

## **Chapter 1**

### **OVERVIEW**

(see Figure 1-0)

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We are all familiar with the five intertwined circles of the international olympic symbol. They symbolize the fact that we live in an ever smaller, more united and interdependent world. The flag of the International Olympic Committee displays this symbol of society's tremendous progress in communications, international cooperation and other areas of material well-being. We are less familiar, however, with the fact that such progress is creating yet another and increasingly problematic circular symbol:

(see Insert p. 2)

It is my experience that many of us do not know how to read the numbers shown on the dials of this electric meter. And even those of us who do rarely stop to think about their significance. Where does electricity, so indispensable for our way of life, come from? Where does energy in general come from? How much energy are we using? How much energy is the world using? Where will our energy come from in the future? How much will it cost? Will all of us be able to afford it?

In a nationwide survey of 3600 people conducted after Iraq invaded Kuwait in the summer of 1990, energy ranked 9th on the list of 11 issues facing the nation (see *Chicago Tribune*, of 11/12/90). Only 12% of Americans considered energy to be one of the top three national issues. Energy fared below education, rising health costs, crime, deficit, even below national defense. This is perhaps a surprising result, given the fact that energy-related reports appear constantly in the media. It is even more surprising when one considers that energy utilization is so intimately connected with environmental protection and air pollution.

As an integral part of the approach that we use at Penn State to teach the course on which this book is based, I ask our students to collect clippings of articles on energy and fuels. I get hundreds of them during unusually hot summers, or unusually cold winters, or when the political situation in the Middle East turns unstable again. But their influx subsides with comfortable weather or as the price of oil comes down from one of its roller coasters.

Do the problems *exist* at all? Do they *really* disappear as the energy-related headlines give way to other political and economic issues? The answer has been obvious for almost three decades now, since the so-called 'energy crises' of 1973 and 1979: these problems are with us to stay and they should be way up there on the national priority list, together with the social security issues and the state of high-school education. Therefore, *everyone* should take an *informed* stand on the issues of energy supply and demand in the coming years. This applies particularly to those of us who are concerned about the environment and do not realize some of the tradeoffs between energy consumption and air pollution.

Here is my 5-cents-worth of advice to Uncle Sam (see cartoon on p. 1) as he ponders what to do under the 'pressure' of the oil burden:

- (a) In the residential and commercial sector, let's use much more natural gas. It is clean and efficient. Let's also use more solar energy right now. Let's not burn oil in our homes. If and when we run out of (cheap) gas, let's get the gas from coal.
- (b) In the industrial sector, let's continue to burn coal, but let's use the best available technology to minimize pollution. Let's not burn oil in industrial furnaces.
- (c) For electricity generation, let's use coal (with mandatory exhaust gas cleaning), hydroelectricity and nuclear power. Let's also make sure that the nuclear plants are absolutely safe by running them like a military operation; after all, we are “playing with fire” in a nuclear reactor. Let's also use more renewable energy in places where the climate is very favorable. Let's not use either oil or natural gas in power plants!
- (d) Finally, let's save the oil for the transportation sector. What else can we use that is convenient and inexpensive, at least for now? And let's work more aggressively on alternatives such as natural gas, coal-derived methanol, or fuel cells. For so long, we've had all the eggs in just one basket and we are paying for it dearly.

The strategy or the ‘policy’ that I suggest may be right or wrong, or something between these two extremes. But that's not the important point here. It is debatable and it should be debated. What is important is that it be defended or debated based on *facts*, and not just on conveniently selected facts or, even worse, on emotions. So in this book we shall emphasize facts. Eventually we shall come back to policy formulation, because that's what the facts are for. But it will be policy formulation at a more authoritative and much more influential level. In anticipation of a discussion of this policy, and indeed as a criterion used in the selection of topics, most chapters begin with quotes from recent federal energy strategies, the “National Energy Strategy” formulated by the administration of President Bush (1988-1992) and the “Sustainable Energy Strategy” formulated during the administration of President Clinton (1992-present). We shall see that some of these policy statements are more important for what they do *not* say than for what they do say. The administration of George W. Bush has its own energy policy proposal, *National Energy Policy* (see [www.energy.gov/HQPress/releases01/maypr/energy\\_policy.htm](http://www.energy.gov/HQPress/releases01/maypr/energy_policy.htm)), which is not unlike the previous two. It remains to be seen how it will fare in Congress in the coming months (or years?).

In Part I (Energy Fundamentals), the facts are laws of nature. Initially, they may be somewhat difficult to grasp, but there is very little controversy about them. We slowly make our way up the somewhat perilous road of elementary thermodynamics toward the central concept in energy use, the efficiency of conversion of one energy form into another. The reward for the diligent and patient reader is very high indeed: it is this concept alone that allows us to make all sorts of simple, interesting and useful back-of-the-envelope calculations that can affect our domestic budget, and we show how it does so.

