# Integrating Policy into Science in the Classroom: Three Case Studies on the Atmosphere

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## Abstract

Three case studies introduce undergraduate non-science students to policy components of air pollution, ozone depletion, and greenhouse warming. This article presents the versions of the case studies used during for a UCSD course entitled Introduction to Environmental Systems during Winter quarter 2003. Students work in groups of four or five to discuss the case studies, research background material, and reach a consensus about their own recommendations. Case studies are successful in engaging students in environmental policy issues, helping them master basic concepts, and creating enthusiasm for the course material.

## 1. Introduction

One challenge in Earth system science education involves engaging undergraduates so that they are able to apply the lessons that they learn formally in the classroom to environmental issues that affect them in their daily lives. This article describes a set of case studies used at the University of California San Diego for Environmental Systems 10: Introduction to Environmental Systems (ESYS 10).

ESYS 10 is intended as a broad one-quarter (10 week) introduction for UCSD's Environmental Systems (ESYS) program. The ESYS major encompasses both science and policy, allowing students to choose from specialized tracks in policy, biology, atmospheric chemistry, and Earth science. Students enroll in ESYS 10 for a number of reasons. Some are considering the ESYS major; some have a general interest in the environment; and others need to fulfill general education requirements.

The course uses a science-oriented text book, Introduction to Earth System Science [*Kump et al.*, 1999]. Four case studies serve as a means to introduce policy issues to the course and to make students think seriously about the core environmental issues covered in the course. Three of the case studies discussed here cover air quality, ozone depletion, and greenhouse warming. A fourth on marine biodiversity and overfishing is less structured and is not included here.

In addition to introducing policy concepts, the case studies are also designed to motivate independent research and to encourage students to feel a sense of "ownership" of

environmental concepts. The case studies derive from the general concepts of problem-based learning [e.g. *Rhem*, 1998; *Duch*, 2001]. One goal of the class is to make sure that students understand the distinctions between air pollution, ozone depletion, and greenhouse warming. For example, I want students to grasp that CFCs, which destroy stratospheric ozone, are benign for us to breathe; that ground level ozone is a component of smog and a nasty pollutant; and that $CO_2$, the leading greenhouse gas, is a gas that we emit when we breathe, and not a pollutant that causes asthma.

This brief article describes the atmosphere-related case studies that were used in Winter quarter 2003. My own expertise is more oceanographic than atmospheric, and the case studies topics were selected to represent environmental policy issues that make make headlines. Because environmental policy evolves continuously, most case studies will be updated before being used again. Section 2 describes each of the case studies and describes some of the traits that are common to all case studies and how they operate in my classroom. Section 3 evaluates the success of the experience. Anticipated future changes are described in Section 4, and the approach is summarized in Section 5.

## 2. Using the case studies

For all three of the atmospheric case studies in Winter 2003, students worked in groups of four or five. Students are assigned to groups in order to ensure diversity of gender, year of study, and major in each group. They normally remain in the same groups throughout the quarter, although enrollment adjustments require some adjustment of group assignments through the course of the quarter.

The first case study, entitled, “Should Alex Buy a Battery-Powered Car?” presents a group of four undergraduates (Alex, Baylor, Chris, and Dale), who debate whether Alex should take the plunge and buy a “zero emission vehicle” or ZEV. The case study was motivated by California’s ZEV Program, which originally mandated that 10% of cars sold in 2003 should produce zero tailpipe emissions. The ZEV program originated in 1990 through the California Air Resources Board as an air-quality program, without concern for $CO_2$ emissions or greenhouse warming. (Over time, these objectives have shifted. Since the end of Winter quarter 2003, California’s Air Resources Board has adjusted the objectives of the ZEV program to push for more fuel efficient gas-electric hybrids and eventually hydrogen fuel cell vehicles.) In the case study, students are asked to consider four possible stances: buying a ZEV as advocated by Alex, buying a hybrid gas-electric car (Baylor), pursuing public transportation and bicycling (Chris), or sticking to conventional vehicles (Dale).

