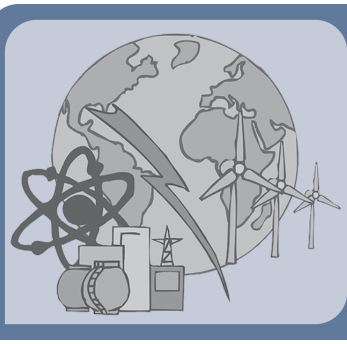


Energy Futures

Students analyze trends of energy use in Wisconsin, explore consequences of these trends by using a Futures Wheel, and use scenario writing to envision a plan that addresses these effects.

Grade Level: (5–8) 9–12

Subject Areas: English Language Arts, Family and Consumer Science, Science, Social Studies

Setting: Classroom

Time:
Preparation: One hour
Activity: Three 50-minute periods

Vocabulary: Futurist

Major Concept Area:

- Future outlooks for the development and use of energy resources

Getting Ready: This activity is divided into three parts. Based on your classroom needs, you can do only one part, two parts, or all three. Prior to this activity, you may want to have students post on a bulletin board news articles and reports on energy and on projections about the future. Some articles are included in this activity; students may want to find more current information.

Objectives

Students will be able to

- interpret a variety of graphed trends about energy (Part I);
- develop forecasts based on these trends (Part I);
- use a Futures Wheel to project needs and consequences of energy use practices (Part II);
- create a scenario that envisions possible effects of energy use (Part III); and
- predict how scientific, technological, and social changes will influence future resource availability (Part III).

Rationale

Using future studies helps students evaluate how their actions affect the quality of life and the environment of their community, their nation, and the world.

Materials

- Copies of the following:
  - ***Orientation***
  - ***Part I: Trend Analysis***
  - ***Part II: Futures Wheel***
  - ***Part III: Scenario Writing***
  - ***Facts about Future Energy Resources***
- Paper and writing utensils

Background

"Demand for oil will exceed production by the year 2040..."
"Global warming will melt ice caps and cause ocean levels to rise. . ."
"The fuel cell is the answer to our future energy needs."

Envisioning the consequences of current events helps us become aware of our alternatives. Once the possibilities are identified, we can try to make the desired prospects become realities and prevent the undesired outcomes from ever being realized. Therefore, the purpose of making these predictions is to help us take steps toward creating a positive future for ourselves and future generations.

Professionals who envision future possibilities are often called futurists.

They are scientists, scholars, government officials, and business leaders. The main goal for futurists is to explore the many possibilities of the future in order to understand various opportunities and challenges that may lie ahead. Their research involves looking at apparent trends as well as envisioning unintended, unknown, and delayed consequences of current and future events.

Futurists use a variety of research and investigation strategies. These include trend analysis and extrapolation, creation of scenarios, model design, and simulations. Futurists consult experts in various fields to ensure that their projections present the most realistic and accurate viewpoints. Obviously, the futurists' projections will be influenced by the outlook of experts.

No matter how carefully futurists research the facts, they are still talking about the future. Unforeseen changes and events will occur. Being right or wrong is not the main concern of futurists. Their aim is to present possible scenarios to help people be more prepared.

Almost every aspect of our society, including energy, has been scrutinized by futurists. Energy itself has many facets that can be explored. For example, how we develop and use energy resources will influence lifestyles, the quality of the environment, health, and relationships among nations. The depletion of nonrenewable energy resources and the effect this will have on our society is a much debated topic among futurists. Because our society depends so heavily on oil, this resource often receives the most attention.

All of us at one time or another consider what the future may bring. We weigh the options, ask others what they think might happen, and imagine best and worst case scenarios. Having studied the possibilities, we can prepare for the worst but plan (and hope) for the best. The same holds true for thinking about energy and the future. For example, when considering the future of energy resources, futurists might ask, "What are the worst and best case scenarios?" By studying current trends and envisioning future possibilities, we can begin to take actions now that will prevent the worst scenario and promote the best.

Procedure

NOTE: There are limitless issues regarding energy development and use in our future. This activity focuses on just a few. Students may be interested in applying some of these future studies tools to different energy topics, or to help develop their own personal energy use plan. In addition, there are other tools futurists use to study possible future events (for example, cross-impact matrices, trees of impact, problem-solving techniques, Delphi surveys, etc.).

Orientation

Ask students about graphing they have done in mathematics and other classes, and have them list reasons for presenting data in graphs. One reason should be that graphs help us recognize trends. Trend analysis involves looking at current and past data and making observations (see ***Orientation: Analyzing Trends***). If we try to use the data to guess what will happen next, we are making an extrapolation or projection (see ***Orientation: Trend Extrapolation***).

Share ***Orientation: Simple Trends*** with students and have them make observations and projections. They can also read ***Orientation: Creating Forecasts from Trends*** and complete the ***Orientation: Automobile Production*** activity sheet.

Help students understand that although forecasts are based on careful analysis, they are only educated guesses and could be wrong. Most people have dressed for rain based on a weather forecast, only to find that the sun shone all day. The meteorologist didn't necessarily make a wrong forecast. Unforeseen events, such as changes in wind direction, occurred.

Discuss and have students list reasons why people make forecasts about the future. For example, why do people want to know what the weather will be like? Students should recognize that projections help people make decisions and plans.

Ask students if they have thought about energy and the future. Students may be familiar with a variety of concerns related to energy, such as running out of fuel, the greenhouse effect caused by buildup of carbon gases, discovery of new fuel sources, etc. (see **Getting Ready**).

Steps

Part I—Trend Analysis

1. Inform students that graphs are used to analyze a variety of trends associated with energy development and use. Show students the graph of ***Wisconsin End Use Energy Consumption, by Type of Fuel 1975–2015*** and have them interpret it.

