An Energy Assessment of Ifrane City

An Interactive Qualifying Project

submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in conjunction with Al-Akhawayn University

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

Date: March 3, 2000

By:

Jason Boudreau

Nicolas J. Kociuk

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TEL 1999

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Date: December 10, 1999

Approved:

Professor Tahar El-Korchi, Major Advisor

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Abstract

This project, conducted in conjunction with Al-Akhawayn University on the town of Ifrane, Morocco, examines the effects of energy use on the population and the surrounding forest. Using survey and interview data, an assessment was made to confirm the extent of energy used and the condition of the forest. This assessment was used to make recommendations to reduce the amount of wood consumed by the population, in the interest of improving the sustainability of the forest.

Acknowledgements

We would like to thank the following people for their help and guidance in the development of this IQP. First, we would like to thank Professor Richard Vaz and Professor Tahar El-Korchi for their ideas, guidance, and constructive criticism in the preparation of our proposal and document, and execution of our project. We would also like to thank Dean Bachir Raissouni of AUI for his ideas and willingness to help in developing and carrying out this project; without him, this project would not have been possible. Many thanks to Amy Fishburn of AUI for her ideas, and for all she has done to make our stay at the university enjoyable. A special thank you to the President of AUI, Rachid Benmokhtar, for his interest and concern for environmental issues, and everything he did to make this project possible.

A very special thank you to Mr. Allam, the Governor of Ifrane Province, and Mr. Moundi, Pàche and First Khalifa of Ifrane, who throughout the project have provided invaluable assistance. An additional thanks to Mr. Tachkout, Mr. Amhana, Mr. Hassnaoui, and Mr. Ghmari, for their time in guiding us from house to house during our survey. This project would not have been a reality without the support of these fine people.

Furthermore, we extend our most sincere gratitude to Mr. Abdelghani El Asli and Ms. Zahra Bouya, for their advisement and countless hours spent working with us. We would also like to thank Chama El Bousserghini, and Yasmine Bahaji, who donated their time to translate for us. In addition to verbal translation, we also needed help translating several documents; Hicham Zerouali was an invaluable resource in this regard.

Also, we want to express our appreciation to Bouchra Saad, who tirelessly made arrangements and appointments for us. Thanks to Ali Salhi and Abdellatif Ouddach, who provided us with several households to survey. For help in analyzing our data, we would like to thank Professor Vaugeois and Professor Ghayur. An extra special thanks to Moulay Abdellah Kassimi for his generosity and time in taking us into the forest.

Our warmest thank you to all the exchange students and our Moroccan friends, who made us feel welcome during our stay. An additional thanks to Ali Salhi who always somehow managed to brighten our day. Without their support and friendships, our stay in Morocco would not have been as memorable.

الحمد لله

Authorship

While it was impossible for all group members to contribute equally, through collaborative writing and editing, we feel that we have come as close as possible. This document is a result of our combined efforts and credit should be equally distributed.

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Executive Summary

In the town of Ifrane, Morocco, there is a problem with depletion of the local forests in that the population heavily relies on the wood from these forests as a source of energy. This problem, which integrates economic, cultural, health, and environmental issues, is very complex. This project, conducted in conjunction with Al-Akhawayn University, suggests ways to improve the sustainability of the local forests by improving the efficiency of home heating and energy use in Ifrane.

The first step in developing recommendations was to assess the problem and its related issues. As part of this assessment, we looked at the amount of energy consumed by the businesses and residents in Ifrane, and the related economics. In addition, we made an evaluation of the heath issues involved with this energy use. To determine the impact on the environment, we gathered information from the forestry department and local wood suppliers. All of this information was analyzed and compared to develop an understanding of the problem and make recommendations.

A survey of Ifrane's residents was conducted as part of the energy assessment of the town. We conducted this survey by interviewing the residents in their homes. This allowed us to gather information on the general demographics of the residents, their housing conditions, and the types, quantities, and uses of energy sources. This information was used to determine the approximate energy consumption rates and affordability levels of the residents. An overall, qualitative understanding of the energ use habits of the residents was also gained.

We conducted interviews with two bakeries, one *faran* (public oven), three *hammams* (public baths), and the hospital in the town of Ifrane to ascertain the extent of their fuel usage. In addition, we also gathered statistics on the frequency of use for the *hammams*.

To complete our energy use assessment, we collected information on the cost and energy content of wood, butane, propane, coal, and electricity. This data was used to develop a cost-of-energy comparison for these fuels. Assuming 100% efficiency, we found wood to be the least expensive source of energy.

The assessment of health issues related to energy use was based on information gathered from the hospital, pharmacists, and the residential survey. The hospital provided statistics over a five-year period on the incidents of carbon monoxide poisoning, butane inhalation, and burns. These statistics were broken down into men, women, and children. The pharmacists were questioned about the types and frequencies of reported injuries relating to energy use. One question from our residential survey targeted any injuries or sicknesses resulting from energy use. This data was analyzed to get a qualitative understanding of energy-related health risks.

Interviews with the local forestry department and wood suppliers were conducted to ascertain current forest conditions and costs of wood. The local wood suppliers provided information about prices and types of wood sold. They also indicated where they obtained their wood from, and the distribution of where they sold it. The forestry department gave us detailed statistics on the species composition of the woodlands and management techniques.

The data from the residential survey shows that wood is a major source of energ in homes. The wood is used for heating by nearly all of the residents surveyed. From our observations, the heating furnace in most homes visited was a hand-welded metal stove in which wood is burned. Most of the stoves observed appear to be inefficient because of air gaps that allow excess air to enter the stove, which in turn contributes to a higher level of wood consumption. It was also observed that most of the homes surveyed are built out of concrete and lack insulation. Doors and windows are often left open while heating for ventilation.

