

ACKNOWLEDGEMENTS

This activity book was made possible by the efforts of many individuals. We would especially like to thank Allison Beale of the American Lung Association, Jack Bowman of U.S. Electricar, Ralph Dobson of Hawaiian Electric Company, Lloyd Ennor of Cummins Hawaii Diesel Power, Katherine Friend and Bill Givens of the Gas Company, Warren Hall of EA Engineering, Science, and Technology, Herb Hendrickson of the Hawaii Electric Vehicle Demonstration Program, Colleen Murakami of the Hawaii State Department of Education, Ross Sasamura of the City and County of Honolulu, Darla Willis of the U.S. General Services Administration, Eileen Yoshinaka of the U.S. Department of Energy, and Andrea Beck, Maurice Kaya, Dean Masai, Louise Mott, Carilyn Shon, Gail Suzuki-Jones, Priscilla Thompson, and Maria Tome of the Hawaii State Energy Office, for assistance with developing activities, reviewing, and editing. Special thanks also to Servillano Lamer, who put together the original draft, Scott Tome of General Printing for his artwork and design help, KathySue Lavine of Epyx Corporation for assistance with fuel cell information, and the National Oceanic and Atmospheric Administration's Climate Monitoring and Diagnostics Laboratory for the carbon dioxide data. And last but definitely not least, thanks go to our Junior Reviewers: Abigail Bentley, Elissa Haverty, Patrick Haverty, Daniel Ichikawa, Justin Ichikawa, Steven Mott, Kevin Qi, Ryan Sasamura, Amanda Suiso, and John Walsh.

DISCLAIMER

This project was supported, in part, by U.S. Department of Energy award number DE-FG51-97R020881. Neither the United States nor the United States Department of Energy, nor the State of Hawaii, nor Honolulu Clean Cities, nor any of the Honolulu Clean Cities' member organizations, nor their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or services by trade name, mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government, the State of Hawaii, the City and County of Honolulu, or any agency thereof.

This document has been catalogued as follows:

Hawaii's fun-fueled activity book. Honolulu: Energy Resources and Technology Division, Dept. of Business, Economic Development and Tourism, State of Hawaii, 1999.

1. Fuel switching-Juvenile literature-Hawaii. 2. Energy conservation-Juvenile literature-Hawaii 3. Games-Hawaii.
TP343.H3.1999

Key words: activity book, air, alcohol, alternate, biodiesel, clean, electric vehicle, fuel, fuel cell, games, Hawaii, pollution, propane, vehicle.

Second Printing, June 2001

Welcome!

This Fun-Fueled Activity Book was created by Honolulu Clean Cities to provide accurate, reliable information on “alternative fuels” (also called “clean fuels”) in a fun and interesting way. (An “alternative fuel” is any vehicle fuel that’s not gasoline or diesel — examples are biodiesel, electricity, ethanol, hydrogen, methanol, natural gas, and propane fuel.)

Alternative fuels — and cars & trucks that use them — are becoming more and more widely used. Federal agencies, State governments, and electric and gas companies across the U.S. **are required by law** to purchase alternative fuel vehicles. County governments and large corporations may be required to purchase alternative fuel vehicles beginning in September of 2001 (when the 2002 model year starts).

The vehicles are available. Automakers (for example, Daimler-Chrysler, Ford, General Motors, Honda, Nissan, Solectria, Toyota, and U.S. Electricar, to name a few) are already producing and selling alternative fuel vehicles. Researchers and engineers are excited about the new technologies, cleaner fuels, and better vehicles.

The fuels are sold in Hawaii. Several alternative fuel fueling stations are already here in Hawaii, and more will soon follow. A network of “rapid charge” electric vehicle charging stations has been announced for Oahu, propane fuel is available on all islands, biodiesel is available on Maui, and alcohol fuel production could happen soon.

Still, many people are not aware of the reasons for switching to alternative fuels, the differences between the fuels, or even that these fuels and vehicles exist!

There are several good reasons to be excited about the opportunities: alternative fuels are good for the **environment** and can provide **new jobs** and high-tech industries for Hawaii.

For example, some Hawaii companies are worldwide leaders in new **electric vehicle** technology! Cutting-edge development work by Hawaii companies is being funded by the Advanced Research Projects Agency of the United States Government and the State of Hawaii.

Hawaii is also a national leader in the production of **biodiesel** fuel from vegetable oil – and the Maui company that produces it is marketing the production process overseas.

For over twenty years, important research on renewable fuels, including **biomass** and **hydrogen**, has been conducted in Hawaii at the Hawaii Natural Energy Institute, the Pacific International Center for High Technology Research, and the Hawaii Agriculture Research Center. Their work has contributed to success in diversified agriculture that will help Hawaii to recover from recent closures of sugar and pineapple operations. And byproducts (or waste) from diversified agriculture, forestry, and other sources, could be used to produce alternative fuels!

This book can help you to be one of those who knows about these new fuels & vehicles.

If you have questions, or if you’d like to see the vehicles, please call the resource people listed inside the back cover. They’d love to talk with you, and might even visit your class! (If the teacher invites them.)

Have fun!

Table of Contents

Transportation Page 1

Coloring	1
Rolling Dots, It's a-MAZE-ing!	2
Puzzle Dots, Wheels Away	3
Match-up#1, Scramble, Crossword #1	4
Word Search #1, Wheels, wheels, everywhere	5
Math Teaser #1	5

Pollution Page 6

Cause-and-Effect	6
Fill in the words	7
Extra Tricky Quiz	8
Math Teaser #2	9

Clean Fuels Page 10

Picture the Fuels	11
Go U.S.A.	12
True or False, Find the Phrase	13
Word Search	14
Crossword Puzzle	15
a-MAZE-ing fuels!	16
Summary (Extra Credit)	17

Fact Sheets (information on clean ("alternative") fuels and vehicles) Page 18

Alcohol Fuels (ethanol and methanol)	19
Biodiesel	20
Electric Vehicles	21
Electricity	22
Fuel Cells	24
Propane (LPG)	25
Vehicles (internal combustion / electric / fuel cell)	26

Add Up Your Points Page 27

Answers Page 28

Transportation

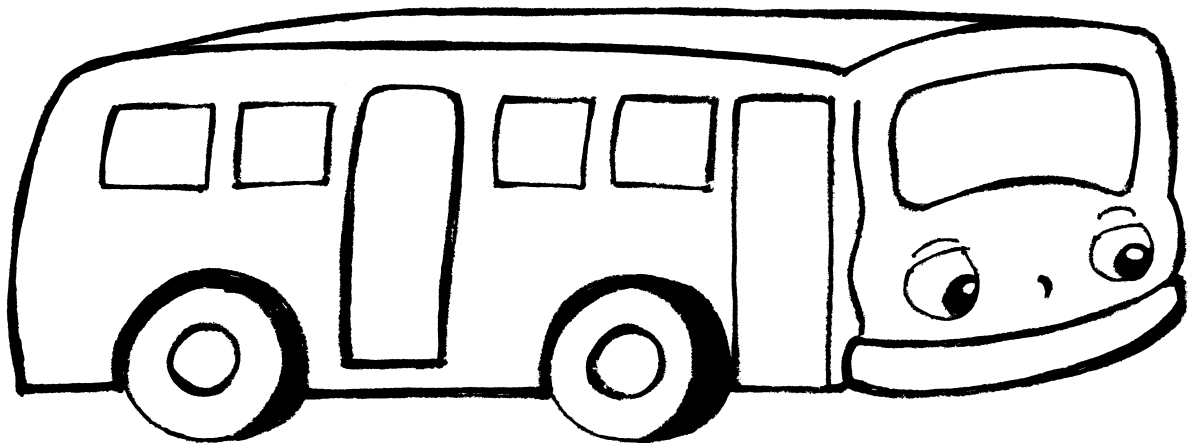
Let's **EXPLORE** the world of **NEW FUELS** and the high-tech **CARS** and **TRUCKS** that use them!

First we'll start off with **TRANSPORTATION**.
Then, we'll do activities about **POLLUTION**.
Finally, we'll cover **CLEAN FUELS**.

Some of the games are easy. Some are hard.
But try them all - and don't be afraid to ask questions!
(You can track your points on page 27.)

Let's **GO!**

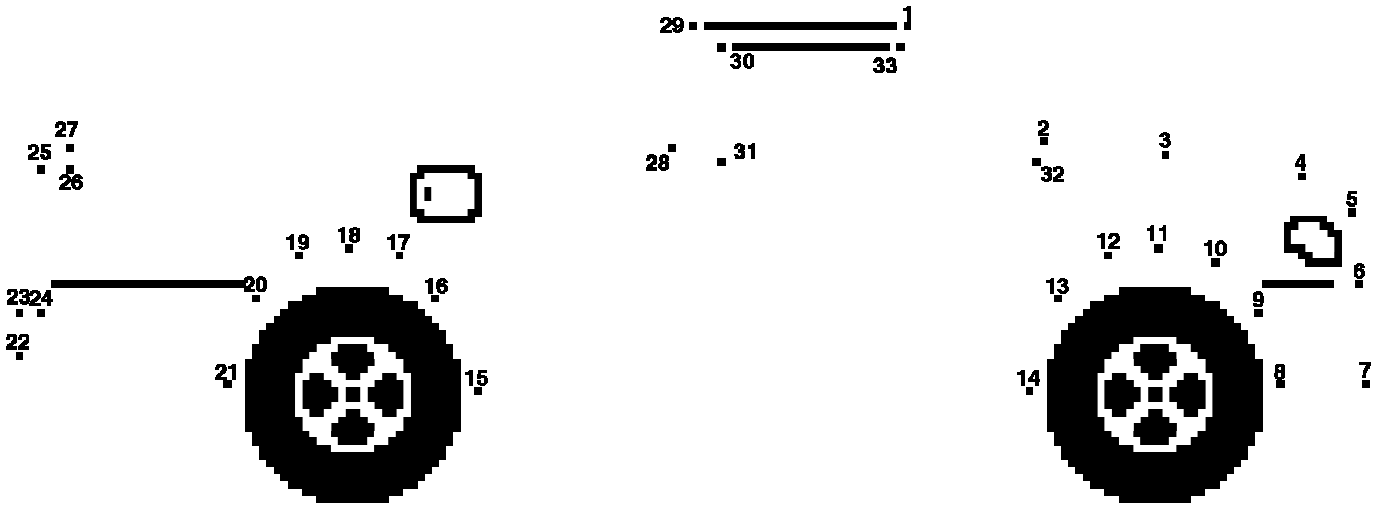
COLORING



Most buses and large trucks use **DIESEL** fuel. So does this one. Can you color it to look like a bus you've seen?

