Upper Technical Elective – 400 level & 3 credits

Sustainability, Smart Cities' Infrastructure & Safety

2020 Study Abroad program - Sweden & Denmark

Program Dates:
UMCP Workshops: May 12 &13, 2020

US Departure: May 20, 2019

University of Lund: May 21 – 31, 2020

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Program Director
Dr. Dimitrios Goulias, Associate Professor & Director Undergraduate Studies

Instruction

University of Maryland (UMD)
Department of Civil and Environmental Engineering.

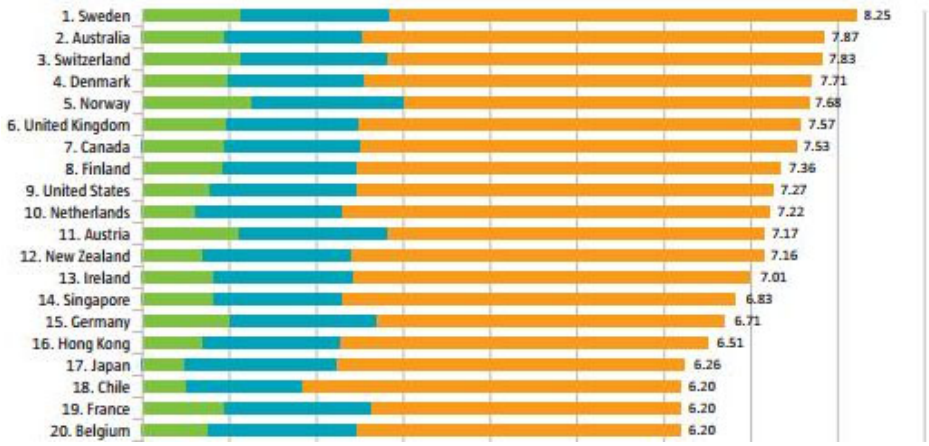
- Dr. Dimitrios Goulias, Associate Professor.
- GTA (TBD)

University of Lund
Department of Technology & Society, Faculty of Engineering, Transport & Roads

- Dr. Carmelo D'Agostino, Faculty, Safety, Road Asset Management, Pavement Evaluation
- Dr. Ebrahim Parhamifar, Faculty, Road Construction
- Dr. Till Koglin PhD., Faculty, Sustainable Transport
- Dr. Aliaksei Laureshyn. Faculty, Sustainability & Safety

Guest Speakers
Guest speakers, expert in smart sustainable cities and sustainable infrastructure components.

Program Description
With the significant increase of people in large cities the implementation of concepts and principles of "Sustainable Infrastructure" and "Smart Sustainable Cities," as well as safety, are vital for the survival of urban settlements and the development of healthy living conditions, along with economic prosperity. Sweden is ranked #1 country in Sustainability practices, while Copenhagen, the capital of Denmark is considered the #1 city in the world in Sustainability. Specifically, Sweden is the most sustainable country in the world, a ranking it earned for its use of renewable energy sources and low carbon dioxide emissions, as well as social and governance practices such as labor participation, education and institutional framework. Similarly, Denmark ranked #4. Thus both countries and several of their cities provide a unique showcase of sustainability examples and provide a unique setting for learning and implementing sustainability solutions than the rest of the world. First the different approaches to the development of smart sustainable cities will be covered. An overview of what smart sustainable cities are and what are their major challenges will be covered as well. Smart cities' building blocks, such as "smart streets" or "smart buildings" will be discussed as a matter of pragmatic and feasible level of details. Additionally, selected tools needed for developing real projects focusing on sustainable smart cities (such as IT, sustainability metrics for Smart Green roadways, buildings, site planning, safety, and other pertinent areas) will be covered along with specific case studies demonstrating the challenges and success. Students will interact with Lund University colleagues for developing their own sustainability design projects using sustainability metrics and Life Cycle Economic and Environmental Impact Analysis, LCA & LCCA, at the **"project level**" on green roadways, buildings, and system **"network level** "on neighborhood/regional planning.



