ENE425 Sustainable Energy (brochure)

Spring 2021

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1 Topics

(∗) An extended version of the course description with extra figures that illustrate the topics and the teaching methodology can be downloaded from the NHH webpage of the course responsible.

During the last century, human activity has reshaped the world from an economic and environmental perspective introducing challenges for sustainability. This course deals with the relation between renewable technology development, economic activity and sustainability. The course is organized in three blocks that complement each other. The first block studies the impact of renewable technology development on energy production. The second block analyzes the impact of renewable technology development on energy demand and energy supply. The third block studies the impact of changes on energy demand and supply on economic activity. The fourth block covers the different policies that could be implemented to boost the adoption of different renewable technologies.

Overview of the course. In the overview of the course we will frame the objective and the content of the course.

- We illustrate the relation between renewable technology development, economic policies and energy sustainability by using the "ecological footprint" game.

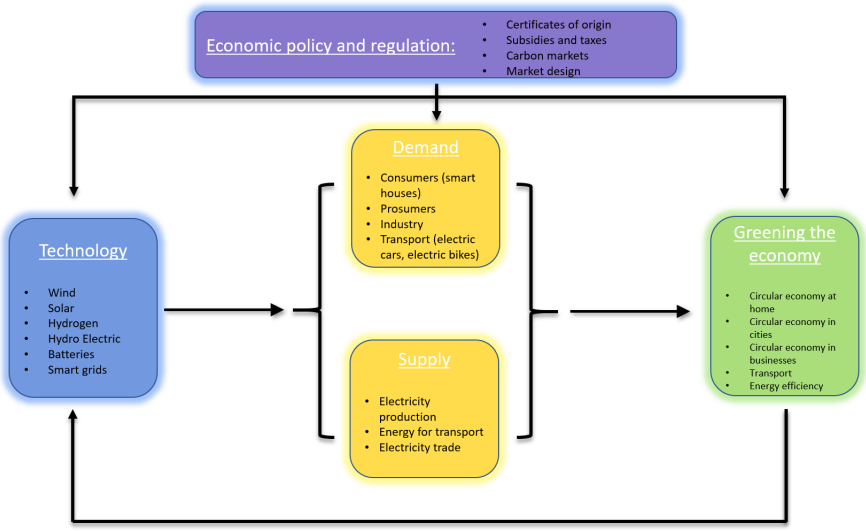
Block *I*. Renewable technology development In this block of the course, we study the impact of renewable technology development on energy production. We will study the different types of renewable energy sources. We will also study the impact of technology in batteries or smart grids, since those devices play a crucial rule in the development of a sustainable energy system. In particular, we will study the next topics (left-hand side panel, figure 1).

1. Wind energy.
2. Solar energy.
3. Hydrogen.
4. Hydro electric energy.
5. Batteries.
6. Smart grids.

Block *II*. Energy demand and energy supply. In this block of the course, we study the impact of renewable technology development on energy demand and energy supply. The technological changes introduce new possibilities to consume and to produce energy and that could have important implications in the abatement of carbon emissions. In particular, we will study the next topics (central panel, figure 1).

1. Energy demand
   (a) Consumers (smart houses, demand response).
   (b) Prosumers (consumers that consume and sell electricity).
   (c) Private transport (electric cars, electric bikes).

Figure 1: ENE425 Topics



2. Energy supply

   (a) Electricity production.

   (b) Energy for transport

   (c) Electricity trade within a country and across countries

Block *III*. Greening the economy. In this block of the course, we study the impact of changes on energy demand and supply on economy. The changes on energy demand and supply could facilitate the introduction of changes in economy that boost the reduction of carbon emissions. We will also study how the changes in the economy could impulse the development of new renewable technologies, since the massive adoption of new sources of energy and new technologies could open new business opportunities to many technological companies. In particular, we will study the next topics (right-hand side panel, figure 1).

1. Circular economy at home.
2. Circular economy in cities.
3. Circular economy in businesses.
4. Transport.
5. Energy efficiency.