Butane gas is also a significant source of energy that is used in nearly all surveyed homes for cooking, baking, and occasionally heating. Electricity is used in all homes surveyed mainly just for lighting. Electricity is used to a lesser extent because of its high cost compared to wood and butane.

Information provided by the businesses of Ifrane indicates that, like the residents, they also rely on wood and butane for energy. The *hammams* use wood to heat their water and the bakeries and the *faran* use wood for cooking and baking. The bakeries and the *faran* also use butane and diesel gas for their baking needs.

From our interviews with the pharmacists and the hospital, we found out that the current methods of using energy cause injuries among the population of Ifrane. The most prevalent form of injury is burns due to heating and cooking. The burns are commonly found on the face and the hands. A majority of the burn victims are women and children. Visitors to Ifrane who are not as familiar with the methods of energy use constitute most of the burn cases. Incidents of carbon monoxide poisoning and butane intoxication were also reported.

Data gathered from the wood suppliers and the forestry department indicates that a significant quantity of wood is being consumed by the population of Ifrane. The forest surrounding the Ifrane-Azrou region consists of Cedar, Holm Oak, Portugal Oak, Maritime Pine, and few other types of trees. Of these species Holm Oak trees are logged specifically for fuel and are sold at an average price of 500DH (Moroccan Dirham) per ton. Cedar trees are logged solely for woodworking. Although there are regeneration programs in existence, there is still a large toll taken on the forest due to wood consumption.

After careful analysis of the situation based on the results, we concluded that because the town of Ifrane relies so heavily on wood for their fuel, the forest is being depleted. This situation is not easily rectified because wood is one of the most inexpensive sources of energy available to a community where most of its residents have a low level income.

Considering the economic, social, environmental, and health factors, we deduced that the first step towards a solution should involve the residents of Ifrane because any change in cost or management of energy sources will directly affect them. Our first recommendation is for the town to conduct research on methods to improve the efficiency of the stoves. Our second recommendation is for the residents to be educated on the importance of proper ventilation and insulation as well as adding insulation to doors and windows. Third, we recommend that the government invest in a program to promote the use of butane instead of wood through subsidizing the cost of butane and butane heaters. Finally, we suggest looking into alternative fuel sources such as acorns, to deter the population from the use of wood. We believe that these actions will reduce the amount of wood needed for heating, thus reducing the toll taken on the forest. Our recommendations especially target the key issues of cost and maintaining comfort levels.

Chapter 1 – Introduction

In the world today, there is increasing interest in preserving the environment. This interest stems from a growing world population and its demands on our limited natural resources. In the town of Ifrane, Morocco, there is a problem of depletion of the local forests. The population relies on the wood from these forests for baking their bread, for heating water in the *hammams* (Turkish style bathhouses), and, particularly, for heating their homes. Wood is the preferred fuel, because it is inexpensive compared to the other readily available fuels.

Ifrane is a tourist town, and much of the local population is employed in activities that support the tourist industry and the general operation of the town. For the town to remain viable all year, it must have a substantial permanent population. Because Ifrane is located in a mountainous region of Morocco, home heating—particularly among its year-round residents—is an important issue. The majority of the population is dependent upon a minimum-wage income; thus, it is necessary for them to use the least expensive heating fuels available. In the town of Ifrane, wood is one of the least expensive sources of energy financially.

1.1 Goal Statement

There is a problem of depletion of the forests around the town of Ifrane. There are many economic, cultural, health, and environmental issues surrounding this problem. The goal of this project is to propose methods to improve the sustainability of the local forests by improving the efficiency of current methods—and/or proposing new ways—of home heating and energy use in Ifrane. To accomplish this, we will provide a preliminary assessment of the total wood energy used in town and an evaluation of living conditions and energy use of the residents. With these assessments, we will make recommendations for reducing the negative impact the town has on the local forests.

1.2 General Procedure

To achieve the goal of this project, it is necessary for us to take into account all the issues surrounding the problem. To do this we need to complete several objectives.

1. Conduct a survey of the residents of Ifrane.
2. Obtain information on local forests.
3. Ascertain the costs of available energy sources.
4. Determine potential environmental impact of available energy sources.
5. Determine health risks associated with current energy use methods.
6. Assess total wood energy used in Ifrane.
7. Evaluate living conditions and heating methods in homes
8. Develop recommendations to reduce the impact of Ifrane inhabitants on the forests.

To complete these objectives, data will be collected using a combination of field research and literature review. This data will then be analyzed using both qualitative and quantitative descriptive statistical analysis techniques. The data will be analyzed to gain information regarding the demographics of the residents, related costs of energy use, health implications involved with energy use, and the impact on the environment. It is through the analysis of all of these issues that we will be able to develop practical recommendations.

1.3 Project Audience

It is our intent to present our findings to Dr. Bachir Raissouni, Dean of the School of Science and Engineering at Al-Akhawayn University (AUI), Dr. Richard Vaz, Associate Professor of Electrical Engineering and Associate Dean of the International Global Studies Division at Worcester Polytechnic Institute (WPI), Dr. Tahar El-Korchi, Professor of Civil Engineering at WPI, and to the interested parties at AUI and in the town of Ifrane. It is our plan to present practical recommendations, so that the interested population of Ifrane can implement them. We also seek to promote environmental interest and concern among the population of Ifrane in hopes of a continued effort towards a more sustainable community.

1.4 Overview

This chapter introduced our project and goals. Chapters 2 and three include relevant background information on issues relating to the project site, problem, procedure, and solution. Chapter 4 contains the methodology, which details what we did and how it was done. We present our results and analysis in Chapter 5. Our assessments and recommendations are contained in Chapter 6.