Sustainability Scores and Rankings (Environmental Leader 2019)

Theoretical Framework

This study abroad program will expose students to the theoretical principles, framework, and techniques required to address the development of sustainable smart cities' infrastructure, complex spatial systems encompassing mobility, environment, energy, and social well-being. The program will deal with the identification of a set of qualitative/quantitative indicators and methodologies. The course will first address with key faculty experts speakers from the US and Sweden/Denmark, the principles of technical, cultural and social approaches used in the design of sustainable smart cities infrastructure. The program is offered in cooperation with the University of Lund that has extensive expertise in safety and mobility, both critical components of the smart sustainable cities development, and will include among other:

Topics (tentative)

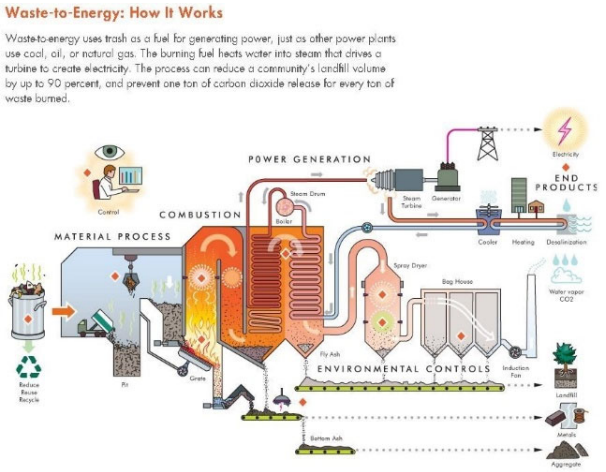
1. System-Oriented Approach to Smart Sustainable Cities;
2. Smart City Strategies: the case of ICT Infrastructure – RISE;
3. Sustainability, Livability & Resilience Principles, Strategies and Metrics
4. Sustainability & Urban Environment: Safety & Mobility
5. Sustainability & Infrastructure: Principles, Design & Analysis of Sustainable Infrastructure Components
    - Infrastructure Components: Buildings, Highways, Bridges, Tunnels, Airports, Ports, etc.
    - Economic Analysis Methods, Life Cycle Analysis/Life Cycle Cost Analysis, LCA/LCCA, Principles (design and performance period, initial, rehabilitation and operating/maintenance costs)
    - Environmental Assessment Analysis (GHG Emissions, RCRA Hazardous Waste, Energy Analysis, Water Consumption, GWP –Global Warming Potential, Noise Analysis, other)
6. Environmentally Friendly Infrastructure & Sustainability Metrics ***"Project & Network Level"***
    - Green Buildings & LEED Sustainability Metrics
    - Green Highways & Sustainability Metrics (*GreenRoads, GreenLites, BE^{2}ST, PALATE, I-Last)*
7. Fundamental Steps of Sustainability Analysis for Green Roadways: ***"Project Level" Analysis***.
    - Infrastructure Condition Assessment: Methods and Ratings
    - Structural Design Principles & Methods
    - Sustainable Rehabilitation Methods: Principles, Structural Analysis, Materials, Methods
    - In-situ Recycling Principles & Methods (condition, materials and techniques)
    - Principles and Design of Permeable vs Impermeable Surfaces
    - Ex-situ Recycled Materials and Alternative "Green" Materials
    - Design of permeable/ porous surfaces; Engineering Analysis and Design
    - LCA/LCCA & Environmental Assessment Analysis for Conventional & Sustainable Alternatives & Tools (Palate, BE^{2}ST)
    - Highway Sustainability Rating Method (BE^{2}ST in Highways)
    - Optimization Analysis of Sustainable Alternatives & Selection of Best Solution
8. Sustainability Assessment of neighborhood/regional planning ***"Network Level" Analysis***
    - Sustainability Principles at Large Scale, & Smart Green Cities
    - LEED NB Sustainability Metrics for Neighborhood/ Regional Assessment

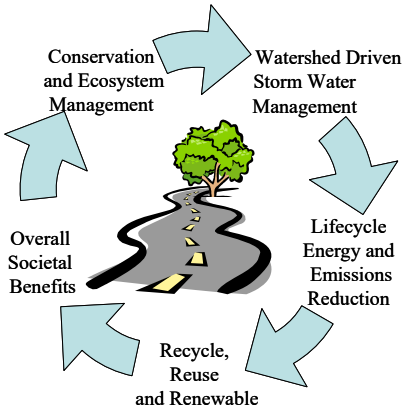
Design Projects for Sustainable Alternatives

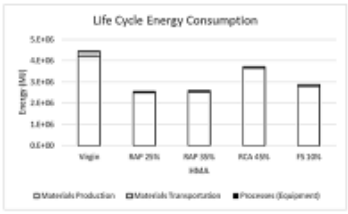
The students will be involved in the development of alternative solutions, using the ***"sustainability" principles*** and ***sustainability metrics.*** The projects will be related to real case scenarios and selected infrastructure components both at the ***"project level"*** and ***"network level."*** The design project analysis follow the steps used in generating, analyzing and compering alternative sustainable analysis in rela world projects and until an optimum solution is identified. The steps are shown below. The sites to be included in the students' projects will be selected with the faculty of the University of Lund and Sustainability experts.