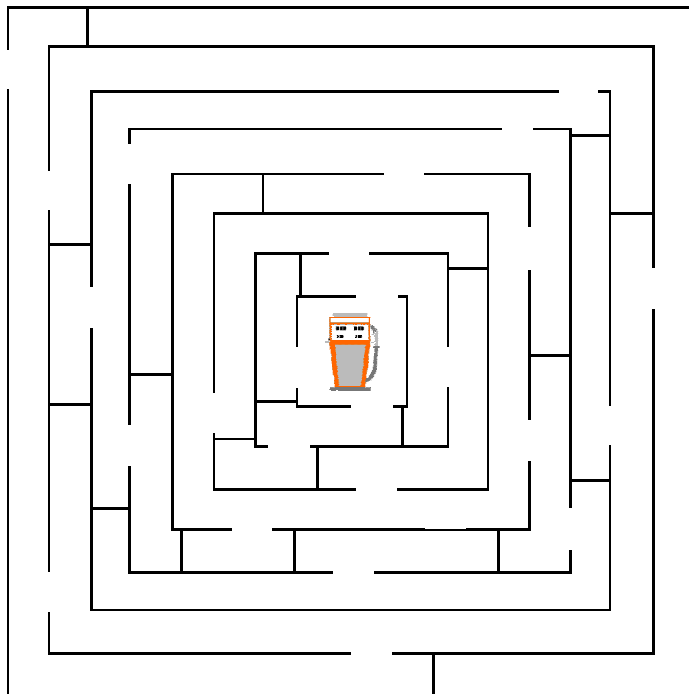
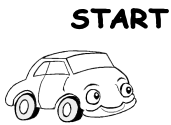
ROLLING DOTS

Connect the dots to make a picture of something you see every day.



It's a-MAZE-ing!

Help Otto Car find his way to the gas pump... BEFORE he runs out of fuel!



The average car or pickup truck uses about 500 gallons of gasoline each year – over a gallon a day!



PUZZLE DOTS

How often does your family go to the gas station?

What do you see there?

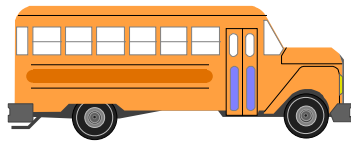
Where do you think the fuel is stored?

Gasoline and diesel fuel storage tanks are usually under the ground.

Connect the dots to make a picture of something you see at a gasoline station.

WHEELS AWAY

Can you fill in the letters of where these vehicles are going?



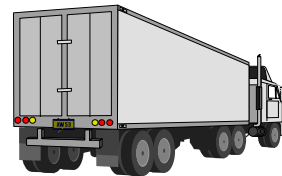
Ben rides a bus to
_ _ _ o o _ _ .



Ben's parents drive a car to
_ o _ _ _ .



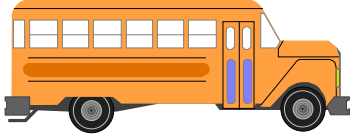


Ann takes an airplane
to the state of
_ a _ _ i _ _ _ o n .



A truck delivers juice to the
_ u _ e _ _ a _ _ e t .

MATCH-UP #1

Transportation fuels, such as gasoline, diesel, and jet fuel, are used by vehicles to move people and things every day. Can you match the fuels to the vehicles?

A. GASOLINE	Ben's bus ____.	
B. JET FUEL	Ben's parents' car ____.	
C. DIESEL	Ann's airplane ____.	

TRANSPORTATION FUEL SCRAMBLE

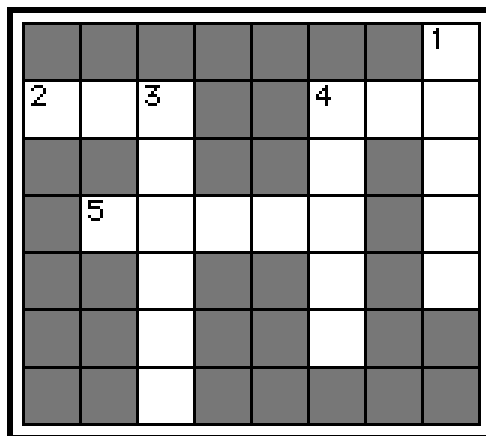
Cars, trucks, vans, buses, and motorcycles use "transportation fuels." Can you unscramble the names of two common fuels?

_____ **N E G A L S I O**
 _____ **L E D I S E**

CROSSWORD #1

ACROSS

- When we go on a field trip, my class rides in a big yellow ____.
- A ____ is a vehicle with four tires and a trunk.
- You must be at least 16 years old before you can ____.



DOWN

- A pickup _____ has space for people in the front and space for things in the back.
- People use the sidewalk; cars use the _____.
- _____ air is better than dirty air.

WORD SEARCH #1

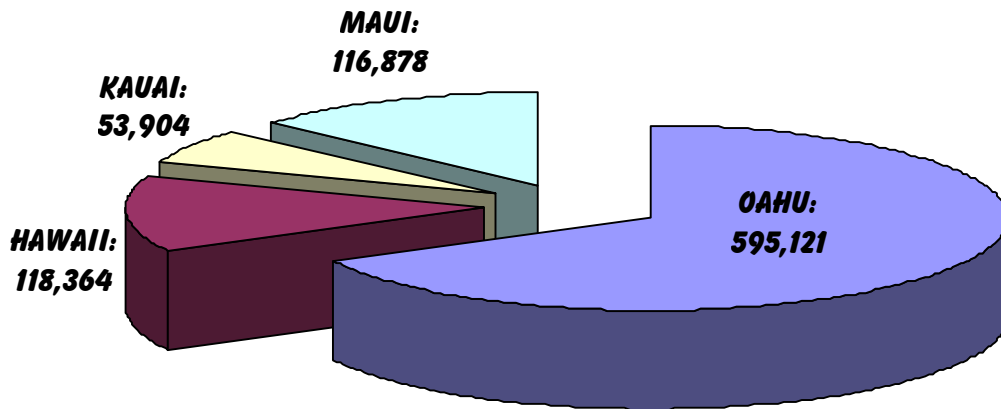
Can you find the words? They might go up, down, diagonally, or backwards!

K	C	U	R	T	E
B	E	D	B	N	V
U	Z	N	I	Z	R
S	Q	G	A	B	A
S	N	E	P	L	C
E	F	U	E	L	P

BUS
CAR
ENGINE
FUEL
PLANE
TRUCK

Wheels, wheels, everywhere!

There are over 884,000 registered vehicles in Hawaii.
How many are on your island? _____



Math Teaser #1

How many gallons of fuel do vehicles in the State of Hawaii use, if the average fuel use per vehicle is about 500 gallons per year?


- About 20,000,000 gallons per year
- About 400,000,000 gallons per year
- About 3,000,000,000 gallons per year

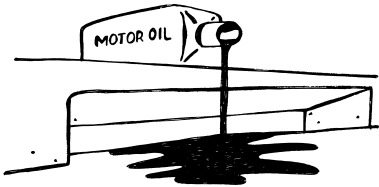
Pollution


POLLUTION is when the air, water, or land becomes dirty through the actions of people. Some types of pollution – such as litter along the beach – are easy to see. Other types of pollution, such as chemicals in the water or air, are not as easy to see but can be very harmful.

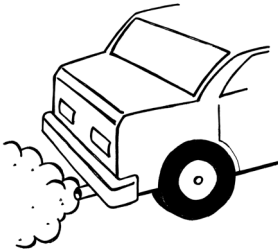
CAUSE - AND - EFFECT

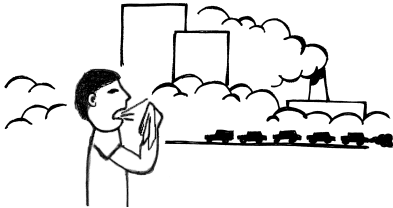
Can you match a pollution source to its result?
Write the letter of the cause (left column) next to its effect (right column).

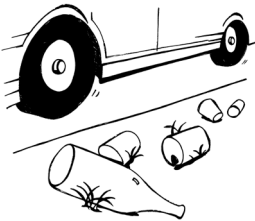
A. 
oil tanker

B. 
pollution going into storm drain

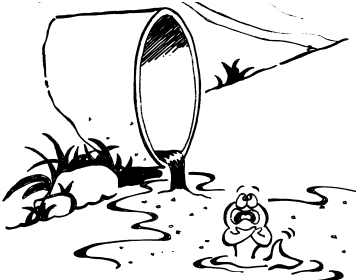
C. 

D. 

_____ 

_____ 

_____ 
oil spill washing up on the beach

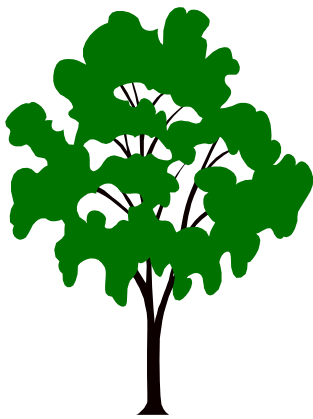
_____ 

Here are some ways

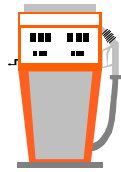
Pollution

can cause problems:

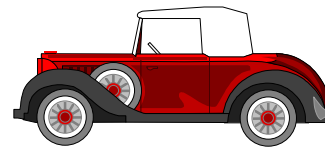
- Pollution is bad for our health. It can make us s ___ and in some cases can even cause death.
- Pollution is harmful to the environment. Toxic chemicals in the air, water, soil, and food chain harm p _____ and a _____.
- It costs a lot of money to clean up damage from p _____.



AIR +



FUEL =



ENERGY +



EMISSIONS

When fuels are burned, they produce heat (energy), carbon dioxide (CO₂), water (H₂O), and small amounts of other chemicals, such as carbon monoxide (CO), unburned hydrocarbons, oxides of nitrogen (NO_x), soot, and particulates.

- Carbon monoxide (CO) can cause headaches and place additional stress on people with heart disease. In higher doses, it binds to red blood cells and can cause carbon m _____ poisoning.
- "Smog" contains ozone, which is created by oxides of n _____ (NO_x) and hydrocarbons. It can cause shortness of breath and lung damage.
- Other fuel e _____ s, such as particulates, may cause cancer.
- Carbon d _____ (CO₂) is a major contributor to "global climate change." Effects of global climate change include rising sea levels, changes in rainfall patterns, and increased severity of major storms.