Chapter 2 - Background

This chapter provides some of the background information needed to conduct this project. Cultural aspects of Morocco, and the Ifrane region will be discussed. Material found in this chapter will help in understanding the environment in which this project will be conducted.

2.1 Morocco

This section is an introduction to the culture of Morocco. Briefly described are the general history and economy of Morocco and its official religion of Islam.

2.1.1 General History

The Berbers were first people to settle in what is now Morocco. It is believed that they originated in southwestern Asia, and migrated towards North Africa as early as 2000 BC. The Berbers lived in small tribes made up of related families and clans, and aside from occasional intertribal wars, little contact was made between the Berbers in one valley and those in the next. This isolation limited the influences of contact with Phoenician and Carthaginian traders on the coast. Indeed, it was not until about the year 40 AD, when the Romans claimed much of northern Morocco as their own, that there was any lasting influence on the Berbers. The Roman province of *Mauretania Tingitana* served to impose Roman law on the northern part of the country, but even the Romans failed to fully impose their will on the territory; from the High Atlas mountains southward, there is little sign of the Romans. It was not until the Arabs invaded around the year 700 AD was there to be any real, lasting impact on the Berber culture that had existed in Morocco for hundreds of years.

After the Arabs arrived in northern Morocco, they proceeded to expand southward. Over the centuries, the Arabs gradually increased their influence and territory with the belief that they were the superior religious authority. Several dynasties rose up, and subsequently fell, each claiming to be descended from Mohammed, and each extending their domain in the name of religion. In the 16th century, the Alawi dynast came to power. Eventually, the Alawi governed all of Morocco north of the High Atlas Mountains. Unlike previous dynasties, the Alawi never lost their power; descendents of this family still rule Morocco today, including the current monarch, Mohammed VI.

The Europeans also had an influence on Moroccan history. As early as the 15th century, Spain, Portugal, France, and England established trading zones along the coast. The Alawi sultans and their governments were influenced by the Europeans, and granted them vast concessions, which effectively gave economic (and thus political) control of Morocco to the Europeans up until the 20th century. In 1912, France established a protectorate in Morocco, made official by the Treaty of Fès. This treaty granted France the power to establish civil order, a power that the French abused. By 1930, the French occupied and governed all of modern Morocco; this was the first time in several thousand years that almost the entire nation, with the exception of a small territory along the northern coast controlled by Spain, had been governed by one entity.

Tension grew, however, between the Moroccans and their French governors. Throughout the 1930's, French policies managed to strengthen the independence movements they were supposed to suppress. The anti-French sentiment continued to grow throughout the 1940's and 1950's, until they came to head in 1953 when the French exiled Sultan Mohammed V to the island of Madagascar. Violence against the French occupation grew, and in 1956, France finally conceded defeat. Sultan Mohammed V, who declared himself king a year later, returned to Morocco and both France and Spain granted Morocco independence. Once again, Moroccans ruled their own country. This was the first time the entire nation was ruled as one. [Hargraves, History of Morocco, Morocco]

2.1.2 Geography

Morocco occupies an area of approximately 446,550 km^2 (172,413 square miles) in the northwestern corner of the African continent. The Atlantic Ocean forms the country's western perimeter. The northern part of Morocco is bounded by the Mediterranean Sea, only 13 km (8 mi.) from the tip of Spain across the Strait of Gibraltar. To the east and southeast lies the Algerian border and the Moroccan Sahara extends along the far south of the country. Within Morocco's borders is a widespread and varied geography. There are mountains, deserts, rivers, plains, and seas. Figure 2.1 is a map of Morocco.

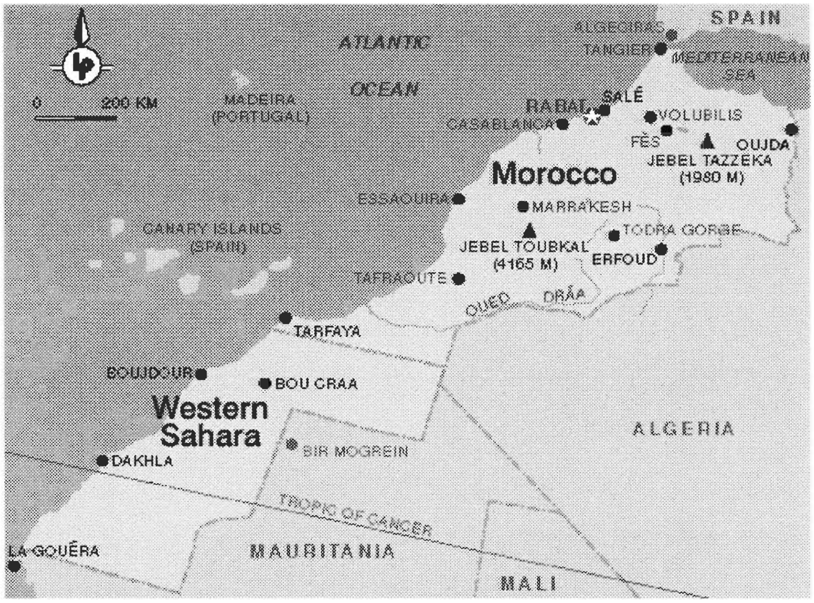

Figure 2.1: Map of Morocco [Lonely Planet]

Mountains make up a majority of the Moroccan geography. There are two major mountain ranges: the Rif and the Atlas. The Rif make up the northern border of Morocco while the Atlas Mountains are spread throughout the center towards the east. The Atlas Mountains are broken down into three smaller mountain chains according to their elevation. They are the Middle Atlas, the High Atlas, and the Anti-Atlas. Forests and woodlands cover the Middle Atlas. Within the High Atlas lies Mount Toubkal, which is the highest peak in North Africa.

