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Renewable Energy, Technology, and Resource Economics

ENGR 3000 (3 credits)

Iceland: Renewable Energy, Technology, and Resource Economics

This syllabus is representative of a typical semester. Because courses develop and change over time to take advantage of unique learning opportunities, actual course content varies from semester to semester.

Description

This seminar takes an interdisciplinary approach to renewable energy to build a holistic understanding and develop competence in critical analysis of sustainable energy systems. Renewable energy technologies are presented in the context of their social, economic, and environmental impacts. Through lectures, experiential learning, access to experts in the field, and student-led activities, each student gains knowledge in areas of personal interest. The seminar aims to engage students intellectually in relevant renewable energy issues and give ample opportunity to exercise their knowledge with program faculty in Iceland.

Learning Outcomes

Upon completion of the course, students will be able to:

- Demonstrate the mechanics of a variety of renewable energy technologies;
- Differentiate among types and scales of energy utilization technologies;
- Relate energy production and consumption to resource use and management;
- Analyze and compare different energy systems and account for costs and benefits of different renewable energies;
- Show ability to work with class concepts of resource economics renewable energy, and technology;
- Assess critically positive and negative environmental impacts from various renewable energy options in Iceland and beyond;
- Describe the challenges faced by remote Northern communities in transitioning to renewable energy.

Language of Instruction

This course is taught in English, but students will be exposed to vocabulary related to course content as well as the nuances of renewable energy, technology, resource economics, and environmental science through in-country expert lecturers and field visits to a wide range of venues and regional locales.

Course Material and Texts

A course pack including selections from the texts listed below will be provided on the class website. You are not required to purchase these textbooks; selected chapters will be available

on the course website; large sections are also available for perusal on Google books. The course website also contains numerous relevant articles and will be updated with required and optional readings throughout the program. Other course resources include the SIT online resources library and the Icelandic national subscription to academic sources online.

Peake, S. (2018). *Renewable Energy: Power for a Sustainable Future, 4th Edition*. Oxford: Oxford University Press.
Common, M. & Stagl, S. (2005). *Ecological Economics: An Introduction. Cambridge*: Cambridge University Press.
Tester, J. W. et al. (2011). *Sustainable Energy: Choosing among Options, 2nd Edition*. Cambridge, MA: The MIT Press.

Suggested Pre-Departure Readings
All pre-departure readings and assignments can be found on the program's Virtual Library at http://sit.libguides.com/ice.

Course Schedule
Students will be provided a detailed course schedule during orientation on the program. Please be aware that topics and excursions may vary to take advantage of any emerging events, to accommodate changes in our lecturers' availability, and to respect any changes that would affect student safety. Students will be notified if this occurs.

Module 1: Foundations – Iceland's Geology and Climate Change; Renewable Energy Technologies

From day one of orientation, the program visits places of significance where students experience renewable energy and sustainable communities firsthand. We will learn about Iceland's remarkable geology, setting the stage for an examination of geothermal and hydropower, the two most widely used renewable technologies in Iceland. We will also explore basic energy concepts, considering how the concept of energy is approached in various disciplines, before focusing on the physics of energy. In Reykjavik, students will be introduced to other major renewable technologies in use in the world today (most of which we find in some form in Iceland) and the challenges of grid-scale electricity storage. Led by faculty from the University of Iceland, we will visit nearby hydropower and geothermal power plants, considering system function and design, energy conversion processes, and the landscape impacts of renewable energy production. The module is designed to be accesible to those with or without engineering backgrounds.

Topics covered may include:
- Volcanic hotspots and plate tectonics;
- Basic energy concepts and the physics of energy;
- Renewable energy for electricity, heating, and transportation;
- Geothermal and hydropower;

- Solar and wind power;
- Energy systems and energy storage;
- Landscape impacts of renewable energy production.

