

Iceland – Integrating Technology,
Needs, and Responsibility
For Sustainable Living

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The Republic of Iceland is an isolated volcanic island in the Arctic Circle known for its profitable fishing industry, geology, and unique energy plan. The energy policy of this small nation has the potential to be the first energy independent nation. Although the venture seems expensive and excessively long term for most other nations' timelines, Iceland is proud of their efforts of promoting the use of renewable and more sustainable energy. For many Americans, much of Europe, and the developing nations the notion of complete energy dependence is not in the foreseeable future. The conventional fossil fuel based economy of the United States is coupled with economic growth, while Iceland's energy policies are based on a very different value system, land ethics. Iceland's Ministry of the Environment, the primary energy and resource concerned agency, believes that environmentally sound practices used to create their policies are one of the countries strongest attributes.

Iceland residents enjoy their less fossil fuel dependant nation. Due to their unconventional approach to producing energy, often the resident have to pay more for goods, supplies, and the infrastructure necessary for their basic energy needs. The citizens understand the value of the tradeoffs. In Iceland, residents who live near power plants do not have to worry about soot or carcinogens being emitted into the air they breathe (Case). The Icelandic people benefit from their power plant's affluent, the Blue Lagoon. The stigma of energy use and continued development greatly differs between Iceland and most other developed nations.

While remaining environmentally friendly, Iceland wants to attract economic development from both domestic and international sources. As the country wants to avoid having a fish-centered economy, it has to attract new investments. To do this, it

must show reasons why it is beneficial to open business in Iceland. One reason businesses choose Iceland are its operational costs. In a study of ten industrialized countries, Iceland has the second lowest operational costs, only behind Canada (“Iceland – the Cost Competitive Edge” : Canada, Iceland, UK, Italy, Netherlands, France, Austria, U.S., Germany, Japan). Expanding industries in Iceland include manufacturing, biotechnology, software, and research and development. However, in the present and near future, fishing remains the largest industry in Iceland. Fishing accounts for over 10% of the GDP and 75% of exports (“Export and Percentage of GDP”). Iceland has tried for years to diversify its industrial sector. One of the major problems lies in the formation of Iceland. Iceland was formed by volcanic eruptions, much of which the ash and volcanic rock is still visible. Only about 1% of the land is significantly arable, and its cold climate limits the type of crops that can flourish (“Iceland”). Iceland also does not have many natural resources such as metal ores or petroleum, as previously stated. However, it has significant locations and capabilities in the energy sector. Industries such as ferrosilicon and aluminum smelting are willing to transfer resources to Iceland because of plentiful and low cost energy.

Hydroelectric power plants supply the power necessary to operate energy intensive processes at a competitive price. Even though Iceland has some of the highest environmental standards for electricity generation in the world, it still is financially beneficial to utilize renewable energy. A recent example of foreign investment is in the aluminum industry. Alcoa is planning to open a large aluminum smelting plant in eastern Iceland. A 700 megawatt hydroelectric plant will be constructed to provide power for the aluminum smelting plant. The 3 billion dollar project will create up to 1000 jobs in

Eastern Iceland (Alcoa, Iceland Ink Agreement for \$3B Hydropower Project). From 1991 to 2001, the population in the region dropped 10.5% (Iceland Ministry of Industry and Commerce). One of the advantages of constructing this project in the eastern region is that it will be one of the few major businesses not near Reykjavik, the capital city. Currently, 62% of the Icelandic people reside in or around the surrounding area of Reykjavik. By building a major plant far from the hub of Iceland, eastern Icelanders should benefit economically from job creation and from future development. Future development will be very important to the Icelandic population. Currently the birth rate is more than twice the death rate (Latest Facts and Figures from Reykjavik), and Iceland is now experiencing a large “baby-boom.” New housing needs and other infrastructures will need to move beyond the capital. However, the housing needs and industrial growth will increasingly alter the landscape and natural habitats.