Extra Tricky Quiz

? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ?

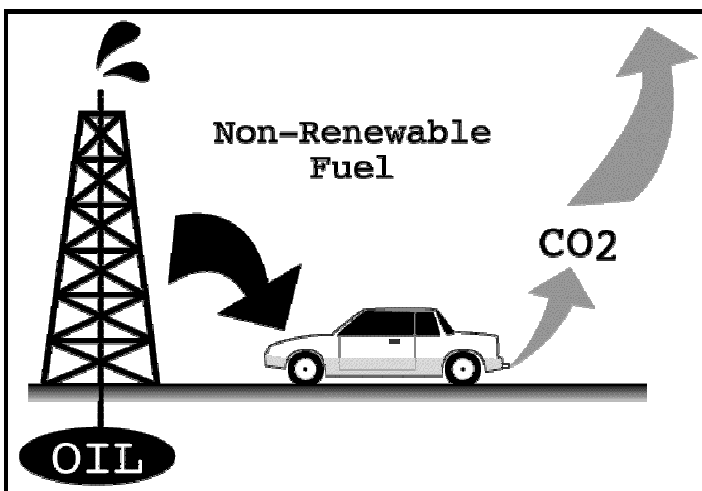
One gallon of gasoline weighs about **6.5 pounds**.
But when it's burned, about **20 pounds** of carbon dioxide
(CO_2) are produced! **How can this be?**

*(Even college students get stumped by this one. But don't give up too soon!
The picture on page 7 gives a hint. Answer in back.)*

? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ? - ?

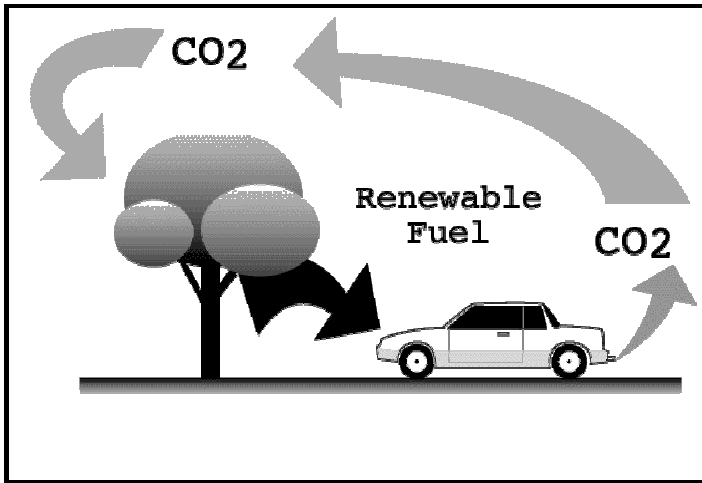
Transportation fuels account for about one-third of the United States' CO_2 emissions. The increasing emission of CO_2 worries people concerned about "g l _ _ _ _ c l _ _ _ _ c h _ _ _ _," also known as the "greenhouse effect."

Every time fossil fuel (like petroleum, also known as "crude o _ _") is taken out of the ground and burned for fuel, CO_2 is released into the atmosphere (air).



Most transportation fuels - gasoline and diesel fuel, for example - are made from oil. Oil is considered a **non-renewable** fuel. When oil is burned, CO_2 is added to the atmosphere. But nature can't make CO_2 back into oil very quickly, so the amount of CO_2 in the air keeps increasing. (And the amount of oil in the ground keeps decreasing.)

Measurements at the Mauna Loa weather station on the Big Island show that global atmospheric levels of CO_2 are increasing every year (see page 9).

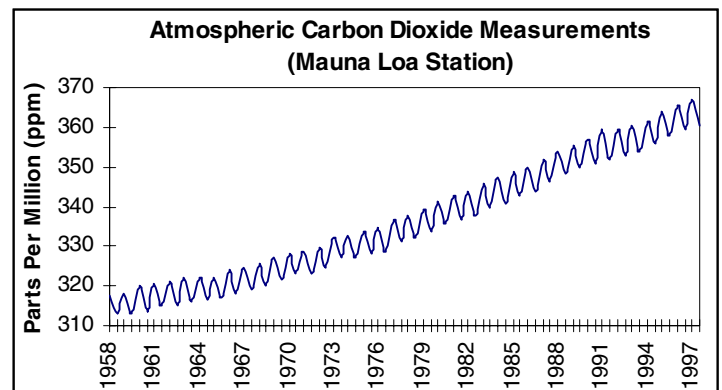


When plants are used to make fuels, these fuels are r _____. When renewable fuels are burned, CO_2 is added to the atmosphere, but in this case there is a balance, since growing plants remove CO_2 . In a perfectly renewable system, the same number of plants that are harvested are replanted. This way, the amount of CO_2 being added to

the atmosphere is the same amount that the growing plants are using, and there is no net increase.

Using **renewable** fuels instead of non-renewable fuels could help to reduce the total amount of CO_2 added to the atmosphere.

Biodiesel and **alcohol fuels** made from plant matter are examples of renewable fuels.



Electricity can also be considered a renewable fuel - **IF** it is produced from renewable energy sources such as wind, sun, plants ("biomass"), or hydropower. (For more information on electricity, see page 22.)

Math Teaser #2

One gallon of gasoline produces about 20 pounds of carbon dioxide (CO_2). Every year, vehicles in Hawaii use about 400,000,000 gallons of fuel. How many pounds of carbon dioxide (CO_2) are produced?

- a. About 1,000,000 pounds (500 tons)
- b. About 1,000,000,000 pounds (500 thousand tons)
- c. About 8,000,000,000 pounds (4 million tons)

Clean Fuels

Alternative fuels are also called "clean fuels." They produce less air pollution than non-alternative (gasoline and diesel) fuels.

True or False: We have no choice - we have to use fuels that can damage our environment and our health.

Answer: False; we can use cleaner fuels. Some can be made right here in Hawaii!

Some types of Clean Fuels are:

- Alcohol** - There are 2 types: "ethanol" and "methanol." Historically, **ethanol** has been made from corn or sugarcane. New processes can make ethanol from paper, yard trimmings or sawdust. **Methanol** is usually made from natural gas but could also be made from wood or sugarcane. Alcohol fuels produce less carbon monoxide than gasoline does.
- Biodiesel** - Made from vegetable (corn, soybean, etc.) oils, including used cooking oil (such as oil used in frying French fries). Its lubricating qualities are good for engines. Biodiesel produces less smoke and particulates than regular diesel fuel does.
- Electricity** - Not really a "fuel" like gasoline or diesel; rather, a form of energy. Electrical energy can be made by burning oil, biomass, or other fuels. Or, electricity can be made (from wind, water, or sunshine) without burning anything. See the "electricity fact sheet" on page 22.
- Electric vehicles** run on electricity stored in rechargeable batteries (the batteries are re-charged by plugging into an electrical outlet). Electric vehicles are "zero emission" vehicles - nothing is burned on-board the vehicle. All emissions are at the powerplant, and are less than would be produced if the vehicle used gasoline or diesel fuel.
- "**Fuel cell**" cars are another type of electric vehicle - they run on the electricity produced by fuel cells (see "fuel cells" on page 24).
- Propane** - Also known as "LPG" (Liquefied Petroleum Gas). Made from fossil fuel. Propane produces less carbon monoxide than gasoline does, and helps engines last longer.

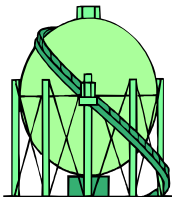
PICTURE THE FUELS

Can you match the fuels (left) with their vehicles (right)?



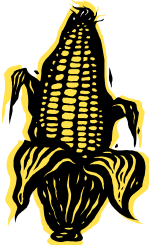
A.

Traditional fossil fuel for cars



B.

Liquefied petroleum gas (LPG)



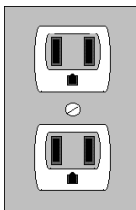
C.

Corn to make alcohol fuel



D.

Used cooking oil



E.

Recharging station

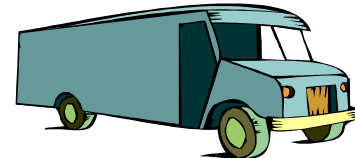
____. ETHANOL



____. ELECTRIC



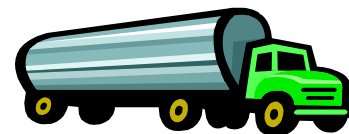
____. PROPANE



____. GASOLINE



____. BIODIESEL



Clean air is not the only benefit from alternative fuels.

Alternative fuels can help with national concerns too:

BALANCE OF TRADE, JOB CREATION,

and NATIONAL ENERGY SECURITY.



Because of issues such as job creation, balance of trade, and energy security, Congress passed the National Energy Policy Act in 1992. This law **requires** fleets of more than 20 centrally-fueled light duty vehicles located in large cities to purchase **alternate fueled vehicles** capable of using "alcohol fuels, natural gas, liquefied petroleum gas, hydrogen, biodiesel, coal derived fuels, biological materials derived fuels, or electricity." In Hawaii, only fleets on Oahu are covered.

Beginning in September 1996, Federal government agencies, fuel providers (such as electric utilities, gas companies, and alternative fuel producers) and State government fleets (including State Government agencies) were required to begin purchasing alternative fuel vehicles. Hawaii State agencies have purchased alcohol, electric, and propane vehicles.

Beginning in 2001, City and County governments and large private fleets may also be required to purchase alternative fueled vehicles.



GO U.S.A.

Can you fill in the blanks?

Transportation is an important part of our lives. And our trucks, buses, and cars need f _ _ _ s to run. Right now, the only fuels used by most vehicles are gasoline and diesel, made from oil imported from other c _ _ _ _ _ s .

Sending all this money out of the U.S.A. is not good for the B _ _ _ _ _ OF T _ _ _ _ . And it doesn't keep the money here to CREATE J _ _ _ _ . And every time there's a war involving (or near) countries that produce the oil we need, it becomes a threat to our N _ _ _ _ _ ENERGY S _ _ _ _ _ .

By a law passed by the U.S. C _ _ _ _ _ in 1992, alternative fuels are now part of the official National Energy Policy of the United States.

TRUE or FALSE?

Indicate whether the following statements are "TRUE" or "FALSE." You may need to refer to the fact sheets in the back (beginning on page 19).

