Burch Seminar in Alaska and Iceland

Global Climate Change and Energy Resource Depletion: The Crises, the Challenges and the Solutions

Summer 2010

Seven weeks (Sunday, June 20-Sunday, August 8)

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I. Introduction

This seminar will empower students to face two of the great crises of the twenty-first century: global climate change and energy resource depletion. Two courses will be offered. The first course will be held in Alaska, where the consequences of climate change are self-evident. The second course will take place in Iceland, where some of the best solutions to energy resource depletion are being developed. Students are expected to forge the link between these crises, and think critically about global solutions.

In the first course (3 weeks) students will be confronted with the crude reality of global climate change, witnessing the consequences of anthropogenic interference in the earth's climate. No other region of the United States is changing as dramatically as Alaska, which like the nearby Arctic is a harbinger of global climate change. Here, large glaciers recede, sea ice disappears, permafrost thaws, forests dry up and burn, and summer gets longer and warmer every year.

The second course (4 weeks) will deal with the energy crisis and the urgent issues of oil and gas depletion, peak oil, and the pressing need for a transition away from our current carbon-based economies. Iceland offers the perfect example of a society that will be soon powered entirely by renewable energy resources. By 2050 Iceland's goals are to become the first advanced society to end its dependence on foreign fossil fuels and the first to completely transform to a hydrogen-based economy.

Background on Global Climate Change

Global warming refers to the rapid increase in temperature of the Earth since the mid-

19th century. Over 30 scientific societies and academies of science agree with the Intergovernmental Panel on Climate Change (IPCC) conclusion that human consumption of fossil fuels is a major driver of global warming. Global temperature increase is expected to cause global climate change: sea-level rise, extreme and unprecedented weather patterns, increase in the intensity and frequency of hurricanes, floods and droughts, followed by regional changes in precipitation and increasing desertification. Scientists also suggests that glacial and sea ice retreat and melting permafrost at the Earth's polar regions is directly linked to global warming. Defined as that area of the northern hemisphere where the average temperature of the warmest month is below 10^{o}C (50^{o}F), the Arctic includes northern and western Alaska. The Arctic is the most rapidly changing environment on Earth. This is because global warming forces sea ice and glacier ice to retreat, which diminishes the amount of sunlight reflected to space. This increases temperature some more, which melts more ice, which further reduces reflection causing greater temperature increase, and so on. Called a positive feedback, this self-propelling process of temperature rise produces regional changes in the Arctic four times stronger than anywhere else on the planet.

Thus the Arctic can be thought of as the 'canary in the mine', the region of the world where a first glimpse of the planet's future environmental change can be discerned. The Arctic is where the impacts of anthropogenic inference in the climate system are easiest to see and measure. In the United States, Alaska has emerged as the poster state for global warming. Researchers from the University of Alaska-Fairbanks (UAF) have determined that since the 1970s, climate change has doubled the growing season in some parts of the state. Since 1950, the overall state temperature has risen by 3.5°F, while wintertime temperatures have risen by 6°F. Unprecedented drought is stressing and killing spruce, aspen and birch. In fact Alaska is currently the target of careful ecologic and environmental studies aimed at understanding the symptoms of and possible responses to global climate change.

We anticipate the students in this class to closely interact with researchers at the Center for Global Change and Arctic System Research at UAF, as well as with engineers in the US Army Corps of Engineers' Cold Regions Research and Engineering Lab. These are the people facing the many challenges global warming is bringing to the state. They are the first line of defense against anthropogenic climate change.

Background on Energy Depletion

It is not difficult to understand that the environmental and energy crises are interconnected, and that if ranked according to urgency, the energy crisis should be the first priority. The fossil fuels that power society are becoming increasingly scarce, yet there is no concerted global plan to find a substitute for petroleum. If this pattern continues civilized life as we know may eventually grind to a halt. Non-renewable, finite and therefore exhaustible fossil fuels provide 82% of the world's total energy demands (~460 quadrillion BTU), yet most large energy/oil companies invest less than 1% of their substantial profits in renewable energy research. Recent forecasts show that the world's conventional oil reserves will last roughly for another 40±15 years, natural gas 70±15 years, and coal 220±30 years. Given the unrelenting (exponential) increase in the world's energy demands, the lower figures are probably more likely. The growth in China and India exemplify this well, as the pressure to provide cheap, abundant energy lies primarily in fossil fuels. The United States consumes 21 million barrels of oil every day, or one-fourth of the world's consumption. By 2050 China will have surpassed the US consumption and the world will require over 100 million barrels of oil per day. But according to the CEO of Total, the largest French oil consortium, such supply rate will become very difficult to meet and even more difficult to maintain.

