive 25 miles</th>
<th>Fuel Economy MPG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>city</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>hwy</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>combined</td>
</tr>
<tr>
<td>2012 Toyota Prius</td>
<td></td>
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<tr>
<td>2012 2500 Chevrolet Suburban 2WD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Auto., 6-speed 6 L, Regular Gas)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012 Ford F150 Pickup 2WD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.2L, 8 cyl, Automatic</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>The car you drive, or the car you would</td>
<td></td>
<td></td>
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<tr>
<td>like to drive (Provided it is on the web</td>
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<tr>
<td>site)</td>
<td></td>
<td></td>
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<tr>
<td>Give model info here:</td>
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</tr>
</tbody>
</table>
1. Which car of the four has the best rating for low greenhouse gas emissions, and low air pollution? (look under the “Energy and Environment” tab, use California for State of purchase)

Why?

2. Examine again the comparison between the Suburban and the Toyota Prius - If you drove a Toyota Prius instead of a Suburban, how much greenhouse gas emissions (annual U.S. tons of CO₂) could be saved each year?

3. With information such as this so readily available, why do you think there aren’t more hybrid cars on the road?

PART II. CASE STUDY

Background Information

Spirometry is a type of lung function test. It measures how quickly your lungs can move air in and out and how much air they can move in and out. For this test, you breathe into the mouthpiece attached to a recording device (spirometer).

Forced expiratory volume (FEV) is a type of exercise stress test. This uses a spirometer to measure the amount of air you can exhale forcefully in a sustained breath. The amount of air you exhale may be measured at 1 second (FEV1), 2 seconds (FEV2), or 3 seconds (FEV3). The total amount of air you exhale during this test is called the forced vital capacity (FVC).

Maximum midexpiratory flow (MMEF) is the average rate of airflow measured between exhaled volume of 25 & 75 percent of the vital capacity during a forced exhalation.

Reference: http://my.webmd.com/hw/health_guide_atoz/hw5022.asp
In this study, 1759 children (average age, 10 yrs.) from schools in 12 southern California communities were recruited. Lung function was measured annually for 8 years. The communities represented a wide range of ambient exposure to:

- Ozone
- Acid vapor (vapor phase nitric, hydrochloric, formic, acetic)
- Nitrogen dioxide
- Particulate matter

Statistical methods were then used to examine the relationship of air pollution to the forced expiratory volume in one second (FEV$_1$) and other spirometric measures (see sidebar). The results of this study indicate that current levels of air pollution have chronic, adverse effects on lung development in children from the age of 10 to 18 years, leading to clinically significant deficits in attained FEV$_1$ as children reach adulthood.

**CASE STUDY 1 QUESTIONS**

1. Compare the plastic relief topographic map and Figure 1 (shared copies). What patterns do you notice between where the communities are located and the levels of NO$_2$, acid vapor, and PM$_{10}$/PM$_{2.5}$? (given a dominant wind direction of ~ west to east)

2. **a.** Examine the ozone levels on Figure 1a. Which community has the highest level?

   **b.** Find Lake Arrowhead (elevation 5,741 feet or 1,722 meters) on the plastic relief topographic map. Give your hypothesis as to why this mountain community could have such a high ozone level.

3. **a.** Notice the communities of Atascadero (AT), Lompoc (LM), Santa Maria (SM). Looking at Figure 1, would you describe these as, in general, good or poor air quality?

   **b.** What is the geographic locality of these three communities – near the coast or far inland?
c. Examine the data for Long Beach (LB). Given that Long Beach is also a coastal city, why is the air quality so much worse (compared to the other coastal communities)? (To answer this question, see the section on Los Angeles Harbor)

   a. What are the new standards for NO₂?

   b. What is the health concern about this pollutant?

   c. Looking at Figure 1b, which communities exceed the NEW annual-average state standard? (hint – to convert from ppm to ppb, multiply the ppm by 1000).

5. Given all of this data, where would you prefer to live and why?
PART III. PORT OF LOS ANGELES AIR QUALITY

In this section, you will be examining data collected around the Port of Los Angeles (shared color copies). See Map A (page 7) for locality information.

Particulate Matter

1. Examine the color graph Monthly Average PM$_{2.5}$ Concentrations at Port of Los Angeles January – December 2010. Notice the dashed red horizontal line near top of graph (Federal annual average PM$_{2.5}$ Standard). Which site, on average, has the highest level? Using Map A, make an hypothesis as to why.

2. How does this compare to the same graph for 2007 (on the other side)?

3. Examine the Annual Average PM$_{2.5}$ Concentrations 2005-2010 bar graph. What changes do you notice over the 6-year period?

4. Read the poster “Particulate Matter – new standards for 2006” on the bulletin board. How/why is particulate matter harmful?