T or F

1. _____ The speed record for an electric vehicle is over 200 miles per hour.
2. _____ Neither General Motors nor Ford produces a propane truck.
3. _____ Biodiesel fuel is produced in Hawaii.
4. _____ Alcohol fuels are most commonly made from grapes.
5. _____ Alternative fuel vehicles are used in Federal and State fleets.
6. _____ Vehicle emissions can be harmful to your health.
7. _____ The distance record for an electric vehicle is 100 miles.

Find the Phrase

Use the clues below to find the motto of Honolulu Clean Cities (the organization that prepared this Activity Book).

1. Washing hands gets them _____.
(1)
2. Food _____ my body.
(2)
3. Electricity is _____ cars too.
(3)
4. We like to breathe _____
(4) _____
(5)

Find the phrase: Honolulu Clean Cities' Motto is:

" _____ "
 (1) (2) (3) (4) (5)

Word Search

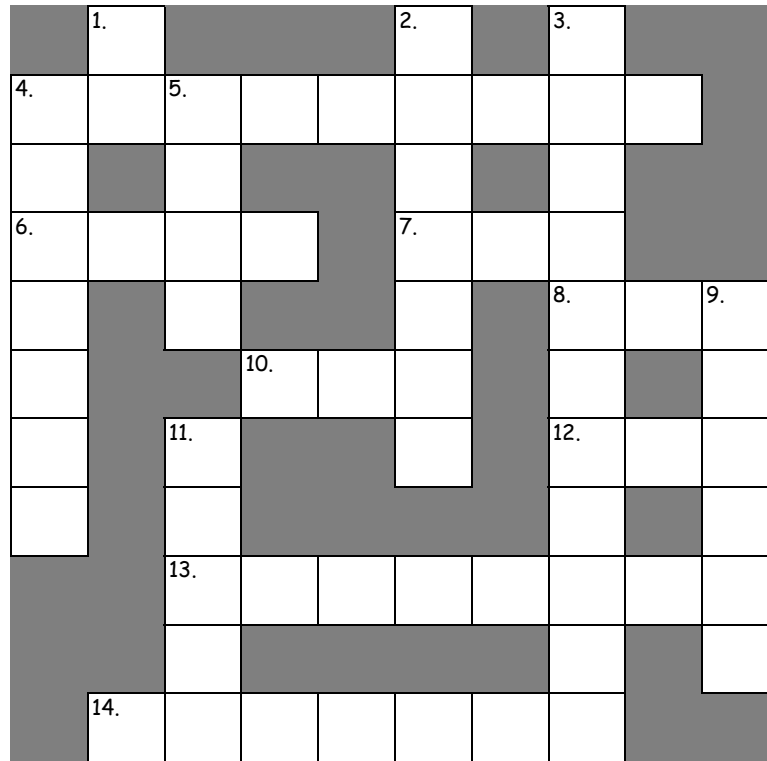
Can you find the words? They might go up, down, diagonally, or backwards!

A	T	R	U	C	K	C	L	E	S	E	I	D	O	I	B
T	L	A	O	Y	C	A	L	O	E	N	S	M	B	H	U
C	V	T	P	Q	A	R	G	K	L	J	P	I	A	Z	S
A	N	E	E	B	Y	B	V	D	E	F	K	L	T	E	L
Y	L	P	G	R	T	A	U	X	C	W	J	O	T	V	R
C	K	C	M	E	N	I	Z	P	T	S	D	H	E	C	E
I	L	V	O	B	T	A	J	L	R	G	M	O	R	F	S
L	S	Y	T	N	A	A	T	Z	I	O	U	C	Y	X	N
O	R	R	U	Q	V	P	B	I	C	W	P	L	H	V	O
P	O	I	C	T	N	E	O	L	V	M	L	A	K	J	I
Y	W	A	R	F	Y	E	R	G	E	E	I	D	N	I	S
G	S	N	T	G	S	G	D	S	H	O	F	H	B	E	S
R	X	A	R	U	D	C	H	F	I	E	I	U	N	O	I
E	P	E	Q	R	F	L	E	G	C	O	X	L	E	B	M
N	N	L	M	K	Q	V	I	H	L	J	N	A	P	L	E
E	N	C	H	A	R	G	E	R	E	W	Y	A	Z	C	S

ALTERNATIVE FUELS
ALCOHOL
BATTERY
BIODIESEL
BUS
CAR
CHARGER
CLEAN AIR
CONVERSION

ELECTRIC VEHICLE
EMISSIONS
ENERGY
ENERGY POLICY ACT
LPG
PROPANE
TRUCK
VAN
VEGETABLE OIL

CROSSWORD PUZZLE



ACROSS

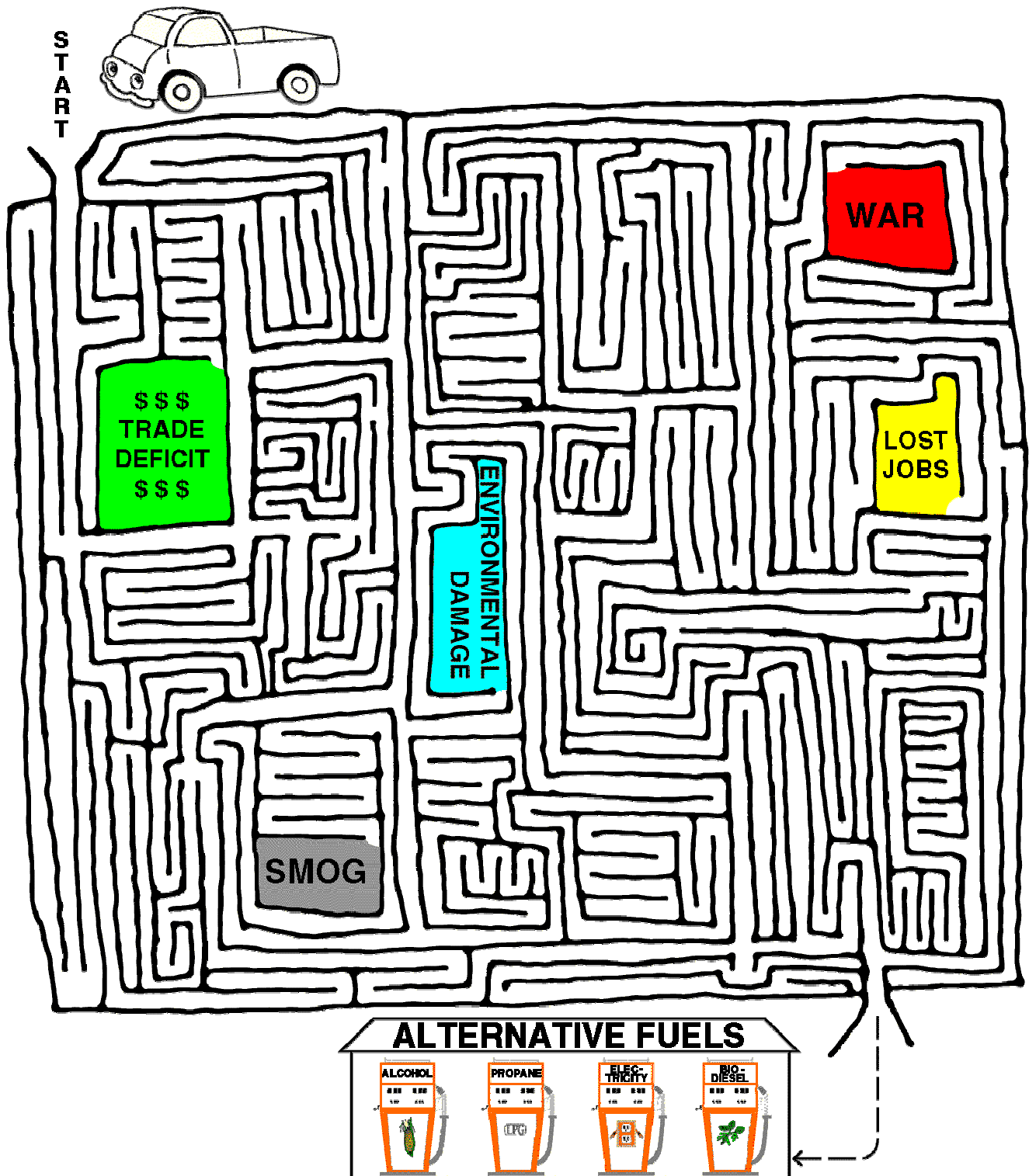
4. Biodiesel fuel is made from ___ oil.
6. Clean fuels can ___ us to have clean air.
7. Solar cars get energy from ___ sun.
8. A ___ light means "stop."
10. Vehicle exhaust pollutes the ___ .
12. Michael ___ the French fries.
13. Most cars use ___ for fuel.
14. ___ is also used in barbecue grills.

DOWN

1. Propane can ___ used as a vehicle fuel.
2. Electric vehicles have more than one ___.
3. Alcohol is an ___ fuel.
4. A car or truck is a ___.
5. Electric carts are used on the ___ course.
9. Most large trucks and buses use ___ fuel.
11. A really *wild* ride would be catching a ___ (large striped black-and-orange animal) by the tail.

a-MAZE-ing Fuels!

Can you help Teddy Truck find his way to the alternate fuels?
Avoid the dead ends!



SUMMARY (extra credit!)

Fill in the blanks below and use the letters in the squares to spell one of the topics of this Activity Book. (Hint: **read the whole sentence** before trying to fill in the missing word.)




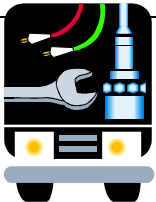


1. Transportation is an I M _ _ _ _ _ T part of our lives.
2. F _ _ _ are essential to our transportation system.
3. We use a L _ of fuel.
4. Millions of gallons of fuel are used in Hawaii _ _ _ year.
5. These fuels P _ _ _ C E many pollutants.
6. But C L _ _ _ _ fuels are becoming available.
7. A L _ _ _ _ _ fuel is renewable.
8. Biodiesel is made R I _ _ here in Hawaii.
9. E L _ _ _ _ _ vehicles are "zero-emission vehicles."
10. Propane has been used in V E _ _ _ _ _ in Hawaii for over 25 years.
11. New Federal laws require government F L _ _ S to purchase alternative fuel vehicles.
12. Automobile and truck M A N _ _ _ _ _ _ _ _ have designed engines to use the cleaner fuels.
13. Some of the vehicles can U _ _ two kinds of fuel.
14. In addition to C _ _ N air, there are other benefits from these fuels.
15. National energy security, more jobs, and improved B A _ _ _ _ of trade are some of the other benefits.
16. Someday, a car you drive may be powered by one of T H _ _ fuels!

