Combining PV and Wind Energy in Secondary Mathematics Classrooms

StR' i. H. Dr. Astrid Brinkmann
University of Münster
Institute of Mathematics Education
Department of Mathematics and Informatics
Fliednerstrasse 21, D-48149 Münster
E-Mail:astrid.brinkmann@math.uni-muenster.de

Prof. Dr.-Ing. Klaus Brinkmann
Umwelt-Campus Birkenfeld
Department of Automation and Energy Systems Technology
University of Applied Sciences Trier
P.O. Box 1380, D-55761 Birkenfeld, Germany
E-Mail: k.brinkmann@umwelt-campus.de

Abstract

One of the most effective methods to achieve a sustainable change of our momentary existing power supply system to a system mainly based on renewable energy conversion is the education of our children. Especially the young generation would be more conflicted with the environmental consequences of the extensive usage of fossil fuels. For our children it is indispensable to become familiar with renewable energies, because the decentralised character of this future kind of energy supply requires surely more personal effort of everyone. In comparison to the parental education, the public schools give the possibility of a successful and especially easier controllable contribution to this theme. This can even be done advantageously for classroom teaching, as realistic and attractive contents have a particular motivating effect on students. In addition to that, a contribution to interdisciplinary teaching would be given, which is a significant educational method, demanded by school curricula. Regarding the fact, that in Germany not all students participate at technical oriented lessons in a comparable proportion, it seems to be especially suited to treat this topic in mathematics education for this purpose. Following the general didactical concept published first by the authors at the ‘12. Internationales Sonnenforum 2000’ in Freiburg, meanwhile continued by several presentations and a book with much positive reactions, this contribution gives an

insight into further examples of mathematical problems concerning future energy issues. The problems presented here deal with the very important and indispensable topic ‘Combining PV and Wind Energy’. They are suitable for lessons in secondary schools and include extensive explanations. This contribution is a further step to integrate such important themes in curricula of public schools.

Intruduction and Motivation

Especially the young generation would be more conflicted with the environmental consequences of the extensive usage of fossil fuels. The education of our children should bring up consciousness for the resulting problems. This would be one of the most effective methods to achieve a sustainable change of our momentary existing power supply system to a system mainly based on renewable energy conversion. Moreover, for our children it is indispensable to become familiar with renewable energies, because the decentralised character of this future kind of energy supply requires surely more personal effort of everyone.

In comparison to the parental education, the public schools give the possibility of a successful and easier controllable contribution to this theme; especially in mathematics education it is possible to reach all students. In addition this would be quite profitable for mathematics education itself, as “the application of mathematics in contexts which have relevance and interest is an important means of developing students’ understanding and appreciation of the subject and of those contexts” (National Curriculum Council 1989, para F1.4). Such contexts might be environmental issues, that are of general interest for everyone. Hudson (1995) states that “it seems quite clear that the consideration of environmental issues is desirable, necessary and also very relevant to the motivation of effective learning in the mathematics classroom”. One of the most important environmental impacts is that of energy conversion systems.

Lack of Teaching Material

However, there is a great lack of mathematical problems suitable for school lessons. Especially there is a need of mathematical problems concerning environmental issues that are strongly connected with future energy issues. An added problem is, that the development of such mathematical problems affords the co-operation of experts in future energy matters with their specialist knowledge and mathematics educators with their pedagogical content knowledge.

In such a co-operation the authors have developed a special didactical concept to open the field of future energy issues for students, as well as for their teachers.

On the basis of this didactical concept, the authors have created several series of problems for the secondary mathematics classroom, concerning the topics of rational usage of energy, photovoltaic, thermal solar energy, biomass, traffic, transport, wind energy and hydro power and finally published in a book (figure 1).