Increasing energy usage and land development will harm the environment. The Icelandic government sees that long-term environmental projection will allow for sustainability of the people, organisms, and landscape. Even in the short-term, it is necessary for Iceland to protect the environment to maintain a positive image: “It must be ensured that the positive image of purity of Icelandic agricultural products continues to be based on solid grounds... The purity of water sources in the countryside must be ensured” (Welfare for the Future 17). The connection between human interaction and the environment is well understood by the government and the people.

Many of the nations engineering and political accomplishments have been created from basic needs. Since Iceland is only about two million years old, and one of the most geologically young land masses on earth, it is too young to have accumulated any of the

massive depositions of organic material of the Carboniferous Period. The lack of fossil fuels has created a unique situation for the island. All of the fossil fuels needed for daily activities have to be imported. This is costly endeavor for three primary reasons. The first being the monetary of cost of shipping fuel such a great distance. The second being the liability cost of having oil tankers spill in their economic fishing zone. Lastly, an oil spill would also affect the entire nations since 90% of the population lives on the coast (Iceland's National Program of Action, 5). Large scale remediation measures would have to be taken in order to protect water supplies, wildlife, and vegetation. The natural resources are economically important to the sustainability of Iceland's energy independence plan; therefore stricter measures are being proposed to protect the resources. To ultimately safeguard the people from such disasters, the option of fossil fuel use in Iceland is being abandoned. The island does have other, possible more valuable resources that the economy can capitalize on. The Icelandic government and the citizens are pushing to develop technologies that are efficient, nonpolluting, and most importantly fossil fuel free.

The primary reasons for so many of Iceland's cutting edge policies are to continually uphold the clean and pristine image of the nation. Many economical and social sectors are relying on the reputation of the Icelandic nation's environment. Its continued world wide reputation will continue far into the future with the great strides in environmental protection that have been made to ensure the image of Iceland remains untarnished. Iceland has a destructive past and a tendency to exploit just like many other nations. But, unlike other world powers, Iceland has recognized its vulnerability to

environmental changes, and they have the time, money, technology, and public support to hopefully learn from their history.

The policy makers and various departments believe the land and marine habitats must be protected for the survival of all organisms. When Iceland was first discovered and settled in, birch wood forests covered one-fourth of the land. Deforestation quickly destroyed most of the forests, as birch wood only covers one percent of the land today (Welfare for the Future 38). Only 3% of the wetlands in southern Iceland and 18% in western Iceland remain untouched. More than half of the areas with significant vegetation have been depleted due to clearing of the lands, overgrazing, and soil erosion; in many cases desertification has occurred. Land destruction affects the entire biota, not just in Iceland, but in the world. There are about 458 species of vascular plants and 75 species of birds in Iceland. Today, 51 of the vascular plant species and 32 of the bird species are on a red list of endangered species (38). The danger of extinction is always present due to human interactions.

There are very few land mammals in Iceland, and only the Arctic Fox is native to Iceland. The most serious threat to arctic foxes lie in human activities. Some of the blue and silver foxes, imported by farmers, escaped from farms and bred with the Arctic species. Until 1994, foxes were considered a nuisance and laws actually promoted the extermination of the Arctic Fox. When the population reached the brink of extinction, the laws were amended. (Biological Diversity in Iceland 12-13). Other mammals which were imported include the American Mink, for its fur, and reindeer. Like the foxes, mink escaped into the wild and began breeding. The spreading of mink are blamed for affecting the breeding distribution of native birds. Habits such as the introduction of

mink and draining of wetlands are reasons for the complete disappearance of the Water Rail, a native bird (13). Human interaction with the environment is the chief threat to nature in Iceland, although recent legislation is attempting to fix some of the flaws.