Solve the puzzle using the letters in the boxes above:

 E A V U
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Fact Sheets

An "alternative fuel" is pretty much anything that's not gasoline or diesel. You may have heard of:

<p>Biodiesel *</p> 	<p>A substitute for diesel fuel, made from vegetable oil (including used cooking oil). Used in boats, buses, and large trucks. Made in Hawaii.</p>
<p>Electricity * (for "electric vehicles")</p> 	<p>An electric vehicle has an electric motor instead of an internal combustion engine. Electricity for the motor comes from batteries or fuel cells. Since there's no combustion happening on the vehicle, electric vehicles are "zero emission," quiet, and cool. Made in Hawaii.</p>
<p>Ethanol (an alcohol* fuel)</p> 	<p>An alcohol fuel made from corn or sugarcane. It could also be made from waste paper, sawdust, or other low-cost materials. Ethanol is a liquid fuel that can be used in an internal combustion engine or a fuel cell. Could be made in Hawaii.</p>
<p>Fuel Cells (not commercially available)</p>	<p>Fuel cell vehicles are the best of both worlds, in theory – they're electric vehicles that could be re-fueled with alternative fuels (ethanol, methanol, or hydrogen, for example). This is attractive since re-fueling is faster than re-charging. Still in the "research and development" stage.</p> 
<p>Hydrogen (not commercially available)</p>	<p>Hydrogen is being considered for use in fuel cells and has been used in internal combustion engines. The main obstacle is fuel distribution and storage, both on and off the vehicle. Vehicles are still in the "research and development" stage. Hydrogen fuel could be made in Hawaii.</p>
<p>Methanol (an alcohol* fuel)</p> 	<p>An alcohol fuel made from natural gas. It could also be made from landfill gas, sugarcane bagasse, or wood chips. Methanol is a liquid fuel that can be used in an internal combustion engine or a fuel cell. Could be made in Hawaii.</p>
<p>Natural gas (also known as "compressed natural gas" or "CNG")</p>	<p>Not commercially available in Hawaii. Although synthetic natural gas is made from refinery byproducts on Oahu, it has a different composition from the natural gas used on the Mainland. Also, Hawaii's synthetic natural gas is only available in a limited area of Oahu (neighbor islands and areas of Oahu use propane instead).</p>
<p>Propane * (also known as "LPG," "liquefied petroleum gas")</p>	<p>Propane, which is made from refinery byproducts on Oahu, is more practical than natural gas for Hawaii and is available statewide. Propane vehicles have been in use in Hawaii for many years. Fuel made in Hawaii from imported petroleum.</p> 
<p>Solar Cars (this is a type of electric vehicle)</p>	<p>Although fun for racing, the size of solar panels required to power your family's car would be too big to be practical (the car wouldn't fit in its lane or parking space). But a car doesn't have to carry solar cells with it – an electric car can plug into solar panels installed on a carport or garage roof, and charge up while it's parked in the shade!</p>

* see individual fact sheets on the following pages.

Alcohol Fuels

What are they?

Alcohol fuels are made from renewable resources like locally grown crops and even waste products such as waste paper or grass and tree trimmings. METHANOL and ETHANOL are two types of alcohol fuels used in cars. Ethanol can be produced from a variety of renewable* resources, most commonly corn and sugarcane. Methanol can be made from renewable resources also, but today, methanol is primarily made from natural gas.

Why Alcohol Fuels?

- Alcohol fuels burn cleaner than regular gasoline and produce less carbon monoxide emissions.
- Local production of fuel, from Hawaii-grown crops, supports agricultural jobs.
- Supporting local business keeps dollars in the state and contributes to a healthier state economy.
- Production of fuels in state provides energy self-sufficiency.

Did you know?

- METHANOL has been used as a racing fuel at the Indianapolis 500 Motor Speedway (for reasons of safety and performance) for the past 20 years!
- ETHANOL was the fuel preferred by Henry Ford back in the early days of the Model T.
- Alcohol fuels have high octane. Unleaded gasoline usually has an octane rating between 86 and 94; alcohol fuels' octane ratings are over 100!
- "Flexible fuel" alcohol vehicles can use both alcohol and gasoline -- at the same time, in any mixture from 100% gasoline to 85% alcohol! A special sensor on the fuel line senses the ethanol/gasoline mixture, sends the information to the engine's computer, and the air:fuel ratio and timing are instantaneously adjusted. A digital readout on the dashboard shows the driver what the alcohol fuel percentage is at that moment!
- Ethanol flexible-fueled vehicles are available for the same price as gasoline vehicles.
- Chrysler makes ethanol flexible-fueled Town & Country, Caravans, and Voyagers.
- Ford makes ethanol flexible-fueled Ranger trucks and Taurus sedans.
- Mazda makes ethanol flexible-fueled B3000 pickup trucks.

* For more information on "renewable" fuels, see pages 8 and 9.

BIODIESEL

What is it?

BIODIESEL is a liquid fuel that can replace regular diesel fuel. It's made from vegetable oil. BIODIESEL can run diesel engines that are commonly found in big vehicles such as trucks, buses, or boats. On the island of Maui, BIODIESEL fuel is already being produced. Biodiesel is used in boats, trucks, and even in diesel-fueled electricity generators.

Why Biodiesel?

- Regular diesel fuel particulates may be carcinogenic (can cause cancer). Using biodiesel fuel, or blending it with regular diesel fuel, can reduce the production of these cancer-causing emissions. In other words, it's better for our health!
- Biodiesel can be made from waste vegetable oil (such as used oil from deep fryers at restaurants). This waste oil can be difficult to dispose of. Making fuel out of it can put it to a good use, and at the same time, reduce disposal problems.
- Biodiesel is a renewable fuel (see pages 8 and 9).
- Biodiesel can help create new jobs; also, keeping our air clean helps everybody (residents and tourists alike) enjoy Hawaii more.

Did you know?

- Biodiesel can be used in pure form or blended with regular diesel in any proportion.
- Biodiesel can even make engines smell better. An engine powered by biodiesel actually smells like French fries!
- Biodiesel fuel is a good lubricant, which helps engines to last longer. It also has a high cetane rating,* which improves engine operation.
- Adding just 20% biodiesel to regular diesel improves the diesel's cetane rating by 3 points, which makes a blend of 80% diesel and 20% biodiesel a "premium" fuel.
- In addition to being used in Hawaii, biodiesel fuel is used in buses in Europe and in the Midwestern United States.
- Biodiesel is used in sensitive wetland areas to reduce the danger of fuel spills to endangered wildlife.

* A "cetane rating" indicates the ability of a fuel to ignite in a diesel engine. (Not to be confused with an "octane rating," which indicates the ability of a fuel to avoid "knocking" in a gasoline engine). A higher number may improve performance, depending on the engine.

Electric Vehicles

What are they?

ELECTRIC vehicles run on ELECTRICITY (see "electricity" fact sheet, next page). Electric vehicles can be one of the most environmentally harmless means of motorized transportation that we can choose from.

Why Electric?

- Electricity is our most familiar source of energy. It can be made from clean, renewable energy sources such as wind, water, or solar power (see "Electricity," next page).
- "Refueling" (recharging) at home is more convenient for people on the go.
- The cost of electricity for recharging is about 1/3 less than the cost of gasoline.
- Special "rapid chargers" can recharge electric vehicles in just 15 minutes.
- Electric vehicles are "Zero Emission Vehicles." They have absolutely zero tailpipe emissions. (In fact, they don't even have tailpipes!)

Did you know?

- The top **speed record** for an electric car is over 200 miles per hour! (**215 mph** record held by "Lightning Rod," owned by the Rannbergs, driven by Eric Luebben, 1998.)
- The longest **distance** traveled by an electric car **on a single charge** is **1043 miles!**
- Batteries store the energy for today's electric vehicles. Future batteries are expected to be lighter, smaller, more efficient, and cheaper - hundreds of scientists and engineers are developing and testing new batteries right now! They are also developing flywheels, capacitors, and other exotic energy storage devices.
- Some electric vehicles are even more energy-efficient -- they use regenerative braking. This means that the energy from braking is captured and returned to the batteries!
- U.S. Electricar sells and services electric vehicles right here in Hawaii at 531 Cooke St.
- The largest commercial electric vehicle in use in Hawaii is E Noa Tours' "Waikiki Trolley."
- In Hawaii's "Electron Marathon," high school teams build electric go carts from scratch!
- Hawaii teams have been very successful in building and racing electric (solar) cars. Hawaii's very own **Konawaena High's** solar car is internationally known and was the basis of the movie, Race the Sun. And the year before Konawaena built their solar car, **Naalehu Intermediate** school built a solar car that won the State competition and went to Indianapolis. And when **Kauai Community College** competed in the GM Sunrayce, they placed 9th out of 36, beating the likes of Stanford University, UC Berkeley, Virginia Tech, and the Universities of MD, MA, MI, MN, MS, OK, PR, TX, (and others) ... the next time, they took 15th place (out of a field of 38) and, once again, beat a host of large universities including Texas A&M, Cal State Long Beach, and Purdue.

Electricity

"When a wire is moved in a magnetic field, an ELECTRIC CURRENT is generated in that wire."

Large-scale electricity generation - whether from fossil fuels, renewable fuels, or other sources - is usually based on the fact that:



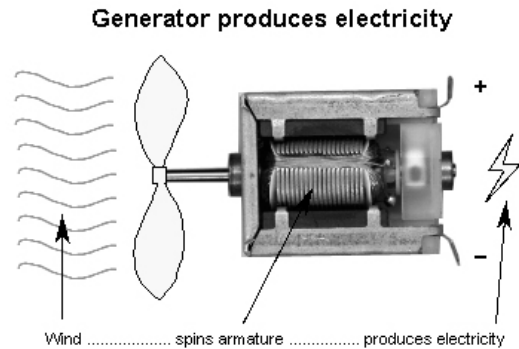
The magnets are on the outside (they don't move). Copper wire is around the "armature."

When something spins the shaft, it causes the copper wire to "move in a magnetic field" - and electricity is produced!

A "generator" and "motor" are essentially the same thing: what you call it depends on whether the unit is producing or using electricity.