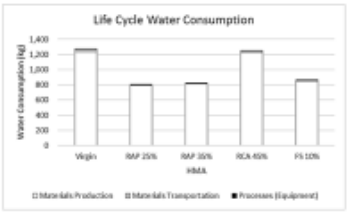
Key Sustainability Analysis Steps

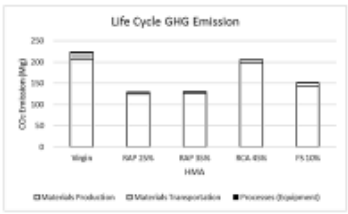
1. Existing Condition Assessment
2. Selection of In-situ Recycling Method
3. Selection of Permeable vs Impermeable Surfaces
4. Selection of Ex-situ Recycling
5. Structural Analysis & Design
6. Life Cycle Economic Analysis (LCCA) for Sustainable Alternatives
7. Life Cycle Environmental Assessment Analysis (LCA) for Sustainable Alternatives
8. Sustainability Analysis & Rating
9. Optimization Analysis of Sustainable Alternatives

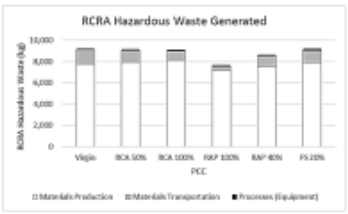


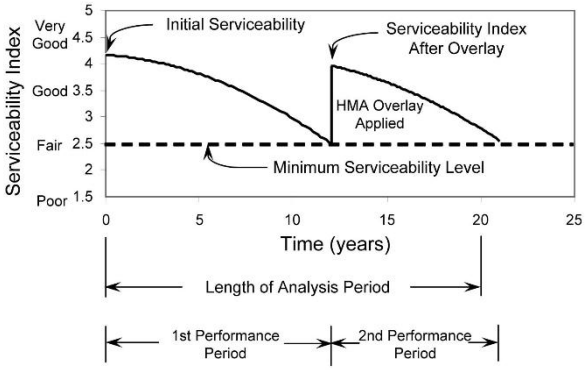








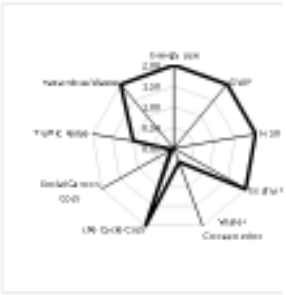




LCA & LCCA Analysis

Targets, Relative Weights & Rating

Criteria	Unit	Target	Reference	Strategy	Performance	Normalized Score
Energy Use	MJ	≥ 10% Reduction (1 pt)	4,708,871	3,899,275	27.68%	2.00
		≥ 20% Reduction (2 pt)				
GWP	Mg	≥ 10% Reduction (1 pt)	282	194	26.28%	2.00
		≥ 20% Reduction (2 pt)				
In Situ Recycling	CY	≥ 10% Recycling Rate (1 pt)	8.08	0.5080	50.08%	2.00
		≥ 20% Recycling Rate (2 pt)				
Ex situ Recycling	CY	≥ 10% Recycled Content (1 pt)	8.08	0.3540	35.48%	2.00
		≥ 20% Recycled Content (2 pt)				
Water Consumption	kg	≥ 5% Reduction (1 pt)	1,258	1,198	3.68%	0.37
		≥ 10% Reduction (2 pt)				
Life Cycle Cost	$	≥ 10% Reduction (1 pt)	347,975	157,827	54.62%	2.00
		≥ 20% Reduction (2 pt)				
Social Carbon Cost	$	≥ $19,758/Ton Saving (1 pt)	$12,587.69	$9,230.59	3.285	0.08
		≥ $39,808/Ton Saving (2 pt)				
Traffic Noise	no unit	HMA (1 pt)	-	1	1	1.00
		SMA or OGFC (2 pt)				
Hazardous Waste	kg	≥ 5% Reduction (1 pt)	85,539	80,485	22.19%	2.00
		≥ 10% Reduction (2 pt)				