2. Share the summary made by the Wisconsin Office of Energy Innovation. Have students compare their interpretations. **Summary:** End use energy is a measure of the energy content of fuels at the point of consumption. Since much of the energy needed to generate electricity is lost in the generation process, end use energy consumption figures will always be lower than the directly linked resource energy consumption figures. Natural gas makes up almost 30 percent of resource energy consumption in Wisconsin, with coal close at almost 28 percent. Coal remains the primary fuel used for electricity generation in Wisconsin, accounting for over 61 percent of the state's total net electricity generation, or 422.1 trillion BtUs.

3. Ask students how they would extrapolate or make a forecast based on the graph. Focus on one resource, such as oil.

4. Locate, or have students locate, an article on a current energy-related topic. Ideally, the topic will be pertinent to your local community. Discuss the different viewpoints or perspectives related to the topic. You may also want to discuss the concept of bias in the article. (For example, what experience does the author have? What agency does he or she represent?)

   Potential topics:
   - Damming rivers for energy production (benefits versus drawbacks)
   - Burning wood as an energy source (benefits versus drawbacks)
   - Electric grid security
   - Nuclear energy (benefits versus drawbacks)
   - Wind turbine (benefits versus drawbacks, siting challenges)
   - Carbon tax

Part II—Futures Wheel

1. Inform students that in addition to trend analysis and projection, there are other methods used to help people consider broader implications of possible future scenarios. Paraphrase the information from the ***Part II: Futures Wheels***.

2. Work with the class to make a Futures Wheel based on the topic in the article you read. An option is to make this a small group assignment where half of the class makes a Futures Wheel that pertains to one viewpoint on the topic and the other half make a Futures Wheel for an opposing view on the topic. Ask students to interpret and compare the two versions.

Part III—Scenario Writing

1. Refer to the **Orientation** for reasons why people make future projections (to plan and prepare for consequences of current events). Tell students they will have an opportunity to be future planners. Have students select one aspect from one of the Futures Wheels that affects their community. The aspect can be something about the future that is good and they'd want to support, or something that could cause a problem.

2. Use brainstorming strategies with the class to generate a list of ideas to resolve or address this problem or to support the outcome if it has positive implications. Encourage students to think about a variety of options (see ***Facts about Future Energy Resources***). If time allows, students can look for information about some of the ideas they generated.

3. Divide the class into groups of two to four students. Have each group devise a plan for their community and write a scenario that describes it and that envisions what would happen if the plan were implemented. Students can also draw maps and use other graphics to illustrate their plan (see ***Part III: Scenario Writing***). Depending on time and expectations for this plan, students can draft an idea in class or consult city planners, the local office of the Department of Motor Vehicles, energy resource managers, and other experts to provide insight.

Closure

Have groups present their scenarios to the class. Discuss similarities and differences among the plans. Students may want to compile their ideas into one master plan. For further scrutiny, they can place their solution in the center of a Futures Wheel and consider other consequences (see **Assessment**).

Assessment

Formative

- Did students properly analyze the simple trends and evaluate trend projections (Part I)?
- How extensively and thoughtfully did students develop their Futures Wheel (Part II)?
- Did students create plans that appropriately

addressed a future consequence of energy use (Part III)?

- How well did their scenario explore and envision possible outcomes of the plan implementation (Part III)?

Summative

- Have students create a Futures Wheel that investigates possible consequences and effects of their plan's implementation. Check to see that the contents of the wheel explores possible effects of their plan.
- Encourage students to find a local energy-related topic and apply skills used in this activity to present a plan to those who are involved in finding a solution.

Related KEEP Activities

Use this activity to extend and enrich many of the concepts presented in other activities in the guide. Some activities that work particularly well include "Digging for Coal," "Energy Divide," "Dealing with Nuclear Waste" and "Get That Gasoline." Several of the Investigation Ideas listed in the Energy Sparks section provide suggestions for alternative topics that can be used with this activity.

Answers to Simple Trends

1. Trend C shows a steady decrease.
2. Trend E shows an increase, then a leveling off.
3. Trend B shows a steady regular increase over time.
4. Trend F shows a slow increase, then rapid growth.
5. Trend A shows no change or a continuous level.
6. Trend D shows an overall increase with many fluctuations. Other events that may produce a similar trend include the stock market prices, seasonal park attendance, and number of absences from school in June.

Answers to Automobile Production

1. Improved railways and an increased interest in bicycles (a and c) would probably result in a decrease. The answer is b.
2. All three developments (a, b, and c) might explain the decrease. Therefore, the answer is d.
3. Forecast D is unlikely because it is highly unusual for any enterprise to die out completely.
4. Answers will vary.
5. Nations dependent on oil from the Middle East began looking for other sources. The price of oil went down. Demand for automobiles increased.
6. Answers will vary.

The Wisconsin K-12 Energy Education Program is supported through funding from

Wisconsin K-12 Energy Education Program (KEEP)
College of Natural Resources
University of Wisconsin-Stevens Point

Orientation

Analyzing Trends

Following are four observations which can be made before analyzing a trend:

1. The general direction of the trend: Toward growth or decline?
2. The rate or intensity of the trend: How fast is the growth or decline occurring?
3. The general "balance" of the trend: Toward steady or erratic growth/decline?
4. The lifetime of the trend: Long- or short-term?

Trends are analyzed by asking the following questions:

1. What are the underlying causes that created the trend?
2. Are those conditions likely to continue in the future?
3. What new developments (like new technologies) might alter the trend?
4. Is the trend approaching a saturation point or limit?
5. Does the trend conflict with some other trend? Which one(s)?
6. Who (business, government, etc.) does the trend benefit?
7. Does the trend have potentially harmful consequences or side effects?
8. Are there likely to be deliberate efforts to halt the trend?
9. How easily could the trend be changed?

