Design Process with Solar Energy
Professional Development Program Guide

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1 Introduction

The purpose of this guide is to provide the information necessary to conduct a professional development program on the design process using solar energy as the basis for the design. The program is divided into eight sessions, each of which will last about an hour. The goal of the program is to provide teachers with a basic background in solar energy emphasizing the use of the design process. The program progresses through this basic outline:

- Discission 1: Identify Problem and Constraints
- Discussion 2: Research the Problem
- Discussion 3: Develop Solutions
- Discussion 4: Select a Solution
- Discussion 5: Construct a Model
- Discussion 6: Test/Evaluate
- Discussion 7: Share Solutions
- Discussion 8: Redesign/Wrapup

The first four discussions will each consist of a short lecture to provide information and guidance, and then some time will be devoted to allow the groups to pursue their own tasks. The last four discussions will be mostly spent with the teachers working together with their groups to implement solutions they have devised. The last discussion is especially important, because this is the discussion that the teachers will be given packages to bring back to their schools and, if they choose, use to teach lessons to their students on solar energy. It is crucial that the teachers know how valuable these lessons can be, especially if it sparks an interest in a few students who want to pursue even more knowledge.

2 Program Sessions

This section will outline each of the eight discussions of the program in greater detail. This document is not meant to be a hard and fast rulebook that must be followed to the letter. It can be followed, or it can be adapted to the particular needs of whoever is running the program. Different resources may be available, or the program could be adapted to a group other than teachers. This is simply a guide that will help direct efforts in the right direction.

2.1 Discussion 1: Identify Problem and Constraints

The purpose of Daiscussion 1 is to introduce the teachers to the problem being addressed, and give a basic outline of what the process will be. This discussion should progress as follows:

- Divide teachers into small groups (3 or 4 per group is good). This is because the design process is much easier to coordinate in small groups, rather than in a group of 20 or 30 people. It also makes it easier for everyone to give their input on the problem.
- Talk with the group about energy and photovoltaics. The basic information that should be covered is:
    - Fossil fuels and nuclear power accounted for 89 percent of the electricity generated in the US in 2001
    - Nuclear waste is difficult to dispose of safely, stays radioactive for a very long time.
    - Fossil fuels endanger environment through mining, waste disposal, and vulnerable delivery systems (such as oil tankers).
    - Fossil fuels are non-sustainable due to finite reserves
    - Average household consumes about 1-2 Kilowatts (1000-2000 Watts)
    - Replacing conventional fuels with clean, renewable sources can reduce reliance on non-renewable sources.
    - Solar panels could partially or completely replace grid-generated electricity.
- Additional information can be added if it is relevant.
- Give the problem: Design a PV system for a typical Worcester residence (house or apartment building) that will produce at least 50% of the power needed by that residence. If doing a house, assume about ½ acre of land. If doing an apartment building, assume little to no land, but a good amount of roof space, either flat or slanted.
- The rest of this discussion should be devoted to discussion among the entire group and/or within the individual groups. Focus on what the problem is, and what constraints are placed on possible solutions (cost, size, weight, etc.)

2.2 Discussion 2: Research the Problem

The purpose of this discussion is to do some research on photovoltaic systems, particularly ones intended for use on residential buildings. One good way to do this is to use a projector connected to a computer and perform some Internet searches on the subject. This should be demonstrated at first if any teachers are unfamiliar with Internet searching. The point of this is not only to get some information, but also to involve all of the teachers in the research process. If the facilities are available, teachers could even separate into their individual groups and do research on their own. Suggest that teachers with the Internet available at home spend some more time researching the subject, and bring notes or printouts of their findings to share with their groups. Give example research questions (shown below) to help give ideas on what to research.

Suggested resources:

http://www.google.com – Very good Internet search engine
http://www.massenergy.com - Massachusetts Energy Consumers Alliance, helps provide PV installations to Massachusetts residents and schools
http://www.mtpc.org/RenewableEnergy/index.htm - Massachusetts Technology Collaborative renewable energy information.