Block *IV*. Economic policy and regulation. In this block of the course, we study the impact of economic policy and regulation on the previous three blocks. The economic policy and the regulation operate as an umbrella that cover the other three blocks. We will study the impact of different economic policies on the implementation of new technologies, and on the development of changes on energy demand and supply. In particular, we will study the next topics (top side panel, figure 1).

1. Certificates of origin.
2. Subsidies and taxes.

3. Carbon markets.

4. Market design.

The course will focus mainly on blocks I and II, but to frame the content of those two blocks, we will connect them with blocks III and IV.

(∗) The curriculum of the course is still under development, and the contents in the blocks could change slightly.

2 Learning outcome

Knowledge: At the end of the course, the students will know the features of renewable technologies and its implications on the development of a sustainable energy system. They will also know the policies implemented by the government to promote the development of those technologies to boost the development of a sustainable energy system.

Skills: The students will learn to find information about new renewable technologies and economic policies that promote the development of those technologies. They will learn to use the economic tools to evaluate the impact of those technologies and policies on economic activity.

General competence: The students will be able to identify relevant problems related to the development of renewable production technologies. They will be qualified to use the most suitable economic tools to study the impact of new renewable production technologies on the development of a sustainable energy system. Finally, they will be capable to present their analysis and conclusions by using written essays and presentations.

3 Teaching

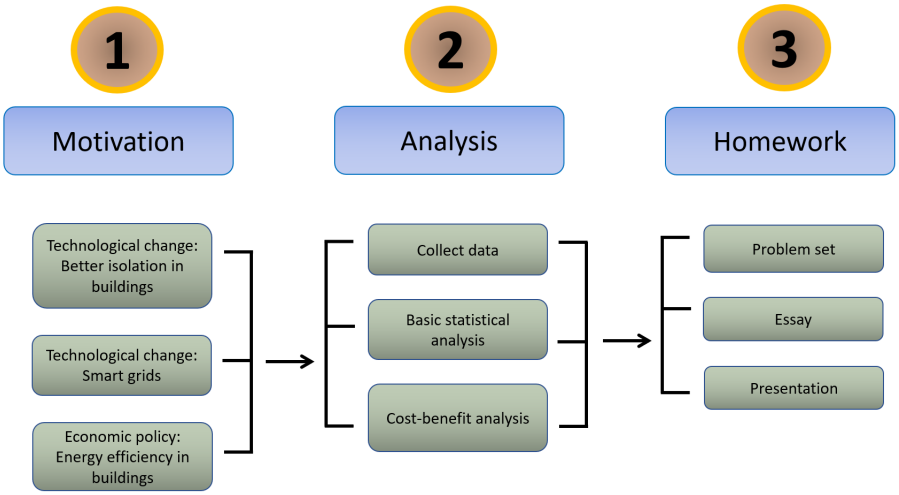
Lectures, about 20. Group presentations and discussion.

The teaching methodology consists on three different pillars that complement each other: **Motivation (overview)**, **economic analysis** and **homework**.

Every lecture in the course begins with an **motivation (overview)** of the economic problem that we address in that lecture. The overview helps us to frame the problem, and to understand the relevance of that problem from an economic and from a social perspective. The overview part of the lectures is also useful to help the students find information about real economic problems by themselves. I encourage the students to work in groups to find relevant information about the problems that we address in the lectures, or economic examples that could be useful during the overview discussion in the lectures. If for example, we study the development of more efficient isolation measures in buildings, we frame that problem by analyzing it from a technological and from a economic policy perspective (left-hand side panel, figure 2).

After framing the economic problem, we present the **economic analysis**. Economic problems are polyhedral, and we have to look at those problems from different angles by using the most suitable economic techniques. The economic analysis provides an holistic view of the tools used in economy by presenting the most advance theoretical models, experiments, econometric analysis and software simulations. If for example, we study the development of more efficient isolation measures in buildings, we try to collect data about real projects, we conduct some basic statistical analysis and a cost-benefit analysis (central panel, figure 2).