Trend Extrapolation

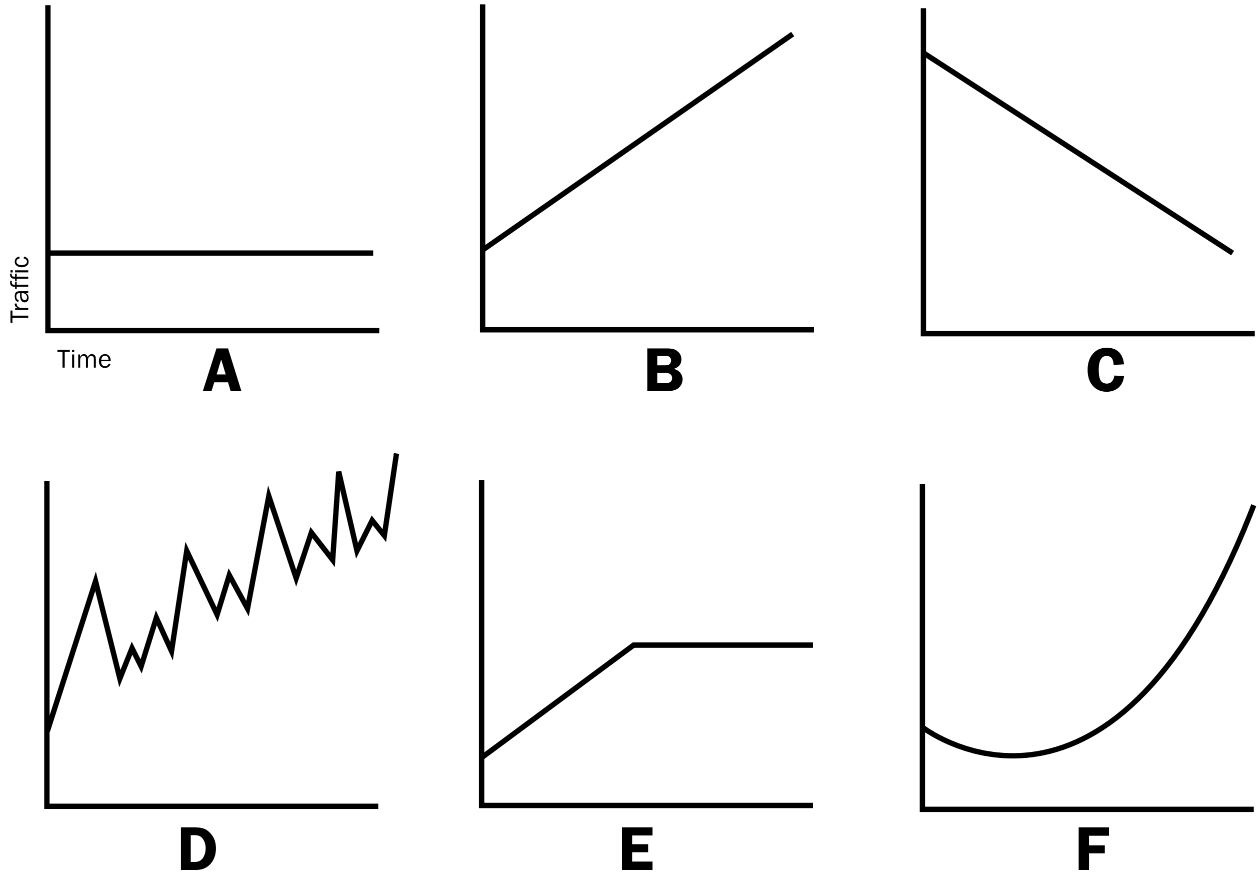
Trend analysis traces a trend from the past to the present date (but no further). Trend extrapolation, on the other hand, is the process of analyzing a trend and predicting what will occur in the future. Trend extrapolation leads to a forecast. The process of extrapolating, or extending a trend into the future as a forecast is based only on the trend's past performance. When you know the background of a trend, the process of extrapolation is a simple linear projection of that trend into the future based on past characteristics.

There is one major warning in trend extrapolation: As a forecasting tool it is only good in the short term. Since the extrapolation of a trend is a simple linear projection into the future, it does not consider many variables that could affect what occurs in the future to modify the trend. The further into the future you extrapolate the trend, the greater the possibility of a something changing the trend and making your forecast inaccurate.

Orientation

Simple Trends

Recall that trends are patterns of past events. The pattern refers to the shape or the slope of the line. Trends can take on a variety of patterns, as shown below.



Suppose that each of these trends represents a comparison of traffic over the past 25 years. The vertical axis represents amount of traffic and the horizontal axis represents time.

Answer the following questions.

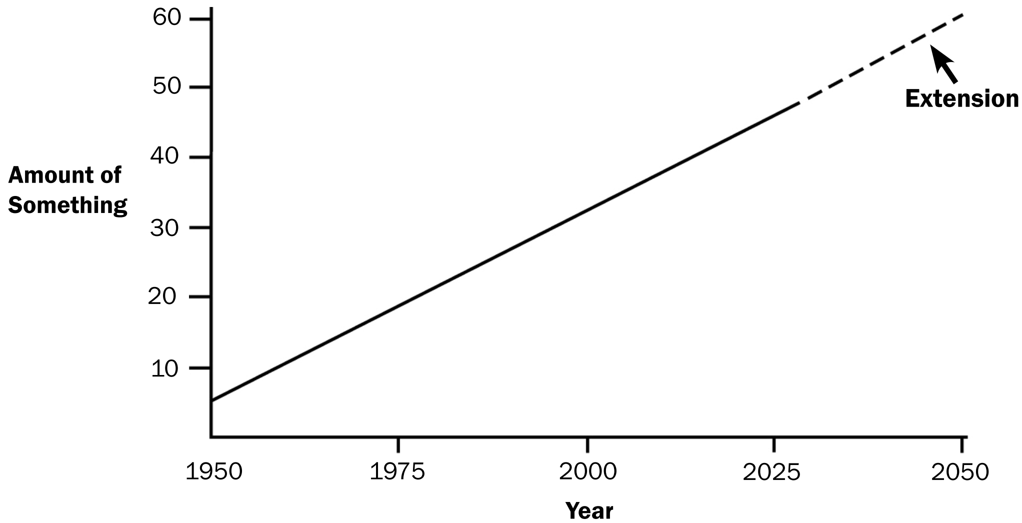
1. Which trend shows a steady decrease in traffic?
2. Which trend shows an increase followed by a leveling off?
3. Of trends B and F, which shows a steady regular increase over time?
4. Of trends B and F, which shows a slow growth in the beginning followed by rapid growth later on?
5. What does trend A show?
6. What does trend D show? Name other events that might exhibit a pattern similar to D.