Required Readings:

Price, C. (2013). Climate Change Impacts and Adaptations in Iceland. Retrieved from: https://www.youtube.com/watch?v=nJ_yipz3vqU (Video)

Tester, J. W. et al. (2011). Chapter 11: Geothermal energy. In *Sustainable Energy: Choosing among Options* (453-518). Cambridge, MA: MIT.

Friðleifsson, I. B. (2001). Geothermal energy for the benefit of the people. *Renewable and Sustainable Energy Review*, 5(3), 299-312.

Tester, J. W. et al. (2005). Chapter 12: Hydropower. In *Sustainable Energy: Choosing among Options (519-542). Cambridge, MA: MIT.*

Boyle, G. (2004). Chapters 2 and 3: Solar thermal energy and solar photovoltaics. In Renewable energy: Power for a sustainable future, 18-103.

Tester, J. W. (2005). Chapters 15 and 18: Wind energy. In *Sustainable energy: Choosing among Options* (613-645; 727-758). Cambridge, MA: MIT.

Recommended Readings:

Thordarsson, T. & Höskuldsson, A. (2002). *Iceland: Classic Geology in Europe*. Edinburgh: Dunedin Academic Press.

Stefansson, V. & Axelsson, G. (2003). *Sustainable Utilization of Geothermal Resources*. Reykjavík: Orkuveita Reykjavíkur.

Gunnlaugsson, E. (2008). *District Heating in Reykjavík: Past – Present – Future*. Reykjavík: Orkuveita Reykjavíkur.

Module 2: Renewable Energy Economics and Policy - Reykjavik

Module 2 will also be held in Reykjavík. As the country's capital and largest city, Reykjavík is the center of much energy policymaking and energy research. Students will have classes in resource and ecological economics, policies, and sustainability concepts. Students will also meet with experts in the field of renewable energy and leaders of industry, research, and development. This module looks broadly at the ecological economics of providing energy for society, including standard (neoclassical) approaches and alternative views, as well as approaches to sustainability. Policy options for a sustainable future are considered. Students produce their own hypothetical energy transition plans.

Topics may include:

- Sustainability concepts and definitions;
- Energy and resource economics;
- Management of energy resources;
- Energy policy

Each topic is related to the wider context, so students gain thorough comprehension of renewable energy in terms of sustainability.

Required Readings:

Common, M. & Stagl, S. (2005). Chapter 4: The economy and the environment—a conceptual framework. In Ecological economics: An introduction (86-120). Cambridge: Cambridge University Press.

Global Energy Review 2022. International Energy Agency. Global Energy Review: CO2 Emissions in 2021 Global emissions rebound sharply to highest ever level. https://iea.blob.core.windows.net/assets/c3086240-732b-4f6a-89d7-db01be018f5e/GlobalEnergyReviewCO2Emissionsin2021.pdf (Links to an external site.)

Renewable Energy Market Update Outlook for 2022 and 2023. https://iea.blob.core.windows.net/assets/d6a7300d-7919-4136-b73a-3541c33f8bd7/RenewableEnergyMarketUpdate2022.pdf (Links to an external site.)

Recommended Readings

Common, M. & Stagl, S. (2005). Chapter 11: Environmental policy instruments. In *Ecological economics: An introduction* (402-438). Cambridge: Cambridge University Press.

Moran, E. F. (2010). *Environmental Social Science: Human-Environment Interactions and Sustainability*. West Sussex: John Wiley & Sons.

Renewables 2021 Global Status Report: Key Messages for Decision Makers. https://www.ren21.net/wp-content/uploads/2019/05/GSR2021_Key_Messages.pdf

Jean-Baptiste, P. & Ducroux, R. (2003). Energy policy and climate change. *Energy Policy*, 31, 155-166.