In the second case study, entitled, “If I had a billion dollars to save the ozone layer ....”, Pat, Riley, Tory, Sasha, and Vic debate ways to preserve stratospheric ozone. The discussion is initiated when Pat reaches for an asthma inhaler, and Riley protests that this will contribute to ozone destruction. By way of background, soon after the Montreal Protocol was signed,

asthma inhaler manufacturers negotiated exemptions to the treaty, allowing them to continue to make use of ozone-destroying chlorofluorocarbons (CFCs) as medication propellants. Because asthma is life-threatening, many patients and doctors have been reluctant to switch to CFC-free medications, and the conversion to new inhalers has been slow. (When I survey my students who have asthma, most report that they have been using the same types of inhalers for 10 or 15 years, and therefore they assume that their inhalers are still CFC-propelled.) In the dialogue, Pat, Tory, and Sasha enumerate a range of additional problems that may lead to ozone destruction including methyl bromide, weak enforcement of the rules, and developing country emissions. Finally, Vic suggests that the Montreal Protocol is doing its job and that education (and staying out of the sun) may be the best strategies for managing stratospheric ozone depletion.

The final case study of the quarter, "Should the Senate Debate the Kyoto Protocol?", addresses greenhouse warming and the U.S. participation in international global warming negotiations. Students are asked to consider four possible standpoints on the Senate ratifying the Kyoto Protocol, as voiced by four summer interns at the Senate Committee on Foreign Relations. Izzy says that since global warming is a serious problem and the Kyoto Protocol is the only international treaty to address the problem, the U.S. should participate. Jay counters that the Kyoto Protocol represents only a minor effort to reduce greenhouse gases in the atmosphere, and that the U.S. should advocate starting treaty negotiations anew. In contrast, Kendall suggests that the evidence for greenhouse warming is not clear enough to justify any strong measures. Finally, Lee argues that the debate over the Kyoto Protocol is about international politics rather than science, implying that the U.S. Senate's stance cannot be determined from scientific considerations alone. The topic plunges students into the complexities of international treaties and feels far removed from student's daily lives, which makes this a difficult case study.

The case studies are each presented as dialogues rather than narratives, because dialogues offer a succinct way to voice a number of opinions without the burden of narrative detail. The dialogues have a certain unrealistic quality: the undergraduate speakers are surprisingly well-informed about environmental topics, and they spew out whole paragraphs of fact and opinion without any interruption. Although this structure can feel a little clumsy, it works reasonably well in class. Dialogues can be read quickly by students, and the background information and opinions are grouped tightly, so that students can easily separate the multiple opinions that they are exploring.

Each case study requires two class sessions and a certain amount of outside work. Students receive the case study text to read prior to the first session. Even though the case study texts are short, students need to be assigned to read them before class. Allowing students time to read the case studies in class requires a surprisingly long time interval, since students read at different rates.

During the first session, they spend about 15 minutes discussing the basics of the case

within their groups. I specifically ask them what additional information they will need in order to fully evaluate the case. The case studies normally present four view points, and each student chooses one viewpoint to research further and represent. At this point, I ask students to split into groups based on the viewpoint that they are representing—thus for the case study on ZEVs, all the Alex's joined together to consider what additional research will be needed before they argue the case for ZEVs to their classmates. Students are encouraged to find ways to split up research responsibilities so that they can explore the material more broadly. I circulate between the groups as they discuss to answer questions, prod discussion, and encourage them to consider alternate points of view.

Between the first and second sessions, students are expected to carry out independent research. I usually provide at least one factual hand out to provide some basic background information. The hand-outs often come from press offices. For the zero emission vehicle case study, the hand-outs included two fact sheets entitled "California's Zero Emission Vehicle Program" and "Zero Emission Vehicle Program Changes" [*California Air Resources Board*, 2001a, b]. as well as a New York Times article on the California policy [*Hakim*, 2002]. For the ozone depletion case study, the hand out is a Press Backgrounder on the Montreal Protocol [*United Nations Environment Program*, 2001]. For the Kyoto Protocol case study, students receive a Fact Sheet on the Kyoto Protocol [*White House Climate Change Task Force*, 1999]. In addition to these hand outs, the course web site identifies identifies a wide range of web links that can serve as starting points for further research. Although many university faculty now worry that students neglect libraries in favor of doing all research electronically, for these current-events oriented case studies, the web provides a broad range of valuable resources. In addition to demanding student research, I also often invite a guest speaker to lecture the class in between the beginning and end of the case study. For example, Bill Brick, from the San Diego Air Pollution Control District, has proved to be a valuable resource to help place the ZEV case study in context.