Orientation

Creating Forecasts from Trends

Recall that a trend graph gives you a picture of what has occurred in the past. If you wish to forecast what will happen in the future, you may begin by extending the line to the date you would like to know about.

Here's what an extension or continuation looks like:



Thus, if everything continues the way it has been going, you can expect the increase to continue to the year 2025. But very few trends look like straight lines on a graph.

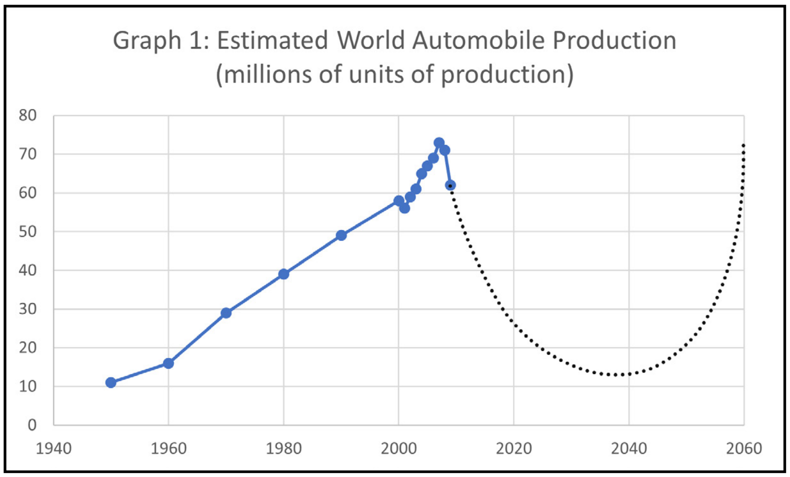
Where will this line be in the year 2050? How do you extend a trend with a shape like this one? What you can do is make an estimate or an intelligent guess (a forecast). For example, if things continue the way they've been going, by the year 2050 there will be somewhere between 50 and 60 (amounts of something).

Orientation

Example: Automobile Production

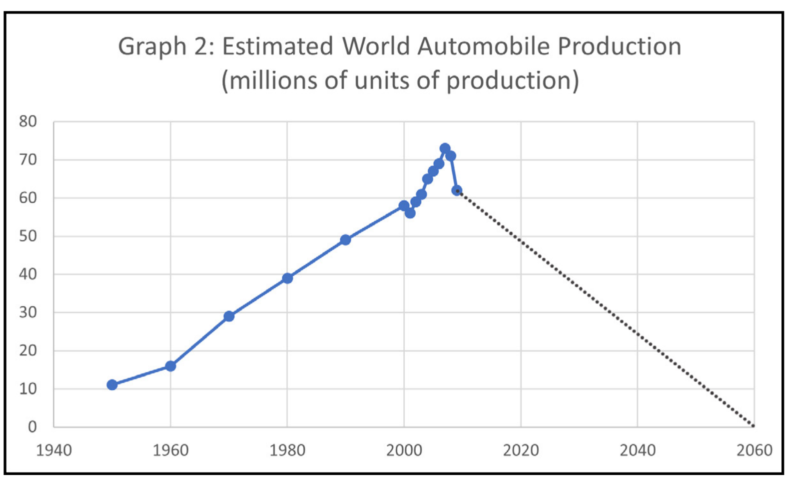
The difficulty with creating forecasts by extending trends is that situations change. "Surprises" happen that change the course of trends. The graph below shows the production of automobiles until the year 1975. During the 1970s, the energy crisis—due primarily to a sharp increase in oil prices—contributed to a drop in automobile production. Imagine that you were asked in 1970 to forecast automobile production through the year 2016. Use a ruler to draw a line to see where the extension would go. Do you think extending the line is a sensible way to make a forecast in this instance? Why or why not?

Answer the following questions to analyze possible forecasts.



1. Which of the following might explain the forecast shown in **Graph 1**? (Choose one.)

a) Railroad travel becomes more extensive, and speed of train travel increases
b) Price of gasoline decreases
c) More people ride bicycles to work
d) All of the above

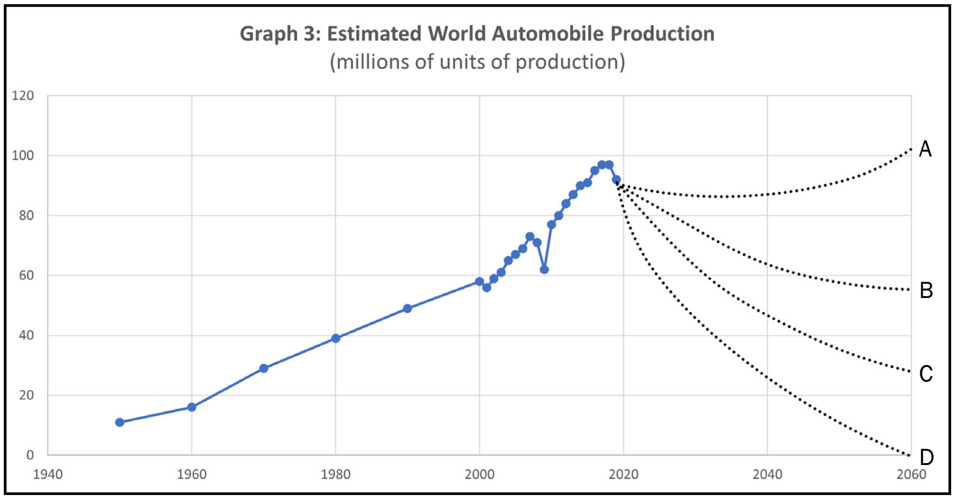


2. Which of the following might explain the forecast shown in **Graph 2**? (Choose one.)

a) No increase in highway construction and existing highways are jammed
b) Gasoline-powered cars banned in many sections of the country
c) Price of gasoline continues to increase
d) All of the above

