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Development of a Graduate Integrated Waste Management Course Using the Case Study Approach

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INTRODUCTION

Solid waste management is an integral part of the environmental engineering profession. At California Polytechnic State University (Cal Poly), solid waste management is taught as a required course in an undergraduate environmental engineering curriculum. The undergraduate course is described in Reference 1. This paper discusses the development of a graduate level integrated waste management course entitled "Resource and Energy Recovery from Waste", which uses a case study approach. The course focuses on resource and energy recovery technologies including composting, unit operations of resource recovery, recycling, and thermal waste conversion including combustion and gasification. The bioconversion of wastes in landfills and digesters is also covered. The course is a technical elective for undergraduates, and part of the core curriculum for master's degree students.

A unique feature of the course is the preparation of a design project which includes a preliminary design, cost estimates, and environmental impact analysis. The class is divided into four or more design teams which prepare design reports on a competitive basis. The teams are judged by the instructor and a design review panel of practicing professionals. The design project is an introduction to the "real world" of competition and teamwork. It has proven to be highly successful and of great benefit to graduates of the program as confirmed by alumni interviews.

The design project assignment is changed each year and is based on an actual project. Prior assignments have included designs of material recovery systems, composting systems, MSW combustion systems, and development of a county integrated waste management plan. The design project for the 1994 class was based on the resource recovery and recycling program which was established on the island of Kauai to process disaster debris after the 1992 Hurricane Iniki.

COURSE ORGANIZATION

The lecture portion of the course focuses on resource and energy recovery aspects of solid waste management. Traditional solid waste management concerns such as collection, and design of landfills are covered in the companion undergraduate course, which is a recommended prerequisite. An outline of the graduate course is given in Table 1. Reading assignments are based on Reference 2. Other textbooks and reference handbooks which can be used include References 3 through 6.

Homework assignments and a midterm examination based on lecture notes and assigned reading compose part of the course grade. However the majority of the course grade is derived from the design project. The project consists of both a formal project report and an oral report to a judging panel.

DESIGN PROJECT

Design projects should be realistic and challenging but still be able to be completed within the time constraints of the school term. This particularly important at Cal Poly, which uses a 10 week quarter system. Table 2 is a time schedule which has been successfully used by the author. Project groups of 4 to 5 students work the best. It is also useful to assign students to groups so that graduate and undergraduate students are uniformly distributed.

Project Selection

Its best to develop projects based on personal experience. If this is not possible, obtain project reports from solid waste consultants or government agencies. The author has received project information from consultants such as Brown and Caldwell Consultants and Harding-Lawson Associates. Government agencies such as the Los Angeles County Sanitation Districts, the City of San Luis Obispo, California, and San Luis Obispo County have also been of assistance in the past. Be sure to obtain permission to use the information in the design project in advance. It may be necessary to change data or to change the location of a project to meet the requirements of the firm or government agency providing the data.

Project Format

The production of a professionally formatted design report and presentation is an integral part of the design project. Table 3 is the format used in the course. Other formats are of course possible,

depending on the requirements of the instructor. Professional design reports should be made available to students as a reference.

Kauai Design Project

The 1994 design project, based on Kauai, Hawaii, came about as a result of the author's participation in the Disaster Response Debris Management Conference which was held in Lijue, Kauai in January 1994. The Conference brought together disaster recovery managers and engineers from four countries to discuss how to deal with the massive amounts of demolition debris remaining after major natural disasters such as earthquakes, hurricanes, and other major storms. Kauai hosted the Conference because the island had just recovered from the 1992 Hurricane Iniki which destroyed thousands of homes and businesses. Kauai's approach to dealing with the problem was unique because they developed a comprehensive system to recover and recycle the maximum amount of materials possible. This scenario was an ideal design project for the graduate class because extensive documentation of the recovery process was available including videotape, consultant reports, and photography of the processing areas taken by the author during the tours conducted as part of the Conference.

To fit the time constraints of the school term, the design project was simplified and standard economic assumptions were provided to the student teams. An extensive briefing was also presented to the student teams based on the materials that the author obtained on-site in Kauai. The actual problem statement as presented to the students is given below.

DISASTER DEBRIS RECOVERY, COUNTY OF KAUAI, HAWAII

The County of Kauai, Hawaii has just been devastated by Hurricane Iniki. The Hawaii National Guard, Federal armed forces units, the Red Cross, and the Federal Emergency Management Administration (FEMA), have assisted the County in feeding and temporarily housing displaced residents. After this initial disaster recovery phase, the County is now faced with the monumental task of cleaning up the island and restoring private housing, public facilities, businesses, and hotels. Since tourist related businesses are the main employers on the island, restoration and cleanup has a high priority.