In the second class session, students return to their viewpoint groups to share the fruits of their research. Viewpoint groups are encouraged to determine what evidence they have that will most clearly support their stance. Finally students reform their original groups to attempt to reach a consensus on the case. We finish up with an overall class discussion to determine the major themes and the overall class opinions. In the ZEV case study, most students argue in favor of hybrid cars in the end. Likewise, most groups favor U.S. ratification of the Kyoto Protocol in the third case study. The ozone depletion case study has less well-defined outcomes, and the groups often reach differing opinions, allowing some useful class discussion.

One week after conclusion of case study, students hand in their own written summaries. I have normally treated the summaries as informal writing assignments, which I graded on a "check/check plus/check plus plus" grading scale. Summaries are normally one to three pages in length. I tell students that they need not be typed, but I usually point out that experience

indicates that typed summaries seem to be more clearly thought out and therefore earn higher evaluations. I require that students include clear reference lists indicate the sources for their independent research, but I am not stringent about their methods for citing web sites.

Many instructors who use problem-based learning approaches such as mine ask that each discussion group submit a group report. In my experience, for relative short case studies such as these, group reports frustrate students, because they feel like their grades depend on their unreliable classmates. Problem-based learning instructors have developed a variety of techniques to help students motivate and work with each other. In my own class, however, rather than governing group dynamics, I have opted to demand that each student submit a full discussion of the case.

Group activities such as these case studies only work if students come to class regularly. Therefore attendance is mandatory in ESYS 10. Normally I take attendance as I circulate among the groups. This approach does not take time away from other class activities, but it leaves students aware that their attendance is being tracked. Ultimately attendance and participation are factored together to represent about 10% of the total course grade.

## 3. Evaluation of the experience

The overall success of the case studies used in ESYS 10 depends on two factors. First, do the students learn material more effectively than they would if they listened to longer lectures? Second, do students appreciate the case studies? For ESYS 10, both of these factors are difficult to evaluate, except in an anecdotal sense.

Overall, student reaction to ESYS 10 is positive. UCSD course evaluations are not designed to evaluate non-traditional teaching approaches. However, student survey responses are uniformly positive. Without exception, in the past two years, all of the ESYS 10 students (9 in 2002 and 17 in 2003) have indicated that they would recommend the course. Small enrollment courses tend to win positive teaching evaluations, but these numbers are particularly strong.

A comparative study at the University of Delaware showed little performance difference between students in “problem-based learning” sections and students in traditional lecture sections of a food service class. However, problem-based learners were much more positive about their course experience [*Lieux*, 2001]. Since UCSD does not offer multiple versions of ESYS 10 with and without case studies, we do not have a clear statistical means to compare learning from case studies with learning in lectures. Exams normally include a range of short answer questions, that tend to test material from the textbook and lectures, and essay questions that tend to revisit material from the case studies. In general, students perform consistently well on essay questions, indicating that most have grasped the key concepts from the case studies. In contrast, performance on short answer questions appears to depend strongly on students willingness to read and review course material to prepare for the exams.

Case studies clearly stick with students long after the end of the term. Students who request letters of recommendation often stop by weeks or months later. As we chat about their plans, they sometimes bring up issues that evolve out of the case studies. ("My Mom just bought an SUV; I tried to persuade her to look at something more environmental.") In contrast details from the lectures and textbook reading have clearly slipped their minds.

In one notable exception to the generalization that students understand and retain material from case studies, in the Winter 2003 final exam, I asked students to comment on a newspaper columnist's comment that driving a sport utility vehicle (SUV) destroys the ozone layer. While top performers in the class easily identified this as a false statement, many others were taken in by this popular myth. Clearly in future years, the course will need to explore the distinctions between $CO_2$ and pollutant emissions and stratospheric ozone destruction more carefully.