The first step in protecting habitats is to identify problems. Government agencies working with universities and the biological community will map out land and sea animals, and arrange animals into groups such as red lists. Regions that should remain untouched or regions that house endangered species will be designated as national parks and natural reserves. Many of these areas will be open to the public and tourism, which will allow the public to appreciate Iceland's natural beauty, while also protecting it completely. Other areas will remain untouched. An amendment to the Nature Conservation Act in 1999 forces the Ministry for the Environment to submit to Parliament a regularly updated Nature Conservation Strategy (28). The act and other current legislation will serve to benefit everyone, from the air they breathe, the water they drink, and the condition the country is left in for future generations. Not only will designated species be able to live untouched by man, but also legislation to lower pollution levels and to invest in reforestation and rewetting of the wetland will result in a better quality of life.

In 1996, the Hestur region in south west Iceland was the site of a rewetting experiment. Drainage ditches were filled with peat. One year after the start of the experiment, water levels began to rise considerably. In the same year, in Kolavatn, a drained lake was filled with soil. In a matter of a few months, water level rose and filled the once dry basin (38). Although the wetlands can never be completely restored, efforts are being made to preserve existing ones and to rewet destroyed wetlands. Another area

of concern is land development. Many nature conservation groups are pushing for the conservation of land use in the Eastern Highlands. The Eastern Highlands is one of the most unique regions in the world – hot springs, volcanoes, glaciers, waterfalls, lava fields, and breeding grounds for birds exist there. Businesses and tourist industries want to open up the region for industry and travel, but environmentalists want to preserve the area. The World Wildlife Foundation claims that the Eastern Highlands is the second largest wilderness area in Europe (Wooford). The Ministry of the Environment drew up a regional plan, which is very controversial today. The plan specifies zones where developing the land is allowed, where roads can be built, and where fishing and agriculture may take place. Ironically, geothermal power plants will not be allowed. Hydroelectric power plants, such as the 700 MW plant necessary to run an Alcoa aluminum smelting plant are allowed. Although hydroelectric power is renewable, it will destroy parts of the natural habitat. Although the government has signed agreements to build in the Eastern Highlands, environmentalists are pushing for the establishment of a national park. Other legislation in Iceland focuses on marine environments. As the economy in Iceland depends on fishing, and since land-based activities largely affect the sea, legislation for marine environments is very important to the sustainability of Iceland.

The tourism industry is growing with a rapid pace. Groups like the Iceland Tourist Board and the Trade Council of Iceland promote the clean and unspoiled image of the nation. This lure of experiencing nature in its raw state has created Iceland's second most profitable industry, tourism. Iceland Air has created new incentives for travelers in hopes of attracting tourists to the country. The tourism industry is the second most profitable business product and a great contributor to the overall gross domestic

product. During certain times of the year, the tourists outnumber the indigenous population. The overwhelming numbers of tourists generated in part by the clean untouched stigma of Iceland have created a demand hotels, restaurants, and recreational venues.

The largest contributor to the Icelandic economy is their fishing industry. Over 70% of their exported goods have their roots in the fishing industry. The area considered their economical zone is also known as the continental shelf. This area is particularly good for fishing since the warm Gulf Stream current converges with the cold Arctic currents. Before the ability to capture the power of the geothermal potential existed, fishing is what developed the island. The marine habitat could be considered Iceland's most valuable natural resource. For this reason, the Icelandic government continues to implement more stringent laws protecting the cod, haddock, saithe, redfish, herring, and capelin that inhabit the continental shelf (Iceland Naturally).

The Icelandic people enjoy a high standard of living. Iceland is a first world nation that has plentiful industry, but refuses to let the economical gain of cheap polluting practices control the way business is done. Team Daedalian spoke with individuals around the city of Reykjavík. The four members of the group also visited the Town Council and the Ministry of the Environment. While visiting the government agencies and talking to the people around town, the group came to a consensus. The people that were interviewed all clearly advocated their government's decisions to provide "green" energy for the public. The literature published by the two agencies also promotes and gives reasons for their advocacy of their environmental policy. The two agencies' publications systematically outline how the government plans to continually improve and

protect the environment and the natural resources. The people surprisingly also commented on their willingness to pay more for products and electrical energy if clean and environmentally friendly processes were used in the generation process. These sentiments are quite different from those expressed by the United States Federal Government and the current Bush administration's National Energy Policy.