Mayor Joanne Yokimura has issued an executive policy statement that " disaster generated debris will be recycled and reused to the maximum extent possible and that small businesses that can process and reuse these recovered materials will be supported to the maximum extent possible ... " Your firm has been selected to present a Preliminary Design and Plan to the County which will comply with the Mayor's policy.

Background

Kauai is one of the smallest of the Hawaiian Islands with a permanent population of 53,000. The economy is based primarily on tourism and limited agriculture (sugar cane and pineapples). Several sugar mills are currently combusting sugar cane residue (bagasse) and selling electric power to the local power company, Kauai Electric. The tourist industry generates 1.3 million visitor-days in a typical year. There is also a small military base, the Navy's Pacific Missile Range Facility (PMRF) with about 450 military and dependents. PMRF played a major role in the initial disaster recovery because of its aircraft and heavy duty airport runways.

In normal times Kauai generates about 80,000 tons/year of residential and commercial solid waste. The composition given in Table 3-4 of the text (Reference 2) can be assumed. Residential MSW is collected by the County, while commercial MSW is collected by private haulers. The County operates several transfer stations and a single landfill.

Effects of Hurricane Iniki

Hurricane Iniki struck Kauai on September 11th, 1992. The eye of the hurricane actually passed directly over the island. In the approximately five hour duration of the storm the following damage occurred according to Red Cross and County estimates:

- two deaths, 1066 injuries

- 1439 homes destroyed, 5360 with "major" damage, 7541 with "minor" damage
- electricity out 1 - 2 months
- 320,000 tons of debris (≈ 290, 000 yd^3)
- 500 autos destroyed
- 6000 utility poles down
- 25 million ft^2 of plastic sheeting generated (for temporary roof repairs)

A consultant retained by the County estimated the following composition for the debris:

- Wood 43%
- Green Waste 17%
- Metals & Appliances 16%
- Other Debris 24%

County Goals
It was obvious to the County that a "traditional" approach to disaster recovery would devastate the economy of Kauai. The disaster debris would completely use the remaining capacity at the existing landfill. The County therefore proposed the following unprecedented response to the disaster:

- Clean-up of debris which affected public health and safety would proceed immediately and be placed in the existing landfill. Some limited open burning was authorized.
- The County sought and received emergency authority to design and construct a new landfill as soon as possible. This design is underway as a separate contract.
- The County received the free use of five Temporary Hurricane Debris Receiving Sites (THDRS) from private landholders.
- The County received the use of 1300 National Guard troops to move debris to the THDRS.
- The County received funds from FEMA for the design and construction of temporary processing systems for the debris collected at the THDRS. Additional funds for a permanent MRF have been allocated from County funds. (This is your project).

Scope of Work
Prepare a Feasibility Study which will present a design for a Materials Recovery Facility (MRF) to meet the County's goals. The MRF should be planned in two phases, Phase I to accommodate the debris which will be stored at the THDRS and Phase II which will be a permanent MRF to accommodate the normal waste stream. Either manual, mechanized, or a combination of separation techniques may be used in the design. The Study should follow the format of Table 3. In addition the Study should include:

- Schematic and plan views of the MRF
- A materials balance
- A preliminary cost estimate of the MRF and associated equipment for each Phase
- An operational cost estimate

- A estimate of the break-even tipping fee for the MRF using a sensitivity analysis on the value of recycled materials (for Phase II)
- A construction and implementation time schedule for both Phases.

Deliverables will consist of the Study and the presentation during Finals Week. Grading will be a combination of a team grade and individual performance during the presentation.

Design Assumptions
The Phase I debris may include the following materials:

- Clean green wastes
- Metals
- Scrap wood
- Mixed demolition wastes
- Aggregates - concrete, roofing tiles
- Plastic sheeting

The Phase II facility will receive two waste streams:

- Commingled MSW
- Source separated recyclables from a curbside collection system

Possible recyclables include:

- aluminum cans
- recyclable glass
- PET plastic
- tin cans
- newsprint
- mixed paper
- corrugated cardboard (OCC)
- yard waste

CONCLUSIONS

The 1994 design project competition was a success. Each of the four design teams in the class developed completely different solutions to the problem, including one very innovative solution involving mobile processing equipment which did not even occur to the County officials or their consultant. The students were uniformly enthusiastic in their course evaluations on the value of the design project.

To be meaningful, design projects such as the Kauai project require that the instructor find a realistic problem and provide students with enough background material to perform the design. A local problem which will permit a field trip and discussion with project personnel is logistically the simplest approach. The Kauai problem was feasible because the author was able to visit the project site and gather significant data.