Module 3: Renewable Energy in the Westfjords – Technologies and Challenges

In Ísafjörður, classes are held at the University Centre of the Westfjords. Building on the foundations in energy technology, economics, and policy established in Modules 1 and 2, students are introduced to the unique challenges to renewable Iceland's renewable energy goals faced by communities in the remote Westfjords. Guided by regional experts, students visit local power plants and engage in both academic and community-oriented projects focusing on energy transitions, regional development, and coastal sustainability. This module also covers in more detail the major renewable technologies currently found in and being considered for the Westfjords, including hydropower, marine renewable energy, and hydrogen.

Sessions in this module may include:

- Grid stability and resilience;
- Marine renewable energy;
- Regional energy transition planning;
- Local sustainability challenges;

- Decarbonizing the fishing industry.

Required Readings:

Mathews, K., & Sowiżdżał, A. (2019). Study of wind power utilization in district heating systems in the Westfjords, Iceland. *Geology, Geophysics & Environment*, *45*(2), 77. https://doi.org/10.7494/geol.2019.45.2.77

Boyle, G. (2004). Chapters 6 and 8: Tidal Power; Wave Energy. In Renewable Energy: Power for a Sustainable Future, 18-103.

Park, S. (2011). Iceland's hydrogen energy policy development (1998-2007) from a sociotechnical experiment viewpoint. In *International Journal of Hydrogen Energy* 36, 10443-10454.

Recommended Readings

Naderian, A., Jamali, B., Hjartarson, T., & Winn, G. (2017). *Comparison of High Voltage Cables with Existing Overhead Lines to Increase Energy Security in the Westfjords of Iceland* (P-17-205-R0). METSCO Energy Solutions Inc. (METSCO) for Landvernd.

Tester, J. W. et al. (2012). Chapter 14: Ocean Wave, Tide, Current and Thermal Energy Conversion. In Sustainable Energy: Choosing among Options, Second Edition (453-518). Cambridge, MA: MIT.

Module 4: Community Sustainability (Akureyri/Grimsey) / Energy and the Environment (Program Excursion)

In collaboration with community partners in Akureyri, students engage in a service-learning project to promote local clean energy initiatives. Students will also have classes, discussions and field research experiences that examine the social and environmental impacts of energy projects and grassroots efforts to achieve net zero carbon emissions. We will meet with experts in the field of renewable energy and leaders of industry, research, and development, and learn about Iceland's progress in exploring alternative fuels. We will also travel to Grimsey Island on the Arctic Circle, where pilot wind and solar projects have recently been installed. Capitalizing on faculty expertise at the University of Akureyri, we will continue our study of renewable energy technology with a session on biofuels.

As part of the program's main excursion from Akureyri back to Reykjavik, we will visit geothermally active areas surrounding Myvatn and investigate the impacts of hydropower development in the highlands. Linking the renewable energy transition to local climate impacts, we also learn the impact of climate change on Iceland's glaciers and implications for future hydropower production.

Topics may include:

- Akureyri – The Green Capital of the North;
- Carbon-neutralizing in practice (site visits to composting plant, methane plant, biodiesel from cooking oil, Akureyri hydropower stations);

- Sustainable transportation including electric vehicles, hydrogen fuel cells, and methane;
- Energy governance, provision, and pricing structures in Iceland;
- Renewable energy technologies: Biofuels;
- Transitioning to renewable energy on Grimsey Island;
- Environmental externalities of hydropower development;
- Climate impacts on Iceland‘s glacier and future hydropower capacity.

Required Readings:

Kristjansdottir, R., & Busch, H. (2019). Towards a Neutral North—The Urban Low Carbon Transitions of Akureyri, Iceland. *Sustainability*, *11*(7), 2014. https://doi.org/10.3390/su11072014

DiBari, C. P. (2019). *Energy Security in the Arctic: A Case Study of Renewable Energy on Grímsey Island*. M.Sc Thesis. Faculty of Industrial Engineering, Mechanical Engineering, and Computer Science University of Iceland.

Bulkeley, H. (2010). Cities and the governing of climate change. Annual review of environment and resources, 35, 229-253.