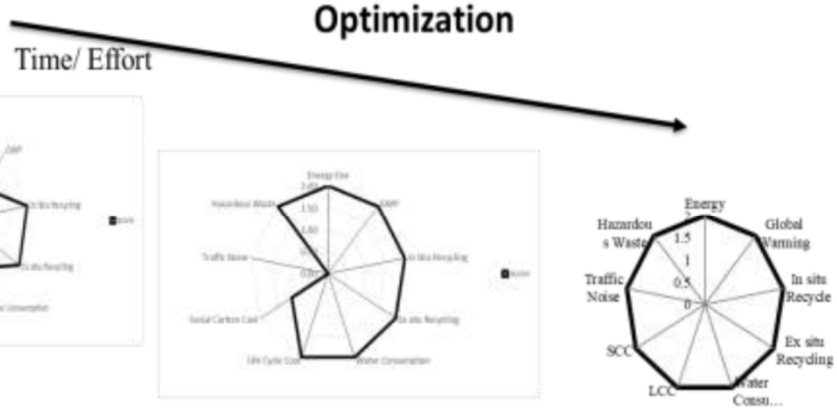
Accomplished Score	91.25%
Awarded Label	Silver

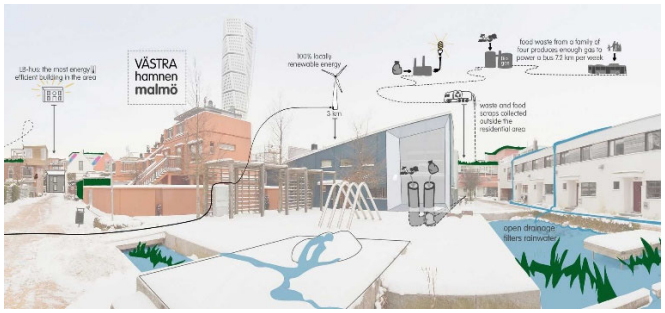
Yellow area = inputs.

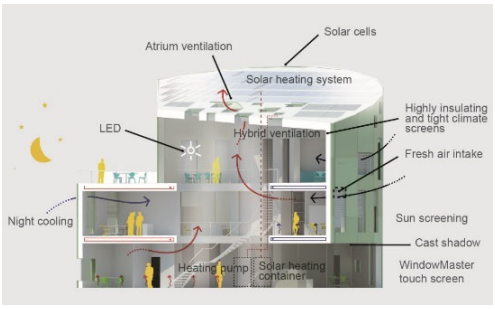
	Total	Energy	Global Warming	In situ Recycle	Ex situ Recycling	Water Consumption	LCC	SCC	Traffic Noise
Score	13.65	2.00	2.00	2.00	2.00	0.37	2.00	0.80	1.00
Weighting (%)	100.00	18.00	18.00	15.00	15.00	10.00	15.00	10.00	2.00
Weighting	1.00	0.10	0.10	0.15	0.15	0.10	0.15	0.10	0.02
Weighted Score	1.5218	0.2000	0.2000	0.3000	0.3000	0.0365	0.3000	0.0804	0.0020

Blue area = weighting parameters.

Sustainability Component Scores and Ratings







Technical Site Visits & Field Trips (tentative)
The following site visits are encompassed in the program.
Sustainability Site Visits
Malmo
- Västra Hamnen - Carbon-Neutral neighborhood
- Augustenborg – Sustainable Residential Neighborhood
- Hyllie - Climate-Smart District
- Turning Torso – Sustainable Skyscraper & Alternative energy/ biogas

Copenhagen
- Amager Bakke/ Copenhill - Waste to Energy Power Plant
- United Nations City – UN Sustainable Office Complex
- Green Light House- Sustainable Building

University of Lund
- LUCSUS Center for Sustainable Studies
- NASCOL National Sustainable Construction Laboratory
- other

Cultural Immersion & Site Visits TBD

Course Registration
- 3 credits upper 400 level Tech Elective for Major (ENCE489C)
- 3 credits approved Tech Elective for Sustainability Minor (double count)
- 1 credit upper 400 level project based course (ENCE489C) by participating in **Green Challenge** international competition (optional)*