Iceland has gone further than any other country in exploiting its renewable energy resources. Leading the world in per-capita income this country may be the first to transform completely to a hydrogen-based economy. The outcome will be a country completely independent of foreign oil, self-reliant in matters of energy.

In the 1970s Iceland was 80% dependent on imported fossil fuels, and was among Europe's poorest economies. Today the International Monetary Fund (IMF) ranks Iceland as the fourth most affluent nation in the world (even after the economic slow down of late 2008). Iceland has corporate giants lined-up to relocate there and take advantage of low-cost clean energy, while a few years ago it had to beg for corporate investments. Iceland leads the world in production of renewable energy, and has set a goal to host the world's first hydrogen-based economy. This is in part possible because of Iceland's abundant hydroelectric and geothermal resources. Glacial rivers and waterfalls are used to produce over 81% of the country's electricity needs. Geothermal energy makes up the difference. Water heated by volcanic activity is also used to heat homes and businesses.

The combination of Iceland's unusual geology and its relatively small population of 320,000 make it the perfect location to test the viability of a new sustainable economy. It may be argued that Iceland's situation is unique and thus difficult to translate into other societies and regions. Indeed, students will learn about Iceland's resources, but more importantly, they will learn from the innovative attitude and policies that drive Iceland's sustainable future. Learning how Iceland's scientific and political leaders are planning for a renewable-only energy future will challenge our students to adapt some of these ideas in the United States.

The students in this class will closely interact with academics, engineers and scientists from Iceland University, Landsvirkjun (Iceland Energy Company), ISOR (Icelandic Geosurvey) and other energy industries. To best understand their future plans we shall meet policy makers and industry leaders in government and in the private sector.

II. Academics

Students on this program will be enrolled in the following academic courses:

- HNRS 351 - Global Climate Change: The Science and the History (4 credits)
- HNRS 351 - Energy Resources: the Science and the Policy (4 credits)

Outline of coursework

a. ***Global Climate Change: The Science and the History***
HNRS 351
4 undergraduate credits
Connections: Physical and Life Sciences (PL), Experiential Education (EE)

Course summary

This course starts by outlining the long history of global warming, including great climate changes of the last 4 billion years. Climate change is controlled in part by variations in the earth's orbital parameters, so the course will outline the astronomical theory of the climate, as well as the use of modern climate models to predict the future climate under the driving forces of increasing greenhouse gas emissions. The causes and effects of global warming: the enhanced or anthropogenic greenhouse effect and climate feedbacks. The course covers the effect of warming of the Arctic the thawing of the permafrost and its impact on urban areas and on industry.

The second half of the course will explore the controversial topic of anthropogenic versus natural components of global warming, including global emissions of carbon dioxide, methane, ozone, nitrous oxides. Other pollutants (aerosols) will be discussed as contributors to the countering effect known as global dimming.

Scientific evidence of climate change in the last millennium (tree rings, ice cores, lake sediments, borehole heat flow, documentary, and other proxy measures) and in he last century will be thoroughly discussed. The course ends with climate policy in general and the Kyoto protocol in particular, examining its strengths and weaknesses, and the political and environmental factors influencing the current state of climate policy in the world.

Textbook: Houghton, J. (2004). Global Warming. Cambridge U. Press.

Recommended reading: Cox, J. (2005). Climate Crash. J. Henry Press.

Academic schedule

The beginning of the course will take place at the University of Alaska, first at Fairbanks (UAF) and then at Anchorage (UAA), with 30 classroom hours (20 hours in UAF) in which the theoretical classroom understanding of global warming will be taught as the foundation for the field visits. We will then travel around the southern half of Alaska to visit the most dramatic visible manifestations of global warming, which are detailed in Appendix 2. These field trips will account for 30-35 hours of course time.

Course requirements and Assessment

Class Participation (essential)………………………….. 20%
5-6 short essays, 2 pages each………………………….. 30%
Term Project Presentation and newspaper article: …….. 30%
Exam: ………………………………………………... 20%

Term Project: The aim of this project will be to mobilize education and action in students' home communities. Students will create a presentation for a high school audience explaining the scientific and political situation surrounding the topic of global warming, including graphs, evidence from multiple sources, and evidence from the field sites visited during the course. Students will also write a newspaper article for their local newspaper relating what they have learned on their trip to global warming with the aim of presenting global warming from a personal experience. Projects will be graded on scientific accuracy, presentation, and creativity. Students will be encouraged to present their work in their home communities, and submit their article to local newspaper. In addition to the team effort, each student will write a report on his/her participation in the project and will present this to the group, so this work is equivalent to an additional essay.