To the south of Morocco lies the Sahara Desert. This desert stretches across the entire northern region of the continent of Africa. Morocco contains the northwest corner of the Sahara. Many of Morocco's traditions were incorporated from other cultures from the Sahara.

Along the northwest border of Morocco are the country's major rivers. The four most important rivers are the Sebou, the Bou Regreg, the Oum r-Rbiâ, and the Moulouya. The Moulouya is the only river among the four that empties to the north into the Mediterranean Sea. The others empty into the Atlantic Ocean to the west. The largest river in Morocco is the Sebou. Two smaller rivers, the Ziz and the Rheris, flow into the Sahara.

Plains lie between the Atlas Mountains and the western rivers. Olives, tobacco, and other fruits and vegetables are farmed in the plains for export. The Moroccan plains also contain the largest natural deposit of phosphate in the world.

Lastly, there are the seas of Morocco. To the north is the Mediterranean Sea and to the west is the Atlantic Ocean. The coast is the home of Morocco's successful fishing industry. Sardines and anchovies are two types of fish that are exported. Much of

Morocco's tourist industry can be found along the seas. The coastal beaches of Morocco attract visitors from all over the world every year. [ArabNet, Hargraves]

2.1.3 Climate

Along with varied geography of Morocco comes varied weather conditions. The climate ranges from the extreme hot to the extreme cold. In general, there are four main climates, desert, Mediterranean, high mountains, and the lower mountain and plateau regions. However, the weather is hard to predict and can change dramatically from year to year.

In the desert, it is hot just about all of the time and it rarely rains. Winters in the desert bring cool and sometimes cold nights. It rarely rains in the desert, but when it does, it is usually during late autumn and late spring.

The most erratic climates can be found in the low mountains and plateaus regions. The low mountain areas, including plateaus and inland valleys, have hot, dry summers and cold, rainy and snowy winters. The rainy season extends from November through early June.

In the high mountains, weather is similar to the low mountains, with hot dr summer days with cold evenings and nights. The rainy season is longer in the high mountain regions, starting with rain in September, then turning to snow in December and continuing through April. Temperatures in this region have been known to drop below -20 °C.

Pleasant weather in Morocco can be found near the coast of the Mediterranean Sea. Weather is mild in both winter and in summer with temperatures of 12 °C (54 °F) during the winter and 25 °C (77 °F) during the summer. This pleasant weather is due to the flow of ocean currents into the Mediterranean Sea and the warm sea breezes.

These are four climate zones are highly generalized. Each of these four zones can be broken down into several smaller, more specific climates. Morocco's climate ranges from hot, dry days in the desert to very cold snowy nights in the high mountains, and just about everything in between. [Hargraves, Insight, Gordon]

2.1.4 Economy

The economic profile of Morocco is certainly unique. In many ways, Morocco is still a developing country, yet much of its infrastructure and economy would indicate that it should be considered mostly developed, rather than developing.

The population of Morocco is roughly 28 million, with just more than half (51.4 %) living in urban areas. Morocco is also a very young country; fully 60 percent of its population was under 25 at the time of a 1993 census. The education level of the population is also relatively high, as compared to other developing nations, with almost 4 million students enrolled in primary schools (1^{st} through 8^{th} grade). Secondary schooling is not so popular, as only 400,000 students are enrolled in secondary schools. While primary and secondary schooling are both free, students are only required to be enrolled in school through age 14; this might well explain why only 10 percent of those in primary schools continue on to secondary schooling. Over half of those in secondary schools move on to post-secondary institutions.

The economy of Morocco is mostly service based, with approximately 40 percent of the Gross Domestic Product (GDP) represented by service industry activity, including tourism. Agriculture employs almost 40 percent of the population, and generates between 10 and 15 percent of the GDP depending on the harvest and international demand. Agriculture continues to be a growth sector for Morocco; the government plans to introduce new irrigation and farming techniques and other financial incentives to farmers to encourage this growth.

Manufacturing represents another large portion of the Moroccan economy. About 19-20 percent of the GDP is from manufacturing revenues. The largest industry section is the refining and processing of phosphate ore; since Morocco is believed to hold almost three quarters of the world's phosphate reserves, the phosphate industry is certain to grow in the future. Textile processing is another principle facet to Morocco's industrial exports. Due to competitive wages and proximity to Europe, the clothing industry continues to grow and will remain a significant part of Morocco's economy.

The fishing industry is another one of the major industries in the Moroccan economy. The fishing industry is spread among Morocco's 3500 km (2175 miles) of coastline. The fishing fleet is composed of roughly 3000 ships. The fishing fleet is divided between coastal and high sea crafts. There are rough 2564 coastal fishing vessels and 464 high sea vessels. The fishing industry accounts for 15% of Morocco's overall exports and 55% of Morocco's food exports. It employs approximately 200,000 Moroccans, and brings in roughly 6 billion DH per year.

The potential for a strong growth economy, and the government's aggressive measures to appeal to foreign investors, has created a very sound financial situation for the country. Banks are conducting extensive local and international trading, and the volume of trades on the Casablanca Stock Market is growing continuously. Morocco's economy is strong, and there is no indication that that trend will stop anytime soon. [Economy]

2.1.5 Isla

A large portion of the Moroccan population follows Islam, the official religion of Morocco. Those who follow Islam refer to themselves as Muslim. Muslims view Islam as the final and most perfect of the three revealed, monotheistic religions, the other two being Judaism and Christianity. They follow the teachings in a sacred book called the Koran. The prophet, Mohammed, is credited with having shown Muslims the way to Allah. It is believed that there is only one God, Allah, who is the same God that is worshipped in all other religions.