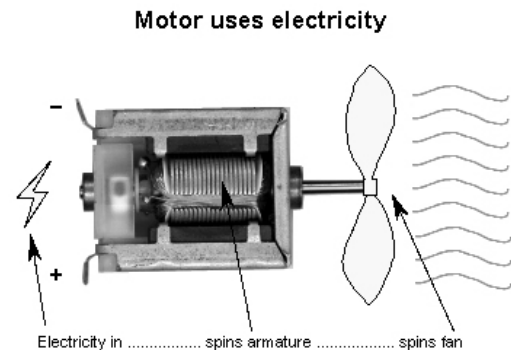
A **generator** produces electricity. In a generator, something causes the shaft and armature to spin. An electric current is generated, as shown in the picture (lightning bolt).

Lots of things can be used to make a shaft spin - a crank, pinwheel, windmill, bicycle, water wheel, diesel engine, jet engine, or steam turbine. They're different sizes but it's the same general idea.



A **motor** uses electricity. In a motor, the electricity comes in through wires attached to the positive (+) and negative (-) terminals. The electric current causes the armature and shaft to spin.

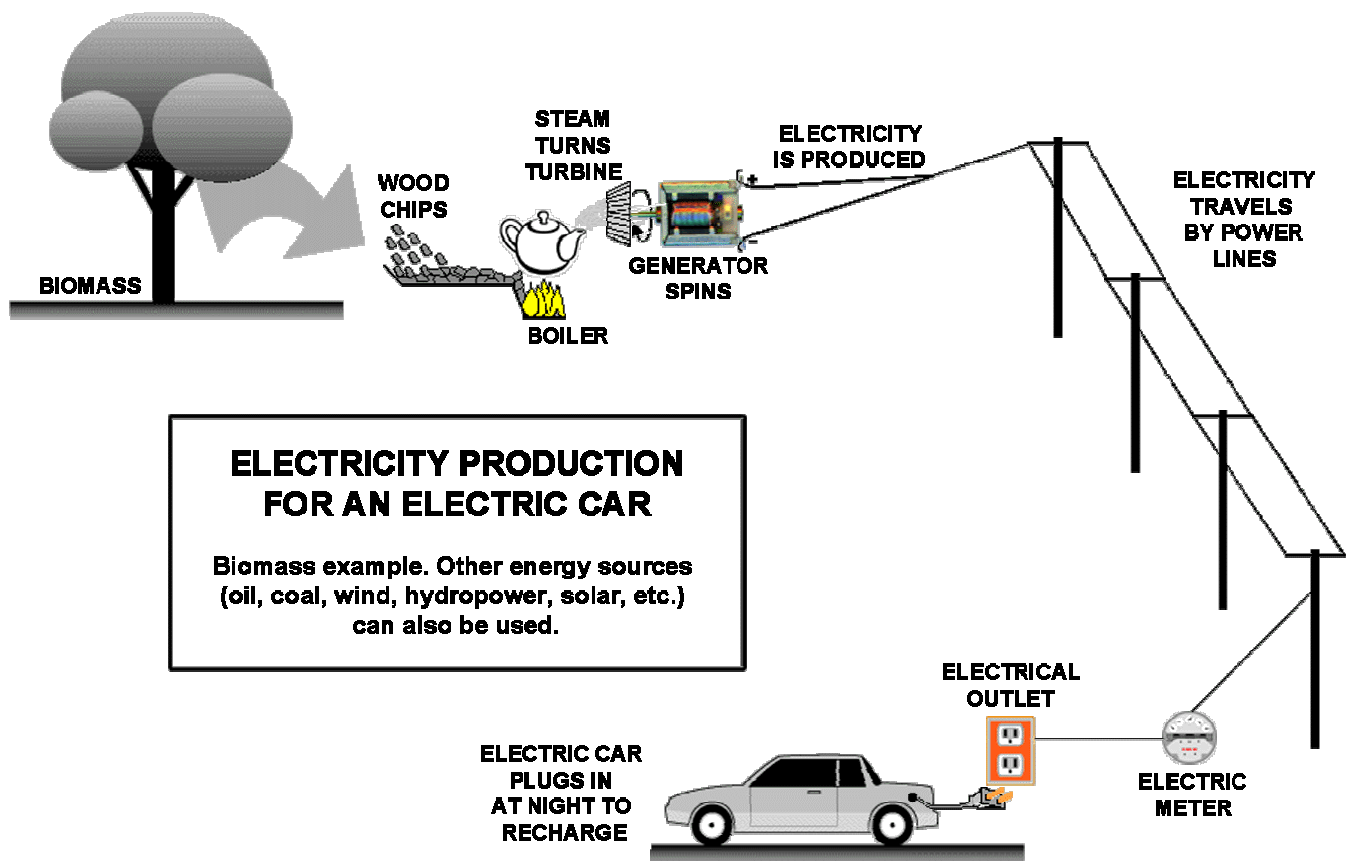
If there's just a little current and it's a small motor, it won't do very much work (i.e. it can only spin a small fan). If it's a large motor and it's using a lot of electricity, it can do a lot of work (i.e. spin a large fan very fast ... or, turn the wheels of a car, bus, or truck).



Electric power plants are essentially **the same thing - just LOTS BIGGER**. A 180-megawatt generator at Hawaiian Electric Company's Kahe power plant on Oahu is 50 feet long, 20 feet in diameter, and weighs over 50 tons. The armature spins at 60 revolutions per second!

The different energy sources all do the same basic thing: **spin something** (connected to a generator made of copper wire and magnets). In a steam power plant, fuel (oil, wood, etc.) is burned to heat water into steam, which spins a turbine (connected to a generator). In a combustion turbine, burned fuel turns the turbine. In a hydropower plant, flowing water spins the turbine. The electricity is the same, regardless of energy source.

Then, the electricity flows from the generator into the powerlines and into your home, school, office, or garage (where it can charge an electric car). **That's it!**



The electro-mechanical approach described here (**electromagnetic induction** generating an **alternating current**) is just one way to produce electricity. There are also electrostatic, electro-chemical, photoelectric, and thermoelectric phenomena (just to name a few) which can be used to produce an electric charge or direct-current electricity. For example, you can generate an electric charge just by wearing leather-soled shoes and shuffling your feet on carpet (if the weather is dry enough). Chemical reactions can be used to produce electricity (batteries and fuel cells are based on this). Light waves can generate an electric current in certain materials (such as photovoltaic cells). A temperature difference can generate a current in a thermocouple. And there are many more examples.

Nevertheless, the electricity at your wall outlet -- that powers your toaster, blender, television, lights, etc., (or charges an electric vehicle) -- is usually produced by spinning a generator made of magnets and wires, as described above.

Fuel Cell Vehicles

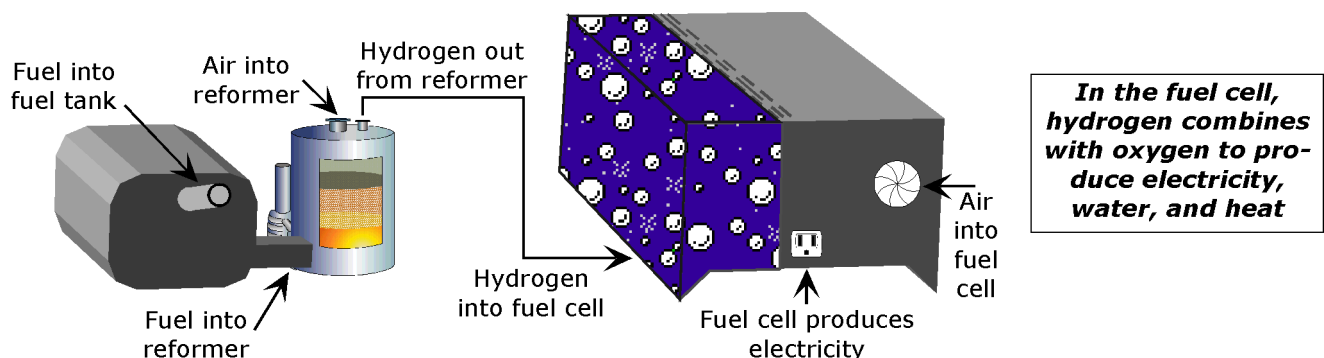
What are they?

FUEL CELL vehicles are still in the developmental stage. From a technical point of view, they are electric vehicles, since electricity (generated by the fuel cell) is used to drive an electric motor. But the vehicle doesn't have to re-charge as an electric vehicle does - the fuel cell is filled up with a liquid (or gaseous) fuel, in the same way that an internal combustion engine vehicle (such as gasoline or diesel) fuel tank is filled up. **See page 26.**

Why Fuel Cells?

- Fuel cells are cleaner and much more efficient than internal combustion engines. For example, if a 40-miles-per-gallon gasoline-fueled internal combustion engine vehicle had its engine replaced by a fuel cell, it could get (theoretically) 60 to 100 miles per gallon! (The systems are still under development, so there's some uncertainty as to EXACTLY how much more efficient they would be in large scale use - but there's no disagreement that they would be more efficient.)
- So, if fuel cell vehicles should someday replace internal combustion engine vehicles, the existing gasoline, alcohol, or propane *fueling infrastructure* (stations, pipelines, pumps, etc.) could still be used. And, if fuel cell vehicles were to replace electric vehicles, the *electric vehicle technology* (motors, batteries, controllers, etc.) would also still be used!

Fuel Cell



Did you know?

- On the space shuttle, fuel cells are used to provide electricity and water.
- DaimlerChrysler, Ford, General Motors, Honda, Mazda, Nissan, Toyota, Volvo, Volkswagen, and others have announced plans to sell fuel cell cars, vans, or buses.
- Fuel cell buses are in use in Ontario, Canada and Chicago, Illinois.

Propane

What is it?

PROPANE is the name commonly used for Liquefied Petroleum Gas (LPG). It's made from petroleum refining and natural gas processing. Propane is normally a gas, but it's stored in liquid form on a vehicle. Once the propane enters the engine, it becomes a gas again, which helps this fuel to burn so cleanly. The propane fuel grade used in vehicles is called HD-5.

Why Propane?

- Propane is widely available. Hawaii has over 300 refueling sites throughout the islands.
- Propane fuel tanks are 20 times more puncture resistant than conventional gasoline tanks.
- "Closed" fueling systems prevent leaking and vapor emissions.
- Propane emits 60% lower carbon monoxide and 50% lower reactive hydrocarbons than gasoline.
- Engines run by propane are cleaner and last longer. Propane vehicles can have as much as double the engine life of gasoline vehicles. Propane reduces lubricant contamination by fuel and produces less carbon build up in combustion chambers and pistons.
- "Premium" gasoline has octane ratings of 91-92. Propane's octane rating is 104.