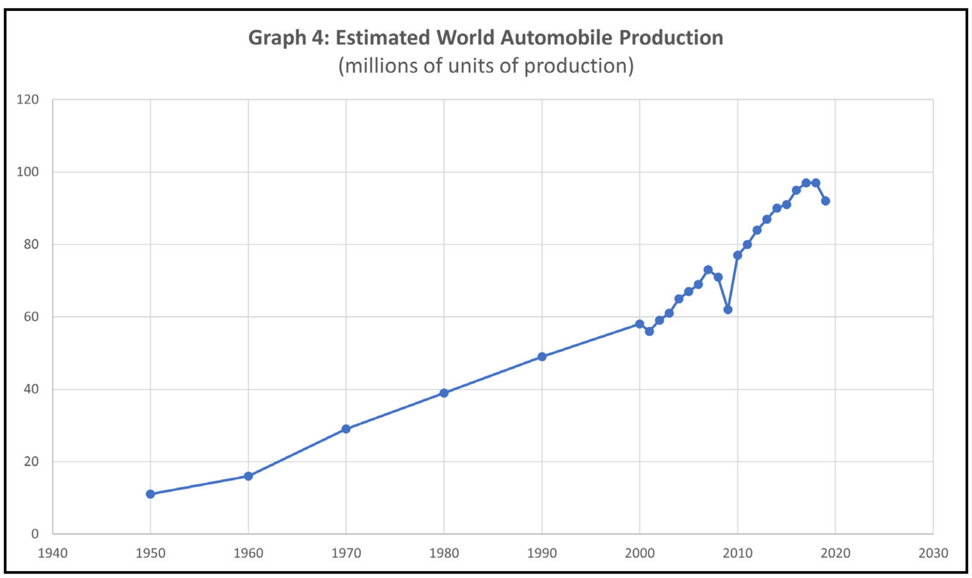
Orientation

Example: Automobile Production



3. Why might forecast D in **Graph 3** be unlikely?

4. Which forecast (A, B, C, D) do you think is the most desirable? Why?

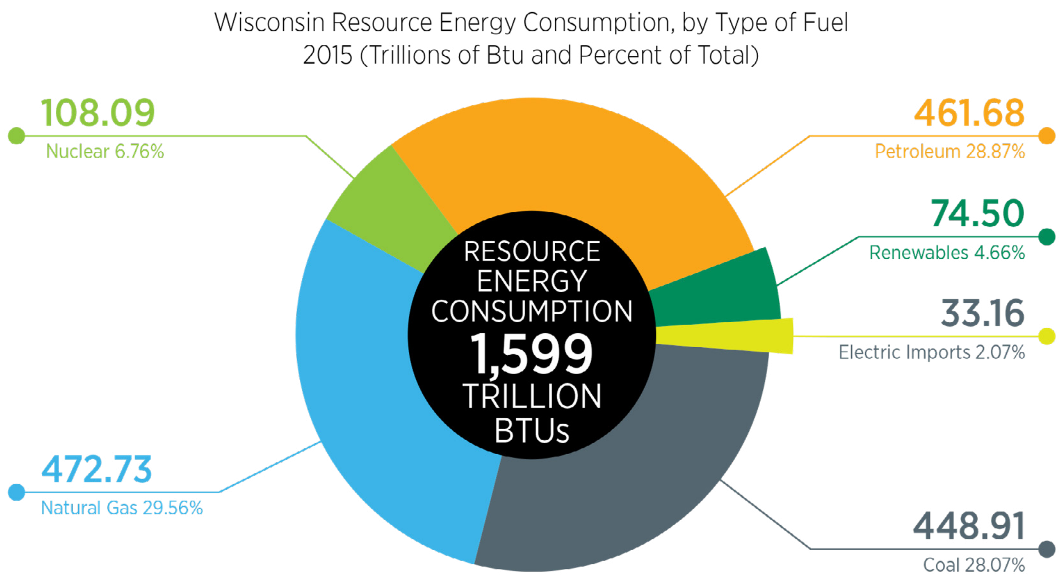


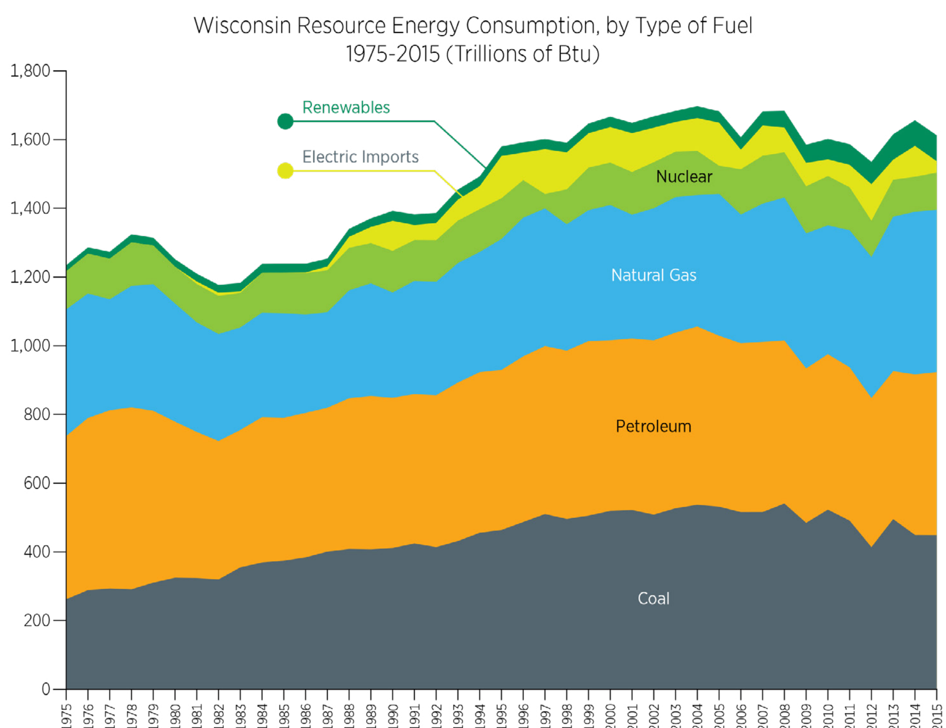
5. Graph 4 shows the actual trend that occurred. What do you think contributed to its pattern?

