TO: University Core Curriculum Oversight Committee

FROM: Drs. Jiuhua Chen (Department of Mechanical and Materials Engineering) and Hector R. Fuentes (Department of Civil & Environmental Engineering)

Subject: Submission of IDS 3XXX – Sustainability Assessment of Energy Alternatives for World Communities (3 credits)

DATE: March 29, 2011

1. UCCC REQUIREMENTS

A. Course Description:

   "An introduction to energy sources, needs and usage, technologies and their sustainability in world communities that includes research concerning the present situation and identification of future solutions."

B. UCC Category:

   Quantitative Reasoning

C. UCC Category Description:

   "The requirement aims at preparing students to master concepts and ideas in logic, deductive reasoning, and quantitative thinking. Students will become proficient in the art of reasoning critically, analyzing data, and solving problems."

   The competencies for this category are to apply logic, employ abstract or quantitative thinking, reason critically, analyze data and solve problems.

D. Rationale for Why this Course Belongs in this Category:

   The objective of this course is preparing students to master concepts and ideas in logic, inductive and deductive reasoning, and abstract and quantitative thinking. Students will become proficient in the art of reasoning critically, analyzing data and solving problems.

   The course will teach students fundamental concepts of energy sources in terms of sustainability and energy conversion, and how to integrate these concepts with logic, inductive and deductive reasoning strategy to quantitatively evaluate and solve real-world energy problems for different communities. The course emphasizes developing student's ability, through individual and team study, to analyze community and energy data, to determine critical factors of energy sustainability, and to make decisions for different world communities.

   Students will learn about the differences in world communities in their population trends, standards of living and needs of energy types from different energy sources, identifying
pros and cons of sources, which may be sustainable or unsustainable. Energy principles (e.g., conservation of energy) and concepts (e.g., life cycle) are introduced “as assumptions or axioms” to understand sustainable energy systems from supply, transformation, delivery to use. The students will be guided to individually study and research information and databases and to solve quantitative problem assignments; they will then actively participate in team-based activities to acquire, understand, apply, analyze, evaluate and synthesize knowledge on the diversity of energy choices of selected world communities and their sustainability. In that process, all students will thus have the opportunity to contribute inductive or deductive arguments to team-based activities, from the perspective of their research, quantitative analysis and personal knowledge (i.e., premises) and conclusions.

Quantitative thinking is an important component of both individual and team study and activities. The course will expect all students to use their math skills as required for college freshmen under the Florida’s College-Level Academic Skills requirements. Quantitative reasoning assignments include, for instance, the use of relations and functions, with graphical analysis and proper use of units. The following is a list of ideas that illustrate the type of quantitative reasoning exercises that students will have to complete at both individual and team levels, in their homework, as follows:

a) For two countries, students will research databases of the energy consumption and population as function of time. They will process the data, graphing it, to estimate trends (i.e., rates of change) for energy and population and analyze them to forecast scenarios of possible future energy needs (e.g., in millions of BTU per capita).

b) Students will identify the spectrum of fuel-based energy sources used by a community (e.g., Miami-Dade County) in the year 2010 and given the energy content of the various fuels (e.g., non-renewable and renewable), they could estimate the breakdown (in BTU per person per day and by percentage) of the various contributions of energy sources to a family.

c) A similar application of the previous idea, for the case of the State of Florida, but with emphasis on the estimation of the equivalent carbon footprint, will have students analyzing community energy portfolios and suggesting the best solution based on the resource availability, cost and environmental impacts.

d) Other example is to analyze if hydrogen as energy source is “clean” as function of the source of hydrogen, by estimating, comparing and analyzing the carbon footprint, in a life-cycle framework, that is associated with each source. Question is then to quantitatively conclude if the hydrogen source is clean or not.

e) An interesting mathematical applications includes the use of “Environmentally Responsible Process Matrices” that offer a framework to quantitatively assess the extent of a number of environmental stressors (e.g., materials selection) at each one of the life stages for a particular energy source or
technology. Students will implement the matrices, in team, using scoring criteria to compare the impacts among stressors and stressors among various sources of energy or portfolios (Professor Fuentes has implemented the use of these methodologies at other levels of teaching).

