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ABSTRACT

This guide presents five lessons designed to: create an awareness of the present energy situation and its relation to various aspects of transportation systems; provide knowledge of energy resources, choices, and alternative actions; develop critical thinking skills about energy and individual roles in the energy management process; encourage problem-solving habits as students examine alternative solutions to energy and transportation issues; and influence participation as students practice consumer roles and decision-making in their homes, school, and community. These lessons focus on: energy, transportation, and the growth of cities; public transporation alternatives for energy saving; automobiles and energy conservation; alternatives to the automobile (e.g., electric and natural gas cars); and aviation. Each lesson includes an overview (which provides inquiry, decision-making, and action objectives; and states the lesson's purpose, time needed, and the readability of student materials); a glossary; a factsheet (providing background material for completing other activities); classroom activities; a case study (presenting a problem or issue for students to discuss); a home study; a community study; a section exploring the short-, intermediate-, and long-range future of issues/problems presented in the lesson; a career-oriented activity; and a list of resources. A list of social studies, government, and economics textbooks with energy and transportation concepts and the page numbers on which they appear is also provided. (JN)

Energy and Transportation Lessons

for the Senior High Grades

energy
education
curriculum
program

Lt. Gov. John M. Mutz, Director
Indiana Department of Commerce

Harold H. Negley, Superintendent
Indiana Department of Education

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Harold H. Negley, State Superintendent of Public Instruction

ENERGY AND TRANSPORTATION LESSONS

FOR THE

SENIOR HIGH GRADES

Division of Energy Policy
Indiana Department of Commerce
Lieutenant Governor John M. Mutz

Division of Curriculum
Indiana Department of Education
Harold H. Negley, Superintendent

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FOREWARD

A society's future resides in its vision. As Indiana educators work with students on energy and transportation issues and problems, together they will explore alternatives for prosperity in the 21st century. What they imagine decades ahead will be created in the classrooms of today.

We believe that students of all ages must understand the relationship between transportation choices and available energy resources. More efficient, effective use of energy will insure a more prosperous future. To help senior high school teachers achieve this significant goal, we are pleased to introduce a High School Energy Education Curriculum. This exciting and innovative program contains important goals, materials, activities, and resources for you and your students.

We encourage you and your students to study these lessons. We hope you will use them to inquire deeply into energy and transportation issues and problems, to explore decisions, then to consider actions. We trust you will go beyond these lessons to enlist the support of other teachers, students, and their parents, other citizens, and community agencies. A broad commitment among Indiana's people is necessary for dealing with this critical energy issue.

Harold H. Negley
State Superintendent
Indiana Department of Education

John M. Mutz
Lieutenant Governor
State of Indiana

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Likewise, special thanks is given to the curriculum development team. The interdisciplinary blend of the talents of the following Ball State University faculty broadened coverage of issues and sharpened insights into the complex relationship between energy and transportation: Dr. Francis Parker, Acting Chair and Professor, Urban Studies and Planning and Dr. Devon Yoho, Director of the Center for Economic Education and Associate Professor of Economics who prepared the Energy and Transportation Lessons for the Senior High Grades; Dr. Mildred Ballou, Professor of Early Childhood and Elementary Education, Mrs. Martha Lane, Instructor of Elementary Education at Burris Laboratory School, and Dr. Marianne Talafuse, Associate Director of the Center for Economic Education and Associate Professor of Economics who assisted in the development of a conceptional framework and an organizational format for these lessons.

The graphic art work prepared by Mrs. Cheryl King, Educational Media Center, assured the creation of visually-appealing materials.

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INTRODUCTION

Transportation involves the carrying of people, goods, and ideas from one place to another. In order to move these things energy -- a source of power -- is required.

Throughout history, a variety of power sources have been used. Muscle power -- human and domesticated animal -- provided the earliest form of energy for transportation. Centuries ago, the Chinese attached sails to wheelbarrows to take advantage of the wind as a power source. Early voyagers used the water in rivers and oceans for transportation.

In 1776 in England James Watt put engines, powered by steam, to work. Within two decades Englishman Richard Trevithick used steam to power a railroad locomotive and Robert Fulton used it for the steamboat. Gradually, coal began to replace steam in moving the locomotive.

Energy sources for modern forms of transportation can be traced to:

1800	Electricity is produced in Italy by Volta who invents the battery and gives his name to the volt
1859	Oil is discovered in Pennsylvania by Edwin Drake
1860	The internal combustion engine is invented in France by Lenoir; who creates an explosion inside a cylinder
1884	The steam turbine and accompanying electrical advances are perfected by Charles Parsons in England
1892	The oil-burning engine is invented by Rudolf Diesel
1903	Gasoline is used to power the Wright brother's plane.

Historically, the form of transportation accessible to members of a society has been tied to energy resources. Then and now, the extent to which these resources have been available for powering transportation has depended largely on the consumption of non-renewable resources. The level of consumption has been influenced by lifestyles and the values and behaviors supporting them.

The Critical Role of Energy Education

Producing appropriate student knowledge and behaviors to maintain and to improve the delicate balance between available energy resources and demands on these resources is the primary role of energy education. To carry out this role, classroom teachers are challenged to accomplish the following tasks:

1. To understand and to communicate basic concepts in energy education;

2. To foster appropriate student attitudes toward energy consumption by sharing insights on the consequences of unwise lifestyles and by modeling energy conservation behaviors;

3. To prepare students to examine thoroughly energy issues and problems and to develop thoughtful plans for resolving them; and

4. To motivate students to help educate citizens in their communities about ways to improve the quality of life while safeguarding non-renewable energy resources.

In these lessons, the preceding four tasks are presented in the context of transportation. The study of energy in relation to transportation is compelling because it pervades so much of our daily living. Where we work, study, shop, and play and how we get to those places provides but a sample of questions resulting from the study of energy and transportation. The costs of the choices we make is as intriguing.

The Indiana Department of Education, in cooperation with the Division of Energy Policy, Indiana Department of Commerce has organized curricula in the past to help teachers and students explore important energy issues and problems. The lessons that follow illustrate the continuing commitment of these agencies in assuring that tomorrow's decision makers will have been prepared to make wise choices — promoting a better quality of life.

Development of the Energy and Transportation Lessons

The first step in developing the Energy and Transportation Lessons for the Senior High Grades involved a careful analysis of concep[illegible] presented in state-adopted government, social studies, and economic texts in grades 9 - 12. On pages 4 - 12 the publishers, titles of the texts, concepts related to energy and transportation, and the page numbers on which the concepts appear are listed. We have included the listing so that you can supplement these lessons with readings from available texts in your school system.

The second step in lesson development was to define goals. Five goals were identified:

1. To create an awareness of the present energy situation and its relation to the transportation system;

2. To provide knowledge of energy resources, cho[illegible]es, and alternative actions;

3. To develop critical thinking skills about energy and individual roles in the energy management process;

4. To encourage problem-solving habits as students examine alternative solutions to energy/transportation issues; and,

5. To influence participation habits as students practice consumer roles and decision-making in their homes, school, and community.

In relation to these five goals three areas of educational development were emphasized:

1. Inquiry:

    (a) identifying an issue or problem,

    (b) understanding background to the issue or problem,

    (c) examining tentative solutions,

    (d) collecting data,

    (e) analyzing data, and

    (f) reaching a conclusion;

2. Decision-Making:

    (a) recognizing the need to make a decision,

    (b) analyzing alternative decisions,

    (c) predicting consequences of decisions, and

    (d) ranking alternative decisions;

3. Taking Action:

    (a) recognizing issues or problems where action should be taken,

    (b) analyzing evidence upon which action should be developed,

    (c) selecting actions,

    (d) predicting consequences,

    (e) initiating action, and

    (f) evaluating the results of action.

Each lesson begins with an overview listing inquiry, decision-making, and action objectives. A brief description of the purpose of the lesson is included, along with the approximate time required for completing the lesson, and the reading level of the materials.

The second component of each lesson is a GLOSSARY. Terms critical to an understanding of the lessons are defined.

The third component of each lesson is a FACTSHEET. The FACTSHEET is a handout that may be reproduced and distributed to students for their reading. Or, it may be adapted for use in a lecture. The FACTSHEET provides background material for completing other activities. Illustrations to go with the FACTSHEET are included at the end of the RESOURCES section of the lesson.

The fourth component of each lesson is CLASSROOM ACTIVITIES. Ideas are presented for in-class study.

The fifth component in each lesson is a CASE STUDY. The CASE STUDY presents a problem or issue for students to discuss. The CASE STUDY is written in such a way as to encourage analysis of alternative points of view.

A sixth component is the HOME STUDY. The HOME STUDY activity is designed to get students to apply what they have learned in class to the home environment. The HOME STUDY activity is intended to engage family members in the exploration of energy and transportation problems and issues.

The seventh component of each lesson is the COMMUNITY STUDY. The COMMUNITY STUDY activity is intended to get students to examine the complications of energy and transportation decisions on communities -- local, state, national, and international.

The eighth component of each lesson is a 21st CENTURY. The purpose of 21st CENTURY is to explore the short -- (3-5 years), intermediate -- (6 to 15 years), and long-range (16-30+ years) future of issues and problems presented in the lesson.

SELECTED RESOURCES are identified at the conclusion of each lesson. The listed films, filmstrips, games, computer software, magazines, books have been chosen carefully to support instruction of the lesson.

Analysis of Senior High Texts

GOVERNMENT BOOKS

American Society, American Book Publishers

Community Impact: 253, 263, 271-274, 300-301, 302-307, 309-311, 381
Conservation: 34, 301, 319-320, 321-322, 327-328, 330-331, 331-334, 337

American Civics, Harcourt-Brace

Community Impact: 427-428, 438-440, 443-444, 446, 480
Conservation: 420, 488-489, 492, 496, 498-499
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American Citizenship, Addison-Wesley

Community Impact: 130, 136-137, 142, 201, 219-235, 225-226, 238, 360, 406
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Supply and Demand: 383-386, 388
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Growth: 231-235, 424-425, 451
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Resources: 130, 135, 200-201, 410-411, 414, 417
Scarcity: 428-429
Sources and Forms of Non-Renewable Energy: 138, 143, 414-415, 416-418, 428-429, 442
Transportation: 38, 225, 238-239, 375-377

American Government, Prentice-Hall

Community Impact: 36, 54, 260, 265, 276
Conservation: 507, 561-562
Consumption: 396, 406, 497
Costs: 507-510
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Sources and Forms of Non-Renewable Energy: 83, 149, 155-157, 250, 502, 529, 549, 559, 561, 562
Transportation: 120-121

State and Local Governments, Allyn and Bacon

Transportation: 50-54
Choice: 53-54

<u>The Future of American Government</u>, Allyn and Bacon

Community Impact: 54-58
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Sources and Forms of Non-Renewable Energy: 64-68
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<u>Power in American Society</u>, Allyn and Bacon

Sources and Forms of Non-Renewable Energy: 46-47
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<u>The United States Government The People Decide</u>, Science Research Associates

Community Impact: 61-65, 219-221, 228, 251, 255, 260-263, 282
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<u>Your Life as a Citizen</u>, Ginn Publishers

Community Impact: 250-260, 263-277, 343, 357, 457
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Consumption: 370, 397, 428-441
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<u>Practical Politics and Government</u>, MacMillian Publishers

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SOCIAL STUDIES BOOKS

<u>Sociology: People in Groups</u>, Science Research Associates

Community Impact: 316, 357, 396, 401-408, 409-416
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<u>Inquires In Sociology</u>, Allyn and Bacon

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Transportation: 279, 280-281
Costs: 162, 163, 164, 165, 166-171

<u>Our Social and Cultural History</u>, Globe Book Company

Community Impact: 160, 161, 162-170, 172, 173, 178
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<u>Population and Progress</u>, Prentice-Hall Company

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<u>The Environmental Crisis</u>, Prentice-Hall Company

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Conservation: 33-38, 61, 95-97
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<u>Voices of Dissent</u>, Prentice-Hall Company

Production: 40-43

The Energy Crisis, Prentice-Hall Company

Conservation: 22-29, 69-72, 95-97
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Production: 78-83

Poverty in an Affluent Society, Prentice-Hall Company

Community Impact: 37-42, 68, 78-86
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ECONOMICS BOOKS

Economics: Meeting People's Needs, Science Research Associates

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Economics: Meeting People's Needs

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Economics Today and Tomorrow, Harper and Row

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The Economic Problem, Prentice-Hall

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Economics: Principles and Applications, Southwestern Publishers

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Free Enterprise in the United States, Southwestern Publishers

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Economics for Young Adults, Sadlier Publishing Company

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Economics of our Free Enterprise System, McGraw-Hill Publishers

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Using Economics: Principles, Institutions, Issues, Oxford Book Co.

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Energy and Transportation Field Study Sites

Field trips can be an integral part of the school curriculum. Indiana has a variety of interesting museums, parks, and other sites devoted to energy and transportation. A listing of these sites is included for planning class field trips and for encouraging parents to take their children on tours of the sites:

1. CANALS AND RIVERBOATS

   Howard Steamboat Museum
   1101 E. Market St.
   Jeffersonville, IN 47130

   Victorian mansion with original 1893 furnishings, also a collection of navigational equipment, paddle wheels and steamboat replicas. Emphasis on Ohio River steamboat era and on the boat-building industry in Jeffersonville.

Whitewater Canal State Memorial
Box 88
Metamora, IN 47030
(317) 647-6512

Ten miles of the original Whitewater Canal (built 1845) have been restored, including masonry locks and feeder dam, and the only wooden covered bridge aquaduct in America. An authentic wooden canal boat, drawn by horses, makes 30 minute trips at the town of Metamora on summer weekends.

Newburgh Lock and Dam
Highways 662 and 66
Newburgh (Warrick Co.), IN 47630
(812) 853-8470

Picnic ground and overlook with view of locks and dam. Watch barges and boats on the Ohio River. Open March - October.

2. RAILROADS and INTERURBANS

Indiana Transportation Museum
Forest Park
Noblesville, IN 46060
(317) 773-0300

Large collection of railroad passenger cars, freight cars and locomotives, also buggies and wagons. Special emphasis on the electric interurban lines which radiated from Indianapolis in the years 1904-1940. Two mile demonstration ride on a restored interurban car. Open daily Memorial Day-Labor Day, weekends April-May and September-November, 1-6 p.m. School tours welcome by reservation.

Museum is also responsible for "Fair Train" -- a diesel powered train ride between Carmel and Indiana State Fair grounds during the weeks of State Fair in August.

Whitewater Valley Railroad
P.O. Box 406
Connersville (Indiana Rt. 121), IN 47331

A 34 mile round trip train ride, pulled by authentic steam and diesel locomotives. Track parallels the scenic Whitewater River and is laid on the towpath of the original Whitewater Canal. Train runs Saturday and Sunday, May-October. Leaves Connersville 12:01 p.m., returns 5:00 p.m.., with 2 hour stopover in Canal town of Metamora. Special school trips (by reservation) are run Wednesday-Thursday-Friday during May, feature lecture on area and transportation history as the train makes its trip.

French Lick, West Baden and Southern Railway
Highway 56
French Lick, IN 47432
(812) 936-2405

A 20 mile round trip, pulled by steam or diesel locomotives. Leaves restored French Lick depot at 10:00 a.m., 1:00 p.m. and 4:00 p.m., Saturday and Sunday from April through November. Features ½ mile long tunnel and rural scenery. Also a 2 mile electric trolley car ride between French Lick and West Baden, a restoration of a trolley operation which connected the two towns between 1903 and 1918. School trips possible by reservation.

Little River Railroad
P.O. Box 178
Angola, IN 46703
(219) 825-9182

A 10 mile round trip steam train ride between Angola and Pleasant Lake, 1:30 p.m. on weekends from Memorial Day through mid October. (During 1984 check for schedule due to major track renovations underway).

LaPorte County Historical Steam Society
Hesston, IN
Mail address 2940 Mt. Claire
Michigan City, IN 46360
(219) 872-7405

A 3 mile steam train ride, also steam farm machinery and sawmill. Open Memorial Day weekend through October, weekends 1-6 p.m. Major show held Labor Day weekend.

Logansport Iron Horse Museum
One Iron Horse Square
Logansport, IN 46947
(219) 753-6388

Restored Railroad Station and exhibits. Iron Horse days, held second week-end in July, features steam train rides and other exhibits.

The Children's Museum
30th and Meridian Streets
Indianapolis, IN 46208
(317) 924-5431

Museum includes large display of model trains, and locomotive from original Madison and Indianapolis railroad. Open Monday-Saturday, 10:00 a.m.-5:00 p.m.; Sunday, Noon-5:00 p.m.

Fort Wayne Pailroad Historical Society
P.O. Box 11017
Fort Wayne, IN 46855

Society has restored a large Nickel Plate Road steam locomotive, built in 1944. The locomotive pulls a variety of special excursions each summer in Indiana and adjoining states. Write for current schedules.

Evansville Museum of Arts and Sciences
411 S.E. Riverside Drive
Evansville, IN 47713
(812) 425-2406

Museum displays include a steam train and replica passenger depot. Open Tuesday-Saturday, 10:00 a.m.5:00 p.m; Sunday 12:00-5:00 p.m.

The Depot
370 E. Jefferson Street
Franklin, IN 46131
(317) 736-6334

Renovated 1906 train station and exhibits. Open Monday-Friday, 8:00-Noon, 1:00-5:00 p.m.

Rochester Depot Museum
Lakeview Park
Race and E. Ninth Streets
Rochester, IN 46975
(219) 223-4436

Restored 1874 Train Station and exhibits. Open June-August, Monday-Friday 9:00 a.m.-5:00 p.m; Sunday 2:00-4:00 p.m.

Leiters Ford Depot Museum
Fulton County Historical Society
7th and Pontiac
Rochester, IN 46975
(219) 223-4436

Restored 1880 Erie railroad depot and exhibits. Open June-August, Monday-Friday, 1:00-5:00 p.m.

Grand Trunk Depot Museum
201 S. Broad
Griffith, IN 46319
(219) 924-2155

Restored railroad station. Open June-August, Wednesday, 10:00 a.m.-2:00 p.m.; Sunday 2:00-4:00 p.m.

3. AUTOMOBILES

Auburn-Cord-Duesenberg Museum
1600 S. Wayne Street
Auburn, IN 46706
(219) 925-1444

Large collection of classic and antique cars in restored automobile show-room. Open 10:00 a.m.-5:00 p.m. October-April, 9:00 a.m.-9:00 p.m. May-September.

Studebaker vehicle collection from wagons through cars. Open Tuesday-Friday, 10:00 a.m.-4:30 p.m.; Saturday, 10:00 a.m.-4:00 p.m.; Sunday, 1:00-4:00 p.m.

Indianapolis Motor Speedway and Hall of Fame Museum
4790 W. 16th Street
Speedway, IN 46224
(317) 241-2500

Collection of antique and classic race cars. Open 9:00 a.m.-5:00 p.m

Early Wheels Museum
817 Wabash Avenue
Terre Haute, IN 47808

Collection of cars, wagons and bicycles. Open Monday-Friday, 10:00 a.m-4:00 p.m.

4. AIRPLANES

Grissom Air Force Base Aircraft Museum
State Highway 31
46971
(317) 689-5211

Collection of military aircraft. Tours by advance appointment.

Wilber Wright Birthplace Memorial
RR 2, Box 258 A
Hagerstown, IN 47346
(317) 332-2513

Restored house. Open Sunday and Tuesday, 1:00-5:00 p.m.; Wednesday-Saturday, 9:00 a.m.-5:00 p.m.

To keep up to date on festivals commemorating special energy and transportation related events and newly established museums, contact:

Tourism Development Division
Indiana Department of Commerce
One North Capitol
Suite 700
Indianapolis, IN 46204
(Tourism Hotline: 1-800-622-4464)

Sources for Free and Inexpensive Materials

A number of energy and transportation agencies and industries provide free materials or reasonably inexpensive materials for classroom use.

For example, an energy and transportation decision-making computer software program was developed for this project. The program can be obtained by writing to: Division of Curriculum, State House, Room 229, Indianapolis, IN 46204. Once you receive the software disk, copy it, then return it to the Division of Curriculum.

Please take advantage of these materials by writing to the following organizations and agencies.

American Petroleum Institute
Publications and Distribution Section
2101 L Street, N.W.
Washington, DC 20037

Amoco Educational Services
Public Affairs - MC 3705
P.O. Box 5910-A
Chicago, IL 60680

Amoco Teaching Aids
P.O. Box 1400K
Dayton, OH 45414

Chevron U.S.A. Inc.
"Career Awareness"
742 Bancroft Way
Berkeley, CA 94710

Division of Curriculum
Room 229, State House
Indianapolis, IN 46204

Division of Energy Policy
1 North Capitol Avenue
Indianapolis, IN 46204

Exxon Company, U.S.A.
Public Affairs Department
P.O. Box 2180
Houston, TX 77001

Exxon Corporation
1251 Avenue of the Americas
New York, NY 10020

Federal Highway Administration
U.S. Department of Transportation
400 - 7th Street, S.W.
Washington, DC 20590

General Motors Corporation
Energy Management Section
3044 W. Grand Blvd.
Detroit, MI 48202

Government Printing Office
Superintendent of Documents
Washington, DC 20402

Gulf Oil Corporation
P.O. Box 1166
Pittsburgh, PA 15230

Indiana Department of Highways
1101 State Office Building
100 N. Senate Avenue
Indianapolis, IN 46204

Indiana Department of Transportation
143 W. Market
Indianapolis, IN 46204

National Coal Association
1130 - 17th Street, N.W.
Washington, DC

National Petroleum Refiners Association
1725 DeSales Street, N.W.
Suite 802
Washington, DC 20036

National Wildlife Federation
1412 - 16th Street, N.W.
Washington, DC 20036

Phillips Petroleum Company
16 D3 Phillips Building
Bartlesville, OK 74004

Public Documents Distribution Center
Consumer Information
Pueblo, CO 81009

Standard Oil Company (Indiana)
Public and Government Affairs
Mail Code 3705, P.O. Box 5910-A
Chicago, IL 60680

Standard Oil Company (Indiana)
200 East Randolph Drive
Chicago, IL 60601

Texaco Inc.
2000 Westchester Avenue
White Plains, NY 10650

Union Oil Company of California
Corporate Communications, Dept. A
P.O. Box 7600
Los Angeles, CA 90051

U.S. Department of Commerce
Washington, DC 20230

U.S. Department of Energy
Educational Programs Division
Washington, DC 20585

U.S. Department of Energy
James Forrestal Building
1000 Independence Ave.
Washington, D.C. 20585

U.S. Department of Energy
Technical Information Cer
P.O. Box 62
Oak Ridge, TN 37830

U.S. Department of the Interior
Bureau of Mines
Mineral Industry Surveys
Washington, DC 20241

U.S. Office of Education
Energy and Education Action Center
Room 514, Reporters Bldg.
300-7th Street, S.W.
Washington, DC 20202

PURPOSE: The purpose of this lesson is to provide an historical overview on the design of cities and how this affects transportation and energy systems.

APPROXIMATE TIME: If each of the following activities is used approximately ten class hours will be needed. This estimate does not include use of supplemental resources.

READABILITY: The Bormuth Readability Index was used to determine the reading level of text material in this lesson.

Ave. Word Length: 4.81

Ave. Sentence Length: 20.8

Readability Index: 63

Grade Level Equiv.: 8-9

OBJECTIVES

INQUIRY	DECISION-MAKING	TAKING ACTION
1. Students will examine how cities take shape.	1. Students will recognize conditions under which transportation systems or energy uses would be altered as a result of the city's shape.	1. Students will determine when the shape of a city poses a problem for energy or transportation use.
2. Students will illustrate how cities' shapes have changed over time.	2. Students will explore the relationships among city shapes, energy resources, transportation systems in their community.	2. Students will analyze data on city shapes to determine energy and transportation problems.
3. Students will analyze the relationship between the shape of cities and the availability of resources.	3. Students will predict the consequences a given change in the shape of a city will have on transportation systems in their community.	3. Students will explore the need to research a proposal to change the city's shape, to reduce reliance on energy, or transportation systems.
4. Students will examine the impact of city shapes and energy in the form of transportation used.	4. Students will rank order the most beneficial shape of cities which show effective energy use and efficient transportation.	4. Students will propose an appropriate change in the city, the transportation system, and/or the sources of energy.
5. Students will develop a conclusion from the relationships among city shape, energy, and transportation.		5. Students will analyze the results of their proposal.

Energy
Glossary
TRANSPORTATION

coal - a black, solid combustible substance formed by partial decomposition over thousands of years of vegetable matter in the absence of oxygen. Coal deposits occur in Southern Indiana and in many other places in the U.S., and form our largest long-term fuel reserve.

energy abundance - situation where fuel exists at a reasonable cost, in enough quantity to satisfy all normal demands including transportation, manufacturing and heating.

energy scarcity - situation where shortage of fuel leads to higher fuel prices, rationing or other ways of limiting fuel distribution, and a curtailment of transportation and other activities which require fuel.

fixed route - in public transportation, a fixed route system is one which, like a bus line, always follows the same scheduled route, rather than responding to individual passenger calls like a taxicab.

flatboat - an early form of water transportation, the flatboat had no power and relied on the current of the river to carry goods downstream.

guild - in medieval times each occupation, such as woodworking, or weaving, or breadmaking, was controlled by a guild, made up of the craftspersons in that field and the apprentices they selected. Persons in one guild often lived and worked together in the same part of the city.

heat energy - the energy created by combustion of a fuel such as coal or oil, which can either be used directly for heating or converted into mechanical work through an automobile engine or other machine.

highway "strips" - the form of roadside development where gas stations, restaurants and other stores spread out along a highway rather than concentrating in the old center of town. Highway strips are wasteful of energy because they usually require an automobile trip to reach any of the business.

Industrial Revolution - the historical period, starting around 1750, when we changed from small scale craft production to large scale factory manufacture of goods, using large machines usually powered by burning fuel.

public transportation - moving people by buses, streetcars, or other means where many people share one vehicle, rather than riding in private cars.

steam power - power produced by burning coal, oil or gas to convert water into steam, which is then used to move a piston back and forth or turn a turbine wheel to produce mechanical motion.

tow path - a flat pathway alongside a canal, along which horses walked to pull canal boats.

urban sprawl - the name for the modern type of city growth, made possible by the automobile, where houses, businesses and industries move out into the countryside rather than remaining close together within the city.

Energy Factsheet

TRANSPORTATION

ENERGY, TRANSPORTATION AND URBAN FORM

Introduction

Imagine what a city would be like if the only transportation available was provided by natural sources rather than mechanical sources. Energy transportation would be limited to human energy and animal energy on land, and to human or possibly wind energy on water. Heat energy would be mostly from wood, which couldn't be economically transported very far. What kind of a city would result, and how would it differ from the city we take for granted?

This is basically the condition under which cities developed for thousands of years, right up to the industrial revolution. It was the condition under which most of the great cities of Europe grew up, and it was still the conditions under which cities in America were started. It even affected the early cities in Indiana, although their most rapid growth came later. In the U.S. these energy conditions probably lasted until around 1830 or 1840. In some other parts of the world, cities in the 20th Century were still developing under these conditions of limited energy. Visiting a foreign city in a country which is still modernizing can tell us something about what our own cities may have been like.

Pre-Industrial Energy Sources

Energy for this city did not yet include mechanical means for converting fuel energy into work energy. Everything was limited to biological forms of energy, such as human or animal exertion, to simple natural forces, such as gravity or wind pressure, and to basic heat energy from burning readily available fuel. In most cases this meant wood, but sometimes peat, or occasionally coal, or even dried animal manure might be burned to produce heat. There was no way to convert this heat energy into transportation or into anything but the simplest production uses.

It may be useful to start by trying to list what was not available to the city dweller under these conditions. This will show how limited the choices were and what it meant for the construction of the city.

What was not available:

1. automobiles, to go to work, or shopping, or school, or movies,
2. trucks, to bring goods to local stores,
3. trains, to carry fuel and heavy loads for industry,
4. airplanes, to visit people far away,
5. elevators, to make tall buildings possible,
6. electricity, to light streets and buildings,
7. telephone, to quickly contact other people,
8. tv or radio, to bring news quickly,
9. records and movies, to bring new sounds and ideas, and
10. assembly lines or big machines to produce goods.

What was available:

1. feet (to walk on), shoulders (to carry things), arms (to push with),
2. horses to ride or pull carriages,
3. oxen for pulling heavy loads,
4. boats and barges to float heavy loads,
5. wind to move ships, turn windmills, etc., and
6. falling water to turn millwheel.