Presentation: 15% Newspaper article: 15%

b. Energy Resources: The Science and the Policy
HNRS 351
4 undergraduate credits
Connections: Connections: The North Atlantic World (NA), Global Issues (GL), Experiential Education (EE)

Course summary

This course begins with the history of energy use, its evolution and the scientific and technological discoveries that propel societal evolution. The geography, geology and geopolitics of the world's energy resources (including water) will be thoroughly discussed. The historical perspective will explore the primitive uses of energy through the industrial revolution and its profound significance in the creation of wealth. The discussion will then move into the main ideas of how energy conservation, energy efficiency and wise energy use are all integral components of solving the crises that the world is facing. The best-known example of how to do this is found in Iceland. Through examples found throughout our exploration of the country the students will become acquainted, first hand, with the uses of hydroelectric, tidal, solar and geothermal energies.

Renewable energy will be the basis for discussion for the rest of the course, which at this time will emphasize the huge price of inaction and the urgency of decisive measures. Included in the discussion will be research on the possibilities of actions that individuals, governments, NGOs, international organizations and individuals can contribute. Detailed discussions will deal with North Carolina, and what we learn from our experience that will benefit our state and the United States.

Textbooks:

Readings will be assigned from the following textbooks:

Wolfson, Richard. (2008). Energy Environment and Climate. W.W. Norton
Kruger, P. (2006). Alternative Energy Resources. J. Wiley & Sons. Pub.
Deffeyes, K. (2005). Beyond Oil. Hill & Wang Pubs.

Academic Schedule

This course will be held at the University of Iceland, Department of Geological Sciences. Initially there will be a two-day orientation session to explore the city of Reykjavik and the geography of Iceland. The two days will include side trips to Reykjavik's center, port and surrounding areas using the local mass transport. The tour of the golden triangle will acquaint students with the general geology of the place and the sources of its hydrological and geothermal energy resources. Classes outlining the basics of renewable energy technologies will be taught in the first week in Reykjavik, totaling 15 hours. The rest of the trip will be spent visiting various sites around Iceland where renewable energy technology is being researched or utilized. A total of 60 contact hours is programmed for this course.

Course requirements and Assessment

Class participation (a vital part of this Burch Seminar) …………20%

Term Paper…………………………………………………..….. 50%

Choose a player in Iceland's goal of renewable energy independence (industry, government, NGO, other) and outline their role in achieving that goal. Demonstrate an understanding in the benefits and criticisms of their actions and policies, and how similar actions can be taken in other areas of the world. This paper should be 12-15 pages in length, and you can use references from the web, textbooks, etc. Papers will be due ten days after the end of the program.

Final Exam (comprehensive).……………………………………….30%

III. PROGRAM LOGISTICS

a. Program Affiliations

The program will be affiliated with the University of Alaska at Fairbanks (UAF) and at Anchorage (UAA), as well as with the University of Iceland's Department of Geological Sciences. The program will use classroom space, and housing at these institutions. Students will also be able to use libraries and other campus facilities.

b. Transportation

Students will fly to Fairbanks Alaska, where they will stay for the first two weeks of the program. The program will rent a bus to transport the group to Anchorage, which is about 6 hours south of Fairbanks. The group will stop at Denali National Park, between Fairbanks and Anchorage, for a weekend excursion. Transportation to excursion sites outside of Anchorage will also be by bus.

Students will fly from Anchorage to Reykjavík. Airport pick-ups will be arranged through the University of Iceland. Transport to all excursion sites in Iceland will be by bus. Road conditions in Iceland are excellent.

c. Safety

Iceland is a highly developed country, with low crime rates. In Reykjavík, students should take the same precaution they would take while traveling in major cities in the US. Potential safety risks in Iceland include environmental risk such as crevasses in glaciers. However, students will always be accompanied by professional guides in such environments and will not be permitted to hike the Vatnajökull and other glaciers during the program.

d. Medical Care

Fairbanks, Anchorage, and Iceland have modern health-care facilities and hospitals and no vaccinations are required to travel there. Although the group will travel to other parts of Iceland for excursions, Reykjavík and other cities with medical facilities are easily accessible form any part of the country.

e. Graduate assistant

The program will employ one graduate student assistant, who has a research interest in this field and, if possible, travel experience in Iceland or the Arctic.