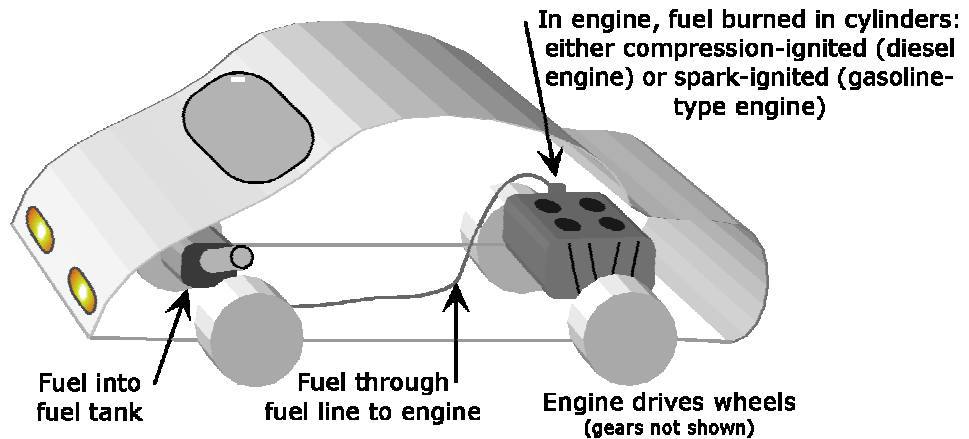
Did you know?

- Both General Motors and Ford manufacture propane vehicles.
- The oil, oil filter, and spark plugs in a propane vehicle last up to three times longer than in a vehicle running on gasoline.
- There are 3.5 million propane vehicles worldwide. In the U.S., more than 350,000 vehicles are fueled by propane.
- Propane is the third most widely used motor fuel, ranking behind gasoline and diesel.
- Propane has been used as an alternative transportation fuel for more than 60 years. In Hawaii, about 1,500 on-road and off-road vehicles are powered by propane.
- Vehicle conversions have been available locally for over 20 years.
- In Honolulu, The Gas Company converts and services propane vehicles at 515 Kamakee St.

Internal Combustion Engine Vehicles

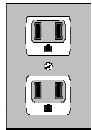
Fuels:

- Alcohol Fuels (SI/CI)
- Biodiesel (CI)
- Diesel (CI)
- Gasoline (SI)
- Hydrogen (SI/CI)
- Natural Gas (SI/CI)
- Propane (SI)
- SI = Spark Ignition Required
- CI = Compression Ignition Required

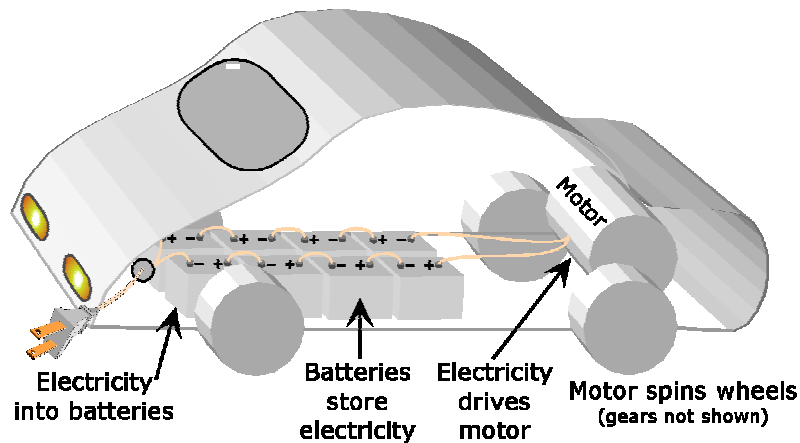


Electric Vehicles

Fuel:



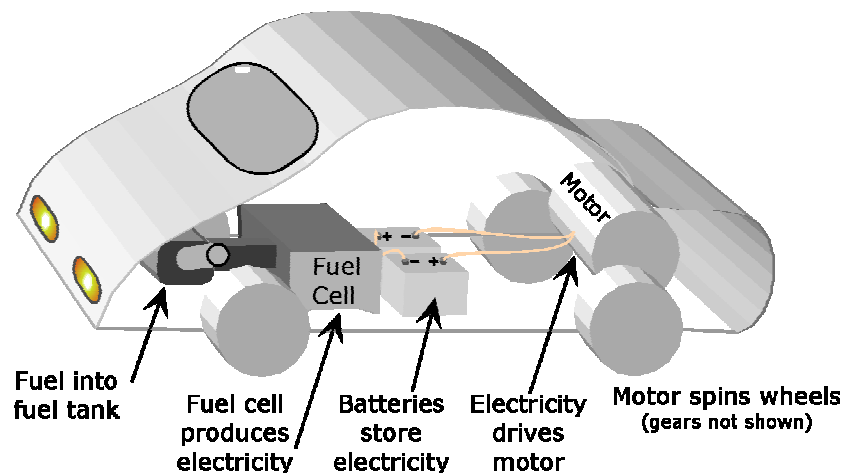
Electricity



Fuel Cell Vehicles

Fuels:

- Alcohol Fuels
- Gasoline
- Hydrogen
- Natural Gas
- Other fuels ("energy carriers") are under development



ADD UP YOUR POINTS

As you probably noticed, all of the activities were challenging -- and some were quite difficult! Some required creative thinking and even “intuitive leaps” (i.e. smart guesses, based on something you may have seen or heard somewhere else). There were those that required research. Some required math. Several required patience. And some even required luck!

Since this was a learning activity book - NOT a test of things you already know - you get points for completing an activity (even if you had to look at the answers!) as long as you understand the answers now. If you didn't have to look at the answers and you got it right, you might get an extra point (or 2, or more) for that activity! (Guidelines in parentheses.)

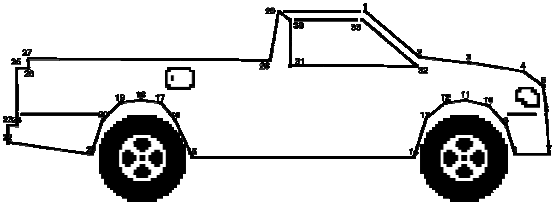
Page		Points
Transportation		
1	Coloring (3 points for completing; +2 more if someone you know recognizes it)	
2	Rolling Dots (2 points for completing)	
2	It's a-MAZE-ing! (2 points for completing, +1 extra if done w/out looking at answer)	
3	Puzzle Dots (2 points for completing puzzle plus 2 points per question) (8 max)	
3	Wheels Away (1 point each word; +1 extra if done without looking at answer) (5 max)	
4	Match-up#1 (1 point each; +1 extra if done w/out looking at answer) (4 max)	
4	Scramble (1 point each word; +1 extra if done without looking at answer)	
4	Crossword #1 (1 point each word; +2 extra if done without looking at answer)	
5	Word Search #1 (1 point each word; +2 extra if done without looking at answer)	
5	Wheels, wheels (2 points for completing; +1 extra if it's right) (ask teacher if not sure)	
5	Math Teaser #1 (3 points for completing; +1 extra if done w/out looking at answer)	
Pollution		
6	Cause-and-Effect (2 points each, +2 extra if done without looking at answer)	
7-9	Fill in the words (1 point ea. word; +2 if done without looking at answers) (15 max)	
8	Extra Tricky Quiz (4 points for completing; +8 more if done w/out looking at answer)	
9	Math Teaser #2 (3 points for completing; +1 more if done w/out looking at answer)	
Clean Fuels		
11	Picture the Fuels (2 points each, +2 extra if done without looking at answer)	
12	Go U.S.A. (1 point each word; +2 extra if done without looking at answer)	
13	True or False (2 points each; +2 extra if done without looking at answer)	
13	Find the Phrase (2 points each word; +2 if done without looking at answer) (12 max)	
14	Word Search (1 point each word; +4 extra if done without looking at answer)	
15	Crossword Puzzle (1 point each word; +3 extra if done without looking at answer)	
16	a-MAZE-ing fuels! (6 points for completing, +4 more if w/out looking at answer)	
17	Summary (1 pt. ea. word, +2 for puzzle at bottom; +3 if done w/out answers) (21 max)	
Total		
	Add up your points.....	

25-50	50-75	75-150	150+
Good start!	Very good!	Excellent!	Expert!

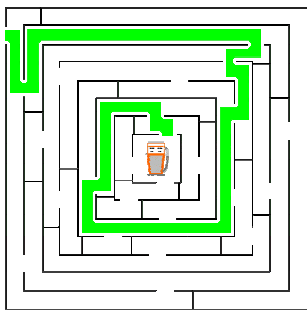
CONGRATULATIONS!

ANSWERS

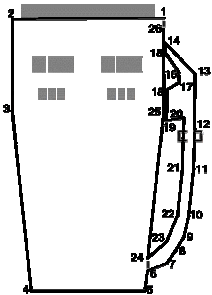
Rolling Dots (page 2)



It's a-MAZE-ing! (page 2)



Puzzle Dots (page 3)



Wheels Away (page 3)

Ben rides a bus to s c h o o l .
 Ben's parents drive a car to w o r k .
 Ann takes an airplane to the state of W a s h i n g t o n .
 A truck delivers juice to the s u p e r m a r k e t .

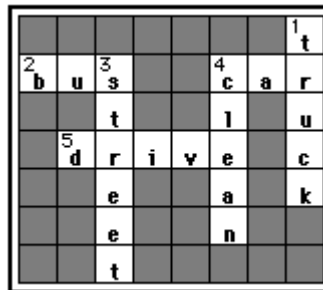
Match-up #1 (page 4)

Ben's bus C (diesel) .
 Ben's parents' car A (gasoline) .
 Ann's airplane B (jet fuel) .

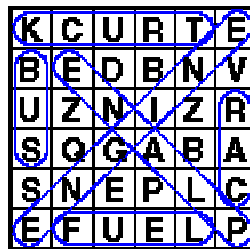
Transportation Fuels Scramble (p. 4)

GASOLINE
DIESEL

Crossword #1 (p. 4)



Word Search #1 (p. 5)



Math Teaser #1 (p. 5)

b. About **400,000,000** (400 million) gallons per year

Cause-and-Effect (p. 6)

D, C, A, B

Pollution problems (p. 7)

Pollution ... can make us **sick** ...
Pollution ... (can) harm **plants and animals**.
It costs a lot ... damaged by **pollution**.
Carbon monoxide ... **monoxide** poisoning.
“Smog” is created ... oxides of **nitrogen**.
Other fuel **emissions** ...
Carbon **dioxide** is a major contributor ...