Transportation and the City Pattern

Based on this, what sort of a city would develop? The city of human and animal energy differed from the city we know in the following ways:

1. The city was limited in population. Not limited like a small town, but limited in comparison to the multi-million population of today's larger cities. There was simply no way to keep food and fuel supplied to a very large city, because there was not enough energy available to collect and move great amounts of food for long distances.
2. The city was tied closely to its immediate region. Most of the food was grown locally, within a day's wagon drive of the city. Some of the farmers lived inside the city and tend fields outside it.
3. The city was physically small. Since most people traveled on foot, the size was limited to a person could travel and still return in a day. It was also limited by the farmers ability to go to market and return in a day. In countries where warfare was a threat, the city was enclosed by walls, and the cost of building walls kept the city area small. There was no tendency for "urban sprawl" - everyone tried to be very close to the center.
4. The city had few tall buildings. There were no elevators, and people could not walk up more than four or five flights. The only tall buildings were watchtowers or church steeples. The first thing the approaching traveller saw was a skyline of spires and steeples, not watertowers, grain elevators and office buildings.

5. The city was very crowded. Since the city could not expand up, and it was difficult to expand out beyond a convenient walking distance, increased population had to be accommodated by putting more people in less space. Crowded conditions, and inadequate medical knowledge, led to epidemics and high disease rates.
6. There was little or no "public" transportation. Horses and carriages existed, but they were only for the wealthy who could afford the space and the servants to maintain them. Travellers might hire a horse or ride a coach outside the city, but inside they usually walked.

All the above show how energy affected the overall shape and size of the pre-industrial city. There are some more subtle ways in which the pattern of the city differed from the cities we know. These also were affected by the availability, or lack of availability, of energy for transportation and labor.

7. There was not a "downtown". There might be a central square or marketplace, but there was not a central downtown as we know it today. Instead of a dense downtown surrounded by lower density residences, the whole city had pretty much the same density throughout. It was compact, and at the edge it just stopped, with or without a wall.
8. There were no separate districts for "shopping," working and living. This fact is perhaps the most basic difference from the modern city. Energy contributed to this development in several ways:

   (a) Since there was no energy to run machinery, most work was done by hand. Work done by hand could be done in small shops, and didn't require a factory. The only powered machines were mill wheels to grind grain, run by water or wind, and these were as likely to be found in rural areas as in the city. Manufacturing, including blacksmithing, pottery, weaving, and all the other crafts, was done in small shops with a master and apprentices.
   (b) Since the workshops were small, they were combined with the master's residence. His family lived in the house, the apprentices might live in the attic, and work was done on the ground floor or behind the house. Since everyone worked at home, there was no commuting, and no morning or afternoon rush hour.
   (c) There was no separate shopping area. There was a marketplace, usually for goods brought in from the countryside, but there was not a specific area of stores as we know them. Most goods were sold directly from the workshops where they were made rather than consuming energy by being transported to a separate store. The purchaser used human energy to walk to the workshop for what he wanted.
   (d) While the city was not divided into homes, stores and industries as we know them, it was divided in a different manner, according to trade or occupation. Each trade, such as blacksmithing or leatherworking, tended to group together in one neighborhood. Sometimes the street name, such as Shoemakers Lane, or Ironmonger Street, reflected these occupations. The tradesmen were further bound together in their guilds, and through attending the same neighborhood church. The neighborhoods tended to reflect individual trades, and a tradesman could live his full life and rarely leave his own neighborhood.

(e) Long distance travel or shipping was very expensive, and was generally limited to luxury items. Inland shipping was by pack animal or wagon, and the generally poor roads reduced the loads they could pull. Water travel, using sailing ships, was the only real way of harnessing outside energy, but it was risky and costly. The first "modern" businesses were those individuals or groups of entrepreneurs who funded trading voyages to bring back luxuries -- spices, gems, costly fabrics, dyes -- from distant places. These "merchant adventurers" shared the risks and profits of sea voyages made possible by harnessing the wind's energy. Their large houses, near the docks in cities which had access to the sea, were also warehouses and places of sale. They foreshadowed the shift to an economy where many goods would be shipped from place of construction to place of purchase.

In all these ways, energy (to be more correct, the lack of energy) shaped the pre-industrial city. It determined how its skyline looked. It determined how it was organized and who lived where, and it was reflected in its social patterns. The city we are describing could be 14th Century London, but it could equally well be 18th Century Philadelphia. The early American cities faced the same lack of energy as found in Europe, and they tended to organize the same way. Their problems were compounded by the greater distances in America. Land transportation and communication was so difficult that the colonial cities found it easier to communicate with Europe than with each other. It was far easier to move things on water than on land, so all the early cities developed on the coast or on rivers. This was still true when Indiana was settled. The early towns, like Madison, were on the Ohio River, on the route of trade. That's why the first state capital was at Corydon, near the river. That's why New Harmony was so important. Today it appears to be in a remote corner of the state, but when people traveled by water it was in a location easily reached on the Wabash River, near the junction with the Ohio.

The Indiana canal experiment was a response to the energy problem. Before the center of the state could be settled, there had to be transportation. Energy for inland travel was still limited to the horse, but the load the horse could pull was limited by the quality of roads. A horse could pull far more on a boat than on a wagon, so canals were built on which the boats could float. The canal was an energy efficient solution. It maximized the useful work done by the horse. It became obsolete when a new form of energy appeared: steam power. Steam power brought in the industrial age, doomed the canals, and changed the pattern of the city.

The Early Industrial City: Centralized Energy

Imagine a city where large amounts of energy are available, but where the energy can only be generated and used in large units -- it cannot be easily subdivided and used by the individual person. This was the energy situation which faced the early industrial city -- the city which grew from the early 19th Century up to the beginning of the 20th Century. It was an important period for Indiana because this is when most Indiana cities were founded and developed their basic pattern. What does a city look like when it grows under these energy conditions?

Energy Technology

The industrial revolution was made possible by the development of technology which could convert heat energy into useful work. This meant primarily the steam engine, which burned fuel (wood, coal or later oil) to convert water to steam. The steam drove pistons which, linked to rods, could make wheels turn.

Figure 1: Steam Engine

The steam engine was developed in a practical form around 1820 and became the basis for both an industrial and a transportation revolution. These in turn changed the shape and arrangement of the city.

For industry, the steam engine provided power to run machines, so that one man and a machine could now do what formerly took dozens of hand craftsmen. The machines were big and heavy, and required strongly built buildings to support them. The only way to transmit energy from the steam engine to the machines was by mechanical means -- by turning driveshafts or by pulleys and leather belts.

Energy was lost in friction, so it could only be transmitted short distances. This meant that all the machines were located as close to the central power source as possible. Factories with multiple floors were designed, with machinery on each floor driven from a few central driveshafts, all linked to each other and to the steam engine with leather belts.

For transportation, the steam engine was harnessed through the steamboat and the locomotive. In the steamboat, the steam driven pistons turned a paddlewheel at the rear or the sides of the vessel, to move it along. Steamboats conquered the oceans and the inland rivers. They could move upstream against the river current, and provide a regular system of communication from New Orleans and the Gulf of Mexico all the way up the Mississippi and Ohio. Evansville, Mt. Vernon, Tell City, New Albany, Jeffersonville and Madison grew as the steamboat brought trade, and Jeffersonville also grew as a center where the steamboats were built.

Figure 2: River Steamboat

On the Great Lakes, the steamboats, driven first by paddlewheels and then by propellers, carried cargo and passengers, and made possible the great steelmaking complex of Northern Indiana.

On land the steam engine was harnessed as the steam locomotive, whose drive wheels propelled it along iron rails and pulled a train of cars. Early efforts were made to use the steam engine to power wagons, but neither the wagons nor the roads were strong enough for the great weight of the steam boiler and cylinders. The solution, developed in England by 1808 and first successfully used in the U.S. in 1830, was to carry the engine's weight on iron wheels running on smooth iron rails. In this way, the steam locomotive could pull more than its own weight in a series of cars.

Steam engine technology had some limitations. Whether for industrial use, for a steamboat, or for a locomotive, the steam engine was big, heavy and clumsy. It needed a firebox and smokestack to burn fuel, a boiler to heat water, and cylinders, pistons and rods to generate motion. It also needed supplies of fuel and water. It needed men to constantly add fuel to the fire and water to the boiler, and to constantly oil the moving parts. If not carefully tended, the boiler could explode. The steam engine demanded skilled attention, and also required a large investment to build. It was not practical for a single individual either to buy or to operate. It was a centralized form of power, and this had consequences for transportation and for city growth.

Toward the end of the Nineteenth Century another technology became available, that of electricity. Electricity did not initially replace the steam engine, it merely extended its reach. Electric generators, powered by steam engines, could send electricity through wires to run motors and machinery which might be miles from the central generating station.

The motors could be easily controlled without the constant skilled attention which the steam engine demanded, and the copper wires could transmit energy with less friction loss than the old belts, pulleys and drive shafts. Like steam power, however, electricity was still a centralized power source, tied by wires to the central generating station. By the time electricity became practical the industrial city was already well developed, but electricity, particularly when applied to urban transportation, permitted it to grow in size and complexity.

Steam Power and Transportation

T : steamboat and the steam locomotive opened up a new era in transportation, and that in turn made possible the growth of cities. The steamboat's impact was felt first. It replaced the flatboats on the river, and made possible faster, more comfortable travel between the Midwest and the Gulf seaports. Unlike the flatboat, the steamboat was not dependent on the river current, and could move upstream as well as down on a regular schedule.

A traveler from Indiana could go from Madison or Evansville either upriver to Pittsburgh or downriver to New Orleans and the Gulf. The steamboat, for a while, reinforced the importance of the river as a transportation route, and encouraged the growth of river cities. The steamboat was, however, too big to use on the canals. It wouldn't fit in the dimensions of the canal locks, and the wash from its paddles damaged and undermined the canal banks. As a result the canals continued to move at the slow pace of a plodding horse. In the winter, of course, the canals and the riverboats didn't move at all.

The steam locomotive had an even greater impact on transportation in Indiana than did the steamboat. The steam locomotive made the railroad practical, and the railroad in turn freed transportation from its dependence on navigable water. The railroad could be built almost anywhere in a midwestern state like Indiana, rather than following the river valleys, and it could operate all year round.

The first railroads were seen as tributeries to river transport, just as the canals had been. The first railroad in Indiana, the Madison and Indianapolis, was authorized in the same 1836 state legislation which authorized the Whitewater Canal. Both railroad and Canal were designed to link the central part of Indiana to the Ohio River.

Figures 3 and 4: Railroad and Canal Maps

This pattern soon changed as the railroad made the canal obsolete. The Whitewater Canal was never completed to its intended destination. Ironically, a railroad was built on the old canal towpath where the horses previously walked. This railroad still operates today as the Whitewater Valley Railroad. In the summer passengers can ride behind a steam locomotive along the banks of the restored canal, from Connersville to Metamora. At Metamora they can transfer to a horse drawn canal boat, seeing two eras of transportation in one afternoon.

Transportation and City Growth

The locomotive and its network of iron rails made possible long distance travel away from the rivers, and made it practical to grow crops in Indiana which could be sold on the East coast. A train could easily travel 100 miles or more in a day, compared to a wagon's 20 miles (if the roads were dry). Without the locomotive and the railroad, most of our Indiana towns would not have been built. Railroads were built in every Indiana county but one, and that one county remains to this day the most isolated and the most lacking in towns and cities. The railroad could carry crops to distant markets, could bring coal and raw materials for manufacturing and carry away the finished products from elsewhere. If a city was on a rail line it was in contact with the rest of the nation. If it was not on a rail line it was isolated and could not grow. Townspeople knew this, and fought to get the railroad to come to their town. If their town was bypassed, the townspeople might even move to the nearest railroad. In one northern Indiana county, they even took their buildings with them, leaving behind a ghost town!

If one railroad was vital to town survival, two or more railroads were helpful for rapid growth. Towns grew at important railroad junctions, where travellers and freight would change from one railroad to another. Indianapolis became an early hub of railroad lines. In 1856 it built a Union railroad station where all the railroads entering the city could exchange passengers. This was the first Union station in the country, and helped Indianapolis to become the largest city in the state.

Some cities grew directly as a result of employment associated with the railroad. Elkhart, Fort Wayne, Richmond, Lafayette, and Princeton, among others, were important railroad towns either for dispatching trains or repairing locomotives. Railroad cars were built in Jeffersonville and later in Hammond. Hammond grew initially as a meat packing center, after George Hammond developed a refrigerated railroad car which could ship butchered meat for long distances. Gary was founded to take advantage of a transportation location where lake steamboats bringing iron ore from Minnesota could meet trains bringing coal and limestone from the Appalachian region. Whether directly or indirectly, the new transportation made possible by steam linked cities into a national marketplace, brought raw materials and finished goods, and helped cities to grow far beyond the size they could have achieved depending purely on their local resources.

Energy and the Pattern of the Industrial City

Energy, harnessed through steam power and new transportation modes, caused cities to grow rapidly in the Nineteenth Century. It also caused them to take on a shape and a form very different from the earlier city. Many of the characteristics that we take for granted in a city were actually caused by the new energy and transportation technologies.

One consequence was the development of the factory, a large centralized structure where many people, working with machines powered from a central steam engine. Produced goods were then shipped by rail to markets and customs all over the country. Factories replaced the small scale workshop and the individual craftsman, and whole areas of the city (usually along the railroad tracks) came to be characterized primarily as industrial areas where people worked but where few people lived. This was a dramatic change from the pre-industrial city where most people worked in the same place where they lived.

A second change was the development of a "downtown" — a recognizable central district of the city with stores and offices. Before this period there was no such area, although a market or courthouse square might have indicated the center. The downtown came about partly because of the way people entered the city, and partly because of the way that homes, factories and stores were beginning to be separate structures.

Before steam transportation, people entered the city by road, sometimes through an actual city gate. Specialized travellers' accommodations, like inns, clustered around these entrance points (just as motels cluster around an approach road today). When the railroad came the entrance changed to the train station, usually located near the center of the city. Traveller's hotels and restaurants clustered near the depot and many other shops or offices which did business with people from outside the city found it advantageous to locate within walking distance of the depot. Specialized buildings, typically of brick and multi-storied, came to characterize this "central business district".

Another factor was the increasing separation among where people lived, worked, and shopped. When goods were produced in the craftsman's home, they were distributed throughout the city. As special store buildings developed, it made sense for goods to be located where they could be reached by the largest number of people. Therefore, stores emerged in the center of cities.

This move was strongly reinforced by transportation. Larger cities developed public transportation consisting of horse drawn streetcars on iron rails. With the harnessing of electricity in the late 19th Century these horsecars were converted to electric streetcars, running on the same iron rails and taking electricity from an overhead wire. Because they followed fixed routes, it became desirable for businesses to locate along these high access corridors. Where several routes converged or crossed was the point of highest accessibility in the entire city, and this inevitably came to be the center of downtown. Business which needed access to large numbers of people and which could afford the high land prices, came to locate at these points. Typically these businesses included the new store type -- the department store, which offered a wider range of goods than any one store had ever offered before, and served as a common shopping source for people all over the city.

The industrial city was characterized by a centralized form of energy and transportation, which was reflected in a centralized spatial pattern. Different areas for shopping, for working and for living developed, with the most densely built up areas in the center where access was easiest. Even different types of residential areas developed based on this transportation -- apartments and multi-family houses along the streetcar lines, and single family homes on lower priced land a short walk away from a streetcar line. The railroad lines entering the city generated smoke and dirt, and these undesirable areas came to be the home of the city's poor. A new phrase described this social pattern -- "the wrong side of the tracks."

The poorest workers -- those who still had to walk to work, lived in crowded neighborhoods near the factories. Those better off, who could afford streetcar fare every day, could move away from the less desirable part of the city and establish middle class neighborhoods made up exclusively of houses, free from either industry or stores. Transportation, based on energy, made possible a separation of the city into areas for production, for shopping and for living, and made possible a social separation into rich and poor areas. All of this was a change from the pre-industrial city, and it was all made possible by the harnessing of energy in new forms for transportation and production.

Energy and Transportation Technology

The modern American city was influenced dramatically by two energy innovations in the late 1800's. The first was the discovery and tapping of underground oil and gas reserves, first in Pennsylvania, later in Texas, and still later in the mideast, in Latin America, and in Alaska. The second was the invention of the internal combustion engine which could convert that oil and gas directly into mechanical energy, without the cumbersome and heavy apparatus of the steam boiler and steam engine. Just as steam power worked a revolution in transportation in the nineteenth century, the internal combustion engine - gasoline or diesel, was to revolutionize transportation in the twentieth century. New transportation forms in turn would influence the shape and pattern of the city.

We are all very familiar with automobiles and gasoline engines, but stop and think what it must have meant when automobiles first became widely available. Some of the new features brought by the automobile were the following:

1. Freedom from fixed routes. Steam era transportation was bound to the railroad tracks and the streetcar tracks. The automobile could go anywhere on a road surface that was reasonably firm. This meant that suddenly many places could be reached by powered transportation that were previously accessible only by foot, horseback or carriage. It was no longer so important to have buildings close to the fixed line of transportation.

2. Freedom from fixed schedules. The railroads ran at fixed times, and for most small towns they only ran a few times a day. City streetcars ran fairly frequently, but only up till certain times at night. The automobile, on the other hand, was instantly available any time of day or night. This meant that business travelers and salesmen were no longer bound to a timetable. They could cover more territory and make more visits in the course of a day.

3. Freedom from fixed stopping points. The streetcars stopped frequently, but trains stopped only at stations. This meant that activities requiring lots of visitors, such as stores, hotels and restaurants, had clustered not only near the tracks but near the train station. Suddenly these locations were older and where the railroad noise and smoke was still present, often went into a period of decline.

4. Convenience. The gasoline engine was simple to operate, unlike the steam engine, and required no initial warm up time. It required no care or feeding when not in use, unlike the horse, and it did not need stables, hay, and removal of manure, all of which had made the horse difficult

and expensive to maintain in the city. Initially a toy of the rich, the price of automobiles soon fell to the point that most working families could afford one. For the first time, the automobile offered a decentralized form of personal transportation which was available to most American citizens.

Automobile Transportation and the City

Most Indiana cities were started and grew before the automobile appeared. When automobiles were new, they were simply an additional form of transportation within the existing city. Later, as their numbers grew, they created pressures which changed the whole nature of the city.

The first pressure was congestion at the city center. The center of the industrial city was crowded, but it was crowded with people on foot, who had come downtown by streetcar. Now, added to this, were the automobiles that needed some place to park. Parking garages were built, but these were too expensive for all but the largest and busiest cities.

The parking problem led to two major changes in the city:

1. The demolition of buildings to make way for parking garages or lots, and

2. The rise of businesses in outlying areas where parking was cheaper to provide.

Both these changes led to the same result: a less compact and more spread out city. In the downtown more and more buildings were torn down to make more parking for the buildings that remained. Often a third to a half of the area in downtown was taken over by the automobile. Students may think of places in their own city which used to be buildings but are now parking lots. The result was a supply of parking spaces, but fewer reasons remaining for people to want to come downtown.

At the same time that parking problems made downtown less attractive, some businesses started springing up in less crowded parts of the city, usually along the main roads leading into town. By the 1920's there were already examples of highway "strips" - areas lined with businesses, each with parking in front, to which people almost always came by automobile. These areas were not convenient for people on foot, and usually had no sidewalks. They were not convenient to reach by bus or streetcar, and really were intended only for people with automobiles.

One thing led to another. More cars led to more traffic jams downtown, and made people less willing to go downtown. Businesses developed out on the strip, and encouraged more and more people to buy automobiles in order to reach them. Downtowns saw more and more buildings torn down to make way for parking, with the result that downtown was less attractive and had fewer reasons to attract people.

At first it was the commercial strips and the individual auto-oriented businesses that competed with downtown. In the 1950's came the next blow: the shopping center. The shopping center was based on the automobile, but it had a whole range of stores and a pedestrian central mall. It was like building a whole new downtown, surrounded by parking, out on the edge of town. In most cities the approval of a shopping center spelled doom for the retail shopping functions of downtown. Downtown came to be a specialized office district, crowded at rush hour and noon hour, and deserted in the evening. The activity was now out at the shopping center or on the strip, accessible only by car. If you did not have a car, you could not share in the opportunities of the city.

As cars become more numerous, public transportation became weaker. More cars meant fewer people to ride the buses and streetcars. Fewer riders meant less frequent service and higher fares, and so on in a vicious circle. Also, the new centers of activity were spread out and hard to reach by transit, unlike the old downtown, where all the transit lines converged. By the 1950s, the streetcars had disappeared, and by the 1970s all of the privately owned city bus companies were failing. The only way that we have been able to keep any buses at all has been for public agencies to run them at a loss.

The same thing that happened to shopping also happened to industries. As workers began wanting to drive their cars, industries had to provide parking. Often they did it by buying and destroying nearby houses to make parking lots. The occupants of the old houses relocated, often in new houses out on the edge of town. Other industries gave up their old buildings in the heart of town and built new ones on the edge of town, where they could only be reached by car. This attracted more workers to live on the outskirts.

All the reasons which had made the city compact and center-oriented in the age of steam and streetcars were now reversed. The automobile tended to disperse everything, to make it spread out, and to consume more energy in getting people to shopping and to work.

In the larger cities there was a further disruption caused by the automobile. That was the construction of freeways, starting in the 1950s. Sometimes the freeway was intended to bring people back downtown, but the result was usually simply to let people live further out than they did before, and still have reasonable driving time to work. The freeway encouraged further spreading out of the city, often into surrounding counties.

Cities also constructed by-passes, whether in the form of freeway loops like I-465 in Indianapolis or simply new roads like route 3 in New Castle. They were built originally to take through traffic past the more crowded parts of the city, but once the cars started using them, businesses, factories and housing projects followed. The roads originally built to be by-passes often turned into main streets, sometimes more crowded than the areas they were originally by-passing.

In all these ways, the automobile led to changes in the shape of the old city. The city spread out, so that the same number of people might require twice as much space. It weakened, and often destroyed, the remaining downtown which had grown up in the previous era, and it created outlying shopping strips and then shopping centers. It led to a dispersal of factories. By competing directly with public transportation, and by promoting developments difficult for public transportation to serve, the automobile led to the weakening and near collapse of public transit. From being a plaything and a luxury, the car became an absolute necessity. Those who could not drive, due to poverty, age or handicaps, were the deprived citizens of the new city the automobile built.

Figure 5: City Shapes

In the automobile city, people who can't afford cars or who can't drive them are actually worse off than they would have been in an older city. In the pre-industrial city they could have walked to their destination, and in the early industrial city they could have either walked or taken public transportation. In the automobile city the distances are too great for easy walking, and the exhaust fumes and lack of sidewalks make many streets unpleasant or hazardous to walk along. A few cities have tried to create pedestrian zones, closed to autos, where people can walk freely once they arrive, but getting to them may still require a car. Walking is the most energy efficient form of transportation available. It needs to be re-introduced into the city pattern.

QUESTIONS FOR STUDY

1. What source of transportation characterized the pre-industrial city? Explain how it helped shape the typical city of the day.

2. How did the lack of energy to run machinery influence the way most work was done in the pre-industrial period?

3. In what ways did the steam engine change the shape, size, and arrangement of cities? How did the development of electricity alter the shape, size, and arrangement of cities?

4. Compare the impact of the steamboat and the steam locomotive on transportation in Indiana. Which technology was widely adopted? Why?

5. List the effects of the automobile on the shape, size, and arrangement of cities. Cite examples from your own city.

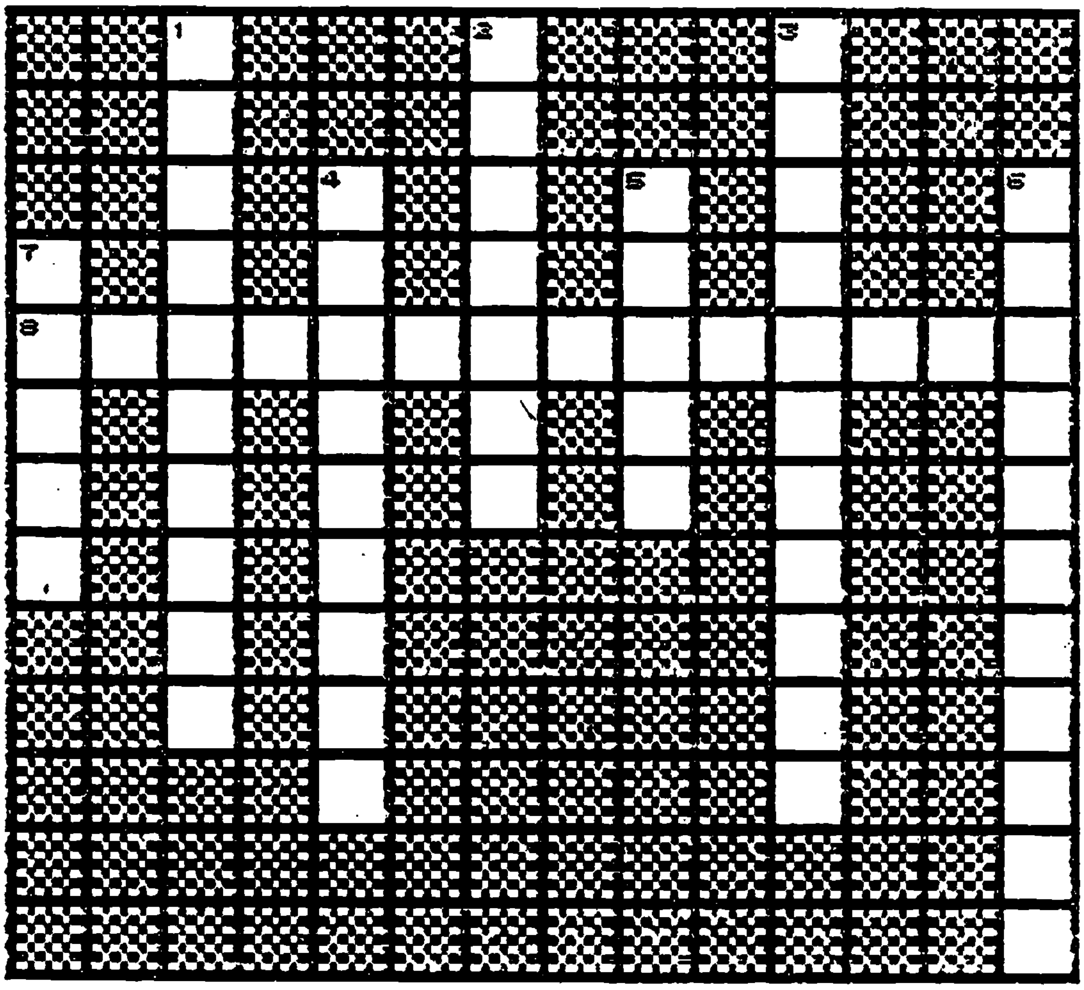
6. What happened to the importance of public transportation as automobiles became more numerous? Did the changes influence who paid public transit costs? Do you agree with the decision to subsidize transportation? Explain.

7. What impact did the decentralization of cities have on energy consumption?

8. Which city (pre-industrial, early industrial, 20th century) would you prefer to live in today? Explain.

9. Using a local map of your city or a nearby city, identify the areas of the city where people work, shop, and live. Are your findings in agreement with the generalization that the automobile dispersed activities? Explain.

10. What role did the automobile pay in the development of convenience stores? What other factors may have had some influence? Do convenience stores have a future? Explain.



ACROSS CLUES

8. THE MOVEMENT OF PEOPLE AND THINGS

DOWN CLUES

1. A SOURCE OF TRANSPORTATION
2. REPLACED THE SMALL SCALE WORKSHOP
3. A CENTRALIZED POWER SOURCE
4. ACTIVITY OF CITY IS SPREAD OUT
5. USED TO COOL STEAM ENGINES
6. ACTIVITY OF CITY IS DOWNTOWN
7. A SOURCE OF MECHANICAL POWER

Energy

Case Study

TRANSPORTATION

In the factsheet three periods of city development were described. The pre-industrial period, the early industrial period, and the industrial period. For each period, how energy sources helped shape the pattern of cities was discussed.

In the late 1970s a Harvard sociologist, Daniel Bell, completed work on a book titled, Toward a post-industrial society. Since then numerous articles have been written about the "post industrial society."

Review characteristics of: the pre-industrial city, the early industrial city, and the industrial city. Take special note of how energy resources shaped city patterns. Next, read one of many articles written about the post-industrial society. Once you have read and studies the article, fill in the blanks below. In the left hand column list characteristics of the post-industrial society which make it different from earlier cities. In the right hand column describe how energy resources will shape the post-industrial city in ways unlike earlier cities.