Refer to Attachment A for examples of homework problems, with contents of research effort and quantitative logic and reasoning.

Students will be able to apply logic and employ abstract and quantitative thinking, as follows:

Students will be able to recognize fundamental principles (e.g., conservation of energy) and concepts (e.g., functions of energy efficiency, carbon-footprint loading) of energy management and sustainability and use them to conclude and identify and compare non-sustainable and sustainable energy sources amongst communities.

Example: Students will research current sources of energy that are used in Honduras and Costa Rica, a countries in Central America, with different GNP per capita, where portfolio of energy include primarily oil, hydroelectric, wind and some solar, amongst others. They will then compare those sources based on the expected efficiencies of electricity generation, carbon-foot print, environmental impacts, among other criteria, to then identify the most sustainable sources of energy.

Students will be able to reason critically and to analyze data or solve problems:

Students will be able to use their acquired knowledge, via lectures and assignments to contribute inductive or deductive arguments to team-based activities, whereby they will raise and assess arguments in a team-setting while seeking characterizing or solving a problem to increase energy sustainability.

Example: Students working in teams will assess and analyze, with arguments, the various energy sources currently used in Costa Rica and Honduras, considering each country resources and opportunities, in reference to sustainability criteria, to support their proposed solutions for more sustainable energy portfolios.

2. SYLLABUS

A) Global Learning and Competency Core Outcomes and Assessments

Global Awareness: Students will be able to demonstrate knowledge of the diverse energy sources and associated sustainability issues within and among communities across the globe.

Assessment:
One (1) Readiness Assurance Tests (RATs): Students will be able to describe and contrast their knowledge of energy sources and associated sustainability issues for two regions (or communities) in two different countries.

Evaluation Process: Number of correct answers for the RAT.

Minimum Criteria for Success: Students will get 70% correct response rate for the RAT.

Sample: All students will be assessed.

One (1) team-based activity: Teams of students, using available information (e.g., government publications, articles, internet websites), will produce a report whereby they will be able to select and explain more sustainable portfolios of energy sources for each of the two regions (or communities) in the same two different countries than present energy sources. The report will be evaluated by a panel of judges that is chaired by the instructor.

Evaluation Process: A 5-point analytical rubric for the team-based activity.

Minimum Criteria for Success: Students will achieve a 3 or better on a 5-point rubric.

Sample: All students will be assessed.

Global Perspective Outcome: Students will be able to develop a multi-perspective analysis of the interconnectedness of local energy needs with global and international frameworks and limitations.

Assessment:

One (1) Readiness Assurance Tests (RATs): Students will be able to analyze the interconnectedness of local energy sources and their associated sustainability issues with global and international frameworks and limitations, for two regions (or communities) in two different countries.

Evaluation Process: Number of correct answers for the RAT.

Minimum Criteria for Success: Students will get 70% correct response rate for the RAT.

Sample: All students will be assessed.

One (1) team-based activity: Teams of students will use available information (e.g., government publications, articles, internet websites) to produce a report on those regional, global or international aspects that may cause the current portfolio of energy sources at two different regions (or communities) in two different countries, appraising
the needs for change in those portfolios. The report will be evaluated by a panel of judges that is chaired by the instructor.

Evaluation Process: A 5-point analytical rubric for the team-based activity.

Minimum Criteria for Success: Students will achieve a 3 or better on a 5-point rubric.

Sample: All students will be assessed.

Global Engagement Outcome: Students will demonstrate their basic understanding and willingness to address issues and problems associated with the energy needs of world communities.

Assessment:

One (1) team-based project with both a written report and an oral presentation: The students will be able to formulate and develop a plan to improve the sustainability of the current portfolio of energy sources for a world community. The report will be evaluated by a panel of judges that is chaired by the instructor.

Evaluation Process: A 5-point analytical rubric for this team-based activity.