## 4. Difficulties in the case study approach

Case study approaches to education present problems that are distinct from problems in lecture classes. This section summarizes some of the problems that have evolved in ESYS 10 and some of the problems anticipated in the future.

One first challenge involves convincing students to take up the viewpoint of one of the dialogue speakers. In 2002 versions of the dialogues, speakers were half women and half men. While the gender balance seemed valuable, the result was that male students specifically opted not to represent the viewpoints voiced by women. To avoid this problem, the dialogues were subsequently rewritten with gender ambiguous names. Names are grouped alphabetically (e.g. Alex, Baylor, Chris, Dana) to simplify blackboard discussion. Gender neutral names puzzle everyone, and students sometimes assume that the speakers are men or arbitrarily select genders for the speakers. However, the ambiguity in the names seems to serve the intended purpose of ensuring that students consider all opinions when choosing what viewpoint they would like to research and represent.

A second problem involves keeping students engaged in the small group discussion process throughout the quarter. As the term progresses, some groups are able to speed through their case study discussions so that they can spend class time socializing. For the socializing groups, class time would be more productive if the professor took over guiding a class-wide summary discussion of the case study. However, often when one group deteriorates into gossip, other groups continue to analyze the case productively. As the quarter progresses, it therefore seems particularly important to set clear guidelines and objectives for in-class discussion.

Would it be better to use case studies as basis for class-wide discussion rather than dividing students into groups? This might alleviate some of the difficulties with socializing groups, but overall students appear to feel more pressure to perform for a small group of peers than for a large class discussion. The use of groups seems to motivate the majority of the

students to do independent work and to come to class prepared for discussion. Most students come supplied with notes or printouts indicating that they have spent time surfing their web to prepare for class debate. In addition, small groups are considerably less intimidating than large classes, and students who rarely participate in full class discussion will happily contribute to small group discussion. This experience is borne out by the extensive literature on problem-based learning, which advocates small group activities as a means to engage students in the learning process.

Despite their engagement in group activities, in the first few case studies of the quarter, students sometimes have trouble remembering who is in their group, particularly because a week or more may pass between case study activities. During the first couple of case studies, students often need a refresher of the group participant lists. Students would probably identify more closely with their groups if they had to select team names, but I have so far not asked them to do that.

At UCSD, ESYS 10 has only been taught twice (in 2002 and 2003), both times to relatively small enrollments. However, the class is intended as a general education class, and ultimately should have an enrollment between 50 and 150 students. Larger enrollment will bring new challenges to the class. Teaching assistants can provide additional guidance for small group discussion. Since Scripps Institution of Oceanography graduate students have few opportunities to work as teaching assistants, I have sometimes recruited grad students to act as volunteer discussion facilitators. This necessitates some preparatory work; assistants must have a clear idea of the case study background, objectives, and discussion schedule in order to provide helpful advice to students.

Attendance would also be difficult to track in a class of 50 or 100 students. One strategy would be to stop monitoring attendance and assume that students would attend class anyway, particularly if they had interesting case studies to analyze and the threat of an eventual group-evaluation of their participation. A second strategy is to schedule weekly quizes for the days when case study discussions will take place, so that students have an extra motivation to attend class on case study days. The literature on problem based learning provides a number of suggestions that may help in extending these case studies to large classes [*Dion*, 1996; *Shipman and Duch*, 2001].

## 5. Summary

At UCSD, a series of case studies accompanying Introduction to Environmental Systems (ESYS 10) ask students to apply the material that they learn in class to analyze specific environmental problems. This article has discussed the three case studies that focus on atmospheric air quality, stratospheric ozone depletion, and global warming. (A fourth, on overfishing, has a different feel, and is not included in this article.)

Case studies offer several benefits compared with simple lectures. Students do not fall

asleep during small group discussion. They participate broadly in class discussion. And they seem to retain material that they have discussed during their case study analyses. The case studies presented here are sure to change in response to policy developments, scientific discoveries, and student comments, but the general case study structure is likely to continue in ESYS 10, provided it remains feasible as enrollment increases.