Characteristics	Energy Resources
1. ______________________	1. ______________________
2. ______________________	2. ______________________
3. ______________________	3. ______________________
4. ______________________	4. ______________________
5. ______________________	5. ______________________

Energy

Home Study

TRANSPORTATION

Try to find three persons in your family who lived a major part of their lives or remembers someone who lived in each of the three periods of city development described in the factsheet: pre-industrial, early industrial, and industrial. Have them answer the following questions. Carefully take notes as they do.

1. What was the first form of transportation you remember riding?

2. What did you use the transportation to do?

3. How much did it cost to ride?

4. How was the form of transportation powered?

5. What kind of energy was used?

6. How much did the energy source cost?

7. In what ways did this form of transportation shape the city?

The factsheets have suggested a typical pattern of development, based on different eras in the historical application of energy. Discuss the pattern of development in your community. Identify parts of the town that were built in different eras. Relate the different parts of town to the forms of energy that were available when they were built. A good aid for this is to look at old photographs and newspapers of the community. These help visualize the community as it once was, and to see how the older parts often remain, although sometimes changed in function (See Figure 5, "City Shapes"). Look for such things as the once common livery stable - the horse drawn eras equivalent of our gas station and auto rental agency. Look also for the railroad station, for the cluster of warehouses, elevators, etc. near the station, and for the compact main street. Indiana towns still reveal much of their history in their urban form. Looking at cities in an historical perspective is the first step to thinking of alternative futures for your city. By seeing how much the community has changed in the past, they can be prepared to think about changes in the future.

1. What parts of the community were developed during the pre-industrial era?

    (a) How can you show this?
    (b) What energy systems did they use?

2. What parts of your community were developed during the early industrial era?

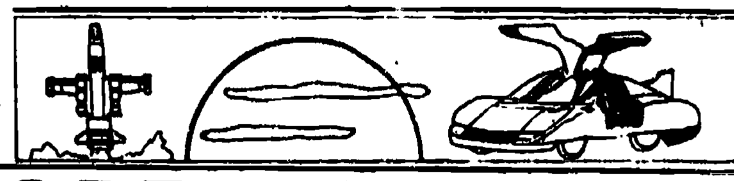
    (a) How can you show this?
    (b) What energy systems did they use?

3. What parts of your community have been developed during the automobile era?

    (a) How can you show this?
    (b) What energy systems were used?

Energy

21st Century



TRANSPORTATION

Complete this exercise in imagining a future city. Divide into several groups. Check with comparable information in each group, such as the number of people in the city, and the type of location it has. It is best to keep these assumptions fairly close to your experience, so imagine a community with the same number of people as now live in your community.

Each group some assumptions about energy and transportation in the future. Either give in each work with the same assumption in each groups or work different assumptions. The types of assumptions to be considered will be:

1. Energy scarcity: heavy emphasis on public transportation, bicycle and walking.

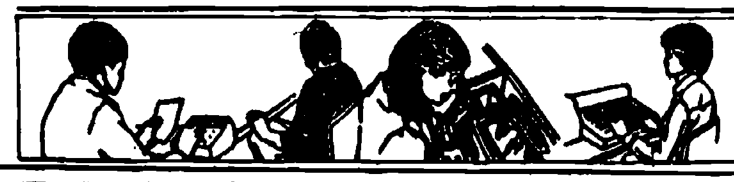
2. Energy moderately available, but in different forms. Conventional automobiles not used, but electric cars and others available, with performance characteristics somewhat limited compared to ours.

3. Energy abundance. New oil discoveries and new technology make gasoline plentiful and cheaper than before. Continued and expanded use of automobiles, with some improvements to reduce their harmful side effects.

You can use any or all of these three assumptions. For each assumption, concentrate not on the transportation technology (except briefly), but rather on the type of city which will result. Will it be spread out and decentralized? Will it be dense and compact? Where will people live, and work, and what will their daily routine be like? Remember how different the city has been in each of three different periods, all because of energy and transportation, and imagine equally large changes in the future. Don't focus too much on feasibility. Brainstorm ideas as a basis for more specific planning.

Each group should be given time in class to work on their ideas. They should be encouraged to get together after school as well. Each group should present their ideas to the class, with the others asking questions or making comments. The point is not to come up with the "best" city, but rather to see what may happen if certain conditions occur in the future energy supply for transportation. Encouraged to use sketches or diagrams to help them explain their ideas to the rest of the class, as this helps to focus discussion.

After all groups have presented, you may wish to close with a discussion about the likelihood of one or another assumption coming true. What do you think will really happen with energy supplies, regardless of which team you were on. What should we be doing now to anticipate some of these energy developments.

Energy
Careers


TRANSPORTATION

1. Valuable information on energy - related occupations can be found in the following books:

   (1981) The energy job finder. Englewood Cliffs, NJ: Prentice-Hall.

   G. Davis (1980). Your career in energy-related occupations, NY: Arco Publishing Inc.

   R. B. Vleck (1981). Energy jobs handbook. Gaithersburg, MD: Prospect Press.

   R. Fermoselle (1980). Energy occupations in demand, Arlington, VA: R. F. Associates.

2. Research and development jobs are critical to discovering or developing new energy sources. For information on research and development careers, write to:

   (a) Lawrence Livermore Labs
   Public Information Office
   P.O. Box 808
   Livermore, CA 94550 and

   (b) Department of Energy
   Department of Public Affairs
   1000 Independence Avenue, S.W.
   Washington, D.C. 20585.

3. Interview a worker in one of the following energy exploration occupations and report on your findings:

   Geologist
   Geophysicist
   Log plotter
   Paleontologist
   Petrographer
   Microbiologist
   Mining Engineer
   Seismologist
   Stratigrapher
   Surveyor

Energy

Resources

TRANSPORTATION

For history of the community students should be referred to the library and to the local historical society, if there is one. Some students may have elderly relatives who can describe the community when they were young. The local newspaper may retain a file of historical material.

A particularly useful source of information about the older parts of the city is the Sanborn fire insurance atlases. These were very detailed large scale maps, showing each building in the community and indicating its use and its construction. The fire insurance atlases were published at intervals from about 1880 to 1940. Often attorney's offices, city offices, or mortgage firms owned copies. Ask whether the local public library or the city planning office has copies. A master collection of Sanborn maps is housed at Indiana University, Bloomington, with a smaller collection at Ball State University.

For thinking about future cities, students may want to refer to science fiction books, to future oriented novels, or to popular books on the future. Some particularly interesting books are:

1. A. Toffler (1970). Future shock. New York, Random House.
2. P. and P. Goodman (1977). Communitas: Ways of livelihood and means of life. New York, Vintage Books.
3. E. Callenbach (1975). Ecotopia. Berkeley: Banyan Tree Books.

A helpful magazine is The Futurist, published bi-monthly by the World Future Society, an Association for the Study of Alternative Futures.

The following films can be obtained from the Indiana University Audio Visual Center:

1. The industrial city CSC 2606

   Describes the role, characteristics, and problems of the modern Industrial City. Illustrates factors leading to the rise and decline of major industrial centers.

2. Neighborhoods change CSC 2519

   Explores reasons for change such as shifts in population, renewal, expansion of transportation systems, changes in population and character.

3. Suburban living CS 1251

   Examines suburbs in Western Europe and Canada designed for maximum efficiency, located near major shopping areas, and with access to transportation systems.

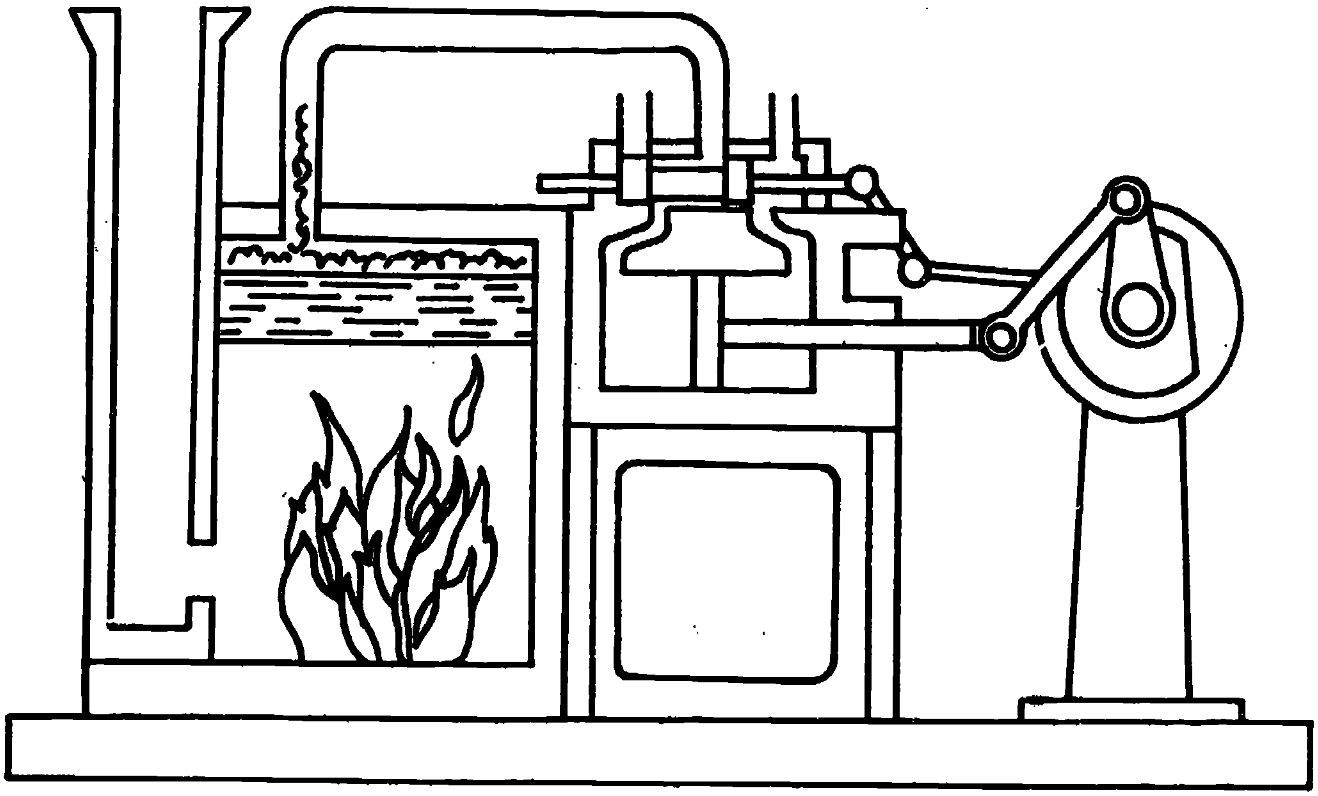


Figure 1

Steam Engine

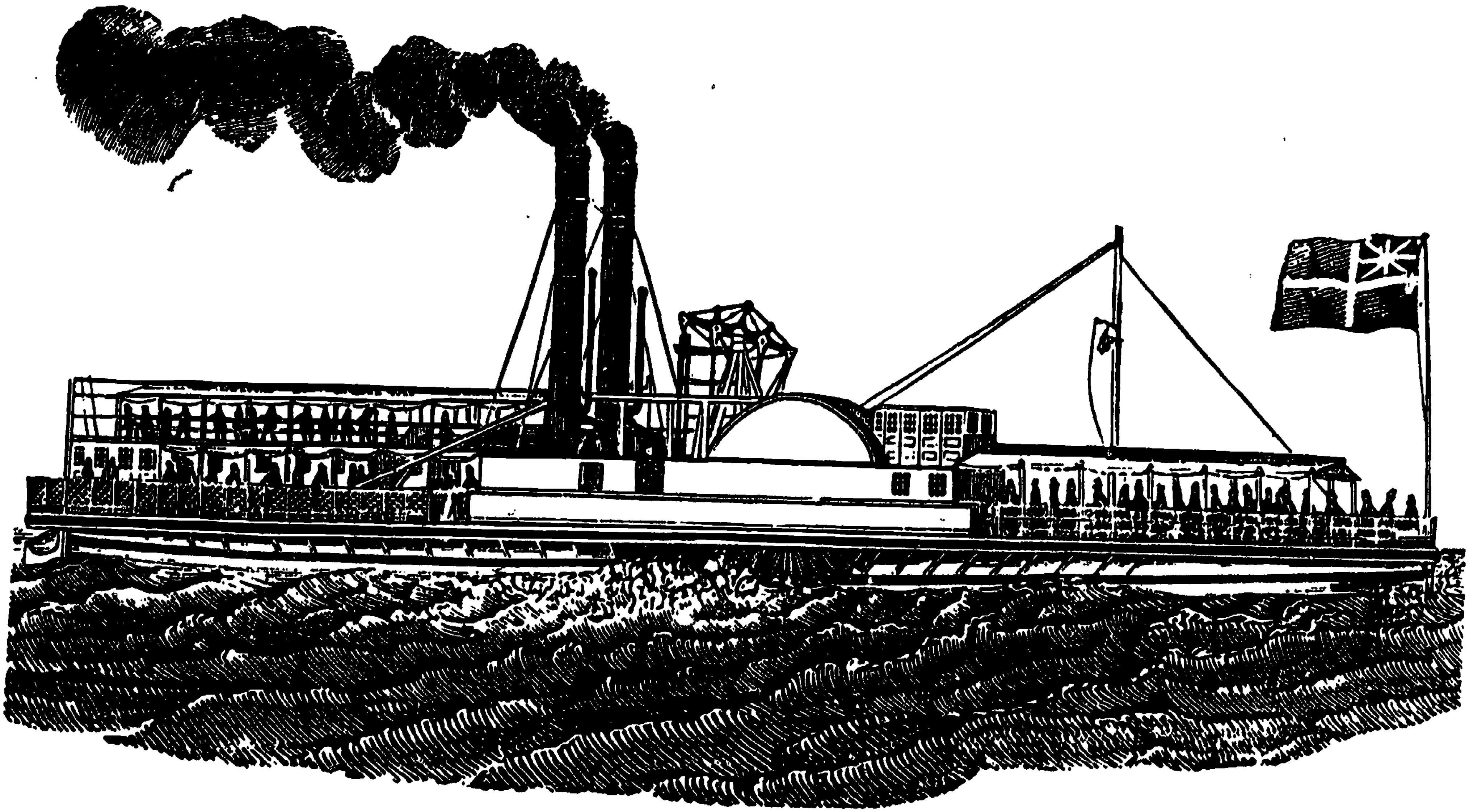


Figure 2

River Steamboat

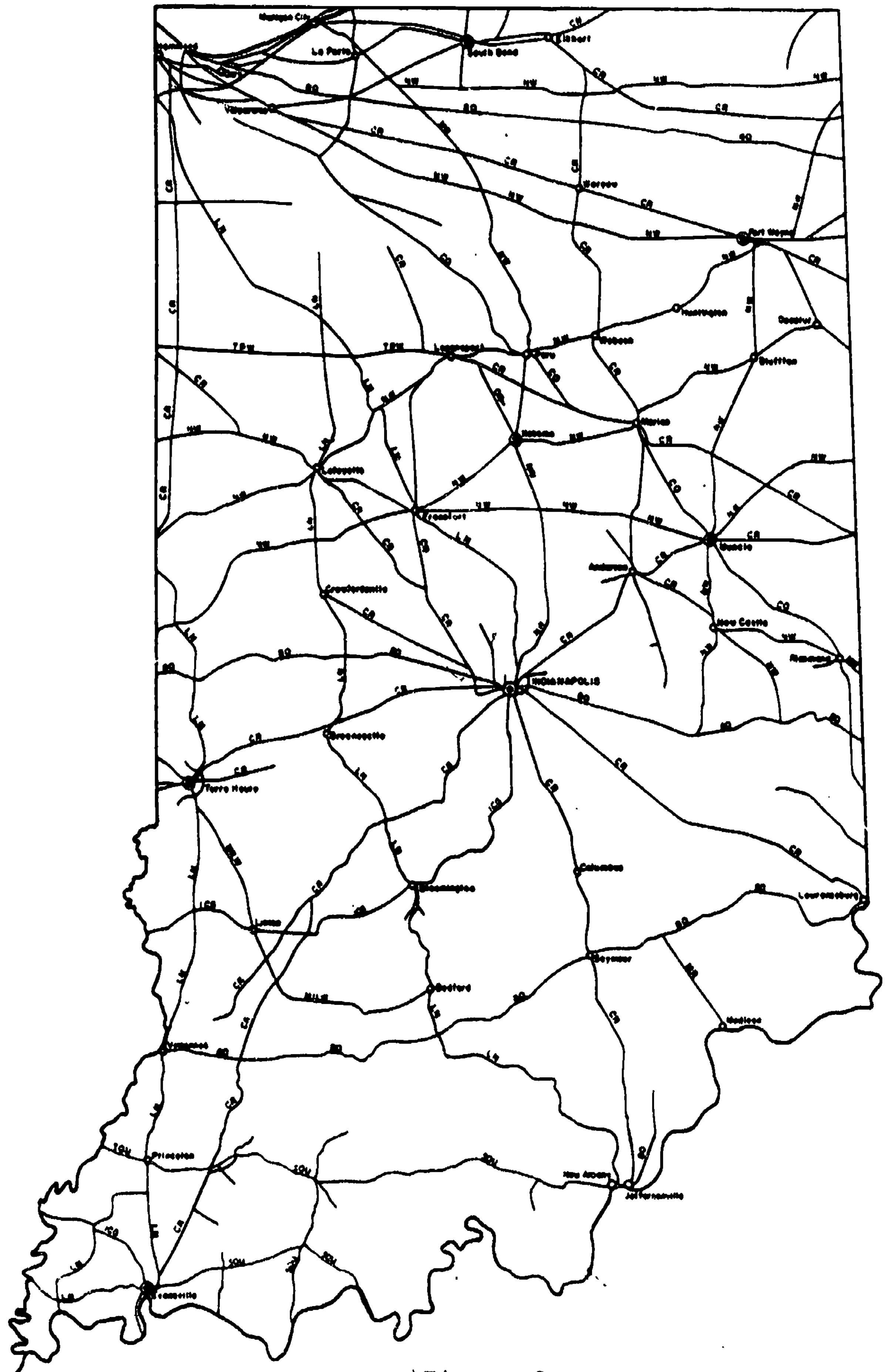


Figure 3

Railroad Map

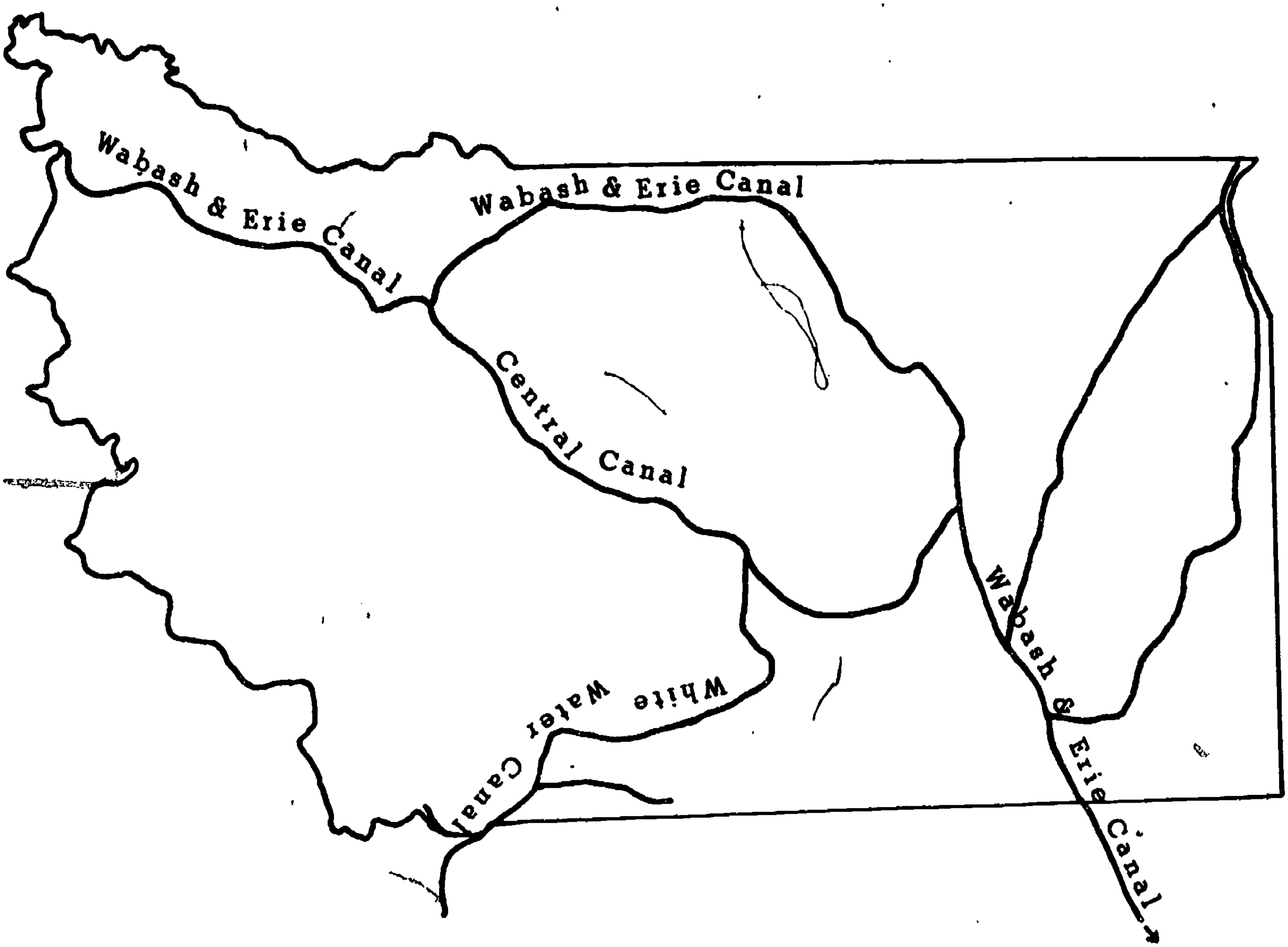


Figure 4
Canal Map

City Shapes

Industrial

Early Industrial

Pre-industrial

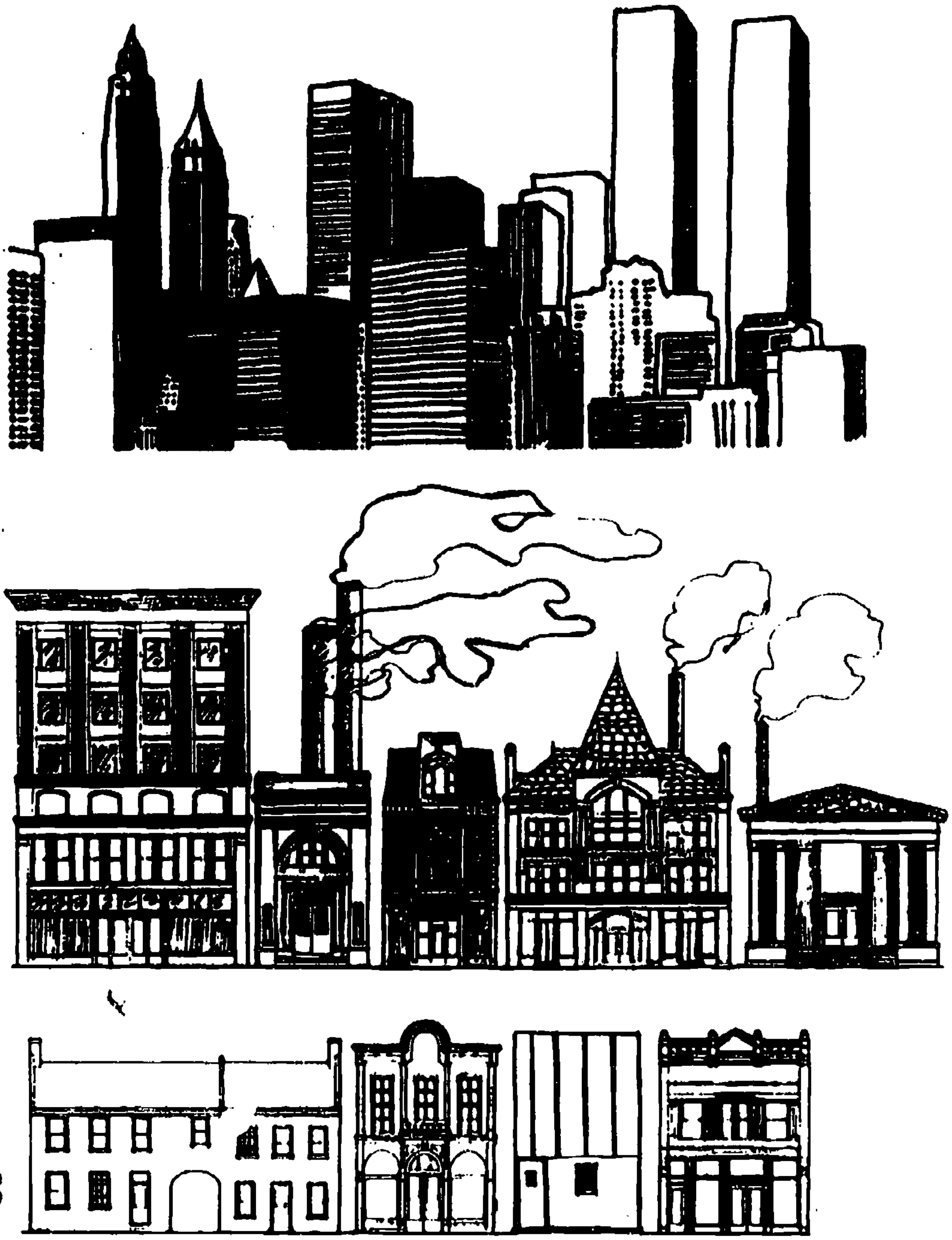


Figure 5
City Shapes

PURPOSE: This lesson encourages students to explore alternative forms of transportation, from buses and light rail transit to automated "people mover" systems. The lesson also is intended to motivate students to consider transportation options in their community, weighing the advantages and disadvantages of each form of transportation.

APPROXIMATE TIME: If each of the following activities is used, approximately eight class hours will be needed. This estimate does not include use of supplemental resources.

READABILITY: The Bormuth Readability Index was used to determine the reading level of text material in this lesson.

Ave. Word Length: 4.92

Ave. Sentence Length: 15.1

Readability Index: 61

Grade Level Equiv.: 7-8

OBJECTIVES

INQUIRY	DECISION-MAKING	TAKING ACTION
1. Students will explore bus and light rail transit as public transportation alternatives.	1. Students will recognize conditions under which buses and light rail transit should be considered important transportation alternatives.	1. Students will determine when an energy problem related to transportation would warrant use of bus and light rail transit.
2. Students will demonstrate the advantages and disadvantages of these alternatives	2. Students will explore the effects of buses and light rail transit in a variety of situations.	2. Students will analyze data to determine how introduction of bus and light rail transit systems would be beneficial.
3. Students will examine the energy efficiency of buses and light rail transit.	3. Students will predict the consequences of bus and light rail use on personal convenience, energy consumption, and economics.	3. Students will determine when a change to a bus and light rail system would be feasible.
4. Students will compare energy efficiency of buses and light rail transit to their effectiveness as a form of transportation.	4. Students will rank order the most effective uses of buses and light rail transit under varying conditions.	4. Students will explore potential effects of a decision to introduce bus and light rail systems.
5. Students will develop a conclusion as to the most beneficial uses of buses and light rail transit in terms of energy consumption.		5. Students will propose introduction or expansion of a bus or light rail transit system.
		6. Students will judge the results of their proposal.

Energy

Glossary

Glossary Glossary

TRANSPORTATION

Busway - a street or freeway lane designated specifically for use by buses, although emergency vehicles and sometimes taxis may also be permitted.

Capital subsidy - money to buy new facilities (such as buses, or fixed guideways) which cannot be recovered from operating revenue. Such subsidies may be beneficial if they achieve a benefit such as energy saving or pollution reduction. They may also replace the need for money spent on other things like wider streets or more parking spaces.

Demand responsive transit - a transit system which picks up passengers by appointment, or after a telephone call, rather than picking them up at a bus stop. This may include special services for elderly or handicapped.

Fixed guideway - a system which steers vehicles automatically, such as a railroad or streetcar track, a monorail, or a self-guiding roadway. Vehicle speed may be automatic as well, or may be controlled by an operator.

Labor efficiency - in transportation, this is measured in terms of passenger miles which can be produced per hour of driver time. It is important because labor costs are about half of total transit system costs.

Light rail vehicle (LRV) - the modern equivalent of a trolley car of streetcar, operating on a fixed guideway system of railroad rails, either laid in a street or on a separate right-of-way. Power is electric from an overhead wire.