IV. Eligibility and Enrollment

The program aims to enroll 12-16 undergraduate students with at least sophomore status and a GPA of 3.0 or higher. No prerequisites are required but GEOL/ENST 213 is strongly recommended.

V. Faculty Director

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At UNC I teach two First Year Seminars that deal with the two major global crises this Burch Seminar is about: Energy Resources for a Hungry Planet (GEOL 076) and Global Climate Change: the science and the history (GEOL 073). I teach a graduate course on Climate Modeling (GEOL 861/ENST490).

My research is international in approach and global in scope, and fully consistent with the proposed Burch Seminar. I have worked in the Arctic and neighboring regions since 2004. Funded by the US Department of Energy and ISOR (Icelandic GeoSurvey), I do seismic research work for the Icelandic geothermal energy industry and the Icelandic geological survey. In Iceland's Krafla and Hengill geothermal fields I have taught students from UNC and Duke both the theory and practice of seismic imaging and geothermal reservoir geology. I have been funded by US Department of Energy for the last twelve years to do research work in renewable energies, focusing on the largest geothermal fields in the country, The Geysers and Coso (CA). With funds from NSF I am currently researching abrupt climate change, using advanced climate models to understand the climatic history of the planet encased in the ice cores recovered from Greenland and Antarctica.

In Greenland I have been involved in glaciological exploration of the ice sheet since 2006, funded by NSF, NOAA and NASA. I study the dynamic response of the ice sheet to the increasing warming of the Arctic. In the field I make students keenly aware of the importance of global warming as a driver of fundamental changes in the earth's climate. My research in Greenland has been chronicled in the national and international media and the Internet.

I am an elected Fellow of the American Association for the Advance of Science (AAAS), and over the last 25 years have consulted for the Venezuelan oil industry, for the US Army Corps of Engineers, Lawrence Livermore National Laboratory, the State of North Carolina (Climate change), Weidlinger Associates (Palo Alto, CA; engineering, energy resources), and most recently for AltaRock Energy Inc. (Seattle, WA; renewable energy).

APPENDICES

Appendix 1- Global Warming in Alaska

Alaska has warmed 4^{o}F in the last 50 years, compared to a global average of slightly above 1^{o}F. Outlined below are a few of the harmful effects that have been observed in Alaska.

Storms and Community Infrastructure

Western Alaska experienced a brutal storm in September 2005 that washed away 10-20 feet of beach, in a storm surge of 9 feet above normal high tides. The coastal degradation continues as permafrost melts, storm intensity increases and sea level rises. The Army Corps of Engineers has estimated that it will cost $355 million to relocate 7 coastal communities that have less than 15 years before their towns wash away.

Water bodies and wetlands

Water bodies throughout almost all of Alaska are shrinking. In an exhaustive study of closed ponds, scientists have documented a significant loss in the number of ponds in key ecological areas in the last half of the 20th century. Similarly, wetlands in the Kenai National Wildlife Refuge have decreased by 88% from 1950 to 1996. The effects on local ecology have been profound.

Vegetation

According to a study that analyzed thousands of satellite images taken over two decades, there are vast reaches of boreal forest where photosynthesis has decreased over the last 22 years. In central Alaska, where it is dry, white spruce and black spruce have shown documented declines in growth. Projecting forward, a 4°C increase in July temperatures would result in no growth of these species in much of interior Alaska. With longer warmer summers, the spruce bark beetle can complete its life cycle in one year instead of two. Winter temperatures have not been cold enough in two consecutive years to depress survival rates of these forest-destroying beetles.

Vegetation has also been impacted by record-breaking fire seasons in Alaska. Between the fires in 2004-2006 over 25% of the forests in the northeast sector of Alaska disappeared. These burn rates are entirely consistent with global warming predictions.

Ice, Glaciers, and Permafrost

Polar bears rely on sea ice for their survival, including feeding, mating, and resting. Because of global warming, Alaskan polar bears have experienced unprecedented loss of sea ice for their habitat, which results in drowning, starvation, and higher cub mortality.

Other Alaska ice dependent species are showing signs of global warming stress, such as walrus and ice seals. As ice pulls away from the continental shelf, the platform used for feeding, there have been observations of abandoned walrus calves. The snow cavities for some ring seals and other ice seals can collapse with warming temperatures, exposing their young to predation or freezing.