Figure 2: ENE425 Teaching methodology



We conclude each lecture with the distribution of different types of **homework**. Depending on the type of problem that we are analyzing in the lectures, the homework could be theoretical, empirical or analytical. We complement the homework part of the lectures with writing essays and presentations (right-hand side panel, figure 2). I encourage students to cooperate and work in groups while they prepare the homework.

I like the students participate actively during the lectures. Even during the time of covid19, I will design online questionnaires, or zoom presentations to give the students the opportunity to interact with each other (virtually) during the lectures.

4 Requirements for course approval

The course analyzes different problems using the most appropriate tools. Therefore, the evaluation will also follow that approach. During the lectures, I will distribute **problem sets** that the students should complete. At the end of the course, the students will have a **writing essay** and a **presentation** based on one of the topics that we study during our lectures. For the essay and the presentation, I will provide some topics that could be of interest for the students. The students could also present a topic that could be relevant for them and for the rest of the students. The problem sets will account for the 20% of the final grade, and the essay-presentation will account for the 80% of the final grade.

Both the problem sets, and the essay (and presentation) will be conducted in groups. The size of the group will vary between three to six students depending on the total number of students enrolled in the course.

The students have to pass the problem sets and the essay-presentation to satisfy the course approval. In case that a student does not satisfy the requirements for course approval, it will be necessary to present the problem sets and the essay-presentation again.

5 Assessment

The assignment for the course consists in two parts. The first part is an essay that accounts for the 40% of the final grade. The second part is a presentation that accounts for the 60% of the final grade. Both parts will be conducted in groups.

We will decide about the topic for the essay, and the topic for presentation after the first month of the course. The essay needs to be delivered before the last week of our lectures. The presentations will take place during the last two weeks of the course.

Both, the problem sets, and the essay (and presentation) will be conducted in groups. The groups will have four or five students, but that the size of the groups could vary depending on the number of students enrolled in the course.

6 Grading scale

A-F.

7 Computer tools

In principle, we will not use software simulations during the course. In case that we run simulations or we conduct some econometric analysis. I will help the students with Matlab and Stata.

8 Workload

The expected workload will be around 200 hours. The 30% of those hours corresponds to lectures and the 70% corresponds to the essay and the presentation. **Summarizing**:

- Lectures (60 hours)
- Homework: Essay and presentation (140 hours)

9 Literature

The aim of this course is to establish a link between renewable technological development and economic analysis. Therefore, during my lectures I will use books and documents that use a technological approach and a economic approach. I will also use documentaries to frame and to motivate our discussion. I will develop a manual with the material that we will use during the course. The lectures will be based on that manual.

(∗) I provide some very preliminary and illustrative literature review. One month before the beginning of the course, I will provide a final version of the literature that we will use during the course. In that final version, I will detail which chapters of which books we will use during our lectures.

1. Renewable technology development.

David JC MacKay, 2009, "Sustainable Energy - without the hot air," *UIT Cambridge, England.*

Stephen Peake, 2018, "Renewable Energy, Power for a Sustainable Future," *Oxford University Press.*

2. Market Failures.

Charles Kolstad, 2009, "Environmental Economics," *Oxford University Press.*

3. The impact of climate change. Energy sustainability policies.

Paul Hawken, 2010, "The Ecology of Commerce Revised Edition: A Declaration of Sustainability," *New York: HarperCollins Publisher.*

Tim Jackson, 2009, "Prosperity Without Growth: Economics for Finite Planet," *Earthscan.*

Naomi Klein, 2014, "This Changes Everything: Capitalism vs. The Climate," *Penguin.*

William Nordhaus, 2013, "The Climate Casino: Risk, Uncertainty, and Economics for a Warming World," *Yale University Press.*

Jonathon Porritt, 2007, "Capitalism: As If the World Matters," *Earthscan.*

Stephen Smith, 2011, "Environmental Economics: A Very Short Introduction," *Oxford University Press.*