Minimum Criteria for Success: Students will achieve a 3 or better on a 5-point rubric.

Sample: All students will be assessed.

B) Interdisciplinary Content & Readings

While the crucial aspects of engineering energy research and technology development have been a main focus area in material and mechanical engineering, the issue of nonrenewable and renewable energy sources and technologies itself has an interdisciplinary nature; for instance, environmental considerations of energy sources and technologies fall within the realm of environmental engineering. In fact, the issue integrates a wide range of disciplines including physics, chemistry, biology and geology when solar energy, biomass, geothermal energy are counted. In particular, because the course not only introduces principles of renewable and nonrenewable energy sources and technologies, but links to the evaluation of their sustainability, in addition to their combined teaching, research and professional experience, the instructors bring together materials and mechanical engineering and environmental engineering knowledge to ensure the successful implementation of the course objective.

As described in the weekly schedule, herein included, the students will attend lectures and conduct their own research and homework in applications that will address the various fundamental principles and concepts of energy (i.e., handouts from selected engineering textbooks in a customized course pack through a publisher to be selected), information about the characteristics of world regions and communities (i.e., reports and
research from United Nations System websites, US Department of Energy, US Agency for International Development, US Department of State, official websites from countries, among others), information on energy sources and technologies (i.e., handouts from texts and governmental documents) and information about sustainability and its measures (i.e., journal articles and selected text chapters). Both lecture materials and student literature research will come from a wide range of areas of knowledge, for instance, physics, chemistry, earth sciences, environmental sciences, social sciences, economics, etc.

C) Common Reading

Students will read the article “The Case of Contamination” by Kwane A. Appiah (New York Times, January 1, 2006). Students will be provided the article at least one lectures in advance to the day when a dialogue will take place in the format of a Socratic Circle. Students will be organized in teams that will then break into inner and outer circles. The purpose of the dialogue is to give students an opportunity to experience global citizenship (i.e., awareness, perspective and engagement). The students will specifically discuss the following: a) what does energy availability or the lack of it have to do with Appiah’s analysis? and b) How different is the student’s analysis?

A 3-point rubric will be used to assess the student’s performance, as follows: Outstanding (≥3 points), average (≥2 points) and below average (≥1 point). Specific rubric details will be provided along with the article.

D) Active Learning Strategies

The course will be a combination of active study assignments, active lectures, homework and graded quizzes, Socratic circles, case discussions and three team-based learning activities. Study assignments, lectures, homework and quizzes will support the review or acquisition of fundamentals concepts about community differences, energy sources and sustainability criteria. Socratic circle is expected to act as motivation for engagement in the purpose of the course. The team-based learning activities will provide the opportunity for the students to assume leadership in their application of learned concepts (i.e., world communities, energy sources, and sustainability) to problem solving; student teams will focused on two regions, countries or world communities.

E) Co-curricular Activity & Assessment

Three types of co-curricular activities are planned within the contents of the course, as follows:

Student Participation: Research that students as team members will complete in order to support the successful completion of the three team-based learning activities, namely, reports on present energy portfolios, global interconnectedness of current energy sources and proposed portfolios of sustainable energy sources, for two assigned world regions, countries or communities.

Assessment:
Student research will be appraised through the grading of scheduled homework and quizzes.

Specialized Lectures: Guest lectures by active researchers in related areas, government representatives from federal, state and local agencies (e.g., USDoE, USEPA, FDEP, Miami-Dade County Government, and FPL).

Assessment:

This activity will be appraised through the grading of scheduled homework and quizzes.

Field Trips: Selected field trips will be considered, if costs and logistics are funded. They could include FPL Power Plant Stations, Everglades National Park, Biscayne National Park, agricultural farms, etc. Field trips will be preceded by introduction of their relevance in the context of energy needs and usage. If costs and logistics are not resolved, students will complete the experience virtually, accessing appropriate websites and other available documentation. Field trips will be scheduled once lectures on energy sources, needs, usage and sustainability are completed.