Extra Tricky Quiz (p. 8)

The extra weight comes from the **OXYGEN** (if you said “**AIR**” that’s OK too)! Oxygen (from the air) combines with carbon (in the fuel) to make CO₂.

Details: Two atoms of oxygen (atomic weight 16) displace two atoms of hydrogen (atomic weight 1) to combine with each atom of carbon (atomic weight 12).

Before it’s burned, one sub-unit of fuel (CH₂) has an atomic weight of 14 (12+1+1).

Burning (combustion) causes the carbon to combine with oxygen to form CO₂, which has an atomic weight of 44 (12+16+16).

(The hydrogen also combines with oxygen, to form H₂O (water), which has an atomic weight of 18 (1+1+16), but that’s not part of the original question).

That’s how fuel with an atomic weight of 14 can produce CO₂ with an atomic weight of 44 – quite a gain!

Fill-in-the blanks (page 8)

Transportation ... **global climate change** ...
Every time ... crude **oil** ...

Fill-in-the blanks (page 9)

When plants ... **renewable**.

Math Teaser #2 (p. 9)

c. About **8,000,000,000** pounds (4 million tons)
And that’s just in Hawaii – and just for one year!

Picture the fuels (p. 11)

C (corn to make alcohol fuel): ETHANOL
E (recharging station): ELECTRIC
B (liquefied petroleum gas): PROPANE
A (traditional fossil fuel): GASOLINE
D (used cooking oil): BIODIESEL

Go U.S.A. (p. 12)

Transportation is a very important part of our everyday lives. And our trucks, buses, and cars need **fuels** to run. Right now, the only fuels used by most of our vehicles are gasoline and diesel, which are made from oil imported from other **countries**.

But sending all this money out of the USA is not good for the **balance of trade**. And it doesn’t keep the money here to create **jobs**. And every time there’s a war involving (or near) countries that produce the oil we need, it becomes a threat to our **national energy security**.

By a law passed by the U.S. **Congress** in 1992, alternative fuels are now part of the official National Energy Policy of the United States.

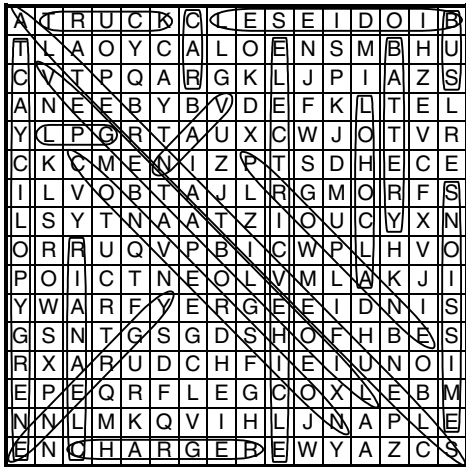
True or False (p. 13)

1. **T** (215 mph record set in 1998.) 2. **F** (Ford offers several propane-powered vehicles.) 3. **T**
4. **F** (corn & sugarcane are used to produce fuel-grade ethanol. Grapes could be used – after all they’re used to make wine, which has ethanol in it – but it’s too expensive to be practical for fuel.)
5. **T** 6. **T** 7. **F** (In 1997, a 5-passenger vehicle powered by zinc-air batteries went 1043 miles without a recharge.)

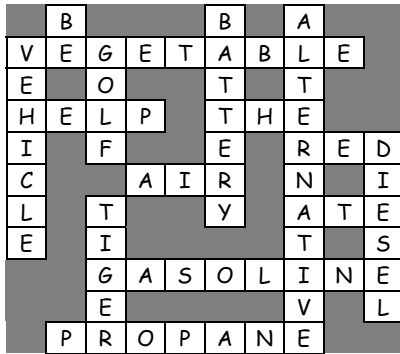
Find the Phrase (p. 13)

The phrase is “**clean fuels for clean air.**”

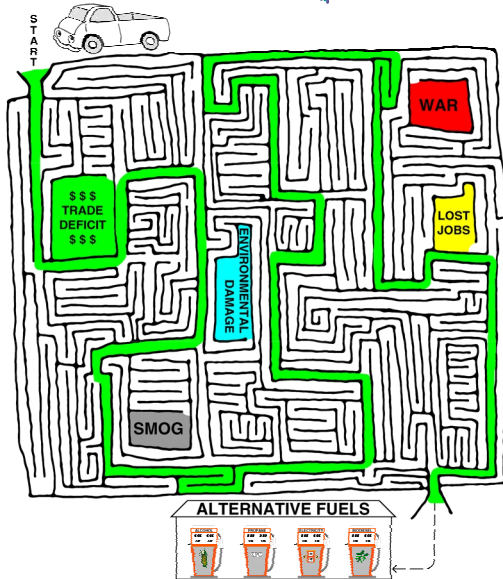
Word Search (p. 14)



Crossword Puzzle (p. 15)



a-MAZE-ing Fuels! (p. 16)



Summary (extra credit!) (p. 17)

1. Transportation is an **important** part of our lives.
2. **Fuels** are essential to our transportation system.
3. We use a **lot** of fuel.
4. Millions of gallons of fuel are used in Hawaii **each** year.
5. These fuels **produce** many pollutants.
6. But **cleaner** fuels are becoming available.
7. **Alcohol** fuel is renewable.
8. Biodiesel is made **right** here in Hawaii.
9. **Electric** vehicles are “zero-emission vehicles.”
10. Propane has been used in Hawaii **vehicles** for over 25 years.
11. New Federal laws require government **fleets** to purchase alternative fuel vehicles.
12. Automobile and truck **manufacturers** have designed engines to use the cleaner fuels.
13. Some of the vehicles can **use** two kinds of fuel.
14. In addition to **clean** air, there are other benefits from these fuels.
15. National energy security, more jobs, and improved **balance** of trade are some of the other benefits.
16. Someday, a car you drive may be powered by one of **these** fuels!

The letters spell:
ALTERNATIVE FUELS

For More Information . . .

- Call these **PEOPLE** for more information on...

Alternative Fuels: Maria Tome, 587-3809 (Oahu); toll-free from neighbor islands: Big Island: 974-4000, extension 7-3809; Kauai: 274-3141, extension 7-3809; Maui: 984-2400, extension 7-3809; Molokai and Lanai: 1-800-468-4644, extension 7-3809.

Biodiesel Fuel: Bob King, 871-6624 (Maui).

Electric Vehicles: Ralph Dobson, 543-4754 (Oahu) or Herb Hendrickson, 594-0100 (Oahu).

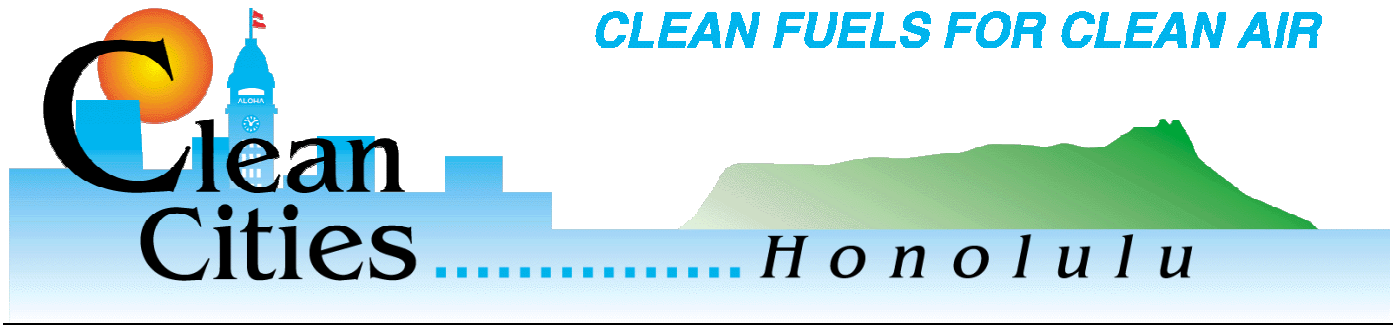
Propane: Bill Givens, 594-5511 (Oahu).

Need a science project idea? Or, need help with a project you're already working on? Want a tour of an alternate fuel facility, or want to see an alternative fuel vehicle? Want someone to make a presentation to your class or community organization? These people can help!

- Go to the Honolulu Clean Cities **WEBSITE:** <http://www.hawaii.gov/dbedt/ert/cc> or the U.S. Department of Energy's Website, <http://www.afdc.nrel.gov>
- **CALL TOLL-FREE** the U.S. Department of Energy's Alternative Fuels Data Center, 1-800-423-1363. Hours of operation: Monday through Friday, 9AM – 6 PM Eastern Standard Time. If nobody's there, you can leave a message and they'll call you back.

Comments or questions? Please send them to:

Alternative Fuels Activity Book
c/o DBEDT-ERT-MLT
P.O. Box 2359
Honolulu, Hawaii 96804
phone: (808) 587-3809
fax: (808) 587-3820
e-mail: mtome@dbedt.hawaii.gov



This Activity Book was created by the **Honolulu Clean Cities** Coalition, a voluntary partnership between private- and public-sector organizations:

American Lung Association of Hawaii
American Public Works Association, Hawaii Chapter
Ameron HC&D
Brewer Environmental Industries
City and County of Honolulu
Cummins Hawaii Diesel Power
EA Engineering, Science, and Technology
Electric Vehicle Association of Hawaii
Fleet Street Graphics
The Gas Company, a Division of Citizens Utilities
Global Electric Motors
HT&T Truck Center
Hawaii Detroit Diesel Allison
Hawaii Electric Vehicle Demonstration Project
Hawaii Natural Energy Institute
Hawaii Transportation Association
Hawaiian Electric Company
Oahu Fleet Safety Organization
Pacific Biodiesel
Pacific International Center for High Technology Research
Pacific Machinery
State of Hawaii Department of Business, Economic Development & Tourism
Travel Plaza Transportation
Unisyn Biowaste Technology
U.S. Department of Energy, Pacific Liaison
U.S. Electricar
U.S. General Services Administration, Fleet Management Branch

For more information on the Clean Cities program, to provide suggestions, or to obtain additional copies of this Activity Book, please call: (808) 587-3809.

Copyright 1999. May be copied, distributed, or modified for educational purposes or use by other Clean Cities, as long as the original source (Honolulu Clean Cities) is acknowledged.