Salmon populations--arguably Alaska's most ecologically and economically significant species--are affected by increased temperatures. Increased river temperatures have led to new parasites, which have led to a 40% decrease in pink salmon harvest since 2004. Less sea ice in the Bering Strait has led to a similar decline in "the nations fish basket".

Economy

The oil industry has experienced a much shorter winter season in which to build ice roads and otherwise traverse on the tundra for exploratory and drilling activities. Alaska's premiere winter activities—a big draw to the tourism industry--have also been negatively affected by global warming. The centerpiece of Anchorage's major winter event, the World Championship Sprint Dog Sled race, has been canceled three times between 2000 and 2006 due to warmer temperatures and less snow, significantly undercutting this source of winter economic activity. North of Anchorage, the town of Wasilla has traditionally prided itself on being the "Home of the Iditarod." However, for four consecutive years between 2003 and 2006, Iditarod organizers have moved the start of the Iditarod from Wasilla, with adverse economic consequences for the city to more northerly Willow or Fairbanks. Also, fighting an increasing number of fires is expensive and dangerous. The record-breaking fire season in 2005 cost over $108 million, while in 2005 fire fighting cost $56 million.

Appendix 2: Renewable Energy in Iceland

Since 1999, over 70% of Iceland's energy needs have been supplied by renewable energy — significantly more than any other country. Iceland is at the forefront of renewable energy research and plans to be the world's first energy independent country using 100% renewable energy sources. Already, virtually *all* of Iceland's electricity needs are met via hydroelectric (81%) and geothermal (19%) energy. The final stage of energy independence requires all private automobiles, fishing boats, and public transportation to run on hydrogen fuel, which Iceland intends to achieve by 2050. Iceland's president, Olafur Ragnar Grímsson, stated: "we have formulated the vision and the ambition to get rid of fossil fuel completely in a reasonably short time".

Iceland's unique geology allows it to produce renewable energy. Iceland is located on the Mid-Atlantic Ridge, which makes it one of the most tectonically active places in the world. There are over 200 volcanoes located in Iceland and over 600 hot springs. This is what allows Iceland to harness geothermal energy and these steam fields are used for everything from heating houses to heating swimming pools. Hydropower is harnessed through glacial rivers and waterfalls, which are both plentiful in Iceland.

Hydropower

In 2005, Landsvirkjun (Iceland Energy Company) produced 7,143 GWh of electricity 93% of which was produced with hydroelectric power plants. Additionally 5,193 GWh or 72% was used for power intensive industries like aluminum smelting. Currently, Iceland is in the middle of its biggest hydroelectric project to date. A 690 MW hydroelectric plant and another aluminum smelter are under construction—the Kárahnjúkar Hydropower Project is very controversial among environmentalists. Iceland's government believes another 30 TWh of hydropower every year could be produced, whilst taking into account the sources that must remain untapped for environmental reasons.

Geothermal power

Currently geothermal power heats 89% of the houses in Iceland and over 54% of the primary energy used in Iceland comes from geothermal sources. Geothermal power is used for many things in Iceland. 57.4% of the energy is used for space heat, 15.9% is used for electricity, and the remaining amount is used in many miscellaneous areas: swimming pools, fish farms, and greenhouses, for example.

The government of Iceland has played a major role in the advancement of geothermal energy. In the 1940s, the State Electricity Authority was started by the government in order to increase the knowledge of geothermal resources and the utilization of geothermal power in Iceland. It was later changed to the National Energy Authority in 1967. This agency has been very successful and has made it economically viable to use geothermal energy as a source for heating in many different areas throughout the country. Geothermal power has been so successful that the government no longer has to lead the research in this field because it has been taken over by the geothermal industries.

The move from oil-based heating to geothermal heating saved Iceland an estimated total of US $8.2 billion from 1970 to 2000 and lowered the release of carbon dioxide emissions by 37%. The equivalent amount of oil that would have been needed in 2003 to heat Iceland’s homes was 646,000 tons.

The Icelandic government also believes that there are many more untapped geothermal sources throughout the country, estimating that over 20 TWh per year of unharnessed geothermal energy is available. Combined with the unharnessed feasible hydropower, tapping these sources to their full extent would provide Iceland another 50 TWh of energy per year, all from renewable sources.

Hydrogen

Currently, imported oil fulfils most of Iceland's remaining energy needs. This is very costly to the country and has caused Iceland to focus on domestic, renewable energy. In 1999 Icelandic New Energy was established to govern the project of transitioning Iceland into the first hydrogen society by 2050. This followed a decision in 1998 by the Icelandic Parliament to convert vehicle and fishing fleets to hydrogen produced from renewable energy.