In Part II (Energy Supply), the facts are straightforward but they are somewhat more controversial. They are based not only on geological and cosmological information, but also on some economic considerations. We analyze the past, present and future of *all*

energy supply options. What is available? How much is available? What are the virtues and what are the liabilities of the available energy forms?

In Part III (Energy Demand), the facts are based on statistics. The demand in the past is well documented and we analyze it in some detail. Here we devote significant space to a topic that has been neglected in books and textbooks on energy, and that I consider essential: a quantitative analysis of residential energy bills. It is here that we need no politics to implement policy. (Now, that's a luxury!) The tools for formulating both technically and economically sound policies at this microeconomic level are shown to be surprisingly easy to grasp and use, and are nonetheless quite effective.

In Part IV (Summary), the transition from facts to opinions is complete. There are few indisputable statements when politics and economics are brought together with the technical aspects, and indeed when these become dominant. (For example, it is well established that natural gas is, in many respects, the ideal residential fuel; yet in many neighborhoods the homeowners do not have this option because the necessary pipelines are not in place.) Even though the material covered comes close to the borders of my expertise and to those of a general education textbook, I consider it essential for understanding media reports. Its incorporation is meant to set the stage for an informed debate on energy policies which do need, and inevitably get, a lot of politics.

Throughout the text, the relationship between energy consumption and environmental pollution is kept in focus. The tradeoffs mentioned above, which represent a complex interplay between population growth, energy consumption, economic growth and air pollution, are illustrated using a simple formula (see J. H. Gibbons, in *Proceedings of the American Philosophic Society*, Vol. 139, pp. 256-264):

Extent of (energy-related environmental) pollution =

$$= \{ \text{Population} \} \left\{ \frac{\text{GDP}}{\text{Population}} \right\} \left\{ \frac{\text{Energy consumed}}{\text{GDP}} \right\} \left\{ \frac{\text{Extent of pollution}}{\text{Energy consumed}} \right\}$$

The second term on the right-hand side of this equation is the per capita income (or gross domestic product) of a nation. The third and fourth terms are called the energy intensity and the pollution intensity. One does not need a crystal ball to predict that the first term will increase in the foreseeable future, especially in the less developed nations. The second one will also hopefully increase as well. If sustainable (or environmentally acceptable) economic development is society's goal, rather than economic growth (through unlimited resource consumption), one does need a crystal ball to figure out how these increases can be counterbalanced with the necessary decreases in energy and pollution intensities. My ambition is to offer you such a crystal ball, or at least a piece of it. The bills mentioned in the subtitle of the book, and discussed throughout, are both economic and environmental!

In the choice of concepts, facts and issues to be included in this introductory course, and especially regarding the depth of their coverage, I needed to be very selective. I wanted to keep the book size within the confines of a one-semester general education course. The

selection was thus made with a utilitarian approach, from the perspective of the general reader. The main guideline was to provide an understanding of the issues that are most commonly raised in the media. This is why throughout the text and in the end-of-chapter Investigations, I provide numerous references to, as well as quotes from, newspaper op/ed pages and news reports. For example, *The New York Times* of 9/27/95 carries an advertisement about the Arctic National Wildlife Refuge. The Wilderness Society is asking the readers to “support President Clinton's pledge to veto oil and gas drilling” there. This is just one illustration of the fact that we are increasingly being asked to take energy-related stands, whether it be on oil drilling or new nuclear power plants or the Kyoto Protocol on greenhouse gas emissions.

Numerous simple calculations (requiring nothing beyond the four basic operations) are also included in the text. They illustrate energy concepts, fuel properties, energy utilization trends and options, and their environmental impact. They are an essential part of this book because they are the basis for much of the decision making. The methodology used in them is more important than the numerical values shown, but I made every effort to use representative numbers.

In today's world undergoing a revolution in communications, it is increasingly easy to obtain all sorts of information. Paradoxically, it may be increasingly difficult to know where to find *reliable* information. The book contains references to selected Internet sites which contain useful and up-to-date technical, economic and socio-political data on energy, fuels and the clean air.

Finally, throughout the book I have included essential statistical information on the patterns of energy supply and demand in the U.S. and the world. Most of it is “hot off the press” thanks to the superb online database of the U.S. Department of Energy (Energy Information Administration) at [www.eia.doe.gov](http://www.eia.doe.gov). The reader should inspect these graphs carefully; they are indeed worth a thousand words. In many cases, blank spaces are left on the graphs for the reader to update this information. Keeping track of the recent trends is essential for *having the facts straight* and for making *informed* judgments. It is this message – above all others – that I want to convey to the reader of these pages.