Elemental Carbon


a. Which site has the highest elemental carbon? Make a hypothesis as to why.

b. Which site has the lowest elemental carbon? Make a hypothesis as to why.

As you can see from the above questions and graphs, the Port has significantly reduced air pollution since 2005. Two major programs are in place:

(1) The Clean Trucks Program (beginning in Oct. 2008)

(2) San Pedro Bay Port Clean Action Air Plan (Nov. 2006 – developed jointly by the Ports of Long Beach & Los Angeles, in cooperation with the U.S. Environmental Protection Agency, California Air Resources Board, and South Coast Air Quality Management District)

More about the sources of air pollution…..
6. Read the attached news article (page 8) from Nov. 2009 (you will notice a few typos -- not uncommon for news articles). List the actions that have been taken to reduce air pollution:

7. Compare the news article to the data table 2005. Which source accounts for the highest % of PM (particulate matter) and SO\(_x\)? (for both the years 2008 and 2005)

Map A. Locations of air quality monitoring stations. Note the triangles.
News article 2009

Report: Port of Los Angeles Pollution Down

Written by Natalie Bruckner-Menchell, PortWorld
Friday, 06 November 2009

Emissions on a per container basis at the Port of Los Angeles have fallen as much as 35% since 2005, according to a report released this week by the port.

"During the three-year reporting period since the 2005 CAAP (San Pedro Bay Port Clean Action Plan) baseline emissions inventory, overall emissions have declined by nearly 27%," the report said.

The ports of Long Beach and Los Angeles adopted the CAAP to curb port-related air pollution from trucks, ships, locomotives and other equipment by at least 45% in five years.

From 2007 to 2008 there was shown to be an average 14% decrease in all primary pollutants, which include NOx, SOx, and PM.

The emission estimates presented in the report include the effects of the vessel speed reduction (VSR) programme requiring 12 knots during transiting outside the harbour, and the use of alternative maritime power (AMP).

It also takes into account newer vessels calling at the port with cleaner and more fuel-efficient engines that meet or exceed standards set by the International Maritime Organization (IMO), and the switch to low sulphur fuel near the coast at and berth for the California Air Resources Board regulation and/or Port Incentive Fuel Switching Program.

Ocean-going vessels were show to be the largest contributor of SOx and PM2.5, while heavy duty trucks were show to emit the most NOx emission during 2008.

Port-related operations accounted for 7% of the diesel particulate matter emissions in the South Coast Air Basin in 2008, a 2% reduction from 2007.

Emission reductions were said to be achieved in all five major source categories: ocean-going vessels, harbour craft, cargo-handling equipment, rail and heavy-duty vehicles.

While the 2008 vessel calls were lower than the previous years, the average twenty-foot equivalent unit (TEU)/call ratio continued to increase, showing an improvement in efficiency.

From 2007 to 2008, there was a 6% decrease in TEU throughput, the number of total calls decreased by 12% and containership calls decreased by 7%.

Greenhouse gases at the port saw reductions of 7%, or approximately 80,000 metric tonnes, since the Port’s 2007 Inventory of Air Emissions.

"It’s gratifying to see significant emissions reductions in all areas of port-related operations," said Port of Los Angeles Executive Director Geraldine Knatz, Ph.D.

"This continuing trend in annual emissions decline shows that our Clean Air Action Plan and other Port initiatives are enabling us to curb emissions, get projects approved and build or modernise our cargo facilities for future growth," Knatz added.

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Table ES.3 illustrates the percentage breakdown of average annual emissions by source category for each pollutant and is an extension of the bar chart above.

<table>
<thead>
<tr>
<th>Source Category</th>
<th>NOx</th>
<th>TOG</th>
<th>CO</th>
<th>PM2.5</th>
<th>PM2.5</th>
<th>SO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean-Going Vessels</td>
<td>36%</td>
<td>21%</td>
<td>14%</td>
<td>56%</td>
<td>53%</td>
<td>86%</td>
</tr>
<tr>
<td>Harbor Craft</td>
<td>18%</td>
<td>34%</td>
<td>41%</td>
<td>18%</td>
<td>19%</td>
<td>11%</td>
</tr>
<tr>
<td>Cargo Handling Equipment</td>
<td>10%</td>
<td>19%</td>
<td>18%</td>
<td>11%</td>
<td>12%</td>
<td>1%</td>
</tr>
<tr>
<td>Railroad Locomotives</td>
<td>13%</td>
<td>9%</td>
<td>6%</td>
<td>6%</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>Heavy-Duty Vehicles</td>
<td>23%</td>
<td>17%</td>
<td>21%</td>
<td>9%</td>
<td>9%</td>
<td>1%</td>
</tr>
</tbody>
</table>
APPENDIX I.