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**Should Alex Buy a Battery-Powered Car?**

*The scene: Lunchtime at a crowded café on campus. Baylor, Chris, and Dale are grabbing a bite to eat as they compare notes about their perpetual on-campus parking woes. From across the café, Baylor spies Alex.*

*Baylor:* Hey, Alex! Come join us. Where have you been? We haven't seen you in weeks.

*Alex saunters over to their table and pulls up a chair.*

*Alex:* Can't stay long. I'm shopping for a new car.

*Chris:* Whatever for? You're car is still running, isn't it?

*Alex:* It's my New Year's Resolution for 2003. I decided that I'd like to live a more environmental lifestyle. So I'm going to be part of California's Zero Emission Vehicle program. I want to buy a car that doesn't pollute.

*Dale nearly chokes on a cup of coffee.*

*Dale:* A ZEV? You're crazy! When the California Air Resources Board started their ZEV program in 1990, they were operating in fantasy land, just hoping that by mandating that 10% of the cars sold in California by 2003 they could force car manufactures to develop electric vehicles. But car manufacturers are market driven. They can't justify developing complicated new technology if consumers won't buy it. And people don't want to buy battery powered cars. The State of California has had to relax the ZEV guidelines several times since the 1990s, just to prevent the automakers from suing the state for creating an unfair business environment. What's the deal now? They require 2% of cars sold to be true ZEVs? And the state is still contending with potential law suits from the auto makers. The ZEV program is toast. Besides, ZEVs have no resale value. At my Dad's car dealership, no one ever comes in asking to buy a battery powered car. You can only use them for short errands—the maximum range is what? About 50 miles?

*Alex (interjecting):* Actually the new electric cars can go nearly 150 miles on a single charge, if they're driven carefully. And the newest ZEVs that use hydrogen fuel cells have a range of more than 200 miles, although they're outrageously expensive and only available for lease at present.

*Dale (continuing on):* And you absolutely don't want to drive a small under-powered car, especially now that over 50% of the vehicles sold in the U.S. are big S.U.V.s and trucks.

*Chris:* I agree with Dale that you shouldn't buy a new ZEV, but I disagree with Dale's reasons. ZEVs just aren't sufficiently environmental to justify their cost. For one thing, manufacturing a new car uses an enormous amount of metals, plastics, and lots of energy. And then once they are built, you have to keep charging the batteries off the regular power grid. So a ZEV still uses power and it still pollutes—-the only difference between a ZEV and a gas-powered car is that the pollution no longer comes out of your tailpipe. Sure in theory ZEVs generate less pollution per mile than conventional cars, but that assumes that

the power plants are following modern emissions guidelines. And you know how problematic electricity can be in California. Finally, when the car dies, the batteries are major environmental contaminants. If you really want to live the pure and simple life, you should stop driving your car altogether. Save it for emergencies if you have to, but take the bus or bicycle to get around day to day.

*Alex:* I thought about giving up my car altogether, but the bus routes really don't meet my needs, and I just hate bicycling in the rain. Plus, it's tough to take a group of friends to the movies on the back of my bicycle. All in all, I estimate that I use a car often enough that I may as well make it an efficient vehicle.

*Baylor:* In that case, why aren't you looking at gas hybrid cars? They're low polluters, and they have enormous range so you don't have to worry about being stranded far from a power socket. Plus their fuel efficiency is amazing. I was reading that they use regenerative braking to charge up their batteries, so they can do more than 50 miles to the gallon, in the city and on the highway.

*Alex:* I've thought about hybrids too, but they just aren't ZEVs. They pollute a little more, and they don't meet California's original zero-pollution goals. Plus, here's the ultimate selling point: with a ZEV, I'll be able to park in a designated spot, at a recharging station right in the center of campus.

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**Questions:**
(1) What is a zero emission vehicle (or ZEV)?

(2) What does the California Air Resources Board mandate for new car sales starting in 2003, and why? Why is air quality an important issue in California?

(3) What four points of view are presented in this dialogue by Alex, Baylor, Chris, and Dale? Each of you should choose one of these perspectives to represent within your groups.