The Blue Lagoon, one of Iceland's hottest tourist attractions was actually formed by an engineering problem. In fact, the tourists are bathing in geothermal power plant effluent. The engineers at the Sudurnes Power Plant were unable to re-inject the water back into the ground. The buildup of the geothermal water, 2/3 salt and 1/3 fresh, became what is now known as the Blue Lagoon (Thorsteinn Jónsson). The healing powers of the silicon rich mud and blue green algae were defiantly not in the master plan when the Blue Lagoon was created. Fortunately, the outcome was the opposite of disastrous, due to the harnessing of the natural energy (geothermal power) source that releases virtually no pollutants.

The island's first law code, established a system of courts, the Althingi in 930 (CIA World Fact Book). This code set up a system of small local courts that were controlled by the overall governing body of the Supreme Court which met at Thingvellir. Since that time, Iceland has gone through many political and social changes. After problems with trade monopolies, natural disasters, and their government being dissolved, the Icelandic people gained the will and support of the Iceland residents to become independent. In 1944, 97% of the population on the island voted to create the Republic of Iceland by dissociating their ties with the Danish Monarchy (Iceland Naturally). The

Icelandic people appreciate their independence as a nation, and are committed to protecting the rights of the people and their environment.

Over the transition away from Danish control the Icelandic people were continually struggling for fishing rights. In 1952 the fishing rights of Icelandic Industries were only up to 4 miles off the coast. Today, the limits of their economic zone extend to 200 miles out at sea (Iceland's National Program of Action, 5). The Icelandic people are very protective of this area, and they have rejected to join the European Union for this reason. They are afraid that the E.U. will try to impose restrictions on their fisheries. Currently Iceland is part of the European Economic Area, so they can trade with other E.U. nations, yet they are not planning on joining the group in the near future. This zone generates pride for the Icelandic people by providing a bountiful yearly harvest.

The Republic of Iceland's government encourages individual companies to develop, but the large utility sectors including power generation are controlled primarily by the government. Iceland's economic infrastructure is dependant on the renewable resources that naturally exist on the island. 90% of the country's heat is generated using geothermal energy (Thorsteinn Jónsson). The geothermal power plants such as Nesjavellir generate energy that is not only clean but price competitive. The prices for the service range between 5 and 6 Kronas for the public sector. One Kroner is worth about = 0.01318 (USD) U.S. dollars. This price is in the ball park of American standards, about 6.6 to 7.8 cents per Kwh (rates for October 20, Economist.com). Traditionally, U.S. power companies charge between 4 to 9.5 cents per kilowatt hour depending on region. In Pennsylvania the average monthly price was 7.57 cents in 1999 (www.eia.doe.gov/cheaf/electricity/page/fact_sheets/retailprice.html). This utility

company exemplifies the ingenuity and engineering capability that the Icelandic people have dedicated to creating a reliable energy source without degrading their environment (Sites and Environment).

The electric works of Reykjavík Energy, named for the nation's capitol, is part of the National Power Company named Landsvirkjun. Nesjavellir, Andakilsvirkjun, and Ellidaarvirkjun power plants are all a part of the National Power Company. The energy generated from these individual sites is sent to the conveying and distribution station in Korpa. The Reykjavik Energy company has committed itself to recultivating new vegetation and protecting wildlife in the areas near the power plants (www.or.is). Currently Reykjavik energy is working on implementing program 14000 of the (ISO) International Organization for Standardization (ISO 14000 in Brief). Although this is a generic regulation, the new plan helps define environmental management as practices that “minimize harmful effects on the environment caused by its activities, and to achieve continual improvement of its environmental performance.” This is a good standard for companies to implement. These programs safeguard against the potential for new management to have different beliefs on environmental topics.