Figure 1: Front-page of the book in Germany (ISBN 3-88120-415-6) [2]

Didactical Concept

The cornerstones of the didactical concept, developed by the authors in order to promote renewable energy issues in mathematics classrooms, are:

- The problems are chosen that way, that the needed mathematical contents in order to solve them are part of mathematics school curricula.
- Advantageously every problem should concentrate on a special mathematical topic, such that it can be integrated in an existing teaching unit; as project-oriented problems referring to several mathematical topics are seldom picked up by teachers.
- The problems should be of a greater extent than usual text problems, in order to enable the students and also their teachers to concern themselves in a more intensive way with the subject.
- The problems should not afford special knowledge of teachers concerning future energy issues and especially physical matters. For this reason all nonmathematical information and explanations concerning the problem's foundations are included in separated text frames.
- By going on this way information in respect to future energy issues is provided for both, teachers and students, helping them to concern themselves with the topic.

The problems to environmental issues developed by the authors must be seen as an offer for teaching material. In each case, the students' abilities have to be considered. In lower achieving classes it might be advisable not to present every problem in full length. In addition, lower achievers need a lot of help for solving complex problems that require several calculation steps. The help given in some problems addresses such students. To higher achievers the problems should be presented without some included help. It might be even of benefit not to present just from the beginning the given hints. Students would thus have to find out, which quantities are yet needed in order to solve the problem. The problem would become more open and the students would be more involved in modelling processes. As the intention of the authors is also an informal one, in order to give more insight in the field of future energy issues, the mathematical models/formulas are mostly given in the problem texts. Students are generally not expected to find out by themselves the often complex contexts, these are already presented, guaranteeing thus realistic situation descriptions. The emphasis in the modelling activities rather lies in the demanded argumentation and interpretation processes, with the aim that mathematical solutions lead to a deeper understanding of the studied contents.

Classroom experiences show that students react in different ways on the problem subjects. While some are horrified by recognizing for example that the world wide oil reserves run low already during their life time, others are unmoved by this fact, as twenty or forty years later is a time they do not worry about. In school lessons there are again and again situations in which students drift away in political and social discussions according to the problem contexts. Although desirable, this would sometimes lead to too much time losses for mathematical education itself. Cooperation with teachers of other school subjects would be profitable if possible.

Experts' and Teachers' and Students` Reactions

The didactical concept described above, and examples of mathematical problems according to this were first published at the '12. Internationales Sonnenforum 2000' in Freiburg (Brinkmann & Brinkmann 2000). Meanwhile several further presentations followed, in the frames of international technical conferences concerning renewable energies as well as in conferences on didactics on mathematics and teacher education events (http://www.math-edu.de/Anwendungen/Energie-Vortraege.htm).

These activities were supported by many positive reactions from experts, as well as from teachers. While experts in future energy matters are familiar with the environmental consequences of the extensive usage of fossil fuels, we could experience that teachers often underestimate the problematic. Thus, teachers were very pleased to get some information and deeper insights in the topic of future energy, and the discussions resulted in a wide consensus about the importance of treating future energy issues in secondary school classrooms.

The didactical concept presented was absolutely convincing. Especially the information frames included in the problems were highly accepted by the teachers. With respect to the implementation of the didactical concept in the presented problems, of course, teachers had sometimes some doubts when thinking on their special courses and students. Here it was of importance to indicate optional possibilities how to suit the problems according to students abilities.

Combining PV and Wind Energy

The mathematical problems concerning renewable energy conversion and usage, worked out in the authors book for secondary classrooms, have to be permanently adjusted to actual and new developments, because of the great dynamic evolution of the technology in this field.

After the successful implementation of such mathematical problems in a school book in Germany, the authors would like to expand their work for international usage. Additionally, the amount of problems should be increased, especially with problems which deal with a combination of different renewable energy converter, like hybrid systems, to give an insight in the complexity of system technology.

On the other hand, the topic hybrid systems is also a good choice for mathematical problems in secondary classrooms, to bring up a spotlight for the students to the important fact, that many problems in the real world have not necessarily a single unit solution. This is an experience, which is up to now not sufficient integrated in didactic concepts for mathematical education in public schools.