Assessment:

A two page essay discussing the following question: “What is the interconnectedness of the visited site to energy consumption, sustainability and the life of the community or region?” A 3-point rubric will be used to assess the student’s performance, as follows: Outstanding (=3 points), average (=2 points) and below average (=1 point).

F) Course Justification and Contents

Energy is an essential driver of the global economy and social well-being. To a large extent, energy influences the quality of our daily life and determines the future of our society. Sustainable and clean energy is a crucial driver of economic health and environmental protection success.

This course seeks to provide students an integrated level of knowledge on the issue of energy sources and their sustainability in world communities (i.e., regions, countries or communities), researching the present reality and identifying most sustainable solutions for the future. The students will conduct individual and group research from available information in textbooks, journal articles and governmental agency documents (at the local, regional, national and international levels). The students will then work in teams on topics to produce reports on the energy portfolios at selected world communities.

The course will introduce energy sources, needs and usage, technologies and their linkage to sustainability. It will emphasize developing students’ ability to understand, explain, compare, evaluate and solve energy problems of world communities in team projects. Students will engage in real-world problems of different energy sources in selected world
regions and their connection to sustainability. They will research information on energy choices, communities, and sustainability for technology assessments, while uncovering their own role as individuals in communities, and their opportunity to engage in solutions for communities worldwide. The projects should also promote students' learning interests about global differences, disparities, and uniqueness of needs, solutions and limitations. In addition, it is expected that class activities will enhance the opportunity for all students to further develop critical thinking, communication and social skills.

G) Weekly Schedule

Week 1:
Topic: “A Case of Contamination” by Kwane A. Appiah
Essential Question: What does Appiah’s analysis relate to energy?
Material: The Case of Contamination” by Kwane A. Appiah
Activities: Socratic Circle
Assessment: Individual participation performance

Week 2:
Topic: Lecture on energy principles, concepts, needs and usage
Essential Question: What principles govern energy conversion, efficiency, availability, costs?
Study Material: Handouts and reference
Activities: None
Assessment: Homework and Quiz

Weeks 3, 4 and 5:
Topic: Lecture on energy sources, types of energy needs, technologies (first, second and third generation), renewable, nonrenewable, green and sustainable choices, and conservation.
Essential Question: What are the various energy needs, types and uses?
Study Material: Handouts and websites
Activities: Homework, videos on the various topics, guest lecturer on electrical grids
Assessment: Graded homework and quizzes

Week 6, 7 and 8:
Topic: Lectures on world communities and the UN Millennium Development Goals, the UN Advisory Group on Energy and Climate Change
Recommendations on the needs of supply, transformation, delivery and use of energy sources, sustainability (environmental, social and economic), life-cycle assessment, global markets and economic forces, and poor and rich countries.
Essential Question: What are the problems of current energy choices?
Study Material: Handouts and websites
Activities: Homework, videos on the various topics, guest lectures on markets and economics
Assessment: Graded homework and quizzes

Week 9:
Topic: Field Trip
Essential Question: What is the relationship of the site to the regional energy supply and community life?
Study Material: Handout on site information
Activities: Site tour
Assessment: Assay
Week 10 and 11:
Topic: Comparative characterization and assessment of present energy portfolios and their sustainability at two world regions or communities.
Essential Question: What are the problems of current energy choices?
Study Material: Research of recommended literature and websites
Activities: Individual and team-based effort
Assessment: iRAT and tRAT

Week 12 and 13:
Topic(s): Comparative characterization of international regional and local aspects that lead to the energy portfolio at two selected communities
Essential Question: What causes the present energy portfolio?
Study Material: Research of recommended literature and websites
Activities: Individual and team-based effort
Assessment: iRAT and tRAT

Week 14, 15 and 16:
Topic(s): Comparative formulation and development of a plan to improve the sustainable portfolio for two target communities
Essential Question: What is the most sustainable energy solution?
Study Material: Research of recommended literature and websites
Activities: Individual and team-based effort
Assessment: iRAT and tRAT