In 2001 Iceland imported 15,470 barrels of oil per day(CIA World Fact Book). The number will hopefully be drastically reduced as the hydrogen and fuel cell technology infrastructures become more feasible and prevalent. Currently, Iceland is developing the infrastructure to be the first nation to have a hydrogen economy. The Icelanders know that this transition away from conventional fossil fuels will be costly and the new infrastructure needed will take time to build and perfect, but as Team Daedalian found, they are ready and willing to embrace this change. Unlike Americans, the

Icelandic infrastructure has gone through many changes in the past century. The geothermal heating and the hot water system that is now common place in 90% of Icelandic homes is not very old. A series of decisions were made only a little over two decades ago, in the early 1980's to harness the geothermal energy (Nesjavellir Reykjavik Energy). The transition away from their old system of electrical generation is still in recent memory. One of Iceland's greatest qualities is the ability of its citizens to adapt and respond positively to progressive change.

The Icelandic government is currently focusing on a few target goals. Included, is a system that decouples continued economic development and environmental degradation. Reducing this problem will hopefully reduce harmful impacts on the environment and preserve the nature. It will be one of first and most successful programs of its kind. The main reason for the in-depth study on this topic is to reduce the harm done to the ocean ecosystems that sustain the Icelandic economic system. As we know, land based pollution is the culprit to many oceanic problems, and more details on the topic are discussed later in this paper. Since everything in the biosphere ultimately connects, the people on island and across the globe must take heed as to what they do on land (Iceland's National Program of Action, 6). The Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem is one of the landmark instances where attention was placed on the fisheries (Ministry for Foreign Affairs). The conference encouraged more use of renewable resources to reduce land based pollution sources, and they concluded that the transportation industry is one of largest polluters.

Icelanders are a major participant in the United Nations activities including The United Nations Convention on the Law of the Seas. This law is one of the first of its kind

that has been globally successful. The law provides information as how to “rationally manage marine resources (www.un.org).” The convention will help Straddling Fish Stocks and Highly Migratory Fish Stocks remain strong while deterring against over harvesting. The program will also hopefully increase the size and productivity of the fisheries (Ministry for Foreign Affairs). The UN Global Programme of Action for the Protection of the Marine Environment for Land-based Activities is also a program that is supported by the Republic of Iceland (Global Program of Action for the Protection of the Marine Environment from Land-Based Activities). The program initiates ways to continually reduce: persistent organic pollutants (POPs), wastewater and sewage, nutrients, particulates, hydrocarbons, litter, heavy metals, and radioactive substances (Iceland’s National Program of Action, 3). However, the I.N.P.A has yet to really take action or promote more research on these pollutants. The program does try to protect the marine and coastline environments from physical alterations and the destruction of habitat. A conference titled, Responsible Fisheries in the Marine Ecosystem was held in Reykjavik. The conference gathered 60 countries, 21 international organizations, and over 200 scientists to discuss topics relating to marine ecosystem problem. The Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem was adopted during this conference in the fall of 2001(Ministry for Foreign Affairs). The document is a way of stating responsibilities and getting the ball rolling on creating sustainable fishery systems.

It is estimated that 80% of pollution in Iceland’s waters originate from land-based activities (Iceland’s National Program of Action 2). As discussed earlier, pollution and chemicals are ingested and absorbed by marine organisms; these hazardous substances

directly harm both marine creatures and humans who utilize these creatures for food. A study by the Ministry of the Environment in Iceland focused on marine pollution from land-based activities. The most serious pollution concerns are sewage, persistent organic pollutants (POPs), heavy metals, radioactive substances, and oils. Sewage originates in residential areas, slaughtering industries, and heavy industries. Much of this sewage is pumped directly into the ocean. Even though the largest number of people live in the southwest near and in Reykjavik, most of the sewage pollution is generated in the northeast from fish processing industries and livestock slaughterhouses (8-9). Surprisingly, little effort has been made to rectify the situation. There is only a single licensed processing station, located near Reykjavik. The approach to solving sewage pollution has been conservative at best. In "Iceland's National Program of Action," the Icelandic government states that its levels of sewage-based pollution are comparable to other countries, and lists a few countries with similar pollution levels. The sewage pollution problem will only worsen if commitment continues to be low and industrial development and population levels increase.