Devout Muslims abide by the five pillars of Islam. They are:

1. *Making the profession of faith.* A person converts to Islam by uttering the profession of faith in Arabic, which translates, "There is no God but Allah, and Mohammed is his prophet." This should be done in the presence of two male Muslim witnesses.
2. *Praying five times a day.* The five times are dawn, noon, afternoon, sunset, and night. The exact times are determined by the position of the sun and thus change throughout the year. Each time has a particular name, and is signaled over loudspeakers by the prayer announcer, who chants from the minaret of a mosque. Muslims pray in a mosque if it is convenient, but may pray in practically any clean, relatively secluded spot. Washings are performed before praying. Women are not allowed to pray with men in the mosques, but

special times are set aside for them. Praying is to be done facing to the east, toward the holy city of Mecca, which is in present day Saudi Arabia.

3. *Giving alms to those in need.* This is done casually to those begging on the street and in formal ways, through various charitable institutions. In Morocco, a governmental foundation called the *habous* oversees religious charity. The Koran stipulates that 2.5% of one's income and 10% of one's crops be given in alms.
4. *Fasting during the month of Ramadan.* Muslims observe a very strict fast, believed to be spiritually cleansing and a sign of one's faith, between dawn and sunset for an entire month each year.
5. *Making a pilgrimage to Mecca at least once in one's lifetime.* Muslims from around the world converge on Saudi Arabia once per year to perform rituals associated with the pilgrimage to the holy sites of their religion. Those who have made the journey gain the title *Hajj* (for men) or *Hajja* (for women). The traditional time to go on the pilgrimage is in the twelfth month of the Muslim calendar.

Muslims share one common view of the world. It is the belief that fate has already been written by Allah and it cannot be changed by man. Regret, blame, and remorse are quickly forgotten because there is no changing what God wills. It is believed God's will is the only reference to the future. A Muslim often includes *insha' allah*, meaning "God willing," when speaking of the future. In Islam, it is blasphemy to believe in more than one or in no God at all. [Hargraves]

2.2 Ifrane

In order to conduct a successful project in any city, it is pertinent to learn about the city and its people. Ifrane is a small resort town located in the Middle Atlas region of Morocco. Often noted for its peculiar architecture of red tile roofs and stucco walls, Ifrane was originally built in the 1930s by the French as an alpine resort. The climate of the area is relatively dry and ranges from warm summer days to cold snowy winters.

The population of Ifrane is dramatically affected by tourism. During the high tourist season (June 1 through September 10) the population of Ifrane can be as high as 50,000. Normally during the low tourist season, the population is around 12,000. Even today, Ifrane continues to be a resort for many Moroccans and tourists. During the winter, from January to early March, many come to Ifrane to take advantage of its three local ski lifts. The best known of these lifts is Mischliffen, where the runs are considered to be good, although the conditions are often unreliable with the uncertain winters of the Middle Atlas.

Outside of the winter season, Ifrane is often a place to escape the heat of the big cities. Some of the more popular activities include trekking into the mountains, taking a horseback excursion through the forests, or simply taking a picnic near one of the several local lakes and watching the many species of birds that live in the area. Overall, the population and economy are significantly effected by the tourism industry. [Gordon]

The socioeconomic distribution of the town is wide, although disproportionate. The overall per capita income of the residents is low. An estimated 80% of the population earns less than 2000DH (Moroccan Dirhams) per month*. Employment positions in town include general laborers, Al-Akhawayn University employees, employees of the several government-run organizations including the hospital, police, schools, and city hall, and local businesses.

2.2.1 Economy of the Province of Ifrane

It is necessary to become familiar with the economy of Ifrane in order to accomplish the goals of this project. Improving heating methods and finding additional energy sources requires knowledge of the economic status of the region. The economy of the Province of Ifrane will be discussed in this section.

The principal activities of the Province of Ifrane are agriculture and livestock breeding; 60% of the population in this region is involved with these two activities. There are 114,000 hectares of farmland in the province. This farmland makes up 32% of the area. Fertile agricultural land makes up 23% of the region. There are 83,000 hectares of meadows distributed between Ifrane's mountains and plateaus. Livestock breeding also serves as a source of income in the province. The livestock bred includes sheep, goats, cattle, and horses and donkeys. Income is earned through the sale of meat, milk, and wool.

The region of Ifrane is not very abundant in industry and commercial establishments. Their main industries are wood and agriculture. The town of Ifrane is often associated with the neighboring town of Azrou, which is also involved in the wood industry. The combined Province of Ifrane has 14 industrial plants, nine of which are involved with the wood industry, and five of which are in the agriculture-alimentary field. Their share in regional industry remains weak (about 7%).

Industrial production has increased, mainly due to the production of wood. The value of production was about 38.6 million DH in 1995, compared to only 28.2 million DH in 1994, which is a growth of about 37%. The released added value was about 5.4 million DH in 1995 recording an increase of 63% compared to 1994. The best performance was that of the wood sector, which increased 95% compared to 1994, going from 2.3 million DH to 4.5 million in 1995. As for the added value of the food industry, fell 11% from 1994 to 1995, going from 0.9 million DH to 0.8 million DH.

Investments carried out in 1995 reached 2.5 million DH in 1995, recording a remarkable progression of 108% compared to 1994. The distribution of these investments, per branch of industry, emphasizes the importance of the wood sector, with 64% of the area's investments attributed to this sector. The agricultural processing industry makes up the rest of investments, with 36%.

The commercial infrastructure of the province is characterized by its traditional and rural aspect, which is based on small trade (approximately 1,000 tradesmen). This small trade is organized into nine weekly *souks* (regional farmer's market), three municipal markets, two cereal warehouses, and six cold stores, which cover approximately one third of the fruit-bearing production. [Royaume du Maroc]

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* This information was gained from an interview with Mr. Moundi the Pàche and first Khalifa of Ifrane

2.2.2 Forests of the Province of Ifrane

Forests constitute 116,000 hectares of land in the Province of Ifrane. The species consist of Cedar, Holm Oak, Portugal Oak, Maritime Pine, and other types of trees. The forest is a major source of income for Ifrane and the neighboring town of Azrou. The demand for wood is very high in the Middle Atlas region. The region uses the wood as sawlogs for woodworking and firewood.