(4) Based on what you know now, what are the advantages and disadvantages of gasoline-powered vehicles, electric cars, and gas-electric hybrids? How do they compare with bicycles or public transportation?

(5) What would you advise Alex to do? What additional information do you need to better advise on car shopping options? Make a list of of questions for which you want to find answers, and come prepared to debate this topic in greater detail next time?

In particular, you'll want to find out why the ZEV program was initially established in 1990, why it was scaled back in the mid-1990s, and why it has not yet been canceled despite lobbying from automakers.

**If I had a billion dollars to save the ozone layer ....**

*The scene: A backyard barbecue on a lazy Sunday afternoon. After downing too many burgers too quickly, Pat, Riley, Tory, Sasha, and Vic are shooting the breeze. A house cat wanders through, settling down on Riley's lap, and immediately, Pat reaches for an asthma inhaler.*

*Riley:* Pat, are you still using one of those evil ozone-destroying metered dose inhalers? If I had a billion dollars to save the ozone layer, I'd spend it all to get rid of those asthma inhalers. With every puff you take, you're ejecting more Freons into the atmosphere, bringing the rest of us one step closer to succumbing to skin cancer.

*Pat:* You're right. This is still the same old prescription inhaler, and I do feel guilty. I'm stuck, because the FDA has only approved a couple CFC-free inhalers, and my allergist doesn't think that either of them would be right for me. But asthma inhalers are really only a tiny source of ozone destroying chemicals. If I had a billion dollars to save the ozone layer, I'd worry more about methyl bromide, which is not only an ozone destroyer but also toxic to humans.

*Tory:* Don't dump on methyl bromide. It may destroy ozone, but methyl bromide is also an important pesticide and fumigant. It's on target to be banned completely by 2005, and after that date, it will be allowed through "critical use exemptions" only when no other technology exists. That means it will probably be used only for emergency fumigation to meet import/export requirements and keep businesses in operation. I don't think methyl bromide is such a big problem.

If I had a billion dollars to save the ozone layer, I'd worry more about forcing individuals and U.S. corporations to really adhere to the rules laid out by the Montreal Protocol. In the U.S., air conditioners and refrigerators built before 1996 use CFCs, but the CFCs aren't a problem as long as they don't leak out into the atmosphere. Current EPA rules prohibit venting refrigerant to the atmosphere, yet every year there are plenty of violations. In June 2001, a hotel in Salt Lake City was fined $216,000 for cutting a bunch of old refrigerant lines. But for everyone who is caught violating the laws, there must be dozens more who get away with destroying the ozone layer. I'd put my money into enforcement.

*Sasha:* I agree that enforcement matters, but the problems in the U.S. are trivial compared with what developing nations face. If you remember, developing countries never wanted to adhere to the Montreal Protocol in the first place. They complained that developed countries in North America and Europe had the privilege of building their powerful economies in whatever ways they could, polluting as much as they wanted as they went. Not surprisingly, developing countries think they shouldn't have to suffer economic hardship to help the planet recover from problems that they didn't create.

Developing countries negotiated a special status for the Montreal Protocol. They are allowed an extra 10 years before they have to stop using CFCs. Developing countries also receive considerable economic aid to help them develop CFC-free industries. But nobody is really adhering to the new rules. Developed countries are dumping old

technology in developing countries. For example, second-hand European refrigerators were sold in Zambia for years after they were banned in Europe. And phasing out CFC production is taking more time than it should. According to Greenpeace, India says that, "unless the North (developed countries) compensates it for not building new CFC plants, it will go ahead and build them." If I had a billion dollars to save the ozone layer, I'd put my money into United Nations aid programs.

*Vic:* Forget saving the ozone layer. We can talk all we want about what should we done, but the political process is functioning well. The Montreal Protocol is renegotiated regularly. New technology is coming on board. To my mind, the biggest problem now is that the ozone layer isn't going to recover nearly as fast as scientists initially thought. We might have to wait 45 years before we even see signs that the ozone layer is recovering, and unfortunately global warming could slow the recovery. If I had a billion dollars, I'd spend it on education. We should be staying inside, wearing big hats and slathering on sunscreen to protect ourselves from the Sun's harmful rays. Speaking of which, could you pass that bottle of Coppertone?