Grade allocation will be as follows (over 100%):
Individual homework 10%
Individual quizzes, iRATs and tRATs 25%
Socratic Circle Performance 2%
Field trip assay 3%
Team project Phase I 15%
Team Project Phase II 15%
Team Project Phase III 30%

Grading criteria will be as follows:
\[
\begin{align*}
93.3 \leq A & \leq 100.0 \\
90.0 \leq A- & < 93.3 \\
86.7 \leq B+ & < 90.0 \\
83.3 \leq B & < 86.7 \\
80.0 \leq B- & < 83.3 \\
76.7 \leq C+ & < 80.0 \\
73.3 \leq C & < 76.7 \\
70.0 \leq C- & < 73.3 \\
66.7 \leq D+ & < 70.0 \\
63.3 \leq D & < 66.7 \\
60.0 \leq D- & < 63.3 \\
F & < 60.0 
\end{align*}
\]

Example of study materials:
A special package of relevant materials to support the lectures will be assembled and is expected to include journal articles, chapters from a number of selected textbooks, videos and other documents from national and international agencies (e.g., United Nations System, USDoE, USEPA, USDoS, USAID and UN).


II) Instructor’s Qualifications

Dr. Chen’s expertise in energy technologies will combine with Dr. Fuentes’ expertise in environmental engineering, including green and sustainable engineering, to address the sustainable assessment of present and future energy technologies for world regions or communities. Their scientific and engineering background and research perspective and contributions will be enriched by collaborators from a number of areas of knowledge and expertise (e.g., scheduled keynote speakers).

3. ATTACHMENTS

A) Examples of Homework Problems

(Four [4] examples are included to illustrate the kinds of mathematical applications and quantitative reasoning based on the study material – it should be noted that most teaching materials will be developed by the instructors upon the course’s approval).
APPENDIX A

IDS 3XXX

Sustainability Assessment of Energy Alternatives for World Communities

02-29-11
EXAMPLE PROBLEM No. 1

GIVEN: One measure of society's economic wealth is the prevalence of cars. In 1985, there were about 280 x 10^6 people in the USA. In China, there were about 1.1 x 10^9 people but only 5 x 10^6 cars.

FIND: a) How much CO₂ was emitted from people and cars in each country?
   b) What if China had the same ratio of cars to people as the USA? How much CO₂ would be emitted from Chinese cars?

SOLUTION:

a) In the USA:
   \[
   \text{CO}_2 \text{ (people)} = 280 \times 10^6 \text{ people} \times 0.5 \text{ kg CO}_2/\text{person-day} \times 365 \text{ d/yr} \times 0.001 \text{ MT/kg} \\
   = 5.1 \times 10^7 \text{ MT CO}_2/\text{yr} \\
   \]
   \[
   \text{CO}_2 \text{ (cars)} = 150 \times 10^6 \text{ cars} \times 5 \text{ MT CO}_2/\text{car-yr} \\
   = 7.5 \times 10^8 \text{ MT CO}_2/\text{yr} \\
   \]

In China:
   \[
   \text{CO}_2 \text{ (people)} = 1.1 \times 10^9 \text{ people} \times 0.5 \text{ kg CO}_2/\text{person-day} \times 365 \text{ d/yr} \times 0.001 \text{ MT/kg} \\
   = 2.0 \times 10^8 \text{ MT CO}_2/\text{yr} \\
   \]
   \[
   \text{CO}_2 \text{ (cars)} = 5 \times 10^6 \text{ cars} \times 5 \text{ MT CO}_2/\text{car-yr} \\
   = 2.5 \times 10^7 \text{ MT CO}_2/\text{yr} \\
   \]

b) For the "what if" for China:
   \[
   1.1 \times 10^9 \text{ people} \times 150 \text{ cars}/280 \text{ people} = 5.9 \times 10^8 \text{ cars} \\
   5.9 \times 10^8 \text{ cars} \times 5 \text{ MT CO}_2/\text{car-year} = 3.0 \times 10^9 \text{ MT CO}_2/\text{yr} \\
   \]

* Students will research these values and include citations in their homework.