Operating revenue - the money actually paid in by persons riding the bus or transit system. Operating revenues in city transit systems do not pay the full cost of operation.

Operating subsidy - the difference between operating revenue and operating costs, which is met by some outside source such as a government or corporation grant. This is different from a capital subsidy for new investment in the system.

Passenger miles - a measure of transit or ridesharing performance. A bus carrying 10 people and going 5 miles produces 50 passenger miles.

Passenger miles per gallon - a measure of the number of people actually moved a certain distance per gallon, as distinct from the mileage of the vehicle itself. For example, an automobile getting 20 mpg and carrying two produces 40 passenger miles per gallon.

Transit bus - full-sized (40-50 passenger) bus used for most fixed route transit service.

Transit mall - a street which is open for pedestrians with a narrow right-of-way open to transit vehicles but not to automobiles. The purpose is to bring transit passengers directly to a convenient downtown location.

Trolley bus - an electrically powered bus with current taken from a pair of overhead wires. Used in Dayton, Ohio, and formerly used in Indianapolis.

Streetcar - (or trolley car) a vehicle running on railroad rails, usually buried in the street surface, and taking electricity from a single overhead wire. Formerly in widespread use in Indiana cities; since replaced by buses. The light rail vehicle (LRV) is the modern version of the streetcar.

Urban Mass Transportation - the 1964 Federal law which, together with later amendments, established grants for capital and operating subsidies for local public transportation. These funds can be spent for a variety of innovative purposes, and are not limited solely to bus systems.

Vans - vehicles with 10-15 passenger capacity, used for commuting, for demand responsive transit, and for special services for elderly or handicapped.

TRANSPORTATION ALTERNATIVES

Buses

Bus transportation began with small vehicles serving special purposes such as picking up hotel guests at the railroad station — the origin of the "station wagon". Buses for regular transit use became widely used in the 1920s, and by the 1930s were rapidly replacing streetcar lines. A group of companies, including General Motors, Firestone Tire and Rubber, Standard Petroleum and others, actively participated in purchasing streetcar lines in order to convert them to bus lines using the companies own products. In 1949 a Chicago jury convicted the corporations of criminal antitrust violations for their part in wrecking the trolley lines.

Apart from the conspiracy question, buses had the advantage of using conventional streets, and advantage which increased as more streets were paved to handle automobiles, and as the old streetcar tracks deteriorated. By 1950, all Indiana cities had converted from streetcars to buses. A crisis in bus operations occurred in the 1960s and 1970s, when declining revenues caused most private bus operators to lose money and forced them to go out of business. If service was to be maintained, it became clear that government would have to help. Federal assistance for public transportation became available in 1964 when the Urban Mass Transportation Act was passed. Through this act and its later amendments, more has been provided both for capital improvements (new buses, maintenance facilities) and for operator subsidies. Federal aid under these programs has totaled over $160 million in capital assistance and $60 million in operation assistance to Indiana transit systems. State government, through the Public Mass Transportation Fund, has contributed an additional $40 million in capital funding and $66 million in operating assistance. (Transportation Coordinating Board (1983), *Transportation in Indiana: Policies and options*). Local public authorities were created to replace the private bus companies. By 1980 there were 17 public transit systems in Indiana with a total of 588 vehicles, providing approximately 34 million passenger trips per year. Seventy-eight percent of the ridership was due to four systems: Indianapolis, Gary, Fort Wayne, and South Bend, ranging between 3 and 15 million passengers per year. The next category included Anderson, Bloomington, Evansville, Lafayette and Muncie, with passenger loads between .5 and 1.6 million per year. Smaller operations existed in Columbus, East Chicago, LaPorte, Marion, Michigan City, Richmond, Terre Haute and Washington.

After years of declining ridership, Indiana transit authorities are showing ridership increases, spurred by new buses and extended service made possible by Federal and State grants. At the same time, however, operation expenses have increased dramatically, and the systems depend more and more heavily on subsidy to maintain operations. Between 1976 and 1980, ridership increased 11%, farebox revenue increased 18%, and operating expenses increased 77%. The amount of cost covered by fares fell from 51% in 1976 to 34% in 1980. A commitment has been made to public transportation even though it cannot cover its own direct costs. This commitment is made out of a belief that the indirect benefits of public transit outweigh the costs, where the benefits are measured in accessibility for the poor or elderly, reduced air pollution, and less traffic congestion.

Current Technology

City buses fall into two types: standard 40 or 50 passenger diesel powered transit buses, and specialized smaller vehicles used for wheelchair riders, for elderly service, and for other special hires of demand based transit. Most transit vehicles are of the large transit bus design, with multiple doors for quick loading. When fully loaded these buses can get up to 150 passenger miles per gallon, but average fuel efficiencies of 40 passenger miles per gallon are more common. Since American commuters average only 1.4 passengers per car, and tend to drive inefficient cars, they average only 16 passenger miles per gallon.

The transit bus is more fuel efficient, but it is still dependent on oil in an increasingly oil-short world. Experiments are being conducted with alternative fuels. Another alternative is the trolley bus, a bus with rubber tires and powered by electricity from overhead wires. Trolley buses were once fairly common particularly in the transition years between streetcar and bus. Trolley buses were used in Indianapolis until after World War II. A major manufacturer of trolley buses was located in Indianapolis. The number of systems is now very limited. Dayton, Ohio has one of the remaining systems. After the 1973 energy crisis, Dayton was on the verge of replacing worn out trolley buses with converted diesel buses. The city decided to keep the system, equipping it with new trolley buses built in Canada. Seattle has also decided to refurbish rather than replace their extensive trolley bus system. Advantages of trolley buses are the low noise level, non-polluting nature, dramatic acceleration available and ability to use conventional streets. A disadvantage is their overhead wires; they require two wires rather than the one for streetcars or light rail, and the hardware for the wires is considerably more noticeable.

A few cities have used articulated extra length transit buses on heavily used routes to increase their capacity and labor efficiency in terms of number of passengers handled by one driver.

The other category of transit vehicles are small vans, sometimes specially equipped for handicapped or wheelchair access. These do not operate on fixed routes, but provide special service in response to telephone calls or prior arrangements. This demand response transit, as it is known, is half-way between conventional transit and taxi service. The small vans consume less energy than regular buses, but usually have very light passenger loads, so the passenger miles per gallon figure may not be high. The rationale for this specialized transit is not to save energy, but to provide a special service to those who cannot use regular transit or private automobiles.

Buses normally run on regular streets. Some express bus services run part way on regular streets, picking up passengers, and then run at high speed on an expressway to a destination area where they again use surface streets. Congested areas may make one lane a bus-only lane -- usually the curb lane to make it easy to load and unload passengers. Some downtown malls are "transit malls" -- they permit buses but exclude automobiles and trucks. Preferential treatment is given to the bus to encourage more people to use it. In large cities, buses may also be given preferential treatment on expressways, with a special lane reserved just for buses. This lane may be designed to operate in two directions -- inbound in the morning and outbound at night. In a few cases cities have considered building separate "busways" -- or bus only rights-of-way. Usually if bus traffic is this heavy consideration will be given to converting from bus to light rail or rapid transit, with much higher carrying capacity per operator.

Advantages

The bus saves energy. A bus with 40 seated passengers is ten times as energy efficient as a conventional commuting automobile with an average of 1.6 people riding.

The bus reduces parking needs. Fewer buildings must be torn down to accommodate parked cars at popular destinations.

Buses are relatively inexpensive to buy. Buses are standardized and mass produced, so they cost much less than light rail or rapid transit vehicles.

Buses are flexible. Since they use conventional streets, bus route are easily changed to meet current needs. Buses can also detour in case of accidents or street blockage.

Buses increase mobility for citizens who need less costly forms of transportation. The bus lets them get where they need to go, cheaply, without depending on other people for rides. It increases their independence and ability to get about in the city.

Disadvantages

The bus, while it saves energy compared to the automobile, is still dependent on petroleum as an energy source. Only trolley buses escape this dependence on oil, and they require a more costly overhead wire system to distribute electricity.

The bus has high labor costs. When fully loaded, the bus is very efficient, but when ridership is low, the driver's wages are a major operating cost. Most bus lines in Indiana have very low average passenger loads. Wages have increased faster than fares, and the result is that the passenger now pays less than half the cost of the ride. The larger part of the cost is subsidized.

The bus has an "image problem." Many people think of buses as slow, uncomfortable and smelly. Actually the majority of buses are quite new, thanks to Federal grants for bus purchase, but they are not as fast or as convenient as the automobile for most trips. People need to be "sold" on the advantages of the bus before they will use it.

Buses, with their diesel engines, do have a noise and a pollution problem. While the pollution is less than that caused by automobiles with the comparable number of passengers, the pollution is very visible in the form of black exhaust smoke, and tends to make the bus unappealing.

Applications

Bus systems exist in seventeen Indiana urban areas, ranging from Indianapolis with a service area of 698,000 people, down to Washington with 11,000 population. Indianapolis operates 232 buses; Washington 2. There is clearly a broad range of areas within which bus service is feasible.

Most Indiana systems operate a combination of fixed route and demand responsive vehicles. Conventional buses handle the fixed routes. Small vans handle particular services, such as transporting senior citizens and handicapped persons with special needs. Some of these special services may be provided under contract to a city social service agency.

Bus applications in other states include the electric trolleybus (Dayton, Ohio as a nearby example), and a range of special services. Some bus lines have contracted to provide special commuting service to particular factories or high employment areas. Passengers sign up for the service and pay by the month rather than by the trip. In large cities this can be a good way to attract people who normally would drive autos to work. The bus picks people up in a given area, and then runs directly to the factory, offering a faster trip than conventional fixed route service.

The keynote of the bus is innovation and flexibility. Imagination, creativity and practicality are called for in deciding where it can be most useful.

Light Rail Transit

"Light Rail", or LRT is the modern name for what used to be called trolley cars or streetcars - electrically powered transit vehicles running on railroad rails embedded in the street, taking their power, usually at 600 V.D.C., from an overhead wire via a current collector or trolley pole.

Street railways began with horse drawn cars in the 1870s, and by 1890 there were 28,000 horsecars operating on 6,600 miles of track in U.S. cities. A horse car from Indianapolis is preserved at the Indiana Transportation Museum in Noblesville, Indiana. Rapid expansion of street railways came after the first successful electrification in 1888. By 1902 there were 22,577 miles of street railway in the U.S., with all but 600 miles electrified. At its peak extent in the 1920s, thousands of large and small cities had electric street cars. Indiana had systems in all major cities, and in quite a few small ones as well, such as the two mile line connecting Milton and East Germantown (near Richmond), or the equally short line connecting resort hotels in French Lick and West Baden, two miles apart. This last line has recently been restored as a tourist attraction, using a wooden trolley car very similar to the ones introduced on the West Baden trolley line in 1904.

In Indiana the street railway lines also reached out into the country, until they connected with the tracks from other cities, thereby forming "Interurban" (or "between urban") electric railways. The first of these connected Anderson and Alexandria. At its peak in the 1920s, the interurban network radiated in 12 directions from Indianapolis. It connected all Indiana cities of any size except Evansville (which had its own separate network). The line reached Louisville and Chicago, and connected at two places with interurban networks in Ohio. The Indianapolis Union Traction terminal, located where the Greyhound depot and the Blue Cross-Blue Shield building now sit, was the largest of its type in the country. It featured a great iron arched roof which spanned 9 tracks.

Of all of this vast network, only one line survived in Indiana, the Chicago South Shore and South Bend. Only in Michigan City does that line reflect its street railway background by running down the middle of the city streets. The remainder of the line was improved and put on separate rights-of-way over the years. The CSS&SB is now a "heavy rail" operation rather than a streetcar of light rail. All the other city systems have gone, including Indianapolis, Fort Wayne, Terre Haute, Evansville, Marion, Lafayette and a whole host of other cities. The last lines were gone and converted to bus by 1950. The same was true nationally. By the 1950s, 40,000 miles of streetcar track had been torn out and 60,000 trolley cars junked. Today only San Francisco, Philadelphia, Boston, New Orleans and a few other cities still have trolleys on tracks.

Today there is a resurgence of interest in the trolley car, both as a tourist attraction and as a serious transportation alternative. Trolleys are non polluting, energy efficient, and free from reliance on oil, capable of handling large numbers of people and able to operate either on the streets or on separate rights-of-way. While expensive, they cost a fraction of conventional subway or rapid transit lines.

U.S. cities now look to European examples, where street railways, especially in Germany, were extended as part of the post World War II reconstruction, rather than deliberately scrapped as in the U.S. Incremental improvements sometimes permitted the cars put underground for the most congested parts of the trip, and reserved space for the tracks alongside new roads as these were extended to the suburbs. A 1976 study indicated that 43 European cities were extending or rebuilding their light rail systems (DOT, (Spring 1976). Light rail transit). The name Light Rail Transit, or LRT, has been given to these lines to distinguish them from subways or high speed electric lines like the Chicago, South Shore and South Bend.

Current Technology

Light rail technology uses electrically operated cars, running on steel rails, powered by direct current electricity from a single overhead wire. Solid state motor controls provide for smoother acceleration than traditional streetcars, and the cars have modern styling. Standard car designs have been developed which meet the specifications of more than one system. Several recently built systems have imported cars from Germany, identical to those used on several systems in Germany. This reduces the cost per car compared to custom designs.

Light Rail Transit (LRT) uses electrically driven cars, running on street rails, powered by direct current electricity from an overhead wire. The technology can be divided into a) the cars, and b). the right-of-way.

Historically in the U.S., each street railway company designed its own streetcars, and these evolved from 2-axle 4-wheel cars to heavier 4-axle cars. In 1933 a radically improved design was developed, the PCC or President's Conference Committee car, capable of use on many systems. Approximately 5,000 were built, and they are only now being replaced as the mainstays of U.S. systems. The PCC car was 46 feet long, weighed 20 tons, and held up to 69 seats plus standees. Maximum speed was 50 mph. It was a 4-axle car, with features to reduce noise and smooth out the acceleration.

Car design in the 1970s has taken two forms, a 4-axle design similar to, but heavier than, the PCCs, and an articulated two or three unit design with 6 to 8 axles. The Canadian Light Rail Vehicle, designed initially for Toronto and delivered in 1979, is a four axle non-articulated car, costing about $500,000 per car, 50 Ft. long, weighing 26 tons, with speed and acceleration equal to that of the PCC. In the U.S., the Boeing LRT was designed in 1973 as a two unit articulated car, 71 feet long with six axles, weighing 34 tons, with top speed equal to a PCC but an acceleration rate somewhat less. Intended as a replacement for aging PCC fleets in Boston and San Francisco, a joint order of 275 were built. The cars experiences a series of problems, and are not currently being manufactured.

The West German company of DuWag is the leading European Manufacturer of LRTs, and their designs have been used in several new North American systems. The Edmonton system, opened in 1978, uses the DuWag U2 design, a 6-axle, 75 foot long articulated car, weighing 33 tons, with top speed equal to the PCC but acceleration and grade climbing capability substantially less. DuWag cars have also been used in Calgary and in San Diego, both systems opened in 1981.

The emphasis in these recent designs has been on maximizing the size and capacity of the car, so as to reduce labor costs. Further savings are possible by operating several cars coupled together to handle peak loads. Because of their heavier weight and slower acceleration, however, the new cars are less suited to street traffic than were their 1933 predecessors. Intended for use on semi-separate rights-of-way, the cars can hit 50 mph but average 15 to 30 depending on frequency of stops.

Right-of-way

Traditional streetcar lines were constructed primarily, as the name implies, within the street pavement. As auto traffic grew, conflicts between vehicles slowed down the streetcars and often led to their replacement by buses. Current light rail technology tends toward semiexclusive rights-of-way, reducing street running to a minimum. Lines are built in street medians or on shoulders, with some mileage in tunnels. Unlike conventional rapid transit, however, the tracks are usually at ground level, and are not fenced off or protected from other traffic. Streets are crossed at grade, and the cars may share malls with pedestrians. Stops are usually at ground level platforms, although some systems have high level platform boarding at their main stations.

Several light rail systems have been built or are projected to utilize abandoned railroad rights-of-way. This idea is attractive in reducing right-of-way cost, but may lead to a location which is not ideally located for attracting passengers.

Light rail transit occupies a position mid-way between buses and rapid transit in terms of capacity. LRT capacity is generally in the range of 12,000 to 16,000 passengers per hour, whereas bus lines have difficulty accommodating more than 6,000 passengers per hour and rapid transit lines are rarely built to handle fewer than 20,000 per hour. It has been suggested that a density of seven dwellings per acre is a threshold above which transit use of all types increases sharply Light rail is obviously of limited interest to smaller communities, but has potential for a city the size of Indianapolis. Light rail systems have been actively considered for both Dayton and Columbus, Ohio.

Advantages

The advantages of light rail include energy savings per passenger, if the density of traffic is sufficiently great. There are inherent efficiencies in the smooth rail right-of-way, but the heavy car weight requires a greater passenger load to achieve energy savings. PCC cars consume four to five KWH of electricity per car mile. At a current cost of 5¢/KWH this would mean 20-25¢ in fuel costs per mile, the cost equivalent of 6 miles per gallon of gas at current gasoline prices. The new Boeing LRTs consume 9.5 KWH/mile, the cost equivalent of 3 miles per gallon of gas at current prices. This would mean that a LRT carrying 6 or more passengers would have the same fuel costs as an automobile getting 18 mpg and carrying one person. Obviously great energy savings are possible with LRTs, but only if there is enough passenger density to keep the cars loaded. It is also evident that the LRT saves scarce oil resources, since the electricity it uses can be generated by coal or other fuels.

Other advantages include freedom from pollution, since there are no exhaust fumes, and greater comfort than is typical of a bus. Noise levels are quite low, and the LRT system can become a spine for future high density urban development.

Disadvantages

The primary disadvantage is cost, since there is a heavy capital investment in the tracks and cars. The 16 mile San Diego system, at $5 million per mile, is the lowest cost LRT system in the U.S. This is a substantial saving compared to conventional rapid transit systems, but a substantially greater investment than a bus system. Like other forms of public transportation, the LRT system cannot expect to recover its full operating cost, and depends on state or federal subsidies to keep fares within reach of prospective customers.

Other disadvantages involve the fixed right-of-way, which makes it impossible to detour LRTs around accidents, parades or special events. The overhead wire can create esthetic problems, although it can be made practically invisible if viewed against a background of trees or buildings.

Applications

North American cities which still have streetcar operations from the previous streetcar era include Boston, Newark, Philadelphia, Pittsburgh, Cleveland, New Orleans, San Francisco and Toronto, with a short special purpose line in Fort Worth linking a parking lot with a downtown store. Major improvements have been recently made to the Pittsburgh and San Francisco systems, reducing the amount of street running and speeding operations in the downtown core by placing tracks underground in high density areas. This was already true of the Boston operation. New lines, using semi-exclusive rights-of-way, have been built in Edmonton and Calgary, Canada, and in San Diego, California. The San Diego system, besides being the most economical of the new lines, was built without any federal participation, and carries substantial passenger loads between San Diego and the Mexican border at Tijuana. Lines are under construction in Buffalo (expected completion 1984), Portland and Vancouver (both expected in 1986), while new lines or extensions are currently planned in Sacramento, Calgary, San Jose, Long Beach, Detroit, Los Angeles, Denver, Boston, Portland, Rochester, Salt Lake City and San Diego. It is clear that there is a renaissance of interest in light rail in North America. Tentative interest has been expressed in a light rail line using existing railroad tracks between downtown Indianapolis and Carmel, although the project has not yet received a go-ahead.

Another recent application of light rail which perhaps has potential for Indiana cities, this involving the restoration and operation of vintage trolley cars as a component of historic neighborhood revitalization or downtown revitalization. Sometimes existing tracks are used and sometimes completely new lines have been built. These lines are typically quite short, and their purpose is to give people a leisurely ride rather than to get them someplace in a hurry.

Such lines now exist in Yakima and Seattle, Washington, in San Antonio, Detroit, Minneapolis, Philadelphia, San Francisco and Lowell, Massachusetts. San Francisco, in addition to restoring the famous cable cars, operates a collection of vintage trolley cars on summer weekends, using surface tracks along Market Street from which the regular LRTs have been replaced. Philadelphia and Seattle operate historic cars along short stretches of urban waterfront, as an added attraction to bring people downtown. Lowell uses streetcars to tour a historic preservation area, and Detroit has built an entirely new line, operated by historic trolley cars, between the downtown area, the convention center, and Renaissance center. In some cases the trolleys are run as a museum projects, in some cases they are run by the regular transit companies. In all cases the purpose is to sell nostalgia and promote activity in the downtown, rather than to save energy. The cars do provide a legitimate transportation function, though, often tying together several centers of pedestrian activity. Because of their silence and non-polluting qualities the cars are very compatible with pedestrian places from which motor vehicles are excluded.

A 3/4 mile trolley ride of this type exists at the Indiana Transportation Museum in Forest Park, Noblesville, with the purpose of demonstrating the interurban cars which used to run throughout much of the state. A two mile trolley ride between French Lick and West Baden, Indiana, uses a four wheel streetcar for summer trips and serves a genuine transportation function by linking resort hotels in the two communities. Serious discussion has been given to operating streetcars in the downtown Indianapolis area, perhaps linking the Union Station - Hoosierdome complex with the new White River Park and the IUPUI sports complex. PCC cars from Toronto have been imported for potential use on such a line. Other situations may exist in Indiana where a special purpose trolley line of this sort would be functional.

QUESTIONS FOR STUDY

1. What are the indirect benefits of public transit systems?

2. Compare the passenger miles per gallon for the bus and the automobile. Which one is more efficient?

3. List and discuss the advantages and disadvantages of the bus.

4. How many bus systems operate in Indiana? What city operates the largest bus system? Smallest?

5. Why is there a resurgence of interest in the streetcar today?

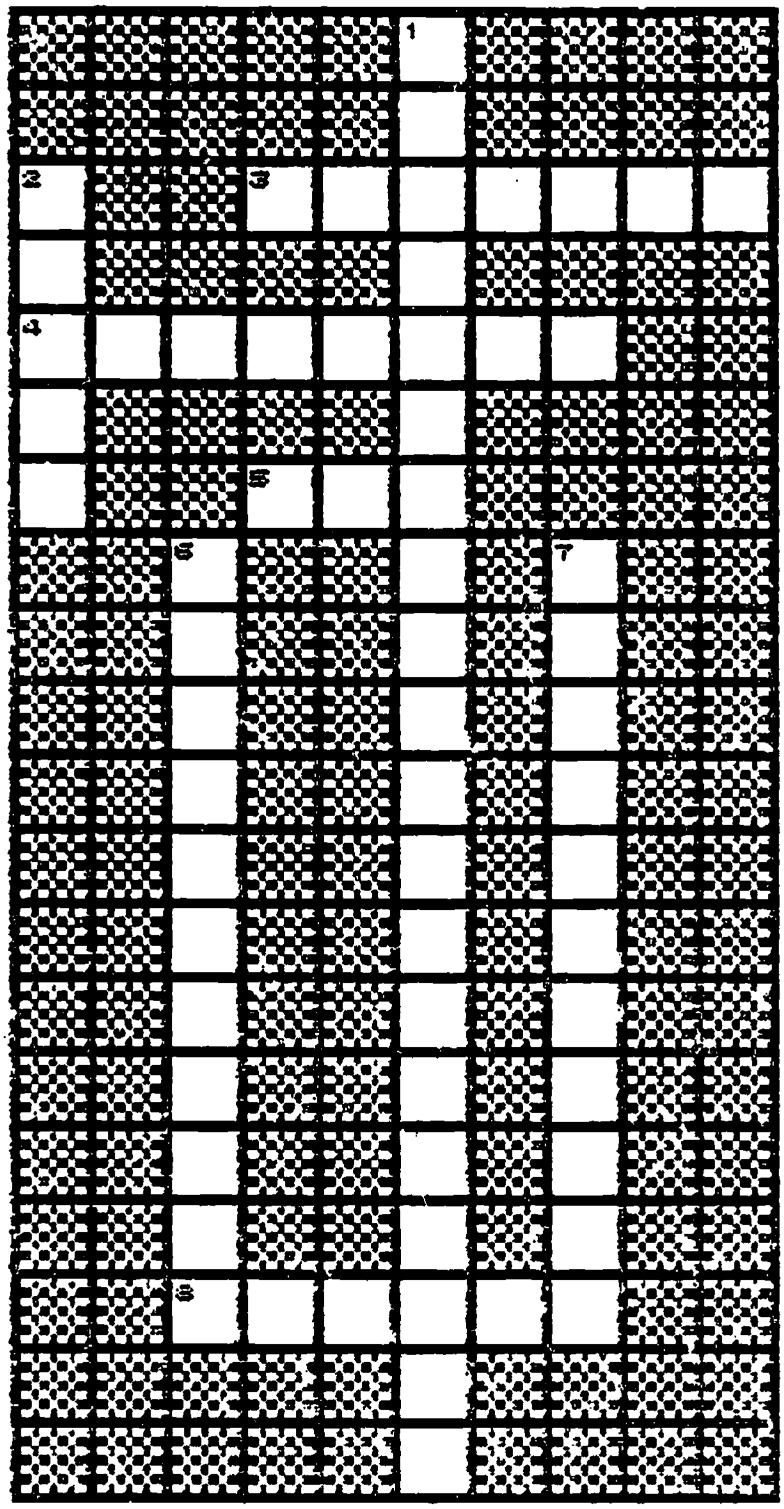
6. Examine the advantages and disadvantages of LRT and make an initial determination of the merits of building a LRT in your community What additional information would you need to confirm your decision?

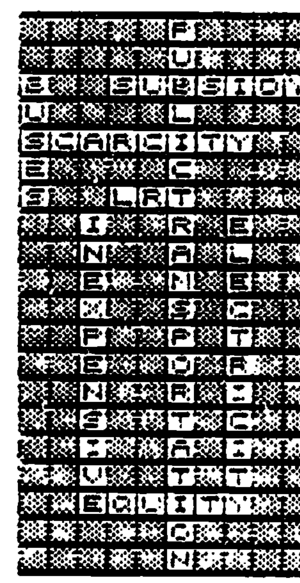
7. How have recent LRT systems reduced costs of operation?

8. According to a 1976 study, where is there the most interest in building and rebuilding LRT systems? Can you explain why?

9. Calculate the total of all subsidies to public transportation in Indiana. Divide this total by the population of Indiana to determine the cost per citizen of the subsidies. Assume this to be your share of the cost of operating public transportation systems in the state, assess your benefits. Have you benefited directly by this amount? Indirectly? If not, do you favor continued subsidies? Explain.

10. Would you expect companies with new technologies (buses) to try and replace existing companies (streetcars)? Explain. If they could not buy them out, how would the movement to the new technology be accomplished? Do you agree with the 1949 Chicago court decision? Explain.





ACROSS CLUES

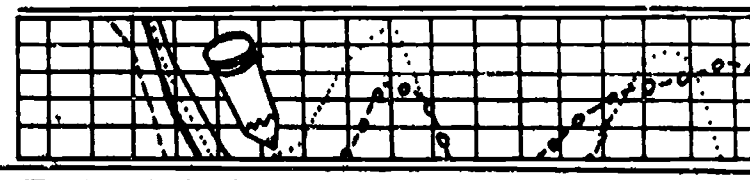
3. USUALLY PAID FOR PUBLIC TRANSIT
4. USES FOR ENERGY EXCEED SUPPLY
5. STANDS FOR LIGHT TRANSIT
8. WHO SHOULD PAY FOR PUBLIC TRANSIT

DOWN CLUES

1. IT IS ENERGY EFFICIENT
2. THEY CAN CARRY 40 PEOPLE
6. MASS PRODUCTION MAKE BUSES THIS
7. LRT ARE POWERED BY THIS

Energy

Case Study



TRANSPORTATION

"Small is beautiful" and "doing more with less" were two themes expressed in the news media during the energy crisis of the 1970s. The first theme, "Small is beautiful," suggested a return to simpler machines for transportation and the use of smaller amounts of energy resources. The second theme, "doing more with less," implied that it was still possible — given more restrictive uses of energy — to maintain a relatively prosperous lifestyle for many U.S. citizens.

Compare the transportation alternatives described in the factsheet using the following form.

Transportation Alternatives

Comparisons	Bus	Vans	LRT
Maximum number of passengers			
Cost per passenger			
Type of energy			
Cost of energy			
Availability of energy			

1. Based on your comparisons which alternative do you consider most energy efficient? Why?

2. Which alternative do you consider to offer the greatest convenience to passengers? Why?

3. Given the choice between energy efficiency and passenger convenience, which do you consider most important? Why?

Energy — TRANSPORTATION

This project is intended only for those communities that now have a bus system.