Persistent organic pollutants found in Iceland waters and in the surrounding ocean are known for their long-lastingness, which in turn, can poison species. POPs carry over from organism to organism, creating biomagnification; thus, POPs are a problem even for species high on the food chain. Icelandic Authorities rank POP's as the highest threat to the sea. There has been no effort to map the sources of the problem, and only a few such as HCH, PCB, HCB, and DDT concentration levels have even been measured. Most of the pollution is blamed on other countries, whose POPs travel by water and air to Iceland (12). The problem with POPs is that they degrade very slowly, which is one reason to

why they have been used extensively for production. The major domestic sources are from industry, agriculture, and from incineration. Polychlorinated biphenyls (PCBs) were used from the 1930s to 1970s in condensers, transformers, lubricants, heat exchangers, plastics, paints, and other chemicals. 30% of PCB's were released into the environment, and 97% of these ended up in the water (11). HCH compounds, another type of POPs, dissolve very well in water. Ocean currents carried significant quantities of this class of chemicals from around the world into arctic waters (11). Although HCHs are not found in fatty tissues due to high water solubility, HCHs may be found to be dangerous in the future. Another compound, DDT, was commonly used in fertilizers. Today, DDT is banned in many countries, including Iceland, and concentrations have gone down significantly. Other POPs, such as dioxins, are formed from the incineration of wastes and from incomplete combustion of petroleum fuels. The significant use of petroleum in industries and in transportation emit large quantities of these pollutants. Fuel efficient vehicles and the introduction of fuel cell powered vehicles and vessels are expected to lower POP concentrations. In 2001, Iceland signed the Stockholm Convention on Persistent Organic Pollutants, which will phase out PCB's and restrict the levels of dioxins and furans (Stockholm Convention). Iceland is also participating internationally to phase out the use of POPs. The international cooperation has been weak, as country collaboration is generally slow. Domestic regulation must be introduced to further protect the environment and for Iceland to maintain its clean image.

Heavy metals contaminations is another pollution problem in Iceland. The classic metals, lead, copper, cadmium, and zinc are found in marine environments and are often the result of human activities, although volcanic eruptions are also blamed another source

(Iceland's National Program of Action 19). Lead pollution used to originate from petroleum use, as it was commonly added to gasoline and diesel. Since the banning of lead in petroleum products, the major sources are from car batteries and fishing equipment. Lead pollution is still a serious issue, especially from waste disposal sites. Other metals come from shipyards, tanning factories, metals processing factories, and sewage. The most serious heavy metals concentrations are found in marine organisms. Cadmium levels in cod and cadmium, copper and zinc levels in mussels have been found in excess of acceptable world values (21). Since the Ministry of the Environment blames heavy metals concentrations on natural processes, soil erosion, and a few industrial sources, only minor progress, mostly with lead has been made.

Unlike other pollution problems, Iceland's marine radioactive substance concentrations are blamed entirely on foreign sources and natural background values. Nearly half of the radiation results from nuclear weapons testing in the atmosphere. Approximately 30 to 40% of radiation comes from the Sellafield nuclear reprocessing plant in England. The Sellafield plant reduced its release of Cesium 137 to the environment, but has increased its release of technetium (Tc-99) by 50 times, a cause for much concern (17). The half-life of Tc-99, 213,000 years, is considerably more than Cs-137's 30 year half-life. An OSPAR meeting decided in 1998 that the Sellafield reprocessing plant must end its release of Tc-99 (above background values) by 2020 (Clove). The 1986 nuclear disaster in Chernobyl is blamed for the remaining 15% of radiation in Iceland's waters. The only domestic source of radiation has been linked to radioactive iodine, used in medicine (Iceland's National Program of Action 16). It has a half-life of 8 days and is released into sewage from patients. There have been no

measurements to the levels of radiation resulting from iodine. Other than radioactive iodine, and other trace sources, radioactive substances is entirely blamed on foreign sources. International cooperation, such as OSPAR meetings, are the basis to reduce pollution levels of radioactive substances.