6. Where do you think the trend will go next? Where would you like it to go? List some changes that could be made to make your most desirable forecast more likely to occur.

Part 1: Trend Analysis

Wisconsin End Use Energy Consumption by Type of Fuel, 1975–2015





Source: Wisconsin Office of Energy Innovation. 2018 Wisconsin Energy Statistics Book.

Part 2: Futures Wheel

When futurists forecast that a significant event will occur, they know that event will affect many other factors or events in society (and perhaps in other countries). Futurists use several tools or techniques to assess the effects of a future event. One of these devices is the Futures Wheel. A Futures Wheel is a method of looking for possible consequences and needs that may result from an event or development. These key questions are asked:

- What might be the results if this were true?
- What might be necessary if this were to happen?

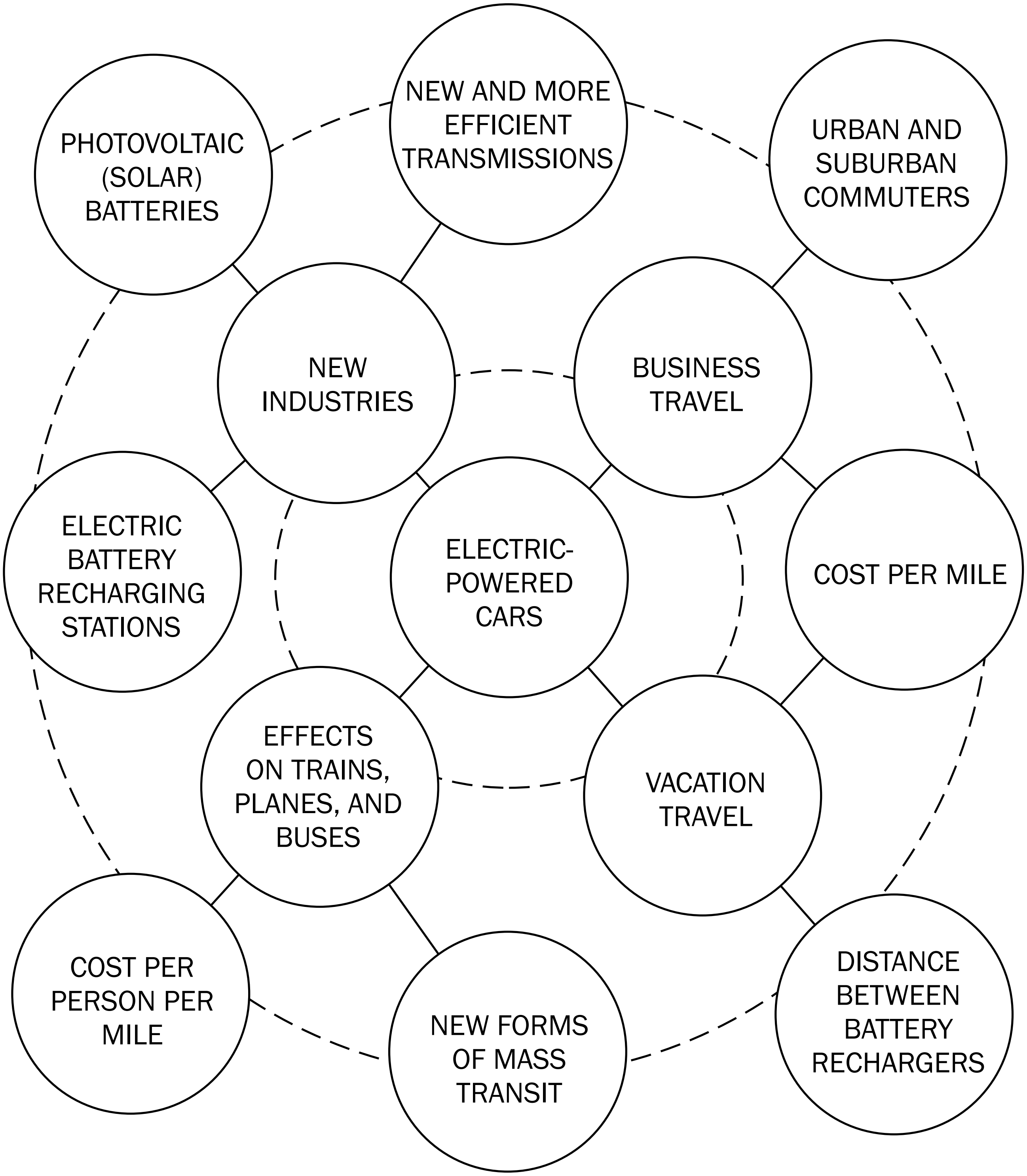
The dynamics of the Futures Wheel are much like what happens when you drop a large stone into a very calm pond. As the stone penetrates the surface of the water, there is a splash and then the displaced water flows outward from the point of contact in gradually diminishing ripples (miniature tidal waves across the surface of the pond).