California and National Ambient Air Quality Standards

California is a diverse state with many sources of air pollution. To estimate the sources and quantities of pollution, the California Air Resources Board (ARB), in cooperation with local air pollution control districts and industry, maintains an inventory of California emission sources.

The ARB recognizes five criteria pollutants: ozone, particulate matter, carbon monoxide, nitrogen dioxide, and sulfur dioxide. Emissions related to these criteria pollutants include total organic gases (TOG), reactive organic gases (ROG), oxides of nitrogen (NOx), carbon monoxide (CO), oxides of sulfur (SOx), particulate matter with an aerodynamic diameter of 10 microns or smaller (PM10), and particulate matter with an aerodynamic diameter of 2.5 microns or smaller (PM2.5).

More information

Particulate Matter (PM$_{10}$ and PM$_{2.5}$)
Exposure to particulate matter aggravates a number of respiratory illnesses and may even cause early death in people with existing heart and lung disease. Both long-term and short-term exposure can have adverse health impacts. All particles with a diameter of 10 microns or smaller (PM10) are harmful. For comparison, the diameter of a human hair is about 50 to 100 microns. PM10 includes the subgroup of finer particles with an aerodynamic diameter of 2.5 microns or smaller (PM2.5). These finer particles pose an increased health risk because they can deposit deep in the lung and contain substances that are particularly harmful to human health.

PM10 is a mixture of substances that includes elements such as carbon and metals; compounds such as nitrates, organic compounds, and sulfates; and complex mixtures such as diesel exhaust and soil. These substances may occur as solid particles or liquid droplets.

Carbon Monoxide (CO)
Carbon monoxide is a colorless and odorless gas that is directly emitted as a by-product of combustion. The highest concentrations are generally associated with cold stagnant weather conditions that occur during winter. In contrast to ozone, which tends to be a regional pollutant, CO problems tend to be localized.

Carbon monoxide is harmful because it is readily absorbed through the lungs into the blood, where it binds with hemoglobin and reduces the ability of the blood to carry oxygen. As a result, insufficient oxygen reaches the heart, brain, and other tissues.

Health damage caused by CO is of greater concern at high elevations where the air is less dense, aggravating the consequences of reduced oxygen supply. As a result, California has a more stringent CO standard for the Lake Tahoe Air Basin.

Nitrogen oxides
Nitrogen oxides are toxic to plants and nitrogen dioxide can cause breathing difficulties in humans. Nitrogen oxides are one of the main precursors of ground level ozone, which can also affect breathing and damage crops and vegetation. Deposition of oxidized nitrogen causes acidification and eutrophication.
What is nitrogen dioxide?

Nitrogen dioxide (NO$_2$) is a reactive, oxidizing gas capable of damaging cells lining the respiratory tract. This pollutant is also an essential ingredient in the formation of ground-level ozone pollution. NO$_2$ is one of the nitrogen oxides emitted from high-temperature combustion processes, such as those occurring in trucks, cars, and power plants. Home heaters and gas stoves also produce substantial amounts of NO$_2$ in indoor settings.

Health and Welfare Effects from Exposure to Ambient Levels of Nitrogen Dioxide

Exposure to NO$_2$ along with other traffic-related pollutants, is associated with respiratory symptoms, episodes of respiratory illness, and impaired lung functioning. Studies in animals have reported biochemical, structural, and cellular changes in the lung when exposed to NO$_2$ above the level of the current state air quality standard. Clinical studies of human subjects suggest that NO$_2$ exposure to levels near the current standard may worsen the effect of allergens in allergic asthmatics, especially in children. Besides causing adverse health effects, NO$_2$ is responsible for the visibility reducing reddish-brown tinge seen in smoggy air in California.

Ozone

Ozone, a colorless gas which is odorless at ambient levels, is the chief component of urban smog. Ozone is not directly emitted as a pollutant, but is formed in the atmosphere when hydrocarbon and NOx precursor emissions react in the presence of sunlight. Meteorology and terrain play major roles in ozone formation. Generally, low wind speeds or stagnant air coupled with warm temperatures and cloudless skies provide the optimum conditions for ozone formation. As a result, summer is generally the peak ozone season. Because of the reaction time involved, peak ozone concentrations often occur far downwind of the precursor emissions. Therefore, ozone is a regional pollutant that often impacts a large area.

Ozone impacts lung function by irritating and damaging the respiratory system. In addition, ozone causes damage to vegetation, buildings, rubber, and some plastics.

References:
http://www.aqmd.gov/smog/index.html
http://www.epa.gov/airnow/consumer.html#good
http://www.epa.gov/airnow/qaq.html
http://www.portoflosangeles.org/environment_aqm.htm