1. Get copies of the bus schedules and a map of the bus routes in the community. Find out which bus routes are nearest, how often they operate, and what their hours of service are. Determine whether you can use the bus for some trip which you now make by car (for example, going to a movie, or to an after school job). How much time would the trip take, including walking time at either end and waiting time? How much would it cost? Compare the cost and the time to the automobile, assuming the automobile cost at 20¢ per mile (plus parking fees). Is the bus a reasonable alternative for this trip? If not, what would have to be different for it be to a good alternative?

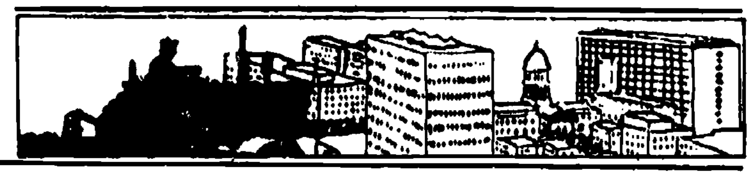
2. Ride a particular bus route from one end to the other (or from an outer end to the center city if it is a long route). Keep track of how many people get on or off and where. Try to tell who uses the bus, by age, sex, or other categories. Does it appear that they are riding to work, or to shop, or what?

3. Arrange, (with permission of the bus company or authority) to interview the driver of that particular route and ask him how the pattern of people on the bus changes throughout the day. Develop a simple questionnaire about bus use, and give it to people as they board the bus, to determine who uses the bus, what they like or don't like about it, what they would do without the bus, and other questions.

4. Talk to someone in the bus company or authority to find out how they decide where their bus routes should go. Bus routing and scheduling is usually a compromise. More people will ride if the buses are more frequent and come closer to their destination, but this means more buses and usually a greater loss on each bus. Find out where the money comes from to make up the difference between what the bus earns and what it costs to operate. Is the money worth it? What other money is perhaps being saved that balances the cost of operating the bus? Discuss the concept of subsidy, and what is being accomplished by the subsidy. Who pays and who benefits, and is this distribution a fair one.

Energy

Community Study



TRANSPORTATION

This project can be done in towns which do not now have bus service, but which are big enough to possibly support some type of public service. 10,000 population is probably the smallest size where this would be feasible.

1. Find out what the most comparable community is in Indiana which does have a public transit service, and compare it to your own community.

2. Find out, by talking to city officials, whether there have been any studies in your community to determine whether a bus service would be feasible.

3. Look at a map of your community to decide where one or more bus routes might go. Try to identify areas which might generate a lot of riders, or destinations to which a lot of people would go.

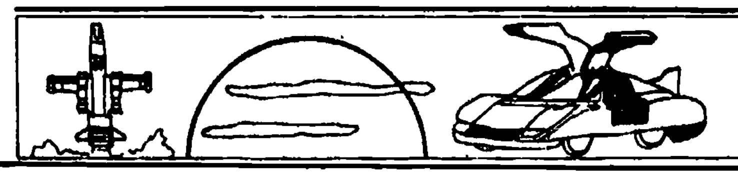
4. Find out what percentage of people in your community are not licensed, or do not have access to a car. (For Indiana as a whole, 66% of the population have drivers licenses). Are there particular groups of people who need transportation but do not have cars?

5. Would some form of demand responsive transit be possible, such as a van to take elderly people to the doctor, or a van for taking wheelchair users places by special appointment, rather than operating on a fixed-route basis.

6. Are there any large factories or other large employers which might justify a bus just at shift time? What sort of route would it follow?

7. Are there any other forms of public transit in your community, such as a taxicab company? How much does it cost to ride, and what people usually use it? Are there ways of using it to provide service to additional people, and would this have any advantages over running regular fixed-route buses.

8. Interview ten people in your community to determine how they feel about supporting public transportation systems.

Energy
21st Century


TRANSPORTATION

Imagine a future where energy has become so scarce, and so expensive, that few people can afford to operate a private vehicle. With fewer vehicles, there is less need for multiple lane highways or freeways, and some of those are closed or narrowed to reduce maintenance costs. Houses, jobs and stores are built more closely together, and most people walk or ride public transportation. The demand for public transportation is much larger then it is today, and even small towns can support public transit.

Have the class imagine some of the forms this new transit might take. Examples might include:

1. Special road systems used only by buses. (The new town of Runcorn, England, near Liverpool, is designed this way, and over half the population ride the buses).

2. Buses which are guided automatically while in certain high density routes, but which can be steered by a driver on regular streets.

3. Monorails like those at Disney World which can go above existing streets, and even through buildings.

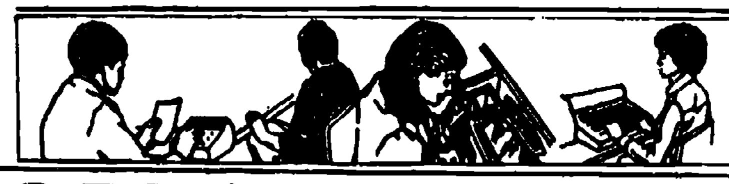
4. Self-operated systems, with small vehicles which wait at a station until someone boards, and then proceeds automatically to the destination entered on a control panel, by passing all other stops. Such systems are already in operation in Morgantown, W.Va., and are being built in Miami, Detroit and elsewhere, and have been extensively studied for possible use in Indianapolis.

5. Buses (or light rail) designed so that people can take bicycles with them on board, to ride between home and the transit line.

6. Buses or other vehicles which use a charge card and record automatically the distance traveled and the correct fare, which is then paid monthly.

All of these are already being used or experimented with, and all could make public transit more attractive and easier to use. Imagine how a system incorporating some of those elements might be applied in a community like yours, under conditions where individual automobile use had become very expensive. Don't overlook conventional buses, trolley buses and light rail, but think particularly about the possibilities of those new forms of transportation, and imagine the type of route they might follow in an actual community.

Energy Careers TRANSPORTATION



1. Valuable information on occupations related to public transportation can be found in:

   A. A. Paradis (1983). Chapter 4, The intercity people movers and Chapter 9, Careers in public transit, Opportunities in transportation, Lincolnwood, IL: VGM Career Horizons.

   Also obtain the following books from Arco Publishing, Inc.:

   (a) (1972) Bus maintainer - Bus mechanic. and

   (b) (1974) Bus operator; conductor.

2. Interview a worker employed in a public transit system, then a worker employed by a private transit company. Through your interview answer the following questions:

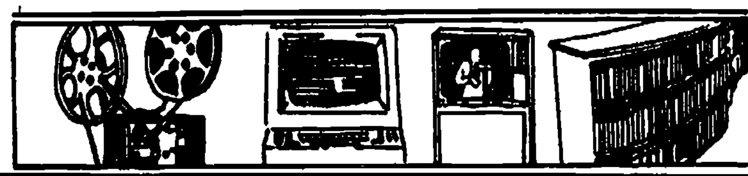
   (a) How do the skills required in a public transportation operation differ from the skills needed in a private operation?

   (b) What are the comparative advantages and disadvantages for a worker in a public transit operation?

   (c) How might a lack of "profit incentive" affect the worker in a public transit operation?

3. A number of government jobs related to public transportation are available. Study and report on opportunities in the following agencies:

   U.S. Department of Transportation
   Federal Highway Administration
   Bureau of Motor Carrier Safety
   Federal Railroad Administration
   Urban Mass Transportation Administration
   National Transportation Safety Board
   Indiana Department of Highways
   Indiana Department of Transportation
   Indiana Department of Commerce



If the community has a bus company or a transit authority, they will probably be happy to arrange a visit to the bus garage, or to send someone to talk to the class. There may also be a transportation planner with the local city planning office who can talk about public transportation alternatives. If there is no one at the local level, the State Department of Transportation collects information on public transportation in each city. They can provide information about public transportation systems in other Indiana cities.

The federal government, through the U.S. Department of ~ansportation, Urban Mass Transportation Administration, provides numerou rts on experiments in public transportation. A good general guide . .

U.S. Department of Transportation (1980, December). Innovative techniques and methods in the management and operation of public transportation services. Washington, D.C.

There may be individuals or groups in your community interested in promoting public transportation. An example in Indianapolis is the:

Hike, Bike and Bus Week Committee
844 North Rural Street
Indianapolis, IN 46201
317/63607851

This group has sponsored a week of events publicizing transportation alternatives in Indianapolis. There may be similar groups in your community.

Division of Energy Policy
1 North Capitol Avenue
Indianapolis, IN 46204

The following films can be obtained from the Indiana University Audio Visual Center:

1. Energy: Less is more NSC 1484

   Considers alternatives to the present wasteful methods of consumption. Examines mass transportation advances.

2. Inner city dweller: Transportation CSC 2390

   Focuses on lack of mass transit unavailable to many inner city dwellers. Notes that poor mass transit systems have lower ses inner city dwellers to buy old, unreliable cars which cost much to keep in repairs.

PURPOSE: The purpose of this lesson is to emphasize current dependency on the automobile and to explore the energy costs of consumption related to automobile use.

APPROXIMATE TIME: If each of the following activities is used approximately eight class hours will be needed. This estimate does not include use of supplemental resources.

READABILITY: The Bormuth Readability Index was used to determine the reading level of text material in this lesson.

Ave. Word Length: 4.44

Ave. Sentence Length: 18.1

Readability Index: 57.8

Grade Level Equiv.: 6-7

OBJECTIVES

INQUIRY	DECISION-MAKING	TAKING ACTION
1. Students will examine the use of the auto as a form of transportation.	1. Students will recognize conditions under which autos should be considered an important transportation form.	1. Students will determine when an energy problem warrants altered use of autos as transportation forms.
2. Students will identify the energy advantages and disadvantages of auto use.	2. Students will explore the effects of autos in a variety of situations.	2. Students will analyze data for deciding effective and efficient auto use.
3. Students will compare the energy efficiency of the auto in relation to its effectiveness as a form of transportation.	3. Students will predict the consequences of auto use on personal convenience, energy consumption, and economics.	3. Students will determine when modifications in auto use would be feasible.
4. Students will develop a conclusions about the most beneficial energy uses of the auto.	4. Students will rank order the most effective uses of autos under varying conditions.	4. Students will explore potential effects of a decision to introduce modifications of auto use.
		5. Students will prepare proposal to change auto use in a transportation system.
		6. Students will judge the results of their proposals or simulations of them.

LESSON 3: THE AUTOMOBILE, ENERGY AND YOU

Energy
TRANSPORTATION

Glossary

air pollution - the lowering of visibility or healthfulness of the air through release of gases, smoke and other undesirable substances resulting from excessive use of fuel.

carbon monoxide - an invisible, odorless, and poisonous gas released into the atmosphere from automobile exhausts.

energy consumption - the rate at which an individual, or an industry, or a city consumes all forms of energy in conducting its normal activities.

EPA - Environmental Protection Agency. The federal agency responsible for monitoring and enforcing air quality standards.

mobility - the ability of people to move about freely, either through personal transportation (like the automobile) or through convenient public transportation.

mpg - miles per gallon. The measure of fuel efficiency which states how far a specific car can travel for each gallon of gas used.

odometer - the instrument on the automobile dashboard which records the number of miles (or kilometers) actually traveled.

"technical fix" - the idea that a new invention will solve all our problems.

Energy Factsheet

TRANSPORTATION

THE AUTOMOBILE: GOOD AND BAD

We have seen that the automobile uses 60% of our transportation energy, and that transportation is about one quarter of all our energy use. There are other ways of looking at the automobile's impact, for good and for bad, on our way of life. Students may want to list some of the automobile's impacts, and then illustrate them with the following figures:

1. Automobiles account for most of our passenger travel -- 93 percent of 2.7 trillion passenger miles in 1977.
2. Automobiles have created much of the demand that created our highway system -- 3,166,200 miles of paved streets, roads and highways. Many of these highways are now old, and the task of repairing them will take a larger and larger chunk of tax dollars.
3. The automobile is the sixth largest cause of death in America. Each year, 50,000 people are killed, and millions are injured. The National Highway Traffic Safety Administration estimates the cost of these accidents at more than $45 billion annually -- in medical costs, insurance and legal expenses and income lost.
4. For Americans under age 35, automobile accidents are the leading cause of death.
5. The automobile has given unprecedented personal mobility to most (not all) Americans. There are 130 million licensed drivers in the U.S., with a fleet of over 100 million cars -- 40 percent of all those in the world. They drive over 1 trillion miles each year.
6. The automobile permits people to look for work in a wide area, but it also requires them to own a car in order to work. Many families require more than one car simply in order to get to their job.
7. The automobile itself creates jobs. The auto industry directly employs five million workers, about 5% of all those in the United States. With all the auto related jobs -- such as gas stations, insurance and travel industries, the automobile may generate one sixth of all American jobs.
8. The automobile has changed the shape of our cities. Henry Ford said "The automobile will let us leave the city and its problems behind". The remark was prophetic, but as many people left the city, they created new problems in the suburbs, and left the city with the concentrated problems of those too poor to move out.
9. The automobile is a major source of air pollution -- including 69 million tons of carbon monoxide each year. Despite stiff standards, the automobile is the leading cause of air pollution in many cities.

Identify as many potential impacts as possible, and then discuss whether each is a good, bad, or mixed impact. This procedure will set the stage for the survey of auto use which follows.

QUESTIONS FOR STUDY

1. If transportation energy is 25% of all energy use, what is the automobile's share of all energy use?

2. How have automobiles' contributed to people's mobility?

3. How would the loss of one car in your family affect its mobility?

4. Did the introduction of the automobile change the shape of cities? Explain.

5. What role does the automobile play in the air pollution problem of the cities?

6. How important is your family's automobile to keeping a job?

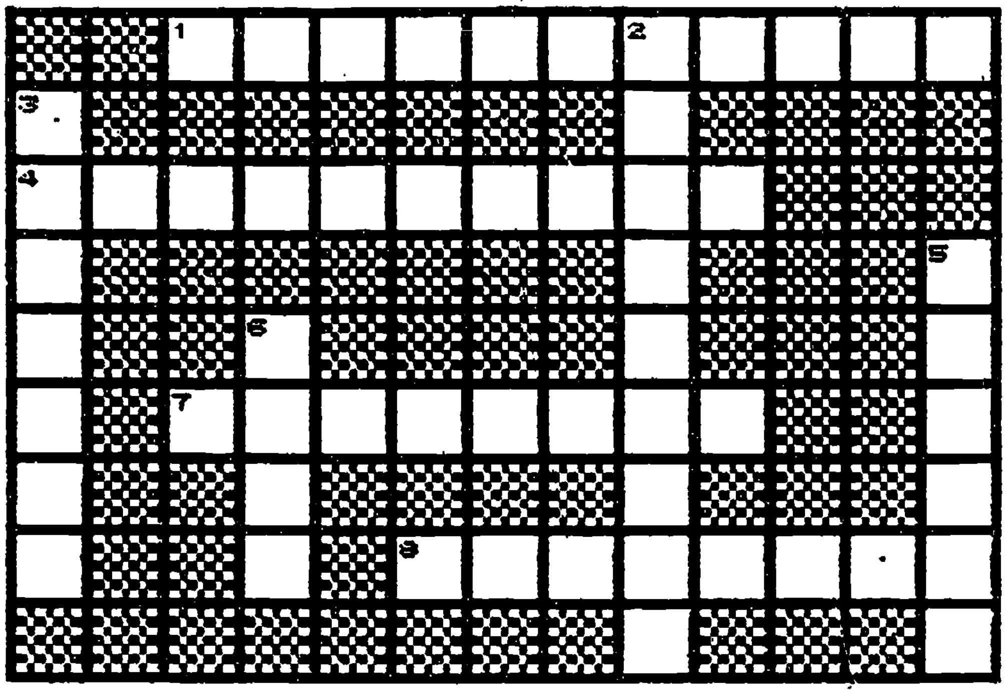
7. Evaluate the impact of the automobile on your community. Describe the benefits and costs. What would you do to increase the benefits and reduce the costs?

8. Inquire about efforts to circumvent on desirable air pollution effects by the unlawful use of leaded gasoline. Why do some people use leaded gas in cars designed to use unleaded fuel? What would you recommend be done to change the situation in your community? What has the federal government decided to do? Do you agree with this decision? Explain.

9. Are automobile accidents a problem among teenagers in your area? What seems to be the cause? What would you recommend to reduce the number of accidents? Who would pay for the proposed changes?

10. Determine the time you use the automobile for transportation to work, for transportation to school, and for leisure. How do you use the automobile the most? If it were not available, what would you do?

11. What automobile would you buy today if you had the money?

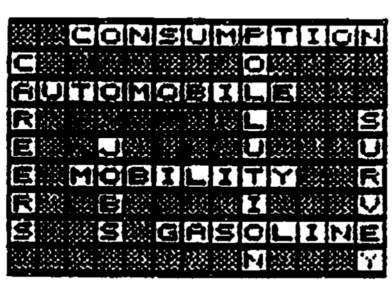


ACROSS CLUES

1. THE USE OF ENERGY BY THE AUTO
4. A MAJOR SOURCE OF POLLUTION
7. ABILITY TO MOVE ABOUT
8. MOST CARS ARE POWERED BY THIS

DOWN CLUES

2. CAUSED BY THE EMISSIONS OF AUTOS
3. JOBS IN THE AUTOMOBILE INDUSTRY
5. USED TO ASK PEOPLE'S OPINIONS
6. TYPES OF WORK IN AUTO INDUSTRY



Energy

Case Study

TRANSPORTATION

Students (and drivers generally) tend to think of automobile costs just in terms of the gas they buy. They overlook all the other costs which are paid periodically over the life of the car. When these total costs are calculated, the cost per mile is likely to be 3 to 4 times the cost of the gas alone.

This experiment is designed to estimate the cost of operating a specific vehicle. It incorporates a worksheet and tables from a U.S. Government Publication, Cost of owning and operating automobiles and vans. Students can use the worksheet to try to calculate costs for a vehicle which they, or their family, owns. If they do not know a specific figure, they should to approximate it from the tables. The tables themselves can be used to stress the total costs involved, and to show how these may change over the life of the vehicle.

"A hypothetical example is given on the next page, using the worksheet and making assumptions about a family owning a typical mid-sized auto used for work trips and general driving."

(Hypothetical Example)

WORKSHEET TO CONVERT COSTS TO ANY LOCALITY

Costs in Your Locality

1.	Amount Paid for your car	$ 8,000.00
2.	Cost of accessory items	$ 500.00
3.	Cost of a tire to fit your car	$ 50.00
4.	Price of gasoline per gallon (including tax)	$ 1.20
5.	Price of oil per quart (including tax)	$ 1.40
6.	Annual cost of your insurance	$ 200.00
7.	Estimated cost of your daily parking	$ 1.00
8.	State registration fee for your car	$ 50.00
9.	Sales/titling, and/or personal property tax	$ 100.00
10.	Mechanics labor charge per hour	$ 20.00
11.	Monthly interest cost (Monthly payment x Number of months for loan less Amount of loan / Number of months for loan	$ 50.00
12.	Term of your auto loan	$ 36 months
13.	Your mileage for the year	$ 14,000 miles

Estimated First Year Cost[1/]

	Ownership Costs (First Year)	Total	Cost per mile (Total Column / line 13)	
14.	Depreciation (25%[2/] of line 1)	$ 2,000.00	14.3	cents
15.	Accessories (line 2 / 12)	$ 42.00	.3	cents
16.	Insurance (line 6)	$ 200.00	1.4	cents
17.	Registration fee (line 8)	$ 50.00	[illegible]	cents
18.	Financing (12 x monthly interest cost)	$ 600.00	4.3	cents
19.	Sales/titling, and/or property tax (line 9)	$ 100.00	.7	cents
	Operating Costs[3/] (First Year)			
20.	Gasoline (Annual gallons used x line 4)	$ 1 120.00	8.0	cents
21.	Oil (line 13 / owners manual change requirements x line 5)	$ 50.00	.4	cents
22.	Snow tires (2 x line 3 x .25)	$ 25.00	.2	cents
23.	Maintenance and Repair (line 10 / 23.42 x First Year Repairs and Maintenance from Table 2, 3, 4, 5, or 6)	$ 150.00	1.1	cents
24.	Parking (250 x line 7) or actual days parked x daily cost	$ 250.00	1.8	cents
25.	Tolls	$ 0	0	cents
26.	Total Cost (Add lines 14-25)	$ 4,587.00	32.8	cents

1/ If you wish to compute your costs for other than the first year, note additional instructions in section titled "Adjustment of Costs to Other Localities."

2/ Use 15 percent for compact or subcompact cars, 30 percent for vans.

3/ All maintenance and repair, both scheduled and nonscheduled, are included in operating costs.

HHP-41/3-82(150M)

TABLE 2 - ESTIMATED COST OF OWNING AND OPERATING

A LARGE-SIZE 1981 MODEL AUTOMOBILE[1]

(TOTAL COSTS IN DOLLARS, COSTS PER MILE IN CENTS)

ITEM	FIRST YEAR (14,500 MILES)		SECOND YEAR (13,700 MILES)		THIRD YEAR (12,500 MILES)		FOURTH YEAR (11,400 MILES)		FIFTH YEAR (10,300 MILES)		SIXTH YEAR (9,700 MILES)	
	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE
COST EXCLUDING TAXES:												
DEPRECIATION	2,457.00	16.94	1,421.00	10.37	1,200.00	9.60	1,015.00	8.90	831.00	8.07	708.00	7.30
SCHEDULED MAINTENANCE	(98.85)	(.68)	(194.95)	(1.42)	(287.46)	(2.30)	(155.50)	(1.36)	(163.00)	(1.58)	(236.86)	(2.44)
NONSCHEDULED REPAIRS AND MAINTENANCE	(66.75)	(.46)	(117.55)	(.86)	(430.44)	(3.44)	(275.45)	(2.42)	(498.48)	(4.84)	(693.01)	(7.14)
TOTAL REPAIRS AND MAINTENANCE	165.60	1.14	312.50	2.28	717.90	5.74	430.95	3.78	661.48	6.42	929.87	9.58
REPLACEMENT TIRES	21.01	.14	19.80	.14	29.34	.23	110.27	.97	104.35	1.01	98.28	1.01
ACCESSORIES	11.89	.08	11.37	.08	10.65	.09	9.98	.09	9.34	.09	16.57	.17
GASOLINE	1,039.69	7.17	982.39	7.17	896.33	7.17	817.46	7.17	738.59	7.17	695.56	7.17
OIL	11.25	.08	20.25	.15	20.25	.16	9.00	.08	24.75	.24	15.75	.16
INSURANCE	461.00	3.18	445.00	3.25	445.00	3.56	424.00	3.72	424.00	4.12	256.00	2.64
PARKING AND TOLLS	113.68	.78	107.10	.78	97.71	.78	89.25	.78	80.80	.78	76.10	.78
TOTAL	4.281.12	29.51	3,319.41	24.22	3,417.18	27.33	2,905.91	25.49	2,874.31	27.90	2,796.13	28.81
TAXES AND FEES:												
STATE:												
GASOLINE	76.76	.53	72.53	.53	66.18	.53	60.35	.53	54.53	.53	51.35	.53
REGISTRATION	20.00	.14	20.00	.15	20.00	.16	20.00	.18	20.00	.19	20.00	.21
TITLING	461.60	3.18	-	-	-	-	-	-	-	-		
OPERATING COST SALES TAX 2/	(.09)	-	(.72)	(.01)	(10.33)	(.08)	(7.43)	(.07)	(16.29)	(.16)	(19.94)	(.21)
NONOPERATING COST SALES TAX	(.90)	(.01)	(2.29)	(.02)	(2.78)	(.02)	(1.91)	(.02)	(1.53)	(.01)	(3.18)	(.03)
TOTAL SALES TAX	.99	.01	3.01	.03	13.11	.10	9.34	.09	17.82	.17	23.12	.24
SUBTOTAL	559.35	3.86	95.54	.71	99.29	.79	89.69	.80	92.35	.89	94.47	.98
FEDERAL:												
GASOLINE	34.12	.24	32.24	.24	29.41	.24	26.82	.24	24.24	.24	22.82	.24
OIL 2/	.08	-	.14	-	.14	-	.06	-	.17	-	.11	-
TIRES	4.83	.03	4.57	.03	4.13	.03	3.47	.03	3.13	.03	2.94	.03
SUBTOTAL	39.03	.27	36.95	.27	33.68	.27	30.35	.27	27.54	.27	25.87	.27
TOTAL TAXES	598.38	4.13	132.49	.98	132.97	1.06	120.04	1.07	113.89	1.16	120.34	1.25
OPERATING COSTS	3.511.24	24.21	2,094.61	15.29	1.965.89	15.72	1.626.39	14.28	1.448.87	14.06	1.240.61	12.79
OWNERSHIP COSTS	1.368.26	9.43	1,357.29	9.91	1.584.26	12.67	1,399.56	12.28	1,545.33	15.00	1.675.86	17.27
TOTAL OF ALL COSTS	4.879.50	33.64	3,451.90	25.20	3,550.15	28.39	3,025.95	26.56	2.994.20	29.06	2.916.47	30.06

TABLE 3 - ESTIMATED COST OF OWNING AND OPERATING AN INTERMEDIATE-SIZE 1981 MODEL AUTOMOBILE [1]

(TOTAL COSTS IN DOLLARS, COSTS PER MILE IN CENTS)

ITEM	FIRST YEAR (14,500 MILES)		SECOND YEAR (13,700 MILES)		THIRD YEAR (12,500 MILES)		FOURTH YEAR (11,400 MILES)		FIFTH YEAR (10,300 MILES)		SIXTH YEAR (9,700 MILES)	
	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE
COST EXCLUDING TAXES:												
DEPRECIATION	1,849.00	12.75	1,050.00	7.66	915.00	7.32	735.00	6.45	665.00	6.46	460.00	4.74
SCHEDULED MAINTENANCE	(102.85)	(.71)	(193.20)	(1.41)	(286.58)	(2.29)	(153.75)	(1.35)	(162.00)	(1.57)	(211.23)	(2.18)
NONSCHEDULED REPAIRS AND MAINTENANCE	(66.75)	(.46)	(115.55)	(.84)	(438.69)	(3.51)	(279.95)	(2.46)	(485.85)	(4.72)	(642.08)	(6.62)
TOTAL REPAIRS AND MAINTENANCE	169.60	1.17	308.75	2.25	725.27	5.80	433.70	3.81	647.85	6.29	853.31	8.80
REPLACEMENT TIRES	14.02	.10	13.21	.10	12.05	.10	43.34	.38	62.24	.60	58.52	.60
ACCESSORIES	12.11	.08	11.59	.08	10.84	.09	10.16	.09	9.49	.09	16.72	.17
GASOLINE	930.34	6.42	879.02	6.42	801.98	6.42	731.40	6.42	660.82	6.42	622.30	6.42
OIL	11.25	.08	20.25	.15	20.25	.16	9.00	.08	24.75	.24	15.75	.16
INSURANCE	461.00	3.18	445.00	3.25	445.00	3.56	424.00	3.72	424.00	4.12	256.00	2.64
PARKING AND TOLLS	113.68	.78	107.10	.78	97.71	.78	89.25	.78	80.80	.78	76.10	.78
TOTAL	3,561.00	24.56	2,834.92	20.69	3,028.10	24.23	2,475.85	21.73	2,574.95	25.00	2,358.70	24.31
TAXES AND FEES:												
STATE:												
GASOLINE	68.69	.47	64.90	.47	59.21	.47	54.00	.47	48.79	.47	45.95	.47
REGISTRATION	20.00	.14	20.00	.15	20.00	.16	20.00	.18	20.00	.19	20.00	.21
TITLING	372.45	2.57	-	-	-	-	-	-	-	-	-	-
OPERATING COST SALES TAX 2/	(.09)	-	(.72)	(.01)	(10.75)	(.09)	(7.66)	(.07)	(14.41)	(.14)	(16.92)	(.17)
NONOPERATING COST SALES TAX	(.92)	(.01)	(2.01)	(.01)	(2.55)	(.02)	(1.63)	(.01)	(1.04)	(.01)	(2.91)	(.03)
TOTAL SALES TAX	1.01	.01	2.73	.02	13.30	.11	9.29	.08	15.45	.15	19.83	.20
SUBTOTAL	462.15	3.19	87.63	.64	92 51	.74	83.29	.73	84.24	.81	85.78	.88
FEDERAL:												
GASOLINE	30.53	.21	28.84	.21	26.32	.21	24.00	.21	21.68	.21	20.42	.21
OIL 2/	.08	-	.14	-	.14	-	.06	-	.17	-	.11	-
TIRES	3.25	.02	3.06	.02	2.81	.02	2.55	.02	2.31	.02	2.17	.02
SUBTOTAL	33.86	.23	32.04	.23	29.27	.23	26.61	.23	24.16	.23	22.70	.23
TOTAL TAXES	496.01	3.42	119.67	.87	121.78	.97	109.90	.96	108.40	1.04	108.48	1.11
OPERATING COSTS	1,238.68	8.54	1,232.79	9.00	1,469.91	11.76	1,241.21	10.89	1,401.82	13.60	1,500.32	15.46
OWNERSHIP COSTS	2,818.33	19.44	1,721.80	12.56	1,679.97	13.44	1,344.54	11.80	1,281.53	12.44	966.86	9.96
TOTAL OF ALL COSTS	4,057.01	27.98	2,954.59	21.56	3,149.88	25.20	2,585.75	22.69	2,683.35	26.04	2,467.18	25.42