12
EXAMPLE PROBLEM No. 2

GIVEN: A family of four uses 1250 kWh of electrical energy on average every month.

FIND: a) How many gallons of gasoline is this equivalent to?
   b) Where does this family use more energy in a year, operating their house or operating two cars (say about 20,000 miles per year)?
   c) If gasoline is $3.40/gallon and electricity is $0.0833/kWh, where does the family spend more money?

SOLUTION:

a) \(1250 \text{ kWh/month} \times \frac{1 \text{ gal gasoline}}{36.9 \text{ kWh}} = 33.87 \text{ gal/month equiv}

b) \(33.87 \text{ gal gasoline/month} \times 12 \text{ months/yr} = 406.4 \text{ gal/yr (electricity)}
\quad \text{30,000 miles/yr} \times \frac{1 \text{ gal/20 miles}}{\text{cars}} = 1,000 \text{ gal/yr (cars)}
\quad \therefore \text{ Family spends more energy operating the cars @ year.}

c) \(1250 \text{ kWh/month} \times 12 \text{ month/yr} \times \frac{1 \text{ $0.0833/kWh}}{} = \$1,250/yr (electricity)
\quad \text{1,000 gal/yr} \times \frac{1 \text{ $3.40/gal}}{} = \$1,250/yr (gasoline)
\quad \therefore \text{ The family spends the same amount of money on both forms of energy.}
EXAMPLE PROBLEM No. 3

GIVEN: A 1,000 MW coal-burning power plant is burning anthracite coal from Pennsylvania. The plant has a thermal efficiency of 40%.

END:  
1) The rate of heat emitted to the environment in kJ/s.
2) The rate of coal input to the furnace, in kg/day. (To be researched by students).

SOLUTION:

\[
\begin{align*}
\text{Ein} & \quad (\text{fuel}) \\
\text{PLANT} & \\
\text{Eout} & \quad (\text{electricity}) \\
\text{Eout} & \quad (\text{heat})
\end{align*}
\]

1) From a state-state energy balance (or conservation of energy):

\[
\text{Ein-fuel} = \text{Eout-electricity} + \text{Eout-heat}
\]

where \( \text{Eout-electricity} = 1,000 \text{ MW} \)

\[
\text{Ein-fuel} = \frac{1,000 \text{ MW}}{0.40}
\]

Then \( \text{Eout-heat} = 2,500 \text{ MW} - 1,000 \text{ MW} = 1,500 \text{ MW} \)

\[
[ = (1 - 0.40)2,500 = 1,500 \text{ MW}] \]

b) To estimate the coal input rate, we need the coal energy content (say 14,200 KJ/kg or 3.96 kwh per pound).

Coal input = \( 3,100 \text{ MW} \times \frac{1,000 \text{ kW}}{\text{MW}} \times 24 \frac{\text{h}}{\text{day}} \times \frac{1}{396 \text{ kwh}} \times \frac{1}{2.216} \text{ kg} = 6.89 \times 10^6 \text{ kg/day} \)
EXAMPLE PROBLEM No.4

GIVEN: The following countries in Central America & Caribbean: Costa Rica, Honduras, and Jamaica.

FIND: a) Search the World Resources Institute database for annual energy consumption per capita.
    b) Identify ranges and patterns of consumption (include graphs).
    c) Determine rates of change over the 1990-2005 period.
    d) ....

SOLUTION:

a) COUNTRY            2005       2000       1990
                      (kg of oil equivalent/person)

  Costa Rica        843 (942         657
  Honduras           537 (469         496
  Jamaica            1,445 (1,514  1,232


b) 

\[ \begin{array}{c|c|c}
    \text{Year} & \text{1990} & \text{2005} \\
  \hline
    \text{Costa Rica} & 843 & 942 \\
    \text{Honduras} & 537 & 469 \\
    \text{Jamaica} & 1,445 & 1,514 \\
  \end{array} \]

(c) Student will estimate \( \Delta E/\Delta t \) over the period of record and ....