*Note:* As mentioned above, throughout the text and especially in end-of-chapter Investigations, I have included references to many newspaper and magazine articles. Most are from the period 1990-1996, some are more recent, but they could all have been written last week. (In the energy arena, what goes around really comes around: the same issues tend to linger for decades and the ‘news’ about them are often ‘recycled’.) The ones compiled in the Investigations are thought to be ideal as group projects that can stimulate class discussion. I have *not* relegated them to footnotes because I consider them essential for my main ‘message’. Their inclusion also justifies the subtitle of the book. For convenience and brevity, though, I use abbreviations for the most often quoted newspapers and magazines: NYT for *The New York Times*, PI for *The Philadelphia Inquirer*, BW for *Business Week*, USNWR for *U.S. News & World Report*, and WSJ for *The Wall Street Journal*.

### KEEPING THE FACTS STRAIGHT: A TYPICAL CONFUSION

In the 12/29/96 issue of *The New York Times* (downloaded via AOL), John Holusha writes: “The [Consolidated Edison] utility serves New York City's five boroughs and Westchester County. Since it is proposing to freeze its rates at 13.5 cents a kilowatt [sic] for five years (the national average is 7.2 cents), many users will no longer have to worry about price increases, and some will bargain for savings.”

This is just the most recent example of a very common confusion in people's minds between kilowatts and kilowatthours. The distinction between power and energy is a basic scientific issue. It will be outlined in Chapter 2. But it is also an important practical problem. One illustration is given below; many others are discussed throughout the book.

It is often said, and appropriately so, that we buy power, but we pay for energy. The key issue in the efficient use of electricity is the distinction between total electricity generating capacity (measured in units of power such as kilowatts) and actual electricity consumption (measured in units of energy such as kilowatthours). In Chapter 18 we shall see why the electricity business, in contrast to most other profitable businesses, has a relatively low capacity utilization factor and why some electric utilities are asking you not to consume the product that they sell. This doesn't make sense, does it? It's like your car dealer telling you not to buy the car that he is trying to sell you!? Not really, as we shall see! The fancy term for it is *demand side management*: it simply means that your local electric utility may give you “incentives” to do your laundry, dishes, etc. during off-peak hours (like after midnight)...

### **INVESTIGATIONS**

1-1. On p. 3 I have given the reader my general stand on our future energy policies. Over the last decade, the Mobil Corporation has been publicizing its views on energy policies by taking out advertisements in many newspapers and magazines. It has continued to do the same since it merged with Exxon. See ExxonMobil's web site at [www.exxonmobil.com/news/opeds](http://www.exxonmobil.com/news/opeds). In *Time* magazine of 9/17/90, under the title “A post-crisis national agenda,” Mobil lists the options that the nation should consider. Find out what these options are and summarize them. Consult also a more recent advertisement and summarize the differences and/or similarities between ExxonMobil's statements and the earlier Mobil's stance.

1-2. In a landmark *Foreign Affairs* article (“Energy strategy: the road not taken?,” October 1976, pp. 65-96), Amory Lovins (<http://www.rmi.org>) contrasted the “hard path” and the “soft path” to our energy future.

- (a) Summarize the main differences between these two energy strategies. See also the book by Amory Lovins listed in the Further Reading section of the book.
- (b) Compare the soft path and the hard path predictions with the current primary energy use in the U.S. Are we (still) on the hard path? Are we closer to the soft path predictions?

1-3. In the previous two investigations we have examples of one *for-profit* and one *non-profit* institution advocating certain energy policies. Let’s examine briefly the third category of policy makers: the *government*. Compare the highlights of the two most recent policy proposals of the federal government: (a) *Sustainable Energy Strategy* of the Clinton Administration ([www.hr.doe.gov/nepp/titlepg.html](http://www.hr.doe.gov/nepp/titlepg.html)); (b) *National Energy Policy* of George W. Bush ([www.energy.gov/HQPress/releases01/maypr/energy\\_policy.htm](http://www.energy.gov/HQPress/releases01/maypr/energy_policy.htm)).

1-4. One of the centerpieces of a national energy policy is the Shakespearean dilemma: *To drill or not to drill* (... for oil in the Arctic National Wildlife Refuge)? Twenty-five years after his soft-path vs. hard-path arguments, Amory Lovins, together with his wife, argues in *Foreign Affairs* (“Fool’s gold in Alaska,” July/August 2001, pp. 72-85) that “[d]rilling for refuge oil is a risk the nation should consider taking only if no other choice is possible” and concludes that “if any oil is beneath the refuge, its greatest value just might be in holding up the ground beneath the people and animals that live there.” Make a list of these other choices, which “abound,” according to Amory and Hunter Lovins. (See also Investigation 21-1.)

1-5. A key statistical piece of information, necessary for formulating energy policies, is the *energy intensity* of a nation, and especially its trends over time. Figure 5-7 shows this information for the United States and some other regions of the world. Prepare an updated graph for the U.S. (see [www.eia.doe.gov](http://www.eia.doe.gov)) and make as many comments as you can about the trends observed.