TABLE 4 - ESTIMATED COST OF OWNING AND OPERATING

A COMPACT-SIZE 1981 MODEL AUTOMOBILE [1]

(TOTAL COSTS IN DOLLARS, COSTS PER MILE IN CENTS)

ITEM	FIRST YEAR (14,500 MILES)		SECOND YEAR (13,700 MILES)		THIRD YEAR (12,500 MILES)		FOURTH YEAR (11,400 MILES)		FIFTH YEAR (10,300 MILES)		SIXTH YEAR (9,700 MILES)	
	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE
COST EXCLUDING TAXES:												
DEPRECIATION	1,206.00	8.32	984.00	7.18	730.00	5.84	698.00	6.12	572.00	5.55	480.00	4.95
SCHEDULED MAINTENANCE	(66.10)	(.46)	(172.10)	(1.26)	(208.60)	(1.67)	(133.40)	(1.17)	(203.74)	(1.98)	(60.60)	(.62)
NONSCHEDULED REPAIRS AND MAINTENANCE	(67.00)	(.46)	(117.80)	(.86)	(360.87)	(2.89)	(255.13)	(2.24)	(471.68)	(4.58)	(741.51)	(7.64)
TOTAL REPAIRS AND MAINTENANCE	133.10	.92	289.90	2.12	569.47	4.56	388.53	3.41	675.42	6.56	802.11	8.26
REPLACEMENT TIRES	13.85	.10	13.05	.10	11.91	.10	42.82	.38	61.49	.60	57.83	.60
ACCESSORIES	14.44	.10	13.78	.10	12.84	.10	12.00	.11	11.15	.11	18.28	.19
GASOLINE	736.52	5.08	695.81	5.08	634.86	5.08	579.03	5.08	523.19	5.08	492.72	5.08
OIL	11.25	.08	20.25	.15	20.25	.16	9.00	.08	24.75	.24	15.75	.16
INSURANCE	461.00	3.18	445.00	3.25	445.00	3.56	424.00	3.72	424.00	4.12	256.00	2.64
PARKING AND TOLLS	113.68	.78	107.10	.78	97.71	.78	89.25	.78	80.80	.78	76.10	.79
TOTAL	2,689.84	18.56	2,568.89	18.76	2,522.04	20.18	2,242.63	19.68	2,372.80	23.04	2,198.79	22.66
TAXES AND FEES:												
STATE:												
GASOLINE	54.38	.38	51.37	.37	46.87	.37	42.75	.38	38.63	.38	36.38	.38
REGISTRATION	20.00	.14	20.00	.15	20.00	.16	20.00	.18	20.00	.19	20.00	.21
TITLING	355.55	2.45	-	-	-	-	-	-	-	-	-	-
OPERATING COST SALES TAX 2/	(.10)	-	(.73)	(.01)	(6.25)	(.05)	(6.32)	(.06)	(14.10)	(.14)	(18.68)	(.19)
NONOPERATING COST SALES TAX	(1.00)	(.01)	(1.27)	(.01)	(2.32)	(.02)	(.90)	(.01)	(2.75)	(.03)	(.91)	(.01)
TOTAL SALES TAX	1.10	.01	2.00	.02	8.57	.07	7.22	.07	16.85	.17	19.59	.20
SUBTOTAL	431.03	2.98	[illegible].37	.54	75.44	.60	69.97	.63	75.48	.74	75.97	.79
FEDERAL:												
GASOLINE	24.17	.17	22.83	.17	20.83	.17	19.00	.17	17.17	.17	16.17	.17
OIL 2/	.08	-	.14	-	.14	-	.06	-	.17	-	.11	-
TIRES	2.99	.02	2.83	.02	2.57	.02	2.35	.02	2.13	.02	2.00	.02
SUBTOTAL	27.24	.19	25.80	.19	23.54	.19	21.41	.19	19.47	.19	18.28	.19
TOTAL TAXES	458.27	3.17	99.17	.73	98.98	.79	91.38	.82	94.95	.93	94.25	.98
OPERATING COSTS	1,024.02	7.07	1,031.91	7.54	1,202.26	9.62	1,045.71	9.19	1,234.11	11.99	1,457.25	15.02
OWNERSHIP COSTS	2,124.09	14.66	1,636.15	11.95	1,418.76	11.35	1,288.30	11.31	1,233.64	11.98	835.79	8.62
TOTAL OF ALL COSTS	3,148.11	21.73	2,668.06	19.49	2,621.02	20.97	2,334.01	20.50	2,467.75	23.97	2,293.04	23.64

TABLE 5 - ESTIMATED COST OF OWNING AND OPERATING

A SUBCOMPACT-SIZE 1981 MODEL AUTOMOBILE [1]

(TOTAL COSTS IN DOLLARS, COSTS PER MILE IN CENTS)

ITEM	FIRST YEAR (14,500 MILES)		SECOND YEAR (13,700 MILES)		THIRD YEAR (12,500 MILES)		FOURTH YEAR (11,400 MILES)		FIFTH YEAR (10,300 MILES)		SIXTH YEAR (9,700 MILES)	
	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE
COST EXCLUDING TAXES:												
DEPRECIATION	956.00	6.59	776.00	5.66	580.00	4.64	551.00	4.83	450.00	4.37	383.00	3.95
SCHEDULED MAINTENANCE	(96.85)	(.67)	(177.85)	(1.30)	(205.53)	(1.64)	(138.40)	(1.21)	(152.15)	(1.48)	(122.28)	(1.26)
NONSCHEDULED REPAIRS AND MAINTENANCE	(67.00)	(.46)	(113.80)	(.83)	(304.98)	(2.44)	(212.63)	(1.87)	(459.55)	(4.46)	(653.35)	(6.74)
TOTAL REPAIRS AND MAINTENANCE	163.85	1.13	291.65	2.13	510.51	4.08	351.03	3.08	611.70	5.94	775.63	8.00
REPLACEMENT TIRES	12.40	.09	11.68	.09	10.66	.09	38.32	.34	55.01	.53	51.75	.53
ACCESSORIES	14.96	.10	14.27	.10	13.29	.11	12.41	.11	11.52	.11	18.63	.19
GASOLINE	631.32	4.35	596.46	4.35	544.16	4.35	496.25	4.35	448.47	4.35	422.26	4.35
OIL	9.00	.06	18.00	.13	18.00	.14	9.00	.08	22.50	.22	13.50	.14
INSURANCE	415.00	2.86	401.00	2.93	401.00	3.21	373.00	3.27	373.00	3.62	243.00	2.51
PARKING AND TOLLS	113.68	.78	107.10	.78	97.71	.78	89.25	.78	80.80	.78	76.10	.78
TOTAL	2,316.21	15.96	2,216.16	16.17	2,175.32	17.40	1,920.26	16.84	2,053.00	19.92	1,983.87	20.45
TAXES AND FEES:												
STATE:												
GASOLINE	46.61	.32	44.04	.32	40.18	.32	36.64	.32	33.11	.32	31.18	.32
REGISTRATION	20.00	.14	20.00	.15	20.00	.16	20.00	.18	20.00	.19	20.00	.21
TITLING	281.25	1.94	-	-	-	-	-	-	-	-	-	-
OPERATING COST SALES TAX 2/	(.10)	-	(.53)	-	(6.98)	(.06)	(4.68)	(.04)	(11.07)	(.11)	(13.93)	(.14)
NONOPERATING COST SALES TAX	(1.06)	(.01)	(1.67)	(.01)	(1.66)	(.01)	(1.27)	(.01)	(1.19)	(.01)	(1.89)	(.02)
TOTAL SALES TAX	1.16	.01	2.20	.01	8.64	.07	5.95	.05	12.26	.12	15.82	.16
SUBTOTAL	349.02	2.41	66.24	.48	68.82	.55	62.59	.55	65.37	.63	67.00	.69
FEDERAL:												
GASOLINE	20.72	.14	19.57	.14	17.86	.14	16.28	.14	14.72	.14	13.86	.14
OIL 2/	.06	-	.12	-	.12	-	.06	-	.15	-	.09	-
TIRES	2.33	.02	2.20	.02	2.00	.02	1.82	.02	1.65	.02	1.56	.02
SUBTOTAL	23.11	.16	21.89	.16	19.98	.16	18.16	.16	16.52	.16	15.51	.16
TOTAL TAXES	372.13	2.57	88.13	.64	88.80	.71	80.75	.71	81.89	.79	82.51	.85
OPERATING COSTS	903.22	6.22	913.50	6.66	1,042.64	8.34	904.93	7.94	1,127.03	10.93	1,277.58	13.17
OWNERSHIP COSTS	1,785.12	12.31	1,390.79	10.15	1,221.48	9.77	1,096.08	9.61	1,007.86	9.78	788.80	8.13
TOTAL OF ALL COSTS	2,688.34	18.53	2,304.29	16.81	2,264.12	18.11	2,001.01	17.55	2,134.89	20.71	2,066.38	21.30

TABLE 6 - ESTIMATED COST OF OWNING AND OPERATING

A 1981 MODEL PASSENGER VAN[1]

(TOTAL COSTS IN DOLLARS, COSTS PER MILE IN CENTS)

ITEM	FIRST YEAR (14,500 MILES)		SECOND YEAR (13,700 MILES)		THIRD YEAR (12,500 MILES)		FOURTH YEAR (11,400 MILES)		FIFTH YEAR (10,300 MILES)		SIXTH YEAR (9,700 MILES)	
	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE	TOTAL COST	COST PER MILE
COST EXCLUDING TAXES:												
DEPRECIATION	3,983.00	27.47	1,846.00	13.47	1,361.00	10.89	847.00	7.43	696.00	6.76	665.00	6.86
SCHEDULEO MAINTENANCE	(96.85)	(.67)	(177.85)	(1.30)	(205.53)	(1.64)	(138.40)	(1.21)	(152.15)	(1.48)	(122.28)	(1.26)
NONSCHEDULED REPAIRS AND MAINTENANCE	(67.50)	(.47)	(161.53)	(1.18)	(626.81)	(5.01)	(186.09)	(1.63)	(632.59)	(6.14)	(819.04)	(8.44)
TOTAL REPAIRS AND MAINTENANCE	164.35	1.14	339.38	2.48	832.34	6.65	324.49	2.84	784.74	7.62	941.32	9.70
REPLACEMENT TIRES	15.12	.10	14.24	.10	59.72	.48	94.96	.83	85.82	.83	80.84	.83
ACCESSORIES	18.09	.12	17.28	.13	16.13	.13	15.11	.13	14.08	.14	43.91	.45
GASOLINE	1,262.52	8.71	1,192.91	8.71	1,088.45	8.71	992.63	8.71	896.82	8.71	844.65	8.71
OIL	13.50	.09	24.75	.18	24.75	.20	11.25	.10	29.25	.28	18.00	.19
INSURANCE	585.00	4.03	567.00	4.14	567.00	4.54	544.00	4.77	544.00	5.28	360.00	3.71
PARKING AND TOLLS	113.68	.78	107.10	.78	97.71	.78	89.25	.78	80.80	.78	76.10	.78
TOTAL	6,155.26	42.44	4,108.66	29.99	4,047.10	32.38	2,918.69	25.59	3,131.51	30.40	3,029.82	31.23
TAXES AND FEES:												
STATE:												
GASOLINE	93.21	.64	88.07	.64	80.36	.64	73.29	.64	66.21	.64	62.36	.64
REGISTRATION	30.00	.21	30.00	.22	30.00	.24	30.00	.26	30.00	.29	30.00	.31
TITLING	643.85	4.44	-	-	-	-	-	-	-	-	-	-
OPERATING COST SALES TAX 2/	(.13)	-	(1.65)	(.01)	(16.69)	(.13)	(2.63)	(.02)	(16.16)	(.16)	(20.57)	(.21)
NONOPERATING COST SALES TAX	(1.21)	(.01)	(1.82)	(.01)	(1.81)	(.01)	(1.41)	(.01)	(1.31)	(.01)	(3.16)	(.03)
TOTAL SALES TAX	1.34	.01	3.47	.02	18.50	.14	4.04	.03	17.47	.17	23.73	.24
SUBTOTAL	768.40	5.30	121.54	.88	128.86	1.02	107.33	.93	113.68	1.10	116.09	1.19
FEDERAL:												
GASOLINE	41.43	.29	39.14	.29	35.72	.29	32.57	.29	29.43	.29	27.72	.29
OIL 2/	.09	-	.17	-	.17	-	.08	-	.20	-	.12	-
TIRES	6.53	.05	6.18	.05	5.63	.05	5.14	.05	4.64	.05	4.37	.05
SUBTOTAL	48.05	.34	45.49	.34	41.52	.34	37.79	.34	34.27	.34	32.21	.34
TOTAL TAXES	816.45	5.64	167.03	1.22	170.38	1.36	145.12	1.27	147.95	1.44	148.30	1.53
OPERATING COSTS	1,613.71	11.13	1,635.74	11.94	2,036.01	16.29	1,487.89	13.04	1,841.92	17.88	1,953.77	20.14
OWNERSHIP COSTS	5,358.00	36.95	2,639.95	19.27	2,181.47	17.45	1,575.92	13.82	1,437.54	13.96	1,224.35	12.62
TOTAL OF ALL COSTS	6,971.71	48.08	4,275.69	31.21	4,217.48	33.74	3,063.81	26.86	3,279.46	31.84	3,178.12	32.76

Energy

Home Study

TRANSPORTATION

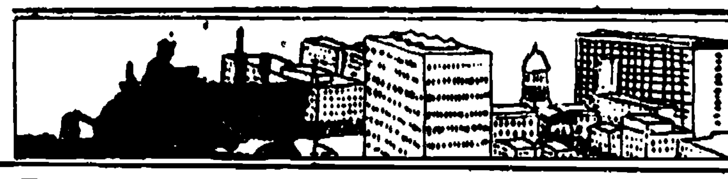
The survey will be introduced after discussing several of the fact sheets on energy use and transportation, and after discussing some of the advantages and disadvantages of the automobile. A preliminary show of hands may dramatize the extent to which each student's family uses the car. Then discuss the idea of collecting information on actual car use in such a way that it could be shown on a map representing the activities of all class members and their families. This will help to structure the questions to be asked. Items to be discussed will probably include the following:

1. What information is to be collected? Basically the purpose of the survey is to record all automobile trips, made for whatever purpose, by any member of the student's immediate household, during the period of the survey.
2. How should the information be collected? The best method is to have a form, developed by the class, with headings for the appropriate items of information. The student, or someone in the family, could fill in the information each time the car made a trip.
3. What would be the best unit for recording travel? Probably the best unit is to record trips, defined as one way trips from an origin (such as home) to a destination (such as school, or work or shopping).
4. What information should be recorded for each trip? At least the following: The origin, the destination, the trip purpose, the actual distance traveled, and the car used. In place of the distance traveled, the actual odometer readings could be recorded, and the trip distance then calculated from that. The purpose of noting the car used is to determine, roughly, the amount of gas used based on the average miles per gallon for that type of vehicle. Other possible items might include the time of day, the number of people in the car, and the driver's name.
5. Can the trips be grouped by type? Yes, and it will facilitate compiling the data later. Basic categories of trips used in most transportation surveys include work, school, shopping, recreation, medical, and other. The class may wish to add several additional categories. They should also decide how to handle trips with more than one purpose, such as school and shopping. This may depend on whether one of the purposes is clearly secondary or incidental to the other.
6. How long should the survey period be? This is a compromise between thoroughness and expediency. The most representative survey would be one covering all trips made by the household for an entire week, including the weekend. This would, however, slow down the sequence of classes considerably, and might lead to sloppiness and lax recording toward the end of the survey period. Since the purpose is to simply collect representative auto use estimates, a period of two or three days should be sufficient.

7. How should the physical survey form be handled? As the survey is developed during class discussion, the columns of needed information can be mocked up on the blackboard. Copy them on blank sheets or, have a student assigned to copy the material and, after review by the teacher, reproduce enough copies for the entire class. A sample survey form is included with this material.

Energy

Community Study



TRANSPORTATION

For this activity the class can be divided into two committees: one to map the information and to sum up the quantitative information. These committees can be working simultaneously.

1. Compiling the data

   The team assigned to compile the data should first check that it has all the survey forms. Team members can quickly number the forms for reference and then give a batch to the map committee to work on. They can then divide their team's work into two parts: (a) checking each form to complete missing data and (b) adding up the data.

   For each form received, team members will check to see that all items of information are included. If items are missing they can ask the individual student and try to complete the forms. Other items, like mileage per trip can be roughly estimated, if missing, based on map information. One person can be responsible for filling in the average mileage figures for the individual car, based on a separate data sheet provided. Another person can then divide total trip miles by mpg to calculate gas consumption for each trip.

   With the forms complete, the committee can then compile total figures according to category of trip purposes. The figures collected would include a number of trips for each purpose, total and average miles driven for each category of trip purpose, and gas consumption. These final figures can then be presented on the blackboard for class review.

2. Mapping the trips

   The team assigned to map the data should include students familiar with all parts of town and proficient at map reading. This team's job is to identify, on the map, the starting and end point of each trip and then to draw a line connecting those points using a designated color for each different trip purpose. No attempt should be made to draw the lines along actual streets. The purpose of this map is to show travel "desire lines" - the lines which would in fact be followed if a driver were able to go straight to the desired destination. In a major traffic survey these lines might in fact be generated by a computer, using the coordinates for each end of the trip. If the class is concurrently involved in computer graphics, this could be fairly readily done, but the manual method will be quicker for most small class surveys. A simple method to avoid confusion may be to use straight pins to mark each end of the trip, and then to align the straightedge on the pins and draw in the appropriate line. Be sure then to remove the pins before marking the next line!

The result should be a map which graphically displays the auto use pattern of the entire class sample at a glance. Together with the numerical data, this can then serve as a basis for discussion.

3. Analyzing the information

With all information displayed, including the mapped lines and the numerical figures, class discussion can then focus on identifying patterns and looking for possible ways to cut travel and energy use. Some of the issues to raise are the following:

(a) Are there particular "clusters" of trip ends? (Usually it will be obvious by the location as to whether these are the "home" ends or the purpose oriented ends of the trips).
(b) Are these clusters located in a place served by public transportation, or by any feasible alternative to the car?
(c) Does it appear that the cluster destinations are generally centrally located, with easiest access for most people, or are they located off center or outside the community, forcing everyone to travel long distances to reach them?
(d) How do the different categories of trip purpose compare in their number of trips, average trip length, and total miles driven? Are there some areas where trip reductions seem most feasible?
(e) Are there combinations of destinations so that trips can serve more than one purpose? In the students individual experience, how often were the trips combined?
(f) Are there possibilities for carpooling to common destinations? How often was that done in the survey sample, and what would it take to organize more carpools?
(g) Are there trips of relatively short distance (1 mile or less for walking; 2-3 miles for bicycling) which could be reached by walking or bicycling instead of taking the car? What would be the advantages and disadvantages of doing this instead of driving?
(h) How much gas could be saved if all trips were made at the EPA mandated new car economy standards of 27.5 miles per gallon, as a fleet average, by 1985?

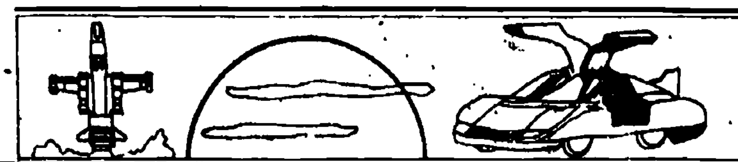
4. Drawing conclusions

Based on the foregoing discussion, the class may want to discuss the degree to which their (and their household's) use of the automobile could be reduced or made more efficient, by alternatives which are already available in the community. One way to structure this might be to divide students into teams, and ask each team to prepare plans for reducing automobile energy consumption in the community by 10%, and by 25%. The plans would focus solely on the trip data generated by the survey, and would consist of a combination of measures which together would reduce trip mileage and/or energy consumption, by the desired amount. The plans might also note side benefits which might occur from the proposed reductions in auto energy consumption, as well as potential drawbacks. Suggest that students discuss their findings at home, since household members will already have been sensitized to the subject through the survey in the previous days. Family discussion may lead to ways in which individual schedules might be adjusted to make more multi-purpose trips possible.

As a final exercise, the class could extend their conclusions to fit the larger community. Assuming that the class and its households are representative of the entire community, how many trips, how much mileage, and how much energy is consumed by the entire community (Divide # of households in the class into total number of households from census information). Similarly, if the community could reduce trips by the 10% and 25% plans suggested previously, how many trips, and how much mileage and energy could be saved? At the current price of gasoline, what would this mean in terms of dollars per year that would not have to leave the community to buy fuel?

Energy

21st Century



TRANSPORTATION

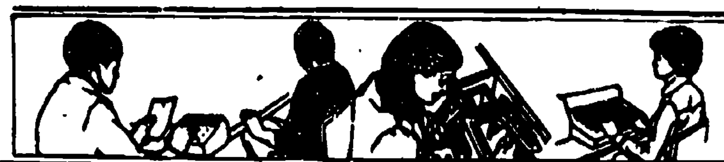
According to most predictions of the future, energy will become scarcer and more expensive. Oil reserves especially are believed to be near exhaustion, which means that gasoline will become more costly and scarce. We believe this is very likely to occur. We believe that wise planning for the future will help prepare for a world of energy shortages.

In contrast, imagine that vast new supplies of oil are discovered, or imagine some technical invention that makes it possible to power automobiles cheaply and without pollution problems. This is called a "technical fix" scenario - the idea that a new invention will solve all our problems.

Let your imagination run wild, and imagine a situation of almost unlimited auto use and ownership. Would this lead to any changes in our cities, in our living patterns and in our social system? This can be a lead to other discussions which focus on designing transportation systems.

Energy

Careers



TRANSPORTATION

The automobile creates a large number of jobs, both directly and indirectly. The automobile industry employs 5% of all workers in the U.S. The percentage in Indiana is much higher.

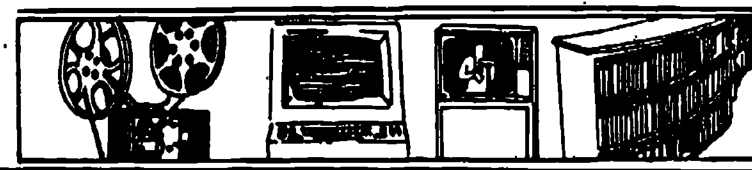
Have a class discussion about how recent changes in the auto industry affect jobs in Indiana. Should there be quotas on imported cars, or does this increase the price to the automobile buyer? Should there be more or less automation in the industry? Family members working in an auto factory might talk to the class about their job, and about changes they see happening.

The automobile also creates other jobs and careers. These include direct jobs (those repairing cars, or providing gasoline) and indirect jobs (jobs in tourist areas, for example, which depend on the auto to bring customers). Find as many examples as possible of each category of job. The school vocational guidance counselor may be able to supply careers related to the automobile.

Discuss with the class how these jobs have changed. Are there new jobs appearing, and old ones disappearing? What will happen if we use the automobile less in the future, or if we use less gas to drive the same number of miles? Will new jobs take the place of old, or will there be a decrease in employment?

Energy

Resources



TRANSPORTATION

1. Obviously there are many books available on the automobile. There are fewer books on the costs of automobiles, or on its future in an energy scarce world. Some that may help are:

   U. S. Department of Transportation (1982). Cost of owning and operating automobiles and vans. Washington, D.C.

   The state department of transportation and the local police department, engineers office, or planning department can help with data on the amount of auto use in your town. Ask to look at the town transportation plan, or Transportation Systems Management study.

2. The following resources can be obtained by writing to the addresses listed:

   (a) Your automobile dollar, and Your financial plan, Money Management Institute, Household - Department FI, 2700 Sanders Road, Prospect Heights, Illinois 60070.

   (b) Some straight talk on how to buy a used car, National Independent Automobile Dealers Association, 3700 National Drive, Suite 208, Raleigh, North Carolina 27612.

3. The following films can be obtained from the Indiana University Audio Visual Center:

   (a) Oil in the middle east NSC 1302

   Interviews industry executives, oil ministers of Saudi Arabia, Kuwait, and Iran; explores internal conflicts of oil producing countries and external conflicts with the U.S.

   (b) Oil in the U.S. NSC 1302

   Interviews with U.S. oil executives, examines the supposed oil conspiracy perpetrated by the oil companies.

PURPOSE: The purpose of this lesson is to encourage students to explore three alternatives to the conventional automobile -- electric auto, and ride sharing -- as ways to conserve energy.

APPROXIMATE TIME: If each of the following activities is used approximately nine class hours will be needed. This estimate does not include use of supplemental resources.

READABILITY: The Bormuth Readability Index was used to determine the reading level of text material in this lesson.

Ave. Word Length: 5.12

Ave. Sentence Length: 22.8

Readability Index: 66.8

Grade Level Equiv.: 9-10

OBJECTIVES

INQUIRY	DECISION-MAKING	TAKING ACTION
1. Students will examine non-conventional forms of auto transportation.	1. Students will recognize conditions under which non-conventional autos should be considered important transportation alternatives.	1. Students will determine when an energy problem warrants non-conventional auto use.
2. Students will illustrate reasons for growing interest in non-conventional forms of auto transportation.	2. Students will explore the effects of non-conventional autos in a variety of situations.	2. Students will analyze data upon which the use of non-conventional autos would be beneficial.
3. Students will analyze the relationship between energy use and non-conventional auto use.	3. Students will predict the consequences of non-conventional auto use on personal convenience, energy consumption, and economics.	3. Students will determine when a change to more non-conventional auto use would be feasible.
4. Students will examine the efficiency of non-conventional forms of auto use.	4. Students will rank order the most effective uses of non-conventional autos under varying conditions.	4. Students will explore potential effects of expanded non-conventional auto use.
5. Students will compare energy efficiency of non-conventional auto use to their effectiveness as a form of transportation.		5. Students will propose an appropriate plan for non-conventional auto use in their community.
6. Students will develop a conclusion as to the most beneficial uses of non-conventional autos in terms of energy consumption.		6. Students will judge the results of their proposals.

Carpooling - the use of one car to take passengers from more than one household to a common destination, typically a place of work.

Compressed natural gas - an alternative fuel which can be burned in a conventional gasoline engine, with advantages of cleaner burning, reduced maintenance, lower cost, and less dependence on imported petroleum.

Deep discharge batteries - batteries capable of being fully discharged and recharged repeatedly, without damage to the battery. Electric automobiles require such batteries, as do golf carts and boats. Regular automobile batteries do not have this capability.

Electric automobile - an automobile powered by a series of storage batteries, which must be externally recharged after each trip.

Emissions - the by-products of combustion in an automobile engine, which emerge from the exhaust pipe and cause air pollution.

Energy density - a measure of the amount of potential electric energy contained in a storage battery of a given weight. Usually described as watt-hours per pound. Conventional batteries store 16-20 watt-hours per pound.

Lead acid battery - the conventional storage battery used in automobiles today. Because of its high weight it has a low energy density, and this limits the range and performance of electric vehicles.

Methane - a gas derived from organic decomposition, as in a sewage plant or landfill. It can be compressed and burned in an automobile engine.

Passenger miles - a measure of transit or ridesharing performance. A bus carrying 10 people and going 5 miles produces 50 passenger miles.

Passenger miles per gallon - the number of passenger miles produced by one gallon of fuel. If the bus in the above example gets 10 miles per gallon, it will burn ½ gallon and produce 100 passenger miles per gallon.

Photo-voltaic cells - thin glass wafers with chemical properties such that they produce electricity when exposed to sunlight. Can be used to recharge storage batteries for electric cars.

Ridesharing - any system of combining passengers who would otherwise drive individual vehicles. Includes carpooling and vanpooling.

Vans - vehicles with 10-15 passenger capacity, used for community, for demand responsive transit, and for special services for elderly or handicapped.

Vanpooling - use of a van by a group of commuters going to the same destination, and driven by one member of the group. The ban may be owned by an individual or leased by the entire group.