In the Futures Wheel, a single future event is placed at the center of the wheel (usually in a word or phrase enclosed in a circle). In the first ring of circles are several—perhaps three to five—direct effects of the central event. In succeeding rings are secondary or indirect effects of the central event linked to the factors in the first ring from the center. Every effect is stated in a word or phrase and enclosed in a circle. The circles are connected by lines of influence radiating out from the central event. Four or five rings (or more, in complicated versions) may extend out from the center circle, all connected by lines of influence or impact.

On the next page is one interpretation for the ***Effects of Electric-Powered Cars*** Futures Wheel. The first ring from the center identifies several things that may be influenced by the eventuality that only electric-powered cars will be in use. The second ring identifies factors that are affected by changes to the items in the first ring. For example, business travel will be affected by use of electric cars. More people may live near or in cities so they don't have to commute so far.

Part II: Futures Wheel

SAMPLE WHEEL: Effects of Electric Powered Cars



Part III: Scenario Writing

Introduction

A scenario is a story created for enhanced awareness of a particular state of affairs. A noted futurist, Herman Kahn, has defined a scenario as "a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points."

Examining links between cause and effect increases people's understanding of how and why a particular situation occurred. Past and current decisions sometimes produce unexpected future consequences. By exploring possible impacts, negative consequences may be avoided and positive results enhanced.

Scenarios are written from a future point of view looking back to the present. A description explains how we arrived at the scenario's projected future from the present by tracing different decisions, options chosen, and the cause-effect results of those past decisions.

Scenario writing is a powerful tool for exploring alternative futures. It allows for the inclusion of realism, imagination, comprehensiveness, and uncertainty. Most important, scenarios allow people to examine and shape their value systems as they speculate about future possibilities and their impact on various stakeholders.

The process of scenario writing draws upon divergent, convergent, and evaluative thinking skills, creative writing skills, research and information retrieval skills, and planning and forecasting skills. The process is adaptable to most ages and offers the type of perspective and attitude building that is helpful in creating a better future.

A scenario should not be confused with science fiction. Science fiction has a broader range of possibilities, is not necessarily tied to a particular past, and is more involved in plot and character. A scenario, in contrast, is a careful study of alternatives and their impacts. A scenario allows the study of one particular future situation, the decisions leading to the situation, and the linkages involved.

Elements of Scenario Writing

Information generated from other strategies to project the future, such as trend analysis or a Futures Wheel, can be used to help construct the scenario. Certain elements of scenario writing are open ended. Time, for example, is a major variable. The time approximated could be on a near or distant horizon (2030 or 3550). The time span examined could involve one day or several decades.

Another variable is the writer's personal point of view. Both positive and negative scenarios have merit. Negative scenarios can challenge the reader to take action to avoid an unpleasant forecast. On the other hand, a positive scenario promises a better quality of life through various technological discoveries and actions of various stakeholders.

Again, considering various factors allows the writer to add clarification and consistency to the scenario. Some factors that can affect a trend include social, economic, political, ecological, technological, and geopolitical elements. The impact of these factors may be viewed on many different levels. The impact levels to consider could be personal, local, regional, national, global, or galactic. Graphic designs and other visual aids can be used to illustrate a scenario.

Facts about Future Energy Resources

Introduction

Fossil fuels and nuclear energy, the resources used to meet most of our energy needs today, are expected to be widely used in the near future. However, fossil and nuclear energy resources are nonrenewable and will someday be exhausted, while their continued use poses environmental risks related to air pollution, global climate change, land use, and waste disposal. These challenges have stimulated the search for alternative means of producing and using energy.

New resources that are being researched or developed include hydrogen, nuclear fusion, ocean thermal energy conversion, and tidal and wave energy. (Solar, wind, and geothermal energy are dealt with in separate fact sheets).

Hydrogen

One fuel that has the potential of being widely used in the future is hydrogen gas (H_2). Like natural gas, hydrogen can be burned to heat buildings, cook food, and produce electricity in power plants. Should hydrogen replace natural gas, the existing natural gas pipeline network could be modified to transport hydrogen. Hydrogen gas can also be compressed in a fuel tank and used to power cars and buses, although difficulties in storing enough hydrogen for motor vehicles to run long distances need to be overcome. Another problem is building the infrastructure to refuel these vehicles.

Fuel cells have high efficiencies (up to 60 percent), or two to three times more efficient than an internal combustion engine running on gasoline. Hydrogen can be used in fuel cells. The electrons in hydrogen atoms generate electricity in the fuel cell. The combination of hydrogen and oxygen creates water and heat from the reaction. The heat may be used to produce electricity, but can be used simply to heat things. At the anode, hydrogen is split into protons and electrons. The electrons move down a separate channel generating electricity. The U.S. space program has used them since the 1960s; the space shuttle uses fuel cells to generate electricity. Electrical power plants could be built using large banks of fuel cells, while small groups of cells could provide electricity for individual home and commercial buildings. Experimental cars and buses powered by fuel cells have already been built and tested and in recent years have been coming onto the market.

Hydrogen is used to store energy produced in other ways. Plentiful hydrogen is available from water (H_2O), which can be split into gaseous hydrogen and oxygen using an electrical process called electrolysis. This process, however, is very energy intensive. Hydrogen can also be produced from natural gas and biomass resources (see Facts about Biomass). Hydrogen is cleaner than other fuels, although it is necessary to take into consideration from where the hydrogen is derived. When burned, because it is reacting with oxygen and nitrogen in the air, it produces only water vapor and, in some cases, small amounts of nitrogen oxides. Hydrogen is often considered a renewable fuel because the water vapor produced by burning hydrogen cycles back into the environment. But, Earth's supply of water is finite, so we are limited to what we have on Earth and the locations of these water sources may change over time. Hydrogen fuel, when produced by renewable sources of energy like wind or solar power, can be considered a renewable fuel. Although hydrogen's explosiveness has given it a reputation for being unsafe, studies have shown that hydrogen is no more hazardous than gasoline and natural gas.