The direct and indirect populations of the region both make use of the wood produced. The capital produced from the forest is as follows:

- sawlog of cedar = 30,000 cubic meters per year
- firewood = 40,000 steres (11,035.8 cords)
- secondary products = 5,000 tons per year

This capital produces 22.5 million DH per year of the profit comes from rural communities, with another 7.5 million DH coming from the state. A significant 50 million DH are spent directly by the local population of Ifrane. The forests also create 15 million DH of employment within the region. There are companies and industries that are involved especially with the production and distribution of the forest's wood. There are:

- forestry companies
- 14 sawlog machine operators
- 10 firewood industries
- forestry development cooperatives

The forests of the Middle Atlas region, particularly around Ifrane, are becoming problem areas. This is due to the mass consumption of wood. Two species of trees, the Cedar and the Holm Oak, are the most endangered. This is due to increasing pressure from livestock, disease, and over-logging for firewood because of the unavailability of lawyers and/or concern for civil action, according to the Government of the Province of Ifrane. This remains a problem for the region. [Royaume du Maroc].

Chapter 3 - Literature Review

The background chapter detailed the information needed to conduct the project in the given environment. Material in this chapter is intended to aid in understanding the scope of the project. These topics include insulation and weatherization, the concept of sustainability, biomass, deforestation, and forest management.

3.1 Insulation and Weatherization

One of the best ways to improve the energy efficiency of a house is through insulation and weather proofing. In the interest of improving home heating, it is important to look at both the amount of insulation and air leaks when evaluating the energy efficiency of a house. It is not uncommon for a house to have between 0.093 and 0.279 square meters (1 to 3 sq. ft.) of air-leaks spread throughout the building. A house that is weather tight and well insulated not only will provide a steadier, more comfortable environment but can also save as much as 30% on heating bills. With both of these topics, there are a number of places where insulation and weatherization can be applied, as well as a number of different materials that can be used. [Harland]

3.1.1 Insulation Materials

When choosing insulation it is important not only to look at how the insulation will be install but where it will be installed because some types of insulation will perform better under different conditions (i.e. some types of insulation will deteriorate in areas prone to moisture). There are three major types of materials from which insulation is made.

1. Insulation made from natural living sources. This category includes all timber products, cellulose fibers, cork granules, softboard and wood-wool, wool products, compressed straw slabs, and kapok.
2. Insulation derived from mineral resources. This category includes rock wool, vermiculite granules, perlite, fiberglass, and foam glass.
3. Insulation produced by chemical synthesis from petrochemicals. This category includes all plastic foams, polystyrene, polyurethane, and phenolic foam.

Insulation comes in many forms, much the same way that it can be made from many types of materials. In general, insulation comes in four basic forms:

1. Batts or Blankets: This type of insulation is usually sold in rolls or bundles and is most commonly used in floors, walls and ceilings.
2. Loose Fill: This type of insulation is usually sold in bags, and is often blown into existing wood framed walls.
3. Rigid Board: This type of insulation is most commonly sold in sheets, and is often used on basement walls and under exterior sheathing.
4. Foam: To be used as a main source of insulating walls, this type of insulation must be installed by a professional. However, there are tubes of foam insulation that can be purchased by homeowners for small jobs, such as filling air-leaks around windows or pipes. [Harland]

3.1.2 R-values

The ability of insulation to resist the flow of heat is measured in what is known as R-values. The higher the R-value, the more time it takes heat to diffuse through the insulation. Most commonly, R-values are measured with respect to thickness. For example, sheep's wool has an approximate R-value of 1.6 per centimeter (4.0 per inch). Therefore, 12.7 centimeters (five inches) of sheep's wool would have a total R-value of 20.0. Table 3.1 includes several types of materials used for insulation and their approximate R-values.

Table 3.1: Materials and R-Values

Material	Approximate R-Value per centimeter	Approximate R-Value per inch
Cellulose Fibers	1.5	3.7
Softboard	1.1	2.7
Cork Granules	1.0	2.5
Compressed Straw Slabs	0.6	1.6
Sheep's Wool Mattin	1.6	4.0
Glass-wool / Rock-wool	1.2 - 1.4	3.0 – 3.5
Foamed Glass	1.1	2.8
Plastic Foams	1.8 - 2.4	4.5 – 6.0

3.1.3 Methods of Insulation

There are three major areas of a building that can be insulated, roof or attic, walls and windows, and the ground floor or basement. The most important and most effective place to insulate is in the roof. Heat rises, and unfortunately, the roof of a building most often has the thinnest construction compared to the rest of the house, thereby allowing heat to dissipate more quickly. Most US homes have either some type of batting or loose insulation in the attic with an R-value between R-22 and R-49.

The part of a building that has the most surface area exposed to the elements is the walls and windows, and therefore is the second most important area to insulate. Typically, in the US exterior walls have insulation in the range of R-11 to R-28. There are some challenges that do exist in insulating walls of a pre-existing structure. If the building has a wood frame construction, the easiest method for insulating the walls is by having a loose insulation blown into the walls (i.e. cellulose). Otherwise, it entails removing either the sheathing from the interior walls to add batting between the studs, or by removing the exterior sheathing to add a solid foam board insulation to the outside of the building.