ELECTRIC AUTOMOBILES

Historical Background

The current interest in electric automobiles often overlooks the fact that in the early years of the automobile, such cars were quite popular. They were commercially available from a number of companies in the U.S., and they appealed to a market which wanted a simple, trouble free car for short in-town trips. At a time when the gasoline automobile often required mechanical know-how to keep running, and a strong arm to start, the electric appealed to people who did not want to have to be automobile mechanics in order to have their own transportation. The electric car was heavy (due to its batteries), slow, and of limited cruising capability, but it was reliable and simple to operate. It became characterized, and perhaps stigmatized, as a car for recreational purposes.

As the gasoline powered car improved in reliability and ease of operation, the electric car was eliminated from the private car market. Electric delivery trucks continued to be made for special door to door services like mall delivery, but this manufacture ceased in the U.S. by 1940, although continuing in Europe. Except for a few inventors, there was little interest in the electric until the 1970s, when it again emerged as a possible alternative to the pollution and oil dependence of the conventional automobile.

Current Technology

The modern electric car may be custom designed, or it may resemble, and often actually be, a converted gasoline car. Under the skin, however, its technology has changed relatively little from its early 20th Century predecessor. The car is powered by one or more direct current motors, coupled directly to the wheels or the drive axle. Because the electric motor can deliver power over a broad range of speeds, no transmission is necessary, and the small size of the motors permits them to fit conveniently next to the axle.

Figure 1: Electric Car

Electricity for the motors is derived from a bank of storage batteries, which must be externally recharged after each trip. The electricity is fed to the motors by solid state electronic controls, energy efficient devices which are probably the biggest advance in electric vehicle technology over the early electric models. Everything else would be familiar to the early 20th Century electric vehicle mechanic.

A few ultra-light vehicles have been constructed which generate electricity directly from a roof-top array of photo-voltaic solar cells. Except for demonstration purposes, however, there is not enough energy density in sunlight to propel a vehicle even under bright sun conditions. The result is that electric vehicles depend upon energy which is externally generated at a conventional power plant. Power is then fed through lines to household electric outlet, where a battery charger converts the 110 volt alternating household current into low voltage direct current which feeds the batteries. A chemical reaction occurs in the battery which restores the charge in each battery. In the typical lead-acid automobile storage battery, a lead component at one electrode interacts with a sulphuric acid solution in each battery cell, releasing electrons which flow through the circuit to provide power. When the battery is recharged, electrons are forced to flow in the opposite direction, restoring the original chemical balance.

The battery remains the weakest link in electric car technology. The conventional automobile battery is too heavy with respect to the amount of energy it can store. While not a problem for intermittent use such as starting a car engine, this is a severely limiting factor for storing basic motive power, and tends to severely restrict either the automobiles range, or its performance, or both. Simply adding more batteries doesn't solve the problem, since a large part of the stored energy of each battery may be needed simply to move the weight of the battery itself.

Conventional batteries are unable to take repeated cycles of heavy discharge and recharge. While batteries for golf cart or marine use are designed for so-called deep discharge, they are more expensive than standard batteries. Battery replacement, as well as initial expense, is a cost factor in the consideration of electric automobiles.

Because of battery problems, the cruising range of contemporary electric cars tends to be 60 miles or less between recharges, at relatively modest speeds. While sufficient for much commuting or local errands, the electric car could not serve for long business or vacation trips. Research focuses on new designs of batteries which will have a higher energy density -- a greater number of watt-hours stored per pound. Lead-acid batteries produce only 16-20 watt-hours per pound, while it has been estimated that an energy density of 90 watt-hours per pound would be necessary to provide an automobile cruising range of 100 miles.

Possible alternative batteries would use molten sodium and sulphur as electrodes. While requiring constant high temperatures of 250° to 330° C in the batteries, they would have an energy density of 200 watt-hours per pound, over ten times better than present battery technology. Energy Development Associations, a Gulf & Western subsidiary, has developed zinc chloride batteries with an energy density of 29 watt-hours per pound. Batteries totalling 636 kg (1390 lbs.) propelled a 4 passenger car for 150 miles at an average 50 mph. The company is now develpping battery applications for delivery vans, seeing these as a logical market for commercial applications. Batteries driving a 28 hp motor will drive a van with a 1,000 lb. payload capacity at a top speed of 55 miles per hour and an operational range in excess of 80 miles.

In Philadelphia, converted Volkswagon Rabbits with lead-acid batteries are capable of 25 miles per charge. Fuel use has been estimated at .74 kilowatt hours (KWH) of electricity per mile. If this energy were purchased at a typical market price of 5¢/KWH, the "fuel cost" for the electric vehicle would translate to 3½ cents per mile for in-city driving. This would be equivalent to buying gasoline at $1.25 per gallon for a car getting 35 miles per gallon, a very high mileage figure for in-city driving. Maintenance costs have been estimated to be lower for electric vehicles than for internal combustion, so the overall cost per mile is probably less.

Advantages

The greatest energy related advantage of the electric car is the fact that the electricity used can be generated by any fuel capable of power plant use, including coal and nuclear energy. Widespread conversion to electric cars would not substantially reduce overall energy use. It would permit switching away from the heavy reliance which our automobiles now have on petroleum, thereby extending the life of present reserves and reducing our dependence on imported oil. Total reduction of energy use would depend heavily on the type of service in which the vehicle was used. In strictly local traffic and delivery service, where a conventional internal combustion engine spends much of its time idling, a total energy reduction would be possible. In sustained highway operation it is not clear that there would be savings apart from fuel substitution. In addition, the electric car would have the following non-energy advantages: (a) quiet operation, (b) mechanical simplicity, and (c) non-polluting - no exhaust fumes.

Disadvantages

The greatest disadvantage is the increased dependence which the electric automobile would place on centrally generated power plant electricity, a form of power which is rapidly increasing in price. While power plants permit efficient utilization of fuel in the initial generation of electricity, losses in transmission lines and transformers reduce the theoretical efficiency. A further loss occurs at the point of battery charging since only 80% of the energy used to charge the battery can be recovered for useful work.

In nonenergy terms, the greatest disadvantages are the presently limited range and performance of electric vehicles, as well as the high costs of providing and replacing the batteries. Since there is now no network of commercial recharging stations, the electric vehicle is effectively limited to an area around its "home" charging station. Even if this changed, the time required to recharge would preclude the long distance trips.

Examples of Application

A number of experimental vehicles have been built to demonstrate the mechanical soundness of the idea. Electric golf carts are a widespread application for low speed short range transportation, and small electric vehicles are widely used in industrial service or institutional maintenance.

Using grants from the Federal Electric and Hybrid Vehicle Demonstration Program, several cities have made trial fleet applications. Tucson, Arizona operates 10 electric vehicles, six converted Datsun sedans and 4 Datsun pick-up trucks, each carrying 18 6-volt lead-acid batteries. The vehicles are use for a variety of in-town maintenance and shuttle duties. Air conditioners are included to combat the 100 degree summer temperature in Tucson; experience to date indicates that the air conditioners do not cut too deeply into the vehicles usable range. Maintenance costs are appreciably lower for the electric vehicles than for conventional internal combustion vehicles.

In Philadelphia, the city electric utility uses 20 converted electric vehicles, including Volkswagon Rabbits and Vans, Volta Vans and one Ford Fairmont. Most of the vehicles have a range of 25 miles or more per charge. The electric vehicles are used for meter reading, field checking on equipment, and customer service calls.

Another interesting application in Phoenix, Arizona, is provided by a private homebuilder named John F. Long. Using Federal demonstration money, Long has built and sold homes with roof top solar arrays of photo voltaic cells, capable of generating enough electricity to make the homes more than electrically self-reliant. As an option, buyers of houses starting at $100,000 can also purchase an electric car, either a converted Datsun Sedan, Chevrolet Citation, or Chevrolet LUV pick-up truck, at a competitive price. Plugged in to the house's electrical system, the vehicle's batteries will be charged by surplus energy from the roof top solar cells, making the homeowner independent of external energy purchases for local transportation as well as for the house. While a special example, this illustrates the use of modern technology to return to a degree of self-reliance known previously by the farmer who heated and cooked with wood from his own lot, and traveled by horse or wagon on the energy generated by oats grown on the farm.

Compressed Natural Gas Vehicles

Conventional automobile engines run, as everyone knows, on gasoline, a liquid derived from petroleum during the refining process. The same engines however, will also run on natural gas, the gas which is extracted directly from the ground, shipped by pipeline, and widely used for home heating. In fact, there are significant advantages to burning natural gas in a vehicle engine. It burns cleaner, causes fewer maintenance problems, and is significantly less polluting, an advantage which has environmental benefits and cost benefits, since expensive antipollution equipment is not needed on the car. The primary problem involves handling the fuel. Since it is normally a gas rather than a liquid it cannot simply be poured into the vehicle, and it must either be stored under high pressure or stored in a very large container. Problems of fuel handling, and the historical cheapness of gasoline, have probably kept natural gas from being more widely used.

The same principles that apply to natural gas also apply to other gaseous fuels such as methane, a gas given off by organic decomposition and sometimes referred to as marsh or swamp gas. Methane is produced in large quantities by decomposition of sewage wastes and of wastes deposited in sanitary land fills. If the gas could be captured and piped to the user, more methane would be needed than natural gas, since natural gas contains about 1000 BTUs per cubic foot and methane contains only 600 BTUs per cubic foot.

Various forms of gaseous fuel have been used in motor vehicles in the past, especially during times of critical shortage of regular gasoline. World War II, when gasoline was rationed in the U.S. and in Europe, saw various experiments, including a German car which ran on methane gas from rotten potato peels! Interest in recent years has increased because of the beneficial non-polluting nature of methane, because of cost savings at current prices, and because of its ability to replace an imported fuel with a domestically produced one, increasing both our national security and our balance of payments.

Current Technology

Vehicles burning natural gas or methane are basically conventional gasoline vehicles, with an added fuel storage and metering system for the gaseous fuel. Conversions take one of two forms: either a complete conversion to natural gas, or a dual fuel system which permits the driver to select either natural gas or gasoline with a dashboard switch. Dual fuel systems give added flexibility, including the ability to refuel at a conventional gas station when out of range of the natural gas supply point. At the same time the dual fuel system reduces some of the savings, since it requires maintaining the conventional carburator, gas tank, and exhaust catalytic converter as well as the natural gas system. Compromises are also necessary on spark timing, since the optimal and most fuel efficient timing differs for gasoline and for natural gas.

Figure 2: Natural Gas Car

In either form of conversion, the principal change is the addition of a pressurized fuel tank, piping, and gas mixer to burn the new fuel. The tank is the heaviest addition. Steel cylinders holding the compressed natural gas under high pressure weigh about 200 pounds and hold enough compressed natural gas (CNG) for a range of 200+ kilometers (120 miles). Aluminum tanks are now becoming available which have half the weight of steel for a comparable capacity. Because of its size, the tank (or tanks) are usually placed, in the trunk, somewhat reducing trunk capacity.

High pressure CNG from the tank flows through a pressure reducer to get back to a desirable pressure for burning in the engine. Valves control pressure, and switch from gasoline to CNG when desired. An air/fuel mixer performs the same function as a carburator in a conventional car. The total installed cost of conversion is about $1200-$1500 per vehicle, and the conversion is expected to pay for itself in 1½ to 4 years, depending on the average mileage driven.

A major component of the CNG technology is the refueling station. Natural gas or methane must be compressed to high pressure before fueling the vehicle. The cost of the compressor station may be $100,000, a cost which needs to be distributed over the number of vehicles used. This means that it is usually impractical to convert fewer than 20 vehicles and still achieve any cost savings. Conversions so far have normally involved entire fleets of city vehicles, school bus or transit vehicles. Until public CNG stations are available, it will not be economical for private owners to convert their cars, despite the fuel and maintenance savings.

Advantages

CNG or methane have numerous advantages over regular gasoline, including energy advantages, environmental advantages, and cost advantages.

The energy advantages involve the substitution of a domestic fuel, natural gas, for an imported petroleum derived fuel. It is believed that natural gas reserves are available in larger quantities than petroleum reserves, natural gas reduces our dependence on foreign imports, particularly from politically unstable areas.

Further energy advantages occur from the use of methane, which can often be locally generated as a by-product of sewage or garbage waste disposal. In this way a community can become more self-reliant by reducing the total amount of fuel it imports from all sources, foreign and domestic. While not as pure or as efficient a fuel as natural gas, methane may become widely available on a local basis.

From an environmental perspective, both natural gas and methane are superior to gasoline. They burn cleanly, improve ignition, and would have a significant positive effect on air quality in congested city areas. Even the conversion of particular fleets, such as transit buses, could help air quality along heavily traveled downtown corridors, making the streets pleasant for pedestrians and cyclists as well.

From a cost viewpoint, most studies show natural gas to currently cost 40 to 60 cents per equivalent gallon of gasoline. These substantial savings are somewhat reduced by the cost of compressing the gas. One current fleet conversion in Minnesota involving 65-100 vehicles estimates the equivalent price to be 73 cents per gallon, including compressing and fueling costs. This is still a significant reduction over gasoline costs. Maintenance is reduced to 30,000 to 50,000 miles between oil and spark plug changes and tune-ups.

Disadvantages

The principal disadvantages at present include the initial cost of vehicle conversion ($1200-1500 per vehicle), a cost which may be somewhat reduced as the market for individual components increases. Other disadvantages include the weight and space occupied by the pressure gas tanks, and the inability to get fueled beyond the service area of the base station. The cost of the base station, and the inavailability of public stations, has limited effective conversions so far to large fleets, either municipal or private. Other countries have taken the lead in providing public fueling stations for natural gas vehicles. New Zealand now has 46,000 dual fuel natural gas vehicles, supported by a network of 130 public fueling stations. The country expects 200,000 natural gas vehicles (NGVs) by 1990. The Canadian government is currently offering $50,000 grants per station in order to establish a national network of 125 natural gas fueling stations across Canada, expecting to have 2.3 million natural gas fueled vehicles by 1992. Some form of U.S. encouragement for public fueling stations may be necessary to extend the benefits of CNG vehicles to small fleet operators or private individuals.

Applications

As noted, a number of public and private vehicle fleets run on dual fuel Compressed Natural Gas systems, including a school system in Syracuse, New York, a large taxi cab fleet in British Columbia, a police department in Pennsylvania, a 65 vehicle gas company fleet in Minnesota, and many others. A Pennsylvania school district developed its own natural gas wells between 1978 and 1980, and uses them to power its fleet of 34 vehicles as well as heat the buildings. The wells paid for themselves in 17 months.

Even more interesting, from an energy self-reliance perspective, have been the conversions using locally generated methane gas. Modesto, California, powers its municipal fleet of 200 vehicles with methane derived fuel, and estimates that the average household generates the methane fuel equivalent of 17 gallons of gas per year in their sewage effluent and garbage. Hagerstown, Maryland, has converted the municipal fleet to burn liquified methane from the sewage plant, calculating that it will cost the equivalent of 35¢ per gallon of gasoline equivalent. In addition, the money spent will circulate mostly within the local economy, rather than going outside to purchase imported fuel. Along with other measures now being adopted, Hagerstown expects its sewage plant to eventually earn money for the city rather than just costing to dispose of waste. This ability to generate energy locally can be a key ingredient in economic development, since a dollar saved or recycled locally is the same as new dollar brought into the community. It has been estimated that by 1980 more than 20 percent of the gross income of a community is paid for energy, 90 percent of those dollars leaving the community rather than recirculating to create extra employment.

CNG and methane powered vehicles seem to be poised on the brink of a very rapid expansion, if the problems of an available public fueling station can be overcome. The technology can be adapted to most existing gasoline vehicles, with benefits for energy, environment and direct cost savings.

Ridesharing

Ridesharing is a way of saving energy on trips to work. Any time that two or more people agree to share an automobile on the way to work they are reducing the overall energy needed. Ridesharing is not a new idea. Whenever gasoline has been limited in the past, people have coped by doubling or tripling the number of passengers in an automobile. When energy is abundant, however, many go back to driving their own car, because the trip is faster if they don't have to drop someone else off first.

Ridesharing includes carpooling and vanpooling. Carpooling typically involves use of a private automobile, or taking turns using the automobiles of several drivers.

Vanpooling is a simple extension of carpooling, but involving a large enough number of people to require a van rather than an automobile. Sometimes the van is owned by one driver, or sometimes it is leased by the entire vanpool. Vanpooling is harder to organize than carpooling, and may almost resemble a small bus operation.

Carpooling or vanpooling could be used for any trip purpose that involves several different people going to the same destination. Typically, these practices are encouraged primarily for trips to work, since such trips remain the same each day.

Technology

There is nothing special about the technology of ridesharing -- just a regular car or a larger van. The other part of the technology involves getting people in contact with each other to organize and maintain the pool. This may start with word of mouth contact or with a bulletin board at work, followed by telephoning to keep the pool organized, to determine who is driving, and to handle individual absences or changes that come up.

A computer may be used to help get potential carpoolers together. A city may have a carpool number that people can call. They are asked to list where they live, where they work, and what time they start and stop work. This information is entered into a computer data bank, with the addresses converted into geographic coordinates. When each new person calls in to ask about carpooling, the computer can give them an individual list of people who live near them, work near them, and might be interested in sharing rides.

Carpools and vanpools may also be encouraged by giving them preferential access to highways and to convenient parking spaces at work. Arrangements include allowing pools to use designated fast lanes (along with buses) or allowing them to pay less at tollgates.

Carpools normally use the regular family car. Vanpools may require initial help in financing the vans, until it is clear whether they will be self-supporting. A public agency, or an employer, can purchase the vans, lease them to the vanpool groups to get them started, and then sell the vehicles outright if the vanpool group wants it.

Advantages

1. High energy efficiency. A carpool with 4 people and a compact car may get better than 100 person/miles per gallon -- four times as efficient as driving alone, more efficient than an average bus load, and approaching the efficiency of a moped. A vanpool may approach 150 person/miles per gallon.

2. Easy to establish. Anybody can set up a carpool, and a public program can help prospective carpoolers find each other. No heavy capital investment or subsidy is needed.

3. Vanpooling and carpooling can be very economical. One vanpool project estimated monthly costs follow:

Lease or purchase of a van	$140
Insurance	40
Gas, oil and maintenance (1000 miles @ 9¢)	90
Total Expenses	$270
Receipts (10 people @ $27 month)	$270

The passengers in this example would be riding 10 to 20 miles to work, each way, each working day, for $27 per month. If they drove their own cars this same distance it would cost each one $200 per month or more, based on ownership and mileage costs.

4. Carpools and vanpools save space on highways and in parking lots. They increase the people moving capacity of the highway without requiring more lanes, and they make better use of parking facilities.

5. Compared to buses, carpools and vanpools don't need to pay a driver, since one or more of the passengers drives (usually the one who has the longest trip).

6. Carpools and vanpools are better than buses at serving a low density community, where houses and jobs may be widely spread out. Since the destination is the same, and carries a small number of people, the pool idea does not require the high density necessary to support regular public transportation.

Disadvantages

1. Convenience. Ridesharing is less convenient than driving your own car, because you must coordinate with others in the group. It may take longer because of the stops to drop people off. This can be offset, however, if the carpool is allowed to park in a preferred spot close to work.

2. Financing. A carpool is no problem, but a vanpool may require outside financing to get it started. This can be done through public agencies, or by an employer.

Applications

Knoxville, Tennessee has one of the largest applications of vanpools. When the Tennessee Valley Authority built a new office building in downtown, parking and highway congestion leading to downtown became serious problems. TVA and the city were faced with millions of dollars for new parking spaces and wider streets.

Another solution was found, however, which cost less and which didn't require building more streets and parking. The solution involved discounts for commuter bus tickets, subsidized parking costs for carpools, and a vanpooling program to encourage employees to vanpool. The TVA credit union purchases vans, and leases them to employees for a monthly per-passenger fee. The drivers usually get a free ride, and get to use the vehicles during off hours for a per mile charge. The vans have assigned parking spaces near their place of work.

The Knoxville vanpool program has been very successful. Before the program, 65 percent of TVA employees drove by themselves to work. Within three years, only 18 percent of the employees were single occupant auto drivers. Of the total 4,500 workers, 1,100 were riding buses, and even more riding in carpools. There were 77 vanpools. (APA Planning, February 1980, p. 16).

The program was so successful that the TVA encouraged it at other work locations throughout the 7 state region. By 1980, there were 550 vanpool operating throughout the TVA area, with 105 more vans on order. TVA provided a 35% direct subsidy to encourage vanpool use. The program cost TVA $50,000 per month, but was estimated to have saved at least $20 million in costs otherwise needed for more parking roads. Both the company and the employees benefitted monetarily, and energy savings were enormous.

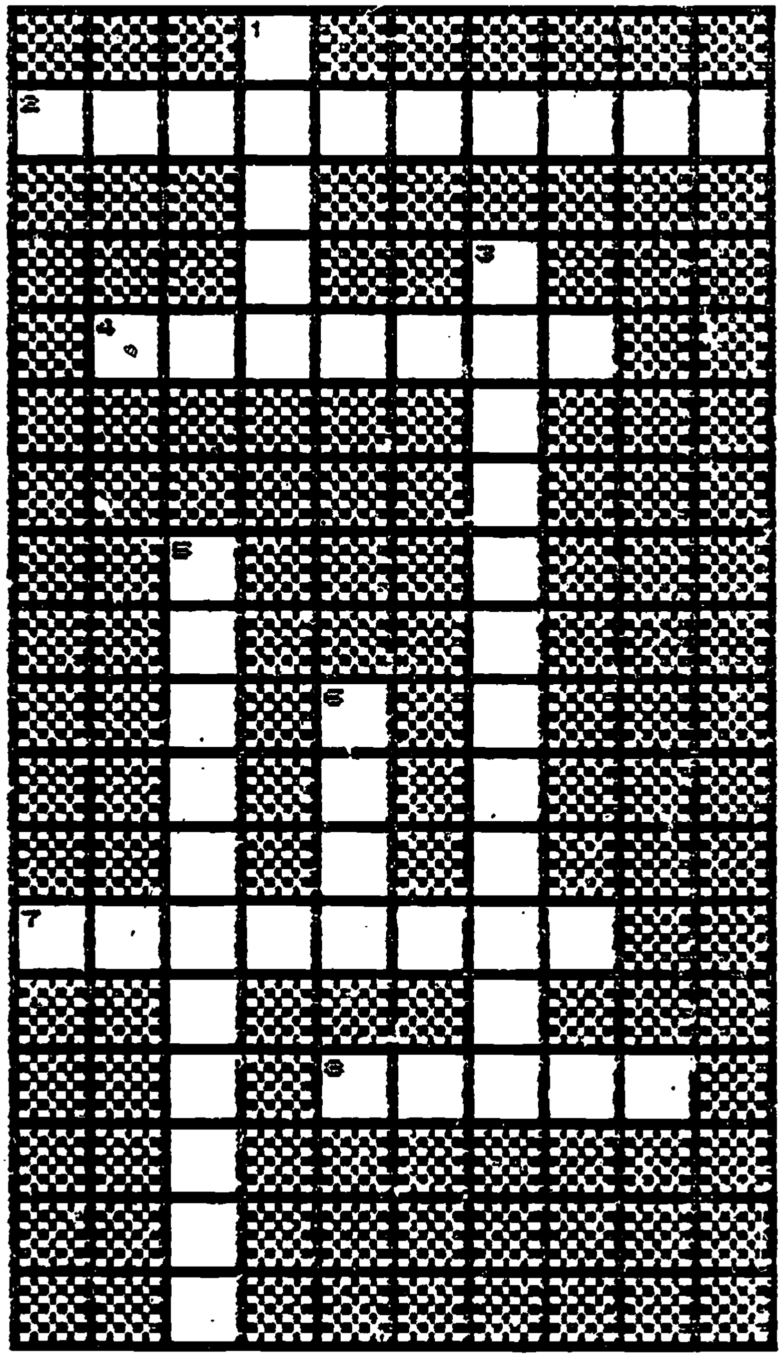
Other examples of vanpools sponsored by employers include the 3M company in St. Paul, Minnesota. The company headquarters were not well located for bus service, and the company, with 10,000 employees, was running out of parking space. Rather than invest in more parking, the company encouraged vanpools and carpools. Today 3M has over 100 vans used by 1,200 employees, and some 2,000 additional employees in carpools.

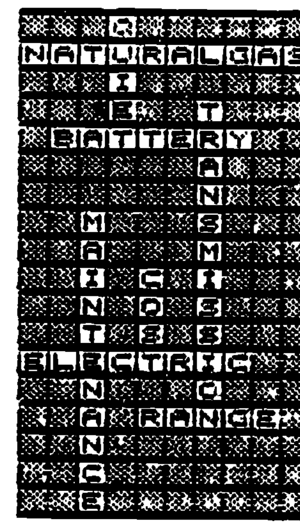
Portland, Oregon and Seattle, Washington, give preferential parking treatment to vehicles used in car and vanpools. The response in each case has been favorable. In Los Angeles, the city council adopted an ordinance allowing ride-sharing to substitute for some of the parking spaces currently required to accompany new buildings. The Federal Department of Transportation funded vanpool projects in four cities, involving about 400 vanpools. The program was considered a success.

Ridesharing is not an all purpose solution, but it can be a strong part of a solution, especially when there are large employers who can be persuaded to encourage vanpooling among their workers. Vanpooling may save money for the commuters, for the company and for the public, and will also save large amounts of energy.

QUESTIONS FOR STUDY

1. Why was the production of the electric car discontinued? Could this happen to the gasoline powered car? Explain.
2. What is the weakest link in electric car technology? Why?
3. List the advantages and disadvantages of the electric car. What advantage of the electric car appeals to you the most? Would any of the disadvantages of the electric car keep you from buying one? Explain.
4. What energy and transportation efficiencies did homebuilder John F. Long accomplish with his Arizona Project?
5. Examine the photo of the electric car. What are advantages and disadvantages about the vehicle? Are these considerations the same as the fuel efficiency consideration? How important are these considerations to the acceptance of the electric car?
6. How do natural gas or methane powered vehicles differ from gasoline powered vehicles? Can the same vehicles be powered by both gasoline and natural gas? Why would you want to do so? What problems would doing so create?
7. Would using natural gas or methane powered vehicles reduce our dependence on foreign fuel sources? Explain.
8. What are the disadvantages of natural gas powered vehicles?
9. Have governments assisted the introduction of the natural gas technology? Should the United States government provide assistance? Explain.
10. Under what conditions would you buy an unconventional automobile?





ACROSS CLUES

2. AN AUTOMOBILE FUEL
4. STORES ENERGY FOR ELECTRIC CAR
7. TYPE OF AUTOMOBILE
8. DISADVANTAGE OF ELECTRIC CAR

DOWN CLUES

1. ADVANTAGE OF ELECTRIC CAR
3. NOT REQUIRED FOR THE ELECTRIC CAR
5. LESS REQUIRED FOR ELECTRIC CARS
6. REDUCED BY USING NATURAL GAS CARS

Energy

Case Study

TRANSPORTATION

One of the alternatives discussed in the factsheets is the electric automobile. The electric automobile does not really "save" energy, it just uses energy in a different form. The electricity which is stored in the automobile's batteries was generated somewhere else, usually in a power plant. The original fuel, which may have been coal, or natural gas, or water power, or even sunlight, has been converted into electricity as a way of storing the energy until it is needed.

Think of as many ways as you can for converting energy from one form to another, and for storing energy until it is needed. For example, sunlight from solar photovoltaic cells can be "stored" in batteries. Power from a power plant can be stored by using it to pump water uphill into a storage lake, and then releasing the water later to power a mill wheel or to turn an electric generator. Electric power can be stored by using it to convert water into hydrogen and oxygen gas, and by burning the hydrogen later to produce power.

All of these forms of energy conversion involve some loss. You never get back quite as much energy as you stored, because some is lost as heat at each step. Discuss this concept of energy conversion. If we lost energy in conversion, why do we do it? Discuss the concept of different energy prices, and the idea of different time costs for energy. For example, if everyone wants to use electricity at the same time, it will cost more than if the use can be spread out evenly throughout the day. By storing energy which is produced cheaply, and using it when it is in high demand, we can more than pay for the energy which is lost in the storage process.

Energy

TRANSPORTATION

Change is visible all around us. Yet, in the case of the automobile we do not observe changes in how they are powered. Consumer behavior is changed by many factors. A few of these appear to be more important than others. Price is one of these more important determinants. To be widely purchased the unconventional automobiles must be less expensive to own and/or to operate. The unconventional automobile is a substitute for the conventional automobile. For substitute goods, when price of one good increases (P) demand for the substitute increases (D). For the unconventional automobile demand to increase the price of the conventional car must increase.