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**Questions:**

(1) This dialogue mentions two types of ozone destroying chemicals: methyl bromide and CFC (technically chlorofluorocarbon and also known by its trade name, Freon). What uses of each are mentioned here? What other uses do you know of?

(2) What international treaty was written to preserve the ozone layer? Why is the ozone layer important?

(3) What five points of view are presented in this dialogue by Pat, Riley, Tory, Sasha, and Vic? As in the previous case studies, each of you should choose one of these perspectives to represent within your groups.

(4) Based on what you know now, if you had a billion dollars, what strategies would you recommend to "save the ozone layer"? What additional information do you need to more thoroughly consider this question?

(5) As you did for the previous case studies, make a list of of questions for which you want to find answers, and come prepared next week to debate this topic in greater detail?

You'll find web links to serve as starting points for your investigations on the course web site: www-mae.ucsd.edu/∼sgille/esys10, but don't feel limited to the links on the web—you're own searches (at the library or on the web) may stir up some interesting perspectives.

**Should the Senate Debate the Kyoto Protocol?**

*Summer was just beginning, and already Washington, DC, was sweltering hot. For Izzy, Jay, Kendall, and Lee, this was the first day of an internship with the Senate Committee on Foreign Relations. The committee staffer who had been charged with briefing them had all of the sympathy of an army drill sergeant. "You may have thought you'd spend the summer photocopying documents during the day and partying in Georgetown at night, but we've got a bigger problem for you," she said. "As you probably know, the U.S. has so far refused to sign the Kyoto Protocol—that's the United Nations treaty on global warming. In fact, the president has not even asked the Senate to consider the treaty. This has posed some problems for us internationally. The committee chair wants to reconsider. We need the four of you to research the pros and cons of the treaty and make a recommendation. You have all of the resources of the internet, government document libraries, and the Library of Congress at your disposal. Figure it out. Should the Senate take the time to debate the Kyoto Protocol?"*

*And with that she ran off to another meeting, leaving the four interns arguing about how to begin.*

*Izzy:* Global warming must be the biggest crisis this planet will face in the next two or three decades. Already we see tremendous evidence for global warming. Carbon dioxide levels in the atmosphere have increased from about 280 ppm in the early 1800s up to 360 ppm today. And global climate really does seem to be changing in response to this increase in greenhouse gases. We've all heard that the 1990s were the warmest decade of the millenium. Every year there are news reports of ice bergs breaking off of Antarctica, and the ice over the North Pole seems to be decreasing faster than anybody ever expected. The Kyoto Protocol is the United Nation's only current strategy for addressing global warming, and the U.S. really needs to get on board and sign this treaty. I'm ready to dig out the evidence to persuade the Senate to endorse, whether the president cares or not.

*Jay:* Wait! Not so fast. I agree with you that global warming really does seem to be taking place. And I can come up with a half dozen other examples that terrify me. Global sea level has risen 20 cm (8 inches) in the past century and forecasts suggest that it will rise another 35 cm (14 inches) in the next 50 years. Although I've always wanted to escape the modern world to live on a tropical island, that prospect seems much less appealing when so many low-lying tropical islands are at risk of disappearing completely.

But nonetheless, the Kyoto Protocol is a weak document at best. It simply doesn't address the real problems. It doesn't stop greenhouse gas emissions, but merely asks industrialized countries to reduce their emissions to 93% or 94% of 1990 levels. Everyone will still be spewing $CO_2$ into the atmosphere. As Jerry Mahlman, the director of the Geophysical Fluid Dynamics Lab (a government research facility in New Jersey) said, "The best Kyoto can do is to produce a small decrease in the rate of increase."

There's simply no point in signing the Kyoto Protocol. We need to start working on all new power systems—wind, solar, maybe nuclear—that don't produce greenhouse gases. Everything else is merely offering lip service to a monumental problem.

