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- International Water Resources: Challenges for the 21<sup>st</sup>
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# Century

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## Water Resources Education

2008 UCOWR/NIWR CONFERENCE  
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### Engineering Sustainable Systems: Sustainable Water Resources Dual Degree Program

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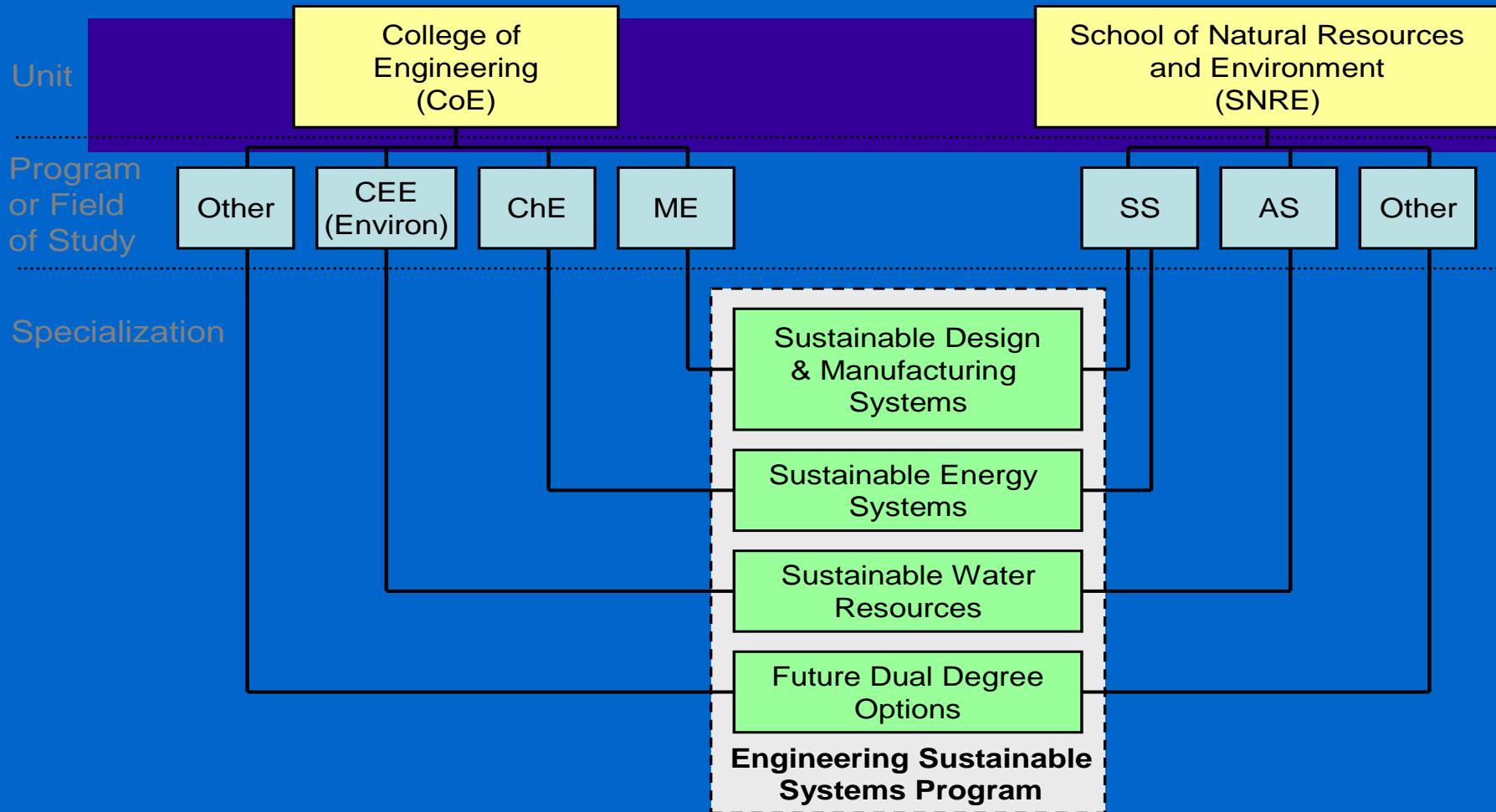
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# Engineering Sustainable Systems (ESS) Program Objectives

To provide masters-level students with :

- A comprehensive understanding of major sustainability challenges
- Knowledge to evaluate the sustainability of engineering systems
- Design methods that lead to the sustainable application of technological approaches
- Case studies and hands-on opportunities that successfully demonstrate the application of sustainable technology design.