Buildings built with concrete, brick, or stone walls present a different set of challenges with respect to insulation. Walls of these structures tend to have a large amount of mass, which acts as a heat-storage unit. This ability to store heat allows the walls to absorb heat from the interior air keeping the house cool in the summer, and absorb the heat from the sun in the winter and gradually transfer the heat to the interior of the building. Concrete has this ability to absorb and store heat, but it is a poor insulator so the majority of the heat it absorbs is transferred to the outside. It is for this reason that it is very important to insulate these types of walls. There are three options for insulating concrete walls.

1. Insulate the interior of walls by attaching rigid board to the walls then covering the insulation with a plaster board, or by constructing a wooden frame inside the concrete walls and use a form of batting or loose fill insulation.

2. Insulating the wall cavity, by filling the void or air pockets in the wall with foam insulation.

3. Insulating the exterior of the walls by attaching rigid board insulation and covering it with some form of sheathing (e.g. clapboards, vinyl siding, etc.).

Insulating the exterior of concrete walls is the most effective method. When concrete walls are insulated well, the combination of insulation and the mass of the wall itself have the ability to even out extreme hot and cold weather.

Windows can be one of the most attractive parts of a house, providing views, lighting, ventilation, and heat from the sun. However, 10% to 25% of heat loss in a house is through windows. The windows with the most insulating quality are double pane windows with some form of high-performance glass (i.e. low-e or spectrally selective). In the case where you have single pane windows, one alternative to replacement would be to get storm windows preferably made of a high-performance glass. It is also important when looking at windows to make sure that the weather stripping is tight and in good condition.

The last area of a building to consider insulating is the ground floor or basement. The ground itself acts as a good insulator below two feet. For this reason, the floor or basement has the least priority when it comes to insulating. There are two main types of floors, suspended and solid. Adding batting between the floor joists can easily insulate a suspended floor. Solid floors are more difficult to insulate because it requires the removal of the current flooring and its replacement; the expense of this would hardly be worth it unless the floor was in disarray. [United States Dept. of Energy]

3.1.4 Weatherization

As mentioned previously, it is just as important to weatherize a house as it is to insulate it. Weatherizing incorporates three main tasks, draft proofing, ventilation and rain proofing. A lack of draft proofing in a house can account for 10% to 30% of annual energy expenditure. Drafts can be found in a large number of locations throughout a building. The following is a list of the most common places drafts occur.

1. Drop ceilings
2. Recessed lighting
3. Attic entrances
4. Electrical wires and boxes
5. Plumbing utilities and penetrations
6. Water and furnace flews
7. Duct work
8. Door sashes and frames
9. Chimney penetrations
10. Warm air registers
11. Window sashes and frames
12. Baseboards, covers, interior trim
13. Plumbing access panels
14. Electrical outlets and switches
15. Light fixtures
16. Sill plates

The majority of these types of drafts can be simply fixed with the use of caulking, foam, or weather stripping.

Proper ventilation in a building has several important functions: to supply fresh air for inhabitants; to exhaust water vapor and pollutants and to aid in the preservation of many materials, particularly timber products and some forms of insulation. It is important to have ventilation in the walls, floors, ceilings, and the roof. Most buildings are built to allow for proper ventilation. One important indicator that there is not sufficient ventilation is the collection of moisture. In this case, it is important to track down the cause of the condensation and fix it either through trickle vents, fans, or possibly a simple solution such as moving some insulation.

The last key to weatherizing a house is rain proofing. Rain proofing is simply stopping rainwater from penetrating the house. This is particularly important when a house is well insulated with brick or stone exteriors for the outside walls. As the weather gets colder the outside of the wall (brick surface) will become colder and more likely to take up more water, which in turn can lead to frost and other types of damage.

It can be very cost effective and important to make sure that a house is well insulated, especially the walls and attic, and weatherized. Improving the weatherization and insulation in a house will improve the comfort and the controllability of the interior climate, but can lead to energy saving of 10% upwards to 50%. [United States Dept. of Energy, Harland]

3.2 Sustainability – Concept and Origins

The concept of sustainability—as described by the Brundtland Commission—is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." The environment has taken much damage, due to civilization, that must be reversed for the population to continue living as it does, and for progress to occur. Sustainable development makes it possible to keep the basic standard of living, without depleting natural resources or endangering the environment. It rests on three main pillars: environmental sustainability, economic development, and social responsibility.

Sustainability is measured with indicators. An indicator is not to be confused with information. Information by itself is a fact about something. Data that is related to information is an indicator, showing how things change over time. This is the idea behind sustainability indicators. Indicators are the start of sustainability. [Rio + 5 What was the Earth Summit?]

The concept of sustainable development originated at the World Commission on Environment and Development (WCED) in 1987. The chairwoman of the WCED, named Brundtland, developed the idea and published it in a report referred to as the Brundtland Report. Then, at the United Nations' Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992, the participants came to an agreement that sustainable development was necessary in order to continue living the same quality of life. It was decided that the goals in the Brundtland Report should become goals for the world. [O'Keefe]

At the same conference in 1992, UNCED decided to raise awareness and concern worldwide by writing a guide to sustainable development called Agenda 21. Agenda 21 was written with the hope that it would promote global cooperation in sustainable efforts. It is a list of actions, which are required to be taken by everyone on Earth in order for sustainability to be achieved. The task of global cooperation is not an easy, because it requires a major shift in the actions taken by governments and by individuals. [Sitarz]

3.3 Biomass

In this section, the method of using biomass as a way of heating homes will be looked at, considering it as an alternative form of energy, in the interest of making a sustainable society. Explanations on the concepts of biomass are provided, along with several case studies of biomass use.

3.3.1 Introduction to Biomass

Biomass is vegetation and organic wastes from animals, which includes wood, grass, algae, garbage, and plant products. Experiments show that using biomass for energy is one beneficial method because it can provide jobs in rural areas, reduce dependency on imported petroleum, reduce fire hazards due to dead and diseased timber, use waste streams to produce renewable fuels, and most importantly, decrease the accumulation of greenhouse gases.