*Kendall:* I'm not so sure that I agree with you guys. There are a lot of uncertainties about

the real impact of greenhouse gases. Climate change is normal, and it's difficult to distinguish the changes of the past hundred years from climate fluctuations at any other point in the Earth's history. And the computer models used to predict climate really aren't very accurate. An organization called the Petition Project has collected more than 17,000 signatures from scientists supporting a statement that "There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gasses is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate. "

*Izzy:* Come on. That's bunk.

*Kendall:* Let me finish. Even if global warming does occur, there's no guarantee that will really destroy life as we know it. Sure a few tropical islands may disappear, and some expensive beach front real estate may be washed away, but overall global warming may not be so bad. It may make cold climates more agriculturally productive. Already there's evidence that ice is melting earlier in the spring and the growing season in Canada and Alaska is several days longer than it used to be. Increased $CO_2$ can help fertilize plants and make them grow more quickly. Maybe in the future we'll have a whole new class of fast growing plants to feed the world. Certainly we shouldn't disrupt our entire lifestyles and change our economy to address a problem that we don't understand.

*Lee:* Kendall, I don't think that scientific uncertainty has much to do with the U.S. refusal to consider the Kyoto Protocol. Most scientists, and even a lot of politicians, would agree with Izzy and Jay that global warming is a big problem. The U.S. refusal to consider the Kyoto Protocol is about politics. The Kyoto Protocol is a compromise document that considers the needs of more than a hundred different countries.

For example, to make it appealing to the former Soviet Union and other Eastern Bloc countries, the Kyoto Protocol says that emissions have to be reduced to a fixed percentage of 1990 emissions. How did the treaty negotiators choose 1990? That was because the Soviet Union collapsed in 1991, and power consumption in that region has decreased substantially since 1990. Russia now stands to make a big profit by selling emissions credits that they are no longer using to countries that emit a lot of $CO_2$, such as the U.S.

But the big stumbling block for the U.S. is that developing countries are not required to participate in the Kyoto Protocol, because emissions limits might hinder their growing economies. That would be fine, except that China's and India's economies are growing so rapidly that they may soon become the world's largest emitters of greenhouse gases. The U.S. Senate was so concerned about this that in 1997 they passed the Byrd-Hagel Resolution with a 95-0 vote. That resolution states that the U.S. will not enter into an agreement to reduce greenhouse gas emissions that does no require "meaningful involvement" of developing nations or that is in any way detrimental to the U.S. economy. In essence, the Senate wants to keep the playing field level, and they're concerned that other countries will experience substantial financial gains at the expense of the U.S. as a result of the Kyoto Protocol.

*Izzy:* But we have to start somewhere if we're going to address global warming. Even if there are costs, the U.S. should sign the Kyoto Protocol.

**Questions:**

1. What is meant by the term "global warming" and why may it be a problem?

2. What is the Kyoto Protocol? What are the provisions of the agreement?

3. What scientific criteria might be used to decide whether to regulate greenhouse gas emissions?

4. What policy considerations need to be considered?

5. What possible responses to the Kyoto Protocol are represented by Izzy, Jay, Kendall, and Lee? In your groups, each of you should choose one of these views to research more closely and defend in group debate.

This text raises a number of scientific related to the Kyoto Protocol that you may wish to explore. Among these are:

Reliability of climate models for predicting future climate.
$CO_2$ fertilization of trees.
Temperature change over the last 100 years relative to natural climate variability
Sea level rise over the last 100 years relative to sea level rise since the last ice age.
Ice thickness over the Arctic Ocean and Antarctic Continent.
Increasing $CO_2$ in the atmosphere.

In addition, the Kyoto Protocol poses a number of additional issues:

What countries should be responsible for controlling emissions?
Should per capita energy use influence how the Kyoto Protocol is considered?
Should it be OK to trade energy emissions emissions credits?

Be prepared to consider the following questions. What evidence is there for and against the existence of global warming? What countries would be influenced by climate change and by treaty provisions? Who should be responsible for controlling greenhouse gas emissions? How do the provisions in the Kyoto Protocol respond to global warming?

In class each group will present the results of their research and offer your own recommendations on whether the U.S. Senate should ratify the Kyoto Protocol.

**References:** available from class web site (http://www-mae.ucsd.edu/∼sgille/esys10)