Iceland provides an ideal location to test the viability of hydrogen as a fuel source for the future, since it is a small country of only 300,000 people, with over 60% living in the capital, Reykjavík. The relatively small scale of the infrastructure will make it easier to transition the country from oil to hydrogen. There is also a plentiful supply of natural energy that can be harnessed to produce hydrogen in a renewable way, making it perfect for hydrogen production. Iceland is a participant in international hydrogen fuel research and development programs, and many countries are following the nation's progress with interest.

Appendix 3: Excursions

Excursions in Alaska

Central Alaska/Fairbanks

Minto Flats State game reserve- Observe 36% loss in lumber of ponds in key ecological area. Accessible by road from Fairbanks (35 miles), but no overnight facilities, so we must stay in Fairbanks.

http://www.wc.adfg.state.ak.us/index.cfm?adfg=refuge.minto

University of Alaska at Fairbanks-Center for Global Change and Arctic System Research – Contact John Walsh- jwalshiarc.uaf.edu

Western Alaska

Unalakleet- Visit a small town (pop. 2000) to observe accelerating shoreline and tundra erosion, and related damage to infrastructure, and the US Army Corps of Engineers' coastal erosion management strategy. Discuss state plan of relocation of seven Alaska coastal communities within 15 years. Visit local fisheries to see impacts of global warming in decreased fish populations. Accessible by plane from Anchorage, Fairbanks, and Nome. Multiple accommodation options.

http://www.adn.com/news/alaska/story/433580.html

Anchorage and southern Alaska

Alaska Native Tribal Health Consortium- Talk with Jim Berner about the health impacts of global warming. Contact: jberner@anmc.org

Talk with Fran Ulmer, director of Institute of Social and Economic research at the University of Alaska at Anchorage on the effects of Climate Change on Public Infrastructure and associated replacement costs. Contact: affau@uaa.alaska.edu

Kenai National Wildilfe refuge- wetland reduction by 88% from 1950 to 1996. Unprecedented tree growth indicates shrinking ponds, with many adverse impacts including adverse impacts on migratory birds. Observe significant drop in pink salmon harvest, a key source for major fisheries and indigenous people. Education opportunities available in visitor's center in Soldotna, as well as in the field on trails. Day hiking and back-country camping available. Accessible by road from Anchorage. Contact: Robin West, Refuge Manager kenai@fws.gov
Kenai River Seafoods-talk to small, local fishery about impacts of decreased Sockeye salmon and the impact on their business. http://www.kenairiverseafoods.com/sell/ (877) 434 - 7449
Denali National Park- observe retreat of glaciers. Visit the Murie Science and Learning Center, and take a ranger guided education program. Accesible by road from Anchorage. Great infrastructure with guided tours on buses (driving is not allowed in the interior due to high traffic), day hikes, backcountry hiking, camping, and classroom/visitor's center.
http://www.nps.gov/dena/index.htm

Excursions in Iceland

Reykjavik and surroundings

- ISOR- Iceland's geosurvey (1 day). Morning talks on geology, geothermal reservoirs. Climatology talks in afternoon on decreasing strength of Icelandic winters.
- Landsvirkjun (1/2 day)-Iceland's national power company headquarters.
- Orkuvieta Reykjavik- Reykjavik's energy headquarters. Visit and talks on energy infrastructure in the capital city.
- Golden triangle tour (1/2 day).
- Pingvellir and the Mid-Atlantic Ridge (1/2 day). Here, we will see where the European and North American plates are moving apart.
- Nesjavellir Power Plant and Hengill volcano (1 day)- This power plant currently produces 120 MW of electricity, which makes it the largest geothermal plant in Iceland.
- Iceland Deep Drilling Project in Reykjanes (1 day). Look at new technology and research on geothermal deep drilling.

South and Central Iceland

- South Hengill (1/2 day). This new geothermal development is under study by UNC researchers.
- Skogafoss waterfall. (1 day) This hike in glacier country and visit to Europe's largest waterfall give students an understanding of the potential of hydropower in Iceland.

East and Northern Iceland

- Karahnjukar Hydropower Plant project (1/2 day) This plant produces 630 MW of electricity for Alcoa.
- Mytvan-Keyajla geothermal plant (1/2 day)
- Akureyri- visit the School for Renewable Energy Science before returning to Reykjavik http://www.res.is/summerschool/

ICELANDIC CONTACTS

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