Recommended Readings:

Hreinsson, E. B. (2012). Iceland’s Energy Resources and Master Plan with Environmental and Economic Constraints. *Power and Energy Systems and Applications*. https://doi.org/10.2316/P.2012.788-022

Hodson, M. and Marvin, S. (2012) 'Mediating low-carb on urban transitions: forms of organization, knowledge and action.', European planning studies., 20 (3). pp. 421-439.

Martiskainen, M. (2017). The role of community leadership in the development of grassroots innovations. Environmental Innovation and Societal Transitions, 22, 78-89

Carton, W., & Andersson, E. (2017). Where Forest Carbon Meets Its Maker: Forestry-Based Offsetting as the Subsumption of Nature. Society and Natural Resources, 30(7), 829–843. doi:10.1080/08941920.2017.1284291

Þórhallsdóttir, Þ. E. (2007). Environment and energy in Iceland: A comparative analysis of values and impacts. *Environmental Impact Assessment Review* 27: 522–544

Bosshard, P. (2003). Kárahnjúkar: A Project on Thin ice. Berkely, CA: International Rivers Network.

Ingólfsdóttir, A. H., & Gunnarsdóttir, G. Þ. (2020). Tourism as a tool for nature conservation? Conflicting interests between renewable energy projects and wilderness protection in Iceland. *Journal of Outdoor Recreation and Tourism*, 29, 100276.

Evaluation and Grading Criteria

Evaluation is based not only on assessment of comprehension of the course concepts listed above, but also on student engagement and initiative in course exercises and activities. Grade is determined by:

Class Assignments (30%)

These will include problem sets and other exercises based on readings, class material, and excursions. Students are encouraged to work together, but each person must submit his or her own assignment.

Module 1 Exam (35%)
An in-class exam at the end of Module I will cover key concepts and skills from that portion of the class.

Group Project (35%)
Module 2 & 3 include a group project in which students will assess an existing or design their own conceptual sustainable energy system and demonstrate mastery of key concepts in resource economics, environmental science, renewable energy, and technology, and communication skills.

Assessment:

Class Assignments	30%
Module 1 Exam	35%
Module 2 Group Project	35%

Grading Scale

94-100%	A	Excellent
90-93%	A-	
87-89%	B+	
84-86%	B	Above Average
80-83%	B-	
77-79%	C+	
74-76%	C	Average
70-73%	C-	
67-69%	D+	
64-66%	D	Below Average
below 64	F	Fail

Expectations and Policies

- Show up prepared. Be on time; have your readings completed and points in mind for discussion or clarification. This raises the level of class discussion for everyone. Frequent tardiness will count as absences.
- Have assignments completed on schedule, printed, and done accordingly to the specified requirements. This will help ensure that your assignments are returned in a timely manner.
- Ask questions in class. Engage the lecturer. These are often very busy professionals who are doing us an honor by coming to speak.
- Comply with academic integrity policies as specified in the SIT Study Abroad Student Handbook.

- Respect differences of opinion (classmates, lecturers, local constituents engaged with on the visits). You are not expected to agree with everything you hear, but you are expected to listen across difference and consider other perspectives with respect.

Please note: the syllabus, course content, lecturers, and readings may modified by the Academic Director in order to better suit the needs of the course and its participants. Should any change of class topics or lecturers be necessary, students will be promptly notified.

Academic Policies: SIT prides itself on providing students with an experientially based program; we hold ourselves, and our students, to the highest of academic standards. Students are asked to refer to the **SIT Study Abroad Handbook** for policies on academic integrity, ethics, academic warning and probation, diversity and disability, sexual harassment and the academic appeals process.

Disability Services: Students with disabilities are encouraged to contact Disability Services at disabilityservices@sit.edu for information and support in facilitating an accessible educational experience. Additional information regarding SIT Disability Services, including a link to the online request form, can be found on the Disability Services website at http://studyabroad.sit.edu/disabilityservices.