Choosing a renewable source of electricity to produce hydrogen is important. Using electricity from coal- or nuclear-fueled power plants can erase hydrogen's advantage as a clean, renewable fuel. Using solar cells, hydroelectric dams, or wind turbines maintains this advantage. A number of experts foresee the expanded

Facts about Future Energy Resources

use of hydrogen going hand in hand with the increased development of renewable energy resources. Before hydrogen is widely developed, three goals must to be met: cheaper renewable electricity, improved fuel cells, and better ways to store hydrogen for vehicles. When these problems are solved, there is a good chance that hydrogen fuel and fuel cells will be common in the future. Since hydrogen can be produced from water and transported by pipeline, there would be few geographic restrictions to its use, making the future use of hydrogen possible in Wisconsin, the United States, and the rest of the world.

Nuclear Fusion

Nuclear fusion occurs when the nuclei of light elements (such as isotopes of hydrogen) are forced together at ultra-high temperatures and pressures to form the nucleus of a slightly heavier element (such as helium). Fusion releases large amounts of energy. The energy of the sun, other stars, and hydrogen bombs come from fusion. A fusion reaction can release over four times as much energy as does uranium fission.

The main challenge of controlled fusion has been to create the same high temperatures (15 million degrees Celsius/27 million degrees Fahrenheit) that exist in the sun's interior. Two strategies have been tried: confining and heating the hydrogen fuel inside a strong magnetic field and shooting hydrogen fuel pellets with powerful laser beams. During the past several decades, a number of countries have built experimental fusion reactors that use these two methods. Although progress has been made, creating a sustainable fusion reaction that produces more energy than it consumes has yet to be achieved.

Should fusion power plants ever be built, they could provide Wisconsin and the rest of the world with abundant electrical energy. This is because plentiful amounts of deuterium, the hydrogen isotope needed for fusion, are found in ordinary water. However, controlling fusion has proved to be a formidable engineering challenge, and it may be many decades before a successful fusion reactor becomes a reality. Even then, it may take many more years to design and construct commercial fusion plants. Some experts believe that fusion power plants could be built by the middle of the twenty-first century, while others do not foresee them ever becoming a reality.

Ocean Thermal Energy Conversion (OTEC)

The large temperature difference between the warm surface waters of tropical oceans and the cold, deep waters lying beneath them provides a potential energy source. A device that works like a refrigerator in reverse can use this difference in temperature to drive a turbine that generates electricity. This process, called ocean thermal energy conversion (OTEC), could provide electricity for tropical islands and coastal nations. OTEC power plants can be placed offshore on floating platforms; they do not need to be built on land.

Since the sun produces the temperature difference between surface and deep ocean waters, the energy source for OTEC plants is inexhaustible for the foreseeable future. On the other hand, OTEC plants are more expensive to build than other types of electrical power plants, and the technology is still young. The best sites for OTEC are often located far from the nations and population centers that most need electricity. The temperature differences in bodies of water outside of tropical latitudes are too small to operate an OTEC power plant. For this reason, OTEC power plants on Wisconsin's Great Lakes are not feasible.

Tidal and Wave Energy

Changes in tide levels can be harnessed as a source of energy by building a barrier similar to a dam across a bay and allowing the incoming and outgoing tides to spin turbines that produce electricity. A large tidal energy site has been built in Canada's Bay of Fundy, near Maine. The tide changes in Alaska's Cook Inlet are also large enough to be harnessed for energy.

Facts about Future Energy Resources

Ocean waves can also be used as an energy source. Ocean waves oscillate, moving in a circular motion. Terminator devices capture an oscillating water column and cause it to move up and down. Scientists and inventors have designed and tested experimental devices that harness the kinetic energy in a wave to generate electricity through turbines. Some of the more promising designs are undergoing demonstration testing at commercial scales.

Tidal and wave energy are renewable resources that produce little or no pollution. Despite these advantages, the potential for developing tidal or wave energy is limited to a few coastal areas. Tidal and wave energy systems may also affect aquatic life. The equipment must also be able to withstand storms and saltwater corrosion.

Because of these limitations, many experts do not foresee tidal and wave energy making a major contribution toward meeting the energy needs of the United States or the world. The Great Lakes do not experience large tides, so tidal energy is not an option for meeting Wisconsin's energy needs. Harnessing wave energy from the Great Lakes may be technically feasible, but it is not likely to be pursued because of limited energy output and high costs.

Outlook

Hydrogen has the best chance of being widely used in the future. Sources of hydrogen are plentiful, it has many uses, and most of the needed technology has already been developed. However, hydrogen is not a primary energy source like solar or wind power; it is used to store energy produced by other means and an input of external energy is needed to power hydrogen fuel cells. Nuclear fusion continues to pose formidable engineering problems and waste disposal and storage obstacles. Limited sites, high costs, and the need for technological development will also likely restrict the growth of OTEC, tidal, and wave energy systems. However, technical breakthroughs combined with the proper economic and environmental incentives may result in the successful development of these energy resources, despite their limitations. In addition, development of energy resources unknown to today's society may also occur.

References

Bureau of Ocean Energy Management: boem.gov/renewable-energy/renewable-energy-program-overview

National Aeronautics and Space Administration (NASA): solarscience.msfc.nasa.gov/interior.shtml

Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy: energy.gov/eere/office-energy-efficiency-renewable-energy

Renewable Energy World: renewableenergyworld.com

World Nuclear Association: world-nuclear.org

Wisconsin Office of Energy Innovation. Wisconsin Energy Statistics Book: psc.wi.gov/Pages/Programs/OEI/WisconsinEnergyStatistics.aspx

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