The fifth largest source of marine pollution is from oil. The Ministry of the Environment does not know where oil pollution comes originates, but speculates that oil pollution is “probably due to minor accidents” (22). There has not previously been laws forcing minor accidents to be reported. A new act, number 75/2000 makes it an obligation to report oil pollution accidents to the Fire Brigade (25). Other sources of oil pollution come from major accidents, either during the transfer of oil to supply depots or damage to supply depots themselves. The worst recorded accidents have occurred when supply depots were in the path of avalanches (23). Other smaller amounts of pollution result from the incomplete combustion of fuel oil and from industrial emissions. Stricter regulation on industry will help to some degree, but since most oil pollution is attributed to accidents, better means of transporting and storing oil is going to help in the long run. Stronger structures with better locations (from natural disasters) and laws forcing better engineering standards will prevent some accidents. The best plan, however, is to decrease the supply of oil in Iceland. To achieve this goal, without lowering the abilities of the people will require tremendous change. Renewable energy for automobiles and fishing vessels is a proposed solution. By utilizing hydrogen-powered vehicles, the reliance on petroleum as well as the amount of carbon emissions will be lowered. Fuel cells, however, are a long way into the future – the change from petroleum to hydrogen will take many years. However, significant steps have already been taken, as well as the ideal

location of Iceland, where more than 99% of electricity is already produced by renewable energy sources.

Currently, transportation uses 80% of all fuel oil in Iceland (Iceland's Political Position on the Use of Hydrogen as Fuel). All fuel oils are imported, as Iceland is geologically too young to have petroleum formations. Iceland is an ideal location to implement a hydrogen economy due to its small population, located in a few hotspots (62% of Icelanders live in or surrounding Reykjavik). There are only a few hundred petrol fuel stations in the country. A pilot program in 2003 will place 3 buses and one car powered by fuel cells in Reykjavik. If the program proves successful scientifically, socially, and economically, all of the 80 buses in Reykjavik will be replaced (Hirsh). Shell's advertising in Iceland predicts the introduction of cars and buses by 2012, and fishing vessels by 2019. As with any new technology, the number of investors is small. The Icelandic Hydrogen and Fuel Cell Company, a joint organization is made up of the Royal Dutch/Shell Oil, Daimler-Chrysler, Norsk Hydro, Vistorka, and a few other businesses, hopes to break the ice. Ballard, a Canadian based business, is producing the fuel cells used in the buses (European Fuel Cell Bus Project). Although the production of hydrogen ultimately will require more electricity, the World Wildlife Fund estimates that Iceland's power plants can already provide enough electricity to produce hydrogen for 22% of current transportation vehicles and vessels (The Hydrogen Economy is Possible: Europe will Take the Lead?). The ideal production would take place during off-peak hours, such as during the night, to provide for a small production. If the program is successful, and more electricity is required than can be produced, additional hydroelectric and geothermal plants would be built to produce fossil-fuel free hydrogen. Current

estimates indicate that less than 20% of Iceland's economically practical hydropower has been exploited.