# Engineering Sustainable Systems: Program Design



## Acronyms

CEE – Department of Civil & Environmental Engineering (CoE)

ChE – Department of Chemical Engineering (CoE)

ME – Department of Mechanical Engineering (CoE)

SS – Sustainable Systems Area of Study (SNRE)

AS – Aquatic Sciences: Research and Management Area of Study (SNRE)

# Need and Competitive Advantage

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- Critical sustainability challenges for the 21<sup>st</sup> century include:
  - Global climate change
  - Water quantity, water quality, water distribution/availability
  - Energy security
  - Ecological degradation
  - Environmental threats to human health and all life forms

Technology can be both the cause of and the solution to many of these problems.

The success of sustainable technologies is based upon their ability to meet societal needs within the context of economic and ecological constraints.

The design and application of new technologies - a focal point of CoE - plays a key role in addressing these complex challenges through research and education in engineering design and the applied sciences.

SNRE serves to provide a comprehensive understanding of technology limitations, opportunities, and consequences, systems thinking and ecological principles, and the mechanisms which bring about social change. This is accomplished through research and education in sustainability sciences, policy, and ecology.

Both elements provided by CoE and SNRE are necessary to develop technology based solutions to the complex sustainability challenges of the 21<sup>st</sup> Century.

## Curriculum Design

- A 54 credit program (1/4 double counting) so that students can complete the program in 2-2.5 years.
- Except for rare exceptions, all students are engineers since ESS students are independently admitted to both CoE and SNRE.
- Strong synergy between the MSE and MS degree programs:
  - CoE and SNRE degrees are science based and analytical; many cross listed courses.
- *All requirements of both degrees are met*





# Specialization in Sustainable Water Resources

For Civil and Environmental Engineering (CoE):

1. Twenty four (24) credit hours in CEE courses (no more than twelve (12) credit hours at 4xx level):
  - A. A minimum of fifteen (15) credit hours must be CEE courses
  - B. A minimum of nine (9) credit hours must be Environmental and Water Resources Engineering related electives
  - C. Up to six (6) of these credits may come from Directed Study (CEE 622,682,921,980)
2. Six hours of cognate (non-CEE) courses
  - A. Three (3) credit hours in mathematics, probability, statistics, or mathematical programming
  - B. Three (3) credit hours of non-CEE related engineering courses

# Specialization in Sustainable Water Resources

## For Aquatic Sciences (SNRE):

1. Fourteen (14) credit hours from Aquatic Sciences field of study courses
2. Ten (10) credit hours in SNRE Core Requirements
3. Eight (8) credit hours in analytics (from SNRE Acceptable Analytics list)
4. Six (6) credit hours in aquatic sciences approved Opus Option additional coursework
5. Includes four (4) credit hours of cognates outside SNRE (satisfied by dual degree standing)

# Specialization in Sustainable Water Resources

The following is a SAMPLE PLAN and represents only a guide for prospective students enrolled in the ESS dual master's degree program with specialization in Sustainable Water Resources (Civil and Environmental Engineering + Aquatic Sciences). The double counted courses are indicated by an asterisk. These courses totaling 18 double counted credit hours are as follows:

- CEE 521 – Flow in Open Channels (3)
- NRE 508 - Wetland Ecology (3)
- CEE 522 - Sediment Transport (3)
- GEOSCI 477 - Hydrogeology (3)
- STAT 412 - Introduction to Probability and Statistics (3)
- CEE 527 - Coastal Hydraulics (3)