The process for modelling of problems in such cases has consequently also a quite different quality as in usual mathematical problems, even as in those of the authors book shown in figure 1. Therefore, problems to hybrid systems would additionally give the possibility to make new experiences with new didactical concepts concerning modelling abilities of students.

As a first step, a problem for the combination of PV and Wind Energy, was worked out, which is presented in the following in short. The following figures show exemplarily the energy production of PV and Wind Converter as well as the combination to reach an equalised supply situation over a whole year.

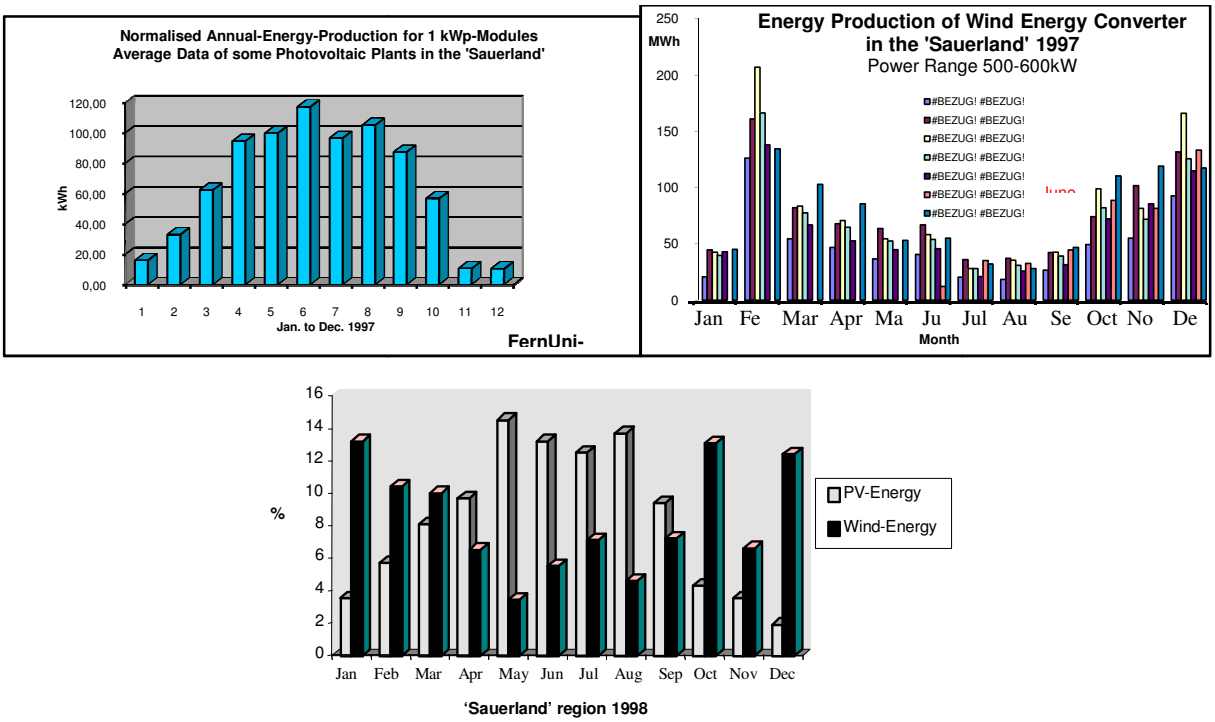

Figure 2: Energy production with PV, Wind and combined systems [16]

The students get statistical information with lists of monthly energy productions from PV-plants and wind energy converter over the period from 2003 to 2007. The following skills would be trained with them:

- correct reading and interpretation of statistical information,
- extraction of filtered or deviated data,
- to build average values and to give different presentations of them,
- comparison of diagrams concerning PV and Wind energy and discussion,
- calculation of concrete values for a single day with given assumptions,
- differentiation of winter and summer conditions,
- combination of bar graphs from PV and wind energy production.

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For further information look at:
http://www.math-edu.de/Anwendungen/anwendungen.html