*In conjunction with this program participants can take part in a unique global engineering 3 day competition in Denmark at Technical University of Denmark**,** DTU. Projects will be designed around the **17 UN Sustainable Development Goals**. The Office of Global Engineering Leadership will provide $1,000 flight voucher , and DTU housing with some meals during the 3 day competition. Winners in 4 categories will earn between $1,000 to $3,000 prizes. Further details at**:** **https://groendyst.dtu.dk/english** **A**pply by February 15 at:
https://docs.google.com/forms/d/e/1FAIpQLSehHUvkGf7l6wJx-abrmpUalwmeune5Uh1leaGDvpYU57XOdg/viewform

Learning Objectives

Students in this course will:

- gain knowledge on the principles and techniques for the design of smart cities sustainable infrastructure components and alternatives;
- be exposed to the complex and multi-disciplinary analysis required for such projects and account for the physical characteristics of the space, the historic and cultural identity of cities, as well as the environmental aspects;
- be exposed to and learn of the set of qualitative and quantitative indicators used in the design of "smart cities' green infrastructure;"
- apply principles and techniques on real case studies.

Learning Outcomes

By the end of the course, students should have attained competency (ABET) in the following areas:

- participatory decision making within a team;
- creating design alternatives based on community needs assessment, and cultural identity;
- creating and analyzing multiple design alternatives;
- determining appropriate techniques and methods to be used in solving societal needs mingled with engineering and environmental principles;
- determining metrics for design projects.

Program Assessment

1. Program & Team Participation (15%)

   This component will assess the interest, participation and interaction of each student in the different phases of this study abroad course (lectures, project design of case studies, site visits).

   Throughout the program, the faculty will assess through one to one interaction and discussions the following: student knowledge of the principles of developing smart cities green infrastructure design alternatives; their ability to recognize the complex and multi-disciplinary analysis required for such projects; their knowledge and ability to identify the set of qualitative and quantitative indicators for the design of "green infrastructure." *Participants will be asked to select one of the technical /cultural site visits included in the program, prepare explanatory material and present their findings and explanation to the rest of the team during the actual visit.*

2. Design Project Report & Presentation (70%)

   Each student and team will be assessed based on the level of performance in regards to the following list of outcomes:

   - participatory decision making within a team;
   - ability to create and administer design alternatives based on community needs assessment, and cultural identity;
   - ability to create and analyze multiple design alternatives;
   - ability to determine appropriate techniques and methods to be used in solving societal needs mingled with engineering and environmental principles;
   - ability to define evaluation metrics for the design project.

3. Reflection Summary (15%)

   At the conclusion of the program *a "Reflection" summary* will be prepared from each student which will highlight:

   - cultural immersion experience pinpointing both social & professional differences between US & Sweden/Denmark;
   - details and impressions from a technical /cultural site visit of choice.
   - study abroad program impressions

Program Schedule (tentative)

UMCP Workshops: May 11 & 12, 2020. "Sustainability Principles & Metrics."

US Departure: May 20, 2020

University of Lund:

-May 21, 2020: Arrival in Copenhagen Airport, transfer to Hotel in Lund. Registration.
On-site orientation and welcome by LUND faculty and students.

-May 22, 2020: Lectures on theoretical framework, strategies, and tools for the development of "Smart Cities and Sustainability."
University of Lund laboratories tour.

-May 23, 2020: Lectures on Green Infrastructure & Smart Sustainable Cities & Infrastructure
Site visits

-May 24, 2020: Field Visit: Malmo: Smart Sustainable City Infrastructure Components.

-May 25, 2020: Field Visit: Copenhagen, Smart Sustainable City Infrastructure Components

-May 26, 2020: Lectures on Green Infrastructure & Safety
Workshop on Sustainability Metrics Tools
Intro to Design Projects: Site Visit, Teams & Logistics, Analysis

-May 27, 2020: Lectures on Green Infrastructure & Safety
Work on Design Projects Analysis
Technical /Cultural Site Visit

-May 28, 2020: Lectures on Green Infrastructure & Mobility
Work on Design Projects Analysis
Technical / Cultural Site Visit

-May 29, 2020: Work on Design Projects Analysis
Technical / Cultural Site Visit

-May 30, 2020: Presentation of Design Projects, Course Assessment
Concluding Remarks.

-May 31, 2020: Copenhagen Airport Transfer & Return to the US.