Iceland has already proven its willingness to change. By switching from fossil fuel-powered power plants to completely renewable power, it has shown its willingness to keep a clean image. The change to a hydrogen economy in the near future is not just a dream; it is nearly a necessity. A primary objective of Iceland is to maintain the image of the world's cleanest country. Unfortunately, there are a few factors that challenge this image. First, Iceland has a small population of about 280,000 and a fairly large amount of 0.522 vehicles per capita. Second, about two-thirds of all energy is used by industry. Iceland's electricity per capita is the highest in the world. Its greenhouse emissions per capita are also high due to large industry (Asgrimsson). In order to dramatically cut greenhouse emissions, Iceland will need to a hydrogen economy. If successful, Iceland will be a model for the world; Iceland will have nearly or completely cut its dependence for fossil fuels and will independently produce all of its energy. Iceland may even be an exported or hydrogen. If the hydrogen economy is successful, it will strengthen Iceland's sustainability.

Iceland is beginning to take away inputs to the fishing industry subsidies. The funds are being withheld to help decrease the total fish catches. They hope this method of reducing over fishing will help bring back the populations, since over fishing often occurs since it is economical to do so with subsidies (Oceans and Law of the Sea). The subsidies give a false sense of price and are not market efficient. The Republic of Iceland is now working with the World Trade Organization to begin eliminating fishing subsidies globally.

Along with Iceland's commitment to sustainable development, the nation wishes to do their part in mitigating problems with global climate change. To help meet the demands of the Kyoto Protocol, more renewable resources must be used world wide. Iceland ratified the Kyoto Protocol in 2002, with the terms that it would be allowed to increase its levels of emissions from the 1990 levels (Equity Watch). They are allowed to increase their emissions on the idea that they do not currently have a huge industrial sector. Iceland wants to cut its emissions in the transportation sector. New vehicles that run on only renewable energy sources allow more of their emission allowance for industrial purposes including aluminum smelting.

Due to Iceland's arctic climate the biological diversity is limited. This also means that species are more susceptible to population decreases and instabilities with even small changes to their habitat and the food chain. The UN Convention on Biological Diversity has helped address Iceland's unique situation, because the island is a breeding ground for many arctic species of migratory seabirds and waterfowl. Another organization, The Benthic Invertebrates in Icelandic waters (BIOICE) has helped scientists discover several new species off the coast on the ocean floor (BIOICE ni.is/bioice/). More scientific research may be necessary to further understand all the many facets of this delicate ecosystem.

Currently Iceland is the chair of the Arctic Council and will be till 2004 (Arctic Council). The group of nations involved in the council promotes "sustainable development and environmental conservation." The group acts as a homogenous body in order to create better policies for their individual countries and for nations across the globe.

The (OECD) Organization for Economic Co-operation and Development plays a fundamental role in promoting the sustainable development practices. Another job of this group is to help write legislation to incorporate environmental awareness (OECD for Iceland). The OECD has helped Iceland, an industrial nation, use their market economy system in a way that includes sustainable development and environmental protection.

Today Iceland meets 70% of its energy needs by using renewable resources. At this time, no other nation can boast of such an accomplishment. But, the nation is not satisfied with 70%, they want to go further by continually reducing their needs for hydrocarbons. Through engineering investments, the nation is on the forefront of creating a viable and realistic hydrogen fueled economy. Currently emissions are eight or nine times less than other countries that have a significant amount of industrial strength.

Iceland is becoming the leader in teaching other nations how to exploit the local geothermal resources. Icelanders want to do this to help decrease the overall global emissions for developed and developing nations. Part of Iceland's development policy requires that the Government of Iceland create a Geothermal Training Program (Orkustofnun UN University). This is a program that teaches engineers from other nations and allows them to take new technology back to their homelands. The program has been in existence since 1979 and has trained 245 participants from 35 countries.

Iceland is acting as a leader by example in the field of environmental conservation. No other nation has made the strides in policy or developed strong and successful political parties that rival that of Iceland's. As Team Daedalian saw, there are many new technological inventions that are present in Iceland that are unique to the

island alone. Iceland is ahead of its time, or maybe the rest of the world is just really behind on developing technology that will sustain its citizens and the environment.

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