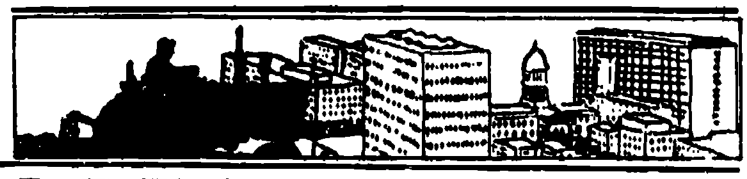
Develop a questionnaire to survey citizen's willingness to produce an unconventional auto. Suggested questions for the questionnaire are listed below. Add questions that will capture other information pertinent to the question. Be sure to develop a standardized statement on the unconventional car so that the individuals interviewed will know what is meant by an unconventional car.

1. What car do you drive?
2. Is it an unconventional car? (If yes, continue with question 3.) (If no, skip to question 5.)
3. What kind?
4. Why did you buy an unconventional car?
5. Why didn't you purchase an unconventional car?
6. As a result of this questionnaire, will you consider an unconventional car?

Compile and Analyze Questionnaire: Examine the answers to questions 4, 5, and 6 for evidence that price and cost of operation are factors in the decision to purchase an unconventional automobile.

Energy

Community Study



TRANSPORTATION

Most of the alternatives presented in this lesson require a community or an institutional response to get them started. For example, ridesharing is often encouraged by having the local government, or a large private employer, use a computer system to match rides coming from the same part of town. Electric or compressed gas vehicles may be more economical if a whole fleet is converted at once, so that the costs and the maintenance knowledge can be spread across more than one vehicle. For example, a fleet of local delivery trucks could be electric (as many once were). A fleet of gas company service trucks could use liquid natural gas, and so on.

Using your own community, identify some of the specific firms, organizations or governmental agencies which might be potential candidates for the introduction of these alternatives, including ridesharing and non-conventional vehicles.

1. From your knowledge of the community, develop one or two of these possibilities as proposals, and invite someone from the corresponding organization or firm to come in and discuss the idea with the class.

2. Or, have a delegation of students present the proposal to a group at the organization.

3. What are some of the specific things which would have to be done to make the alternative practical?

4. Could they be done by the single organization, or would they require outside assistance?

Some of the alternative fuel vehicles now being developed may become common in the next century.

1. Develop alternative fuels scenario for your community.

2. Suppose that gasoline and diesel fuel have both become prohibitively expensive or scarce, but that other fuels have made it possible to continue relying on individual vehicles.

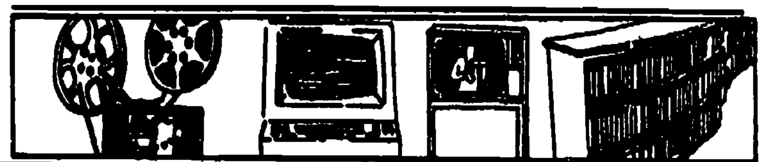
3. Speculate on what some of those fuels will be, how they will be distributed or sold, and how this will change the present system of gas stations with which they are familiar.

4. You may want to introduce the concept of a fuels "supermarket", where vehicles of different types could purchase a whole range of non-conventional fuels.

5. There may be a whole range of alternative fuel vehicles in any community. Start with the individual vehicles, but develop the idea of the support system which will be necessary to fuel and maintain the vehicles.

Energy

Resources



TRANSPORTATION

1. The Federal Government has sponsored a number of ridesharing and vanpooling experiments, and there are reports on many of these which may be available at a library or at the local transportation planning or city planning office. Examples of these reports include:

   U.S. Department of Energy (1979, May). New approaches to successful vanpooling: Five case studies. Washington, D.C.

   U.S. Department of Transportation (1980, June). Evaluation of the Minneapolis ridesharing commuter services demonstration. Washington, D.C.: Administration.

2. Reports on new developments in electric, natural gas, and other non-conventional vehicles are contained in the magazine Advanced Vehicle News, P.O. Box 5200, Westport, Conn. 06881.

3. There may be individuals or groups in your community interested in non-conventional vehicles, who perhaps can bring one to the school for students to view. At Ball State University, the Center for Energy Research, Education and Service has an electric car and is planning to charge its batteries by means of photo-voltaic panels on a building. Contact your local gas company, which may have someone knowledgeable about compressed natural gas vehicles. Indiana Gas Company is currently developing a system for such vehicles. The industrial education teacher in your school may know of people experimenting with such vehicles locally.

4. Contact the local planning office to find out about ridesharing programs, particularly in the larger cities. You could also contact large local employers to ask if they has sponsored any ridesharing programs among their employees, and if they have someone who could talk about the program. Or, contact:

   Division of Energy Policy
   North Capitol Avenue
   Indianapolis, IN 46204

5. The following film can be obtained from the Indiana University Audio Visual Center:

   The automotive American CS 1298

   Shows the effect/impact the automobile has had on Americans. Starts with an examination of the free wheeling days of early automotive history and leads up to modern driving methods and modes.

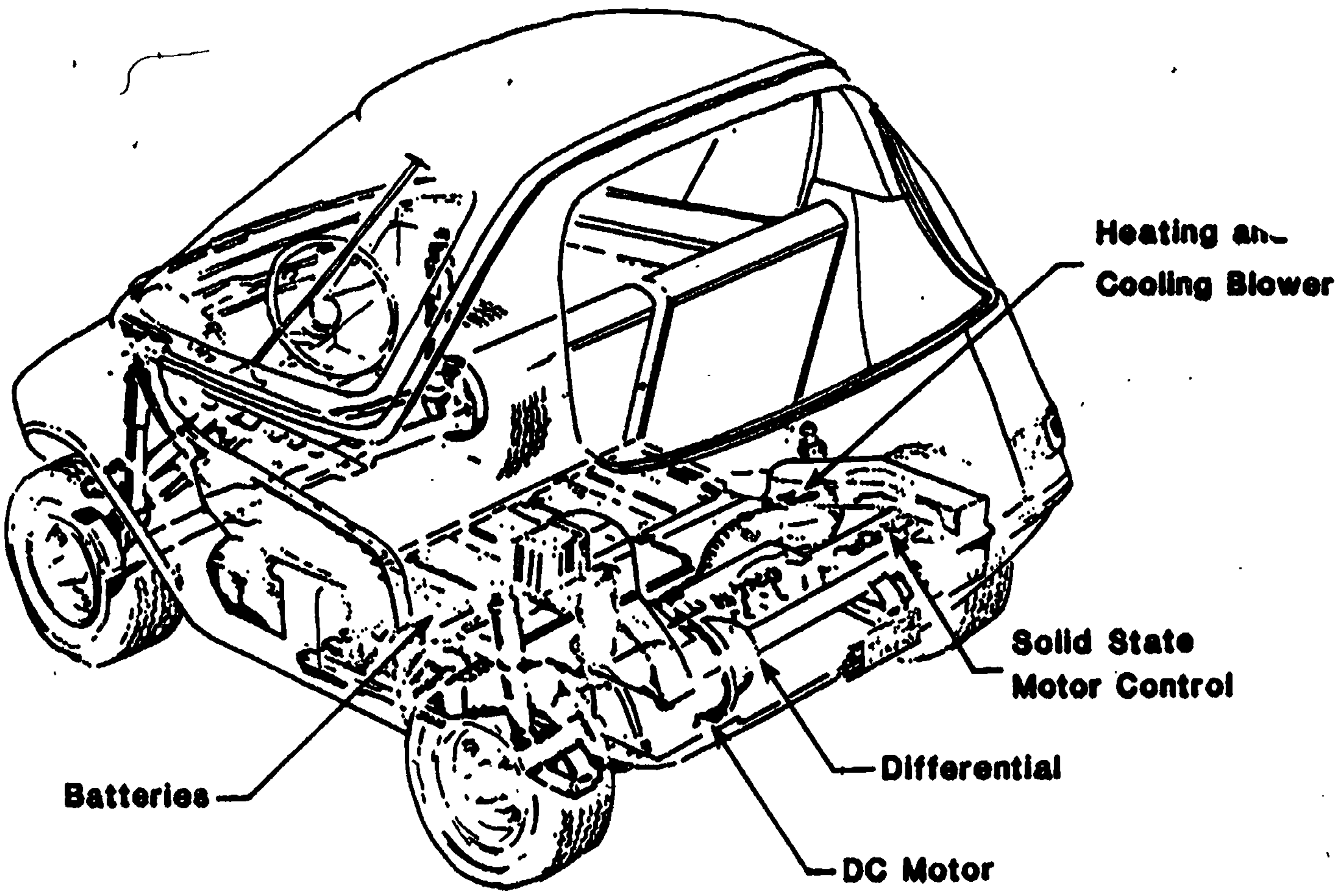
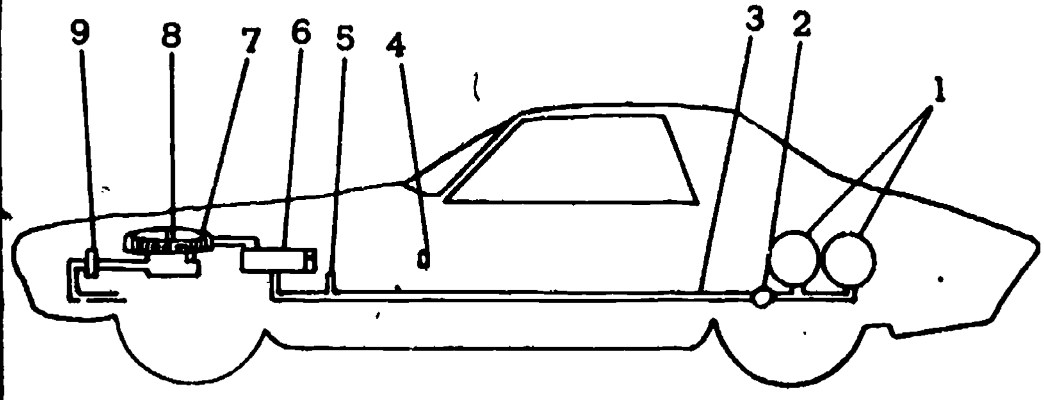


Figure 1

Electric Car



1. Natural gas cylinder
2. Manual shut-off valve
3. High pressure switch and gauge
4. Fuel selector switch and gauge
5. Natural gas fill valve
6. Pressure reducer and natural gas solenoid valve
7. Original equipment gasoline carburetor
8. Natural gas mixer
9. Gasoline solenoid valve

Figure 2

Natural Gas Car

PURPOSE: The purpose of this lesson is to examine energy use related to aviation transportation.

APPROXIMATE TIME: If each of the following activities is used, approximately seven class hours will be needed. This estimate does not include use of supplemental resources.

READABILITY: The Bormuth Readability Index was used to determine the reading level of text material in this lesson.

Ave. Word Length: 5.09

Ave. Sentence Length: 12.6

Readability Index: 60.7

Grade Level Equiv.: 8-9

OBJECTIVES

INQUIRY	DECISION-MAKING	TAKING ACTION
1. Students will examine transportation use of forms of aviation.	1. Students will recognize conditions under which aviation should be considered important transportation alternatives.	1. Students will determine when an energy problem warrants aviation use.
2. Students will illustrate reasons for use of aviation.	2. Students will explore the effects of aviation in a variety of situations.	2. Students will analyze data upon which the use of aviation would be beneficial.
3. Students will analyze the relationship between energy use and aviation.	3. Students will predict the consequences of aviation use on personal convenience, energy consumption, and economics.	3. Students will determine when a modification in energy use would be beneficial.
4. Students will examine the efficiency of aviation.	4. Students will rank order the most effective uses of aviation under varying conditions.	4. Students will explore potential effects of modified aviation use.
5. Students will compare energy efficiency of aviation to its effectiveness as a form of transportation.		5. Students will propose an appropriate change in aviation use.
6. Students will develop a conclusion as the most beneficial uses of aviation in terms of energy consumption.		6. Students will judge the results of their proposals.

Choices - the decisions that must be made because scarce resources have alternative uses.

Costs - sacrifice of something to obtain something else; usually measured in dollars.

Demand - the amount of a good or service people are willing to sell at each possible price during some time period.

Efficiency - making the best use of our limited resources.

Quantity Demanded - the amount people are willing and able to buy at a particular price. They buy more at lower prices, less at higher prices.

Scarcity - exists when wants exceed resources. For individuals, scarcity results from limitations on the supply of personal resources like time, energy, space, or money. For society, scarcity results from limited productive resources such as land, labor, capital goods, and entrepreneurial ability, which have alternative uses.

Tax - a compulsory payment to government that influences resource allocation, income and wealth distribution, and/or economic stability.

Energy
Factsheet
TRANSPORTATION

AVIATION

Historical

The first successful aircraft flight occurred at Kitty Hawk, North Carolina in 1903. The Wright brothers' flight lasted a little less than a minute. By 1905 the Wright brothers had flights lasting as long as 30 minutes. Early aircraft development was subsidized by governments interested in military applications.

The domestic airline industry began in the late 1920's. Passenger business developed as an afterthought to the transportation of mail. The Ford Trimotor, introduced in 1926, was the first U.S. aircraft designed primarily to carry passengers. With the introduction of the DC-3 in 1935 the airline industry developed its present day characteristics.

During the 1950's jet aircraft, first used during World War II, were introduced to the airlines. They operated at two or three times the speed of propeller aircraft and were much smoother. Jets accommodated approximately 30 percent more passengers. By the late 1960's the jumbo jets, seating more than 450 passengers, were placed in service.

Current Technology

Commercial airlines fly jet engine or jet propelled propeller aircraft. A jet engine produces motion as a result of the rearward discharge of heated air and exhaust gases. They burn jet fuel which is essentially kerosine, a distillation of petroleum. General aviation aircraft are usually screw propeller driven and have internal combustion engines burning aviation fuel which is essentially gasoline, also a petroleum distillate. Some businesses operate jets with the same speed capabilities as airline aircraft.

All commercial aircraft and many general aviation aircraft have electronic equipment which allows pilots to fly under conditions of limited visibility. IFR stands for instrument flight rules. These rules take effect when visibility is limited. Pilots must be instrument rated to fly during poor visibility.

Advantages

Aircraft are time efficient. They allow long distance travel in much less time than the automobile, bus, or train. In addition to time, expenditures for meals and lodging may be reduced or eliminated. If desirable, travel to and business in a distant city may be accomplished in one working day. Whether for work or play airplane travel allows more time for both. Traveling from Indianapolis to Hawaii, with its warm sun and beautiful beaches, is approximately 10 hours away.

Air travel is very safe. In some years there are no fatalities of passengers on U.S. domestic carriers.

Disadvantages

Fuel efficiency of aircraft is the lowest of the options for long distance travel. Buses provide the best fuel efficiency with 126 passenger miles per gallon. Amtrak is next best with 44 passenger miles per gallon. Even the auto is more fuel efficient than aircraft with 25 to 41 miles per gallon. Aircraft produce 17 passengers miles per gallon.

Aircraft are noisy especially jets. People living near airports complain about the noise. Much of the opposition to thé Concorde SST aircraft operating into New York's Kennedy airport was because of the noise it generated. Newer jets have quieter engines.

Aircraft contribute significantly to air pollution in large cities. Upon take off a great quantity of fuel is consumed. The hot gases and heated air remain behind to pollute the air.

A lot of land is required to accommodate today's aircraft. Large jets require runways 7,000 to 9,500 feet long. In addition they require considerable additional land to accommodate land transportation to the airport and the large number of people loading and unloading aircraft. The buildings must be very large to handle the large crowds at peak times of landings and departures.

Applications

The approximately 215,000 general aviation aircraft greatly outnumber the about 3,000 airline aircraft. General aviation aircraft provide flight service to communities without scheduled airline service. Of the approximately 11,000 airports only 700 commercial airlines compete with each other for air space and runway usage at major airports. This is a major problem that is likely to get worse in the future.

At the end of 1983, The Regional Airline Association, a Washington-based trade group, counted 196 small passenger airlines operating in the U.S. This is down from a peak of 246 in 1981. Several more have failed this year and others appear headed for trouble. Low gasoline prices coupled with frequent and lengthy delays at many airports have given travelers an incentive to drive instead of flying the typically short routes of many commuter lines. Major airlines are also in financial difficulty. Braniff Airline went bankrupt in the spring of 1982.

No other form of transport still has as much potential for further development than air transportation.

QUESTIONS FOR STUDY

1. When and where did the first aircraft flight occur? How long did it last?

2. What was the first commercial use of aircraft? When were jet aircraft first used by the airline industry?

3. Why do most people fly to Hawaii rather than take land and sea transportation? Are there other advantages to traveling by air? Explain.

4. How fuel efficient are aircraft compared to other means of transportation? How would you prefer to travel to Disney World in Orlando, Florida? Is your choice the most fuel efficient way to travel to Florida? If not, why not? If so, why so?

5. Has there been an aircraft accident in your community in the last six months? How safe is travel on U.S. domestic airlines?

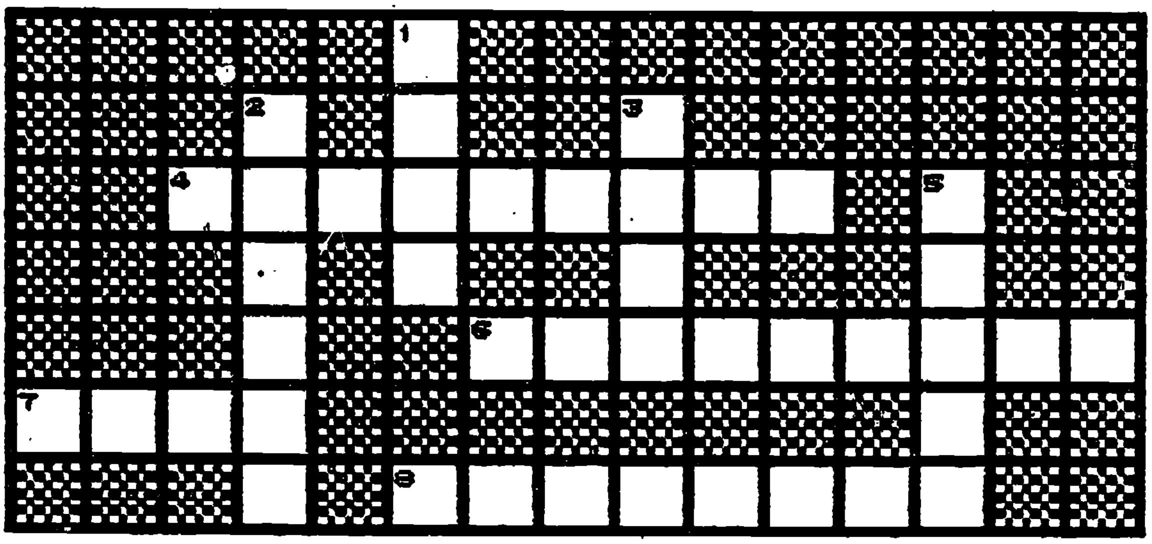
6. In what ways do aircraft contribute to pollution?

7. What resources are required to operate airlines and airports?

8. What is the total number of aircraft in the United States? As this number increases what problems are likely to develop? Explain why this is already a problem at some airports already.

9. What factors have contributed to the decline in the number of small passenger airlines since 1981? Why do you suppose major airlines are in financial difficulty? Do you expect these financial difficulties to continue? Should the government do something about the financial problems of the domestic airline industry? Explain.

10. What changes would you like to see in the airline industry? How would an increasing or decreasing price of fuel influence these changes? Explain.

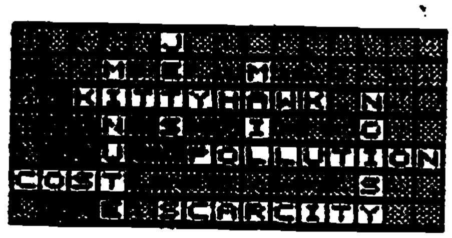


ACROSS CLUES

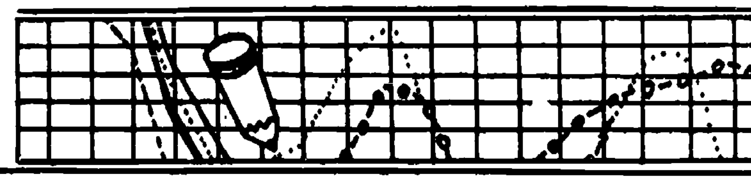
4. PLACE OF FIRST AIRCRAFT FLIGHT
6. FOUL AIRCRAFT EXHAUST
7. DOLLAR VALUE OF AIRPLANE TRAVEL
8. EXISTS IF WANTS EXCEED RESOURCES

DOWN CLUES

1. FASTEST AIRCRAFT
2. LENGTH OF FIRST FLIGHT
3. FIRST COMMERCIAL USE OF AIRCRAFT
5. DISADVANTAGE OF TRAVEL BY JET



Case Study



Energy

TRANSPORTATION

Use the local aviation authority's financial report to determine the cost of supporting local air transportation. Calculate the cost per passenger served. In addition, calculate the cost per passenger served. Focus on the energy use required to provide local air transportation.

Providing local air transportation uses scarce resources. In acquiring these resources the local aviation authority incurs costs.

1. Using the financial report of the local aviation authority, identify the energy resources used to provide aviation service to the community.

2. Determine the costs associated with energy use.

3. Calculate energy costs as a percentage of total cost and energy costs and total cost per passenger served.

4. Use this data in a discussion of the relative importance of energy in the provision of aviation services to the local community.

Energy

TRANSPORTATION

Goals can usually be accomplished several ways. Each alternative generally has different characteristics. One may be more expensive, quicker, or safer than another. A decision requires weighing each alternative against a set of criteria. Some criteria are more important than other criteria.

Decision makers minimize cost while satisfying certain constraints. In our scenario, the least cost travel must also be convenient and quick.

Invite a travel agent to class to explain why some fares are cheaper than other fares. What role does time and convenience play in the pricing structure? Is the size of the aircraft used also a factor? In this scenario, the alternatives are different flights to the same location. The flights are evaluated by such criteria as travel time, convenience, departure time, and size of equipment.

DREAM TRIP

DIRECTIONS: Read the following scenario and answer the questions that follow it.

SCENARIO:

Mary's best friend called last night to invite Mary for a visit. They haven't seen each other for over a year. Jane moved last year to Denver, Colorado. Mary is excited about the trip but is concerned about the expense and time involved. She only recently began working at Sam's Pizza Place and saving money for a used car.

Her parents want her to go but are not willing to pay for the entire trip. Mary needs more information to decide if the trip is financially possible and to decide the best way to travel. She must also get permission to be absent from her job.

Mary asks her boss for a week off. Mrs. Barnes explains that she could only spare Mary for three days. Mary was disappointed because she had wanted to spend a week with her best friend. For a moment Mary considered quiting her job, then she remembered how hard this one was to locate. Mrs. Barnes agrees to allow Mary to split the three days off around a weekend. Mary will have a total of five days for her trip.

She investigated her travel options. In order to spend as much time as possible with her friend, Mary would like to fly to Denver. She could leave right after work and be in Colorado early that evening. Her call to World Wide Travel provided the following information on travel from Indianapolis to Denver:

INDIANAPOLIS, IN - DENVER, CO

Transportation	Time Constraint	Round Trip Cost	Departure
Airplane	3 hours	$359.00	Before 8:00 p.m.
	3 hours	$344.00	After 8:00 p.m.

Mary investigates her alternatives. She found out the following about travel by train and bus.

Transportation	Time Constraint	Round Trip Cost
Train	24 hours	$150.00
Bus	28 hours & 5 minutes	$198.00

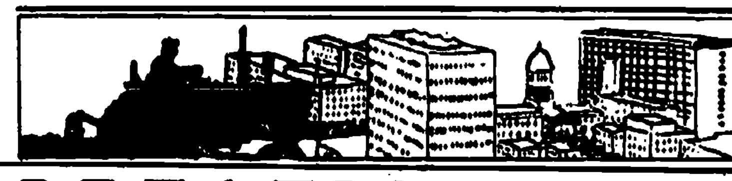
Mary has $275.00 to spend for the trip.

Questions:

1. What is scarce in the scenario?
2. What are Mary's alternatives? Constraints?
3. Has Mary considered all her alternatives?
4. Are your constraints different than Mary's?
5. What alternative would you recommend to Mary? Why?
6. How would you rewrite the scenario to maximize the time Mary can spend with her friend Jane? What has happened to relative scarcity?

Energy

Community Study



TRANSPORTATION

Airports sell services that benefit consumers and businesses. Energy, a resource, is used to produce the services.

Invite a representative of the local Chamber of Commerce to discuss the benefits of the local airport to the community. Prepare the class to ask questions that will focus the discussion on the economic and energy aspects of the impact question. For example:

1. What is transported to our community by air?

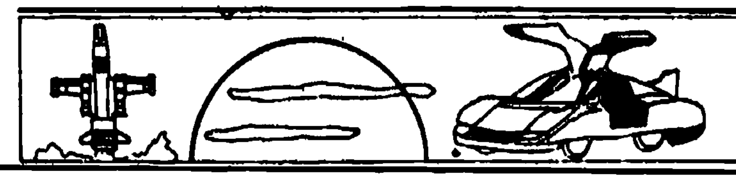
2. How important to business is the local airport? Why?

3. What is the economic impact? How many jobs depend on the airport's continued operation?

4. Do airport uses contribute to the more efficient use of energy?

Energy

21st Century



TRANSPORTATION

Airports are investments. They provide a stream of benefits in the future. Capital investments are usually financed by borrowing. Payments on the loan are made from tax payments and from user fees.

Ask the manager of the local airport to share with your students the airport authority's plans for the future.

1. Identify the resources that are required by the plan.

2. Ask what motivates the authority to propose the changes incorporated in the plan.

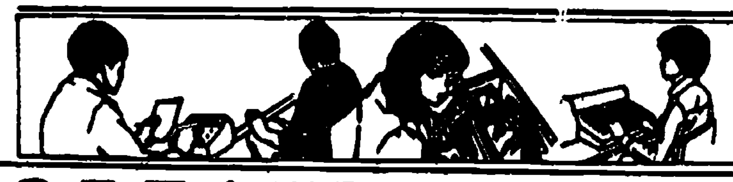
3. What is the expected impact of the plan on the future?

4. Will employment increase?

5. Explore ways to finance the project.

Energy TRANSPORTATION

Careers



1. Six famous aviators have claimed Indiana as their homes sometime during their lives. Study and report on one of the following: Weir Cook, Gus Grissom, Bob Shank, Oliver Stout, or Roscoe Turner.

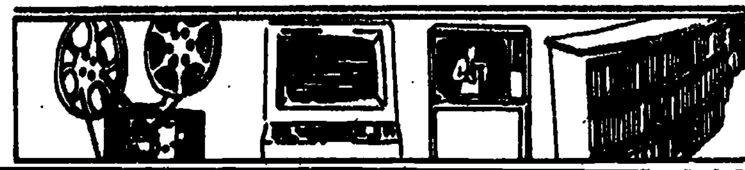
2. Schedule a visit to the nearest airport. List the different job tasks you observe people performing. Note which of the tasks appeal to you. Explain why.

3. Investigate education and training required for the following occupations:

   - Airline pilots
   - Airline mechanics
   - Aerial photography
   - Air traffic controller
   - Aeronautical engineering
   - Meteorology
   - Dispatcher
   - Flight superintendent
   - Aerial advertising
   - Crop dusting
   - Flight instructor
   - Aeronautical sales
   - Parachute riggers
   - Grounds keepers
   - Airline inspector
   - Airline hostess
   - Airline steward
   - Airline ticket agent
   - Airport management

Energy

Resources



TRANSPORTATION

1. For an Indiana Aeronautical Chart for classroom display, write:

   Indiana Department of Transportation
   Division of Aeronautics
   143 West Market Street, Suite 300
   Indianapolis, IN 46204

2. Other valuable sources of information can be obtained by writing to:

   (a) Air Transport Association of America
   1709 New York Avenue, N.W.
   Washington, D.C. 20006

   (b) Airline Pilots Association
   1625 Massachusetts Avenue, N.W.
   Washington, D.C. 20036

3. The following films can be obtained from the Indiana University Audio Visual Center:

   (a) <u>Space flight around the earth</u> FSC 1019

   Shows pre-launch preparations, the launch, the space flight, and return to earth of a manned space capsule.

   (b) <u>Jet and rocket engines</u> FSC 534

   Traces the history of jet and rocket engines and diagrams the principles by which they operate. Starts with simplified examples of the principles involved in a balloon, a rocket toy, and a lawn sprinkler. Further examples are shown by use in a rampit, turbojet, and pulse jet.

For further information or assistance, contact:

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