Questions to consider:
How much energy do solar panels generate? Consider size, angle, facing direction, shading…
How much does a solar installation cost? How does price relate to the kWh rating of the installation?
What incentives are available to residential customers who want to install solar panels?
What procedure do homeowners need to go through to get a solar installation put up on their home?

Materials needed:

Projector and computer with Internet access

2.3 Discussion 3: Develop Solutions

By now, the teachers should have a firm grasp of what the problem they are addressing is, and some background information on photovoltaics. Have them restate the problem to reinforce this concept. Now it is time for them to do some brainstorming on possible solutions to the problem. A Powerpoint presentation is provided. This presentation outlines why brainstorming is a good idea, and gives an example brainstorming method that works well in small groups, the Idea Trigger method. Other methods can be substituted if desired. The presentation should last no more than 15 minutes, after which the teachers should ask any questions if they have any, then go to work on their brainstorming. Be sure to emphasize that brainstorming should be unhindered by any criticism. All ideas are valid, and seemingly crazy ideas could spark another idea in someone's head that could be very good.

Materials needed:

Projector and computer with Powerpoint
Lots of paper to write ideas on
Pencils or pens

2.4 Discussion 4: Select a Solution

After producing as many ideas as possible, it is time to select one of them based on some design criteria. The method which will be used to do this is a value matrix. The Discussion 4 Powerpoint presentation contains a sample value matrix, as well as the procedure that should be followed. The value matrix can be adapted to make it simpler if desired. For example, the ranges for evaluating each criteria could be replaced with a simple "Yes/No" or "1/0" scheme. The main point to get across on this discussion is that decision making is an inherently subjective process, but this value matrix method is helpful for making the process as objective as possible and coming up with a numerical representation of the quality of a solution. Once the presentation is completed, let the teachers go to work producing their own value matrices within their groups.

Materials needed:

Projector and computer with Powerpoint
Paper and pencils

2.5 Discussion 5: Construct a Model

From this discussion forward, the program will be largely unstructured. Teachers will work together with their groups to work towards a final solution to the problem. On Discussion 5, their goal will be to construct a model to represent their chosen solution. Since it is impossible to actually go out and build a complete PV installation in an hour, a smaller-scale solution needs to be used. One good example is a kit from Lego that includes small PV panels. Whatever solution ends up being used, instruct the teachers to produce a model that represents their chosen solution as accurately as possible. Another good idea is to have them draw a diagram of a full-scale version of their solution.

Materials needed:

Model building kits
Poster paper
Pens, markers

2.6 Discussion 6: Test/Evaluate

This discussion will be devoted to testing and evaluating the chosen solutions. Teachers should thoroughly and objectively go over their designs and evaluate how well they fit the criteria they chose. The testing will be mostly theoretical, since the models they are building are not full-scale.

After testing, have the teachers review the design steps used so far.

2.7 Discussion 7: Share your Solutions

Once all of the groups have built and tested their solutions, it is time for the group as a whole to come back together and share solutions. Let each group come to the front and give a short explanation of their model and how it provides a good solution to the problem, as well as any tradeoffs they had to make. Allow the other groups to give suggestions and feedback on the solutions given.

2.8 Discussion 8: Redesign/Wrapup

On this last discussion, the groups should take the suggestions given to them during the presentation on Discussion 7 and make any changes they think would improve on their design. Make sure they keep track of the changes they make, and why they think they are good changes.

After the redesign is finished, it will be time for the wrapup portion. Be sure to provide every teacher with copies of the educational activities developed by WPI Solar IQP Team 2, with the suggestion that they take them back to their students and use them. Also be sure to mention the installation on the roof of Morgan Hall, and go to the website below to show them pictures and information related to the installation.
Morgan Hall installation pictures: http://[to be determined]

Materials needed:

Projector with computer and Internet access
Copies of WPI Solar IQP Team 2 educational modules

3 Conclusion

At the end of this program, the teachers should have a good understanding of the reasons why renewable energy is an important topic, and why photovoltaic installations are a good possibility for reducing consumption of fossil fuels. Through this short design process, they should have gained the knowledge and skills necessary to go back to their respective schools and speak knowledgeably about solar energy. By providing the educational modules to the teachers, chances are at least a few students will become interested in solar power, and pursue more knowledge on their own.