Mathematical Modeling of Renewable Energy Sources

Research proposal prepared by Amelia Musselman and Andrea Levy

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Student Researchers: Amelia Musselman ('11) and Andrea Levy ('11)

Faculty Advisor: Professor Rachel Levy

Location: Harvey Mudd College

Dates: July 5 to August 13, 2010; 6 weeks

Proposed Research: As the supply of fossil fuel dwindles and carbon dioxide pollution increases, the need for alternative energy sources has become apparent. In response to this need, renewable energy sources such as biomass, geothermal, hydrogen, solar, and wind energy have been developed.[1] However, there are still many things to consider in determining the extent to which these sources actually solve the problem. For example, fossil fuel is required for hydrogen production through wind/electrolysis,[2] and hydrogen production from natural gas emits CO_2.[3]

Our goal for this project is to determine which of the five above renewable energy sources will most adequately satisfy society's energy needs with the least negative impact on the environment. Using mathematics such as differential equations, and probability and statistics, we hope to develop a model of how these alternate energy options will affect fossil fuel consumption and CO_2 emission. We also plan to study David Rutledge's research on fossil fuel and determine how the increased use of alternate energy sources would affect his predictions about CO_2 levels and energy usage. Additionally, we plan to study whether methods similar to Rutledge's could be applied to model the quantity of available energy from alternative sources.

We will begin our study with familiarizing ourselves with the various sources of renewable energy available. We will use life cycle assessments from the National Renewable Energy Lab to develop a better understanding of all of the materials and waste involved in each of the various types of renewable energy. We will also develop a better understanding of past trends of fossil fuel usage and Rutledge's model of future usage.

In developing our model we will take into account the availability of the source, and the effect that the source has on the environment, including the materials used in the process and the consequences of disposing of those materials. Since cost is also a driving influence

on the success of the options for renewable energy, we intend to include a financial aspect in our project as well.

Significance of Research for Environmental Quality: As the need for renewable energy sources increases it is important that we understand what our best options are for the future. There are already many renewable energy sources available, and we hope that this project will provide insight into which sources are most valuable overall. By carefully considering the impact that renewable energy processes could have on our environment we hope to find the optimal solution for reducing both CO_2 pollution and fossil fuel consumption.

Educational Value: Working on this project will help both students to learn more about current environmental concerns as well as to contribute to the solution. The quality of the environment is something that affects everyone, so we would be excited to work towards making a positive impact on environmental quality through this project. This project would also be a great opportunity to put the mathematics we have learned into practice, and apply it to something that we hope will benefit the environment. Both of us are interested in applied mathematics, and this project will help us to build our understanding of the use of mathematics in environmental research.

Feasibility: There are many parts to this project including modeling CO_2 emission, fossil fuel consumption, and the affect that increased reliance on renewable energy may have on Rutledge's predictions about both of the above. Even if we are unable to complete all aspects of the project there will still be value in completing some portion of the work.

Both of us will have completed our junior year at Harvey Mudd by this summer. We have completed the math core, and, between the two of us, have taken a good variety upper division math courses including applied analysis, numerical analysis, linear models, operations research, intermediate probability, design of experiments, and graph theory. We would be willing to draw from any of these branches of mathematics, as we see necessary, during our research.

Andrea's MCM team used differential equations in their winning model for the Mathematical Modeling Contest last Spring. Amy participated in an REU at the University of Portland in probabilistic forecast modeling in operations management last summer. We feel that we both have the necessary experience and interest to work on this project. If the project goes well, Amy may consider pursuing a similar topic for her senior thesis.

Proposed Budget:

Item	**Cost**	**Total**
Student Salary	\$400 per student for 6 weeks	\$4,800
Faculty Stipend	\$500	\$500
Total		\$5,300

External Funding: External funding has neither been requested nor recieved.

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References

[1] `http://www.nrel.gov/learning/student_resources.html`

[2] Spath, Pamela L. and Mann, Margaret K., *Life Cycle Assessment of Hydrogen Production Via Natural Gas Wind/Electrolysis*, National Renewable Energy Laboratory, Colorado, 2004.

[3] Spath, Pamela L. and Mann, Margaret K., *Life Cycle Assessment of Hydrogen Production Via Natural Gas Steam Reforming*, National Renewable Energy Laboratory, Colorado, 2001.

[4] `http://www.nrel.gov/hydrogen/energy_analysis.html`