ACKNOWLEDGMENTS

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2. Tchobanoglous, G., H. M. Theisen, and S. A., Vigil, Integrated Solid Waste Management: Engineering Principles and Management Issues, McGraw-Hill, New York, 1993.

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4. Hasselriis, F., Refuse Derived Fuel, Butterworth Publishers, Boston, 1984.

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6. The McGraw-Hill Recycling Handbook, H.F. Lund, Ed.; McGraw-Hill, New York, 1993.

Table I. Course Outline - Energy and Resource Recovery From Waste.

Week	Topics	Reading Assignment[1]
1	Key Issues in Reuse and Recycling	9-1 to 9-3, Chap. 15
2	Mechanical Separation Technology	9-4, 12-1 to 12-5
3	Materials Processing and Handling	12-6 to 12-8
4	Material Recovery Facilities (MRFs)	9-5, 9-6, 12-9
5	Fundamentals of Combustion, Pyrolysis and Gasification	4-3, 9-7, 13-1 to 13-4
6	Environmental Control Systems	13-5
7	Energy Recovery Systems	13-6
8	Anaerobic Biological Systems	14-1, 14-3 to 14-5, 11-4, Ex. 11-8 (pp. 496-506)
9	Aerobic Biological Systems	9-8, 14-2
10	Financing of IWM Systems	Handout

[1]Reading assignments from Reference 2.

Table 2. Design Project Timetable.

Milestone	Laboratory Period
Team Assignments	Week 2
Project Assignment	Week 4
Project Outline	Week 6
Project Draft and Rehearsal	Week 10
Project Presentation (oral and written)	FINALS WEEK

Table 3. Design Project Format.

1. Reports are to be typed or word processed (space and a half). Reports should be copied on 25% cotton content bond, not standard copy paper. Reports are to be bound in spiral plastic binding or equivalent, with front and back covers.

2. Sample copies of professional engineering reports and typical student reports will be placed on 2 - hour reserve for your review.

3. Reports should be divided into sections with tab separators. Sections should be further subdivided with standard subdivisions (see text for examples):

SECTION TITLES

All capitals bold or underlined.

Major Headings

First letter capitalized, bold or underlined.

Subheadings First letters capitalized, bold or underlined, inset text as shown.

4. Required **SECTION TITLES**:

Letter of Transmittal
Executive Summary
Introduction
Review of Waste Generation and Composition
Description of the Recommended Technology
Implementation Plan
Estimate of Resource and Energy Recovery Potential
Economic Evaluation
Environmental Impact Evaluation
References
Appendixes

Table 4. Revenue and Financing Assumptions - Kauai Project.

1. Recovered Materials

Component	Value$/ton
aluminum cans	740
recyclable glass bottles	10
PET plastic	100
tin cans & other ferrous	70
newsprint	20
mixed paper	10
corrugated cardboard	70
compost or mulch	10
wood chips (fuel)	30
concrete & aggregate	5
reject (mixed waste)	0

2. Recovered Energy

Electricity (capacity)	$140/kW
Electricity (energy)	$0.07/kWh
Methane	$6.00/10^6 Btu

3. Project Financing

Phase I - FEMA grant for labor, operational costs, and leasing of equipment for processing of disaster debris (yearly lease rate = 33% of capital cost)

Phase II - 20 year, fixed rate, revenue bond issue, 8.0 % APR, annual payments for construction of permanent MRF

Table 5. Expense Assumptions - Kauai Project.

1. Labor

a. Workyear: 5 days/wk, 52 wk/yr

b. Effective workday for manual systems = 7/hr/day (personnel paid for 8 hr/day)

c. Effective workday for mechanized systems = 8 hr/day (or shift)

d. Wage rates - professional/clerical (salaried)

General manager	$60,000/yr
Shift foreman	$48,000/yr
Administrator/bookkeeper	$30,000/yr
Clerk/typist	$25,000/yr

e. Wage rates - production personnel

Sorters	$5.50/hr
Mechanics	$10.00/hr
Equipment operators	$7.50/hr
Electrician	$15.00/hr

f. Fringe benefits = 25% of base wages or annual salary

g. Shift differential = 15% (for hourly workers only)

2. Minimum Personnel Levels

a. Professional/clerical (salaried)

General manager	1
Shift foreman	1 per shift
Administrator/bookkeeper	1
Clerk/typist	1

b. Production personnel

Sorters	As required
Mechanics	1 per shift
Equipment operators	1 per major item of rolling stock Electrician
1 per shift	

3. Maintenance

a. Buildings	1% of capital cost/yr
b. Machinery and rolling stock	2% of capital cost/yr

4. Current Landfill Tipping Fee: $100/ton