# Specialization in Sustainable Water Resources

Year 1			Year 2		Year 3
Fall	Winter	Spring	Fall	Winter	Fall
NRE 509	NRE 580*	NRE 700/701	NRE 508*	CEE 590	STAT 412*
NRE 510	CEE 520	NRE 601	CEE 522	NRE 538	CEE 587
CEE 521*	NRE 409		NRE 511	GEOSCI 477*	CEE 527*
				NRE 539	

Total Credits 10 10 10 10 9

Indicate  
course  
counting for  
CEE



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# Specialization in Sustainable Water Resources

## YEAR 1

Fall Term (10 credit hours)

NRE 509 – Ecology: Science of Context and Interaction (4) NRE 510 – Environmental Governance, Choices, Institutions, and Outcomes (3)  
CEE 521 – Flow in Open Channels (3)

*Winter Term (10 credit hours)*

NRE 580 – Integrated Problem Solving (3) CEE 520 – Deterministic and Stochastic Models in Hydrology (3) NRE 409–Ecology of Fishes (4)

*Spring/Summer Term (8 credit hours)*

Thesis Research or Group Project Research (6) and/ or approved course work (2-8)

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- **Specialization in Sustainable Water Resources**

## YEAR 2

*Fall Term (10 credit hours)*

NRE 508 – Wetland Ecology (3) CEE 522 – Sediment Transport (3)  
NRE 511 – Fluvial Ecosystems (4)

*Winter Term (10 credit hours)*

CEE 590 – Stream Lake and Estuary Analysis (3) NRE 538 – Linear  
Statistical Models (3) GEOSCI 477 – Hydrogeology (3) NRE 539 –  
Seminar (1)

# Specialization in Sustainable Water Resources

YEAR 3

Fall Term (9 Credits)

CEE/NRE 587 – Water Policy (3)

STAT 412 – Introduction to Probability and Statistics (3)

CEE 527 – Coastal Hydraulics (3)

# MASTER OF SCIENCE ENROLLMENT

## INFORMATION: SNRE

ACADEMIC YEAR 2008-2009 (SEPTEMBER 2008-MAY 2009)

MASTER DEGREE STUDENTS: SUSTAINABLE SYSTEMS FIELD  
OF STUDY

62 ARE RETURNING SECOND YEAR STUDENTS AND 51 ARE  
NEW INCOMING FIRST YEAR STUDENTS: TOTAL  
SUSTAINABLE SYSTEMS STUDENTS ENROLLED FOR  
COMING YEAR: 113.

MASTER DEGREE STUDENTS: DUAL DEGREE PROGRAM  
(APPROVED BY THE HORACE H. RACKHAM SCHOOL OF  
GRADUATE STUDIES IN NOVEMBER 2007.

INCOMING MASTER'S DEGREE STUDENTS: 5

CURRENT MASTER'S STUDENTS WHO WILL ENROLL FOR  
DUAL DEGREE: 2

# EMPLOYMENT OPORTUNITIES

Opportunities exist in the private, public and non-profit sectors.

Private: environmental health and safety, product design, and process engineering- engineering consulting firms, research and development labs, and entrepreneurial startups.

Public: government agencies and laboratories such as the National Renewable Energy Lab, US Environmental Protection Agency, US Department of Energy, state level Departments of Transportation, and state level Departments of Environmental Quality.

Non-Profit: non-profit and non-governmental organizations (NGOs) such as Environmental Defense and the Union of Concern Scientists.

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## CONCLUDING OBSERVATION

The creation of this dual degree program aligns with primary goals of the University as outlined by former Provost, the late Edward M. Gramlich:

“Perhaps the most important challenge facing our society today is to sustain our natural resources and environment. The problems of environmental sustainability are complex and multi-faceted and often can be solved only through the combined efforts of experts in many fields. That is why leading research universities like the University of Michigan, with its range of programs that address these issues, are uniquely suited and have an obligation to engage environmental issues.”