Using biomass has many benefits. Biomass can be used to alleviate current environmental problems like the disposal of wastewater and sewage sludge, which can be used to fertilize crops. Biomass conversion can also provide jobs in rural areas. With all these advantages, using biomass as an energy source can be very promising. [Panettone]

3.3.2 Available types of biomass

Several types of biomass are used today. The main sources of energy come from one of the following: livestock manure, crop residue, wood, sugar crops, urban refuse, municipal sewage, and aquatic plants. The paragraphs below describe the each specific type of biomass.

Livestock manure is a prime source for energy conversion. Cattle, sheep, pig, horses, camels, goats, poultry, and others produce manure. Once dried, manure may be burned. Not all the manure produced is readily available for biomass conversion. If the livestock is dispersed on pasturelands, it may be impractical to collect the manure.

Crop residues have also been considered for biomass energy conversion. Evidence from research suggests that crop remains left on the land function to prevent sediment runoff, conserve soil and water, maintain soil carbon ratios and soil structure, and prevent nutrient loss. Without crop remains, the soil-sediment runoff problem would be worsened. Therefore, it is more beneficial to have crop residue as an agricultural material than as an energy source.

Wood is an important source of energy in many developing countries. Most of the fuel in these countries comes from wood. Wood can be used for cooking and space heating and it can also fuel boilers to produce electricity and steam. Lumber and pulpwood have a greater economic value than wood used directly for burning. Due to the increasing demand for wood as fuel, deforestation is becoming a problem in many countries. Experts say this could lead to serious problems such as soil erosion and scarce water supplies.

For countries with favorable climatic conditions and large areas of productive but unused land, sugar crops may represent an alternative for biomass conversion. Sugar crops have some potential advantages over trees, grains, or aquatic plants in that much of the biomass is in the form of direct fermentable sugars. Sugar crops also have a noticeably high yield.

Urban refuse is another source of biomass. These wastes consist predominantly of paper, yard wastes and food wastes. Municipal sewage is similar to urban refuse and consists of solids. It is more than 99% water, and thus only dry sewage may be burned.

Another source of biomass is aquatic plants. They grow sparsely and contain large quantities of water (90%); thus, they are not easily converted to energy. Brown kelp and water hyacinth are commonly mentioned aquatic plants that might be readily available. Experts suggest that brown kelp is too valuable for food and feed to be used as an energy source. [Vergara]

3.3.3 Case studies on biomass in five countries

In one particular study, by Walter Vergara and David Pimentel from Cornell University, the potential energy of fuels from biomass is analyzed. Five countries are studied: the United States, Brazil, India, Sudan, and Sweden. These countries get their energy from biomass, which was discussed in the previous section. In this study, the countries are compared according to sources of biomass, annual biomass production, and energy gained from biomass harvesting. Studying the effects of using biomass in these five countries will give an idea of how biomass is used and how feasible it is to use biomass. The following charts are results of comparing the five countries on energy, amounts of biomass, and how much biomass is being used. Figure 3.1 shows the sources of biomass that are available for energy conversion within the five countries.

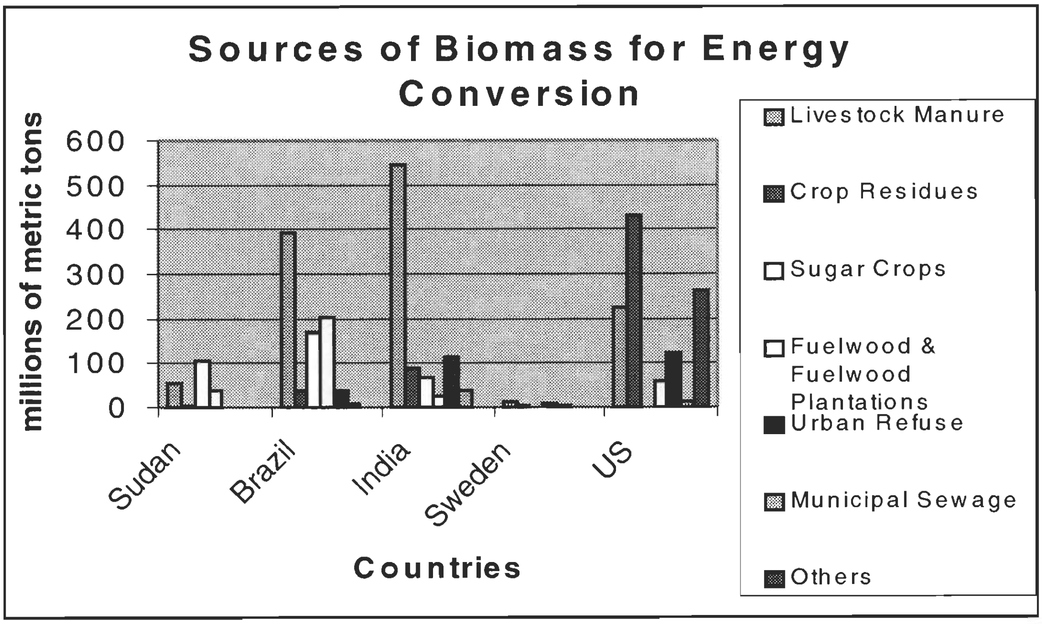


Figure 3.1: Sources of Biomass for Energy Conversion

Figure 3.1 conveys that all five countries use livestock manure and wood for energy. Crop residues are the second most widely used, with urban refuse and sugar crops next. Municipal sewage does not appear to be a popular choice of biomass. Table 3.2 shows how much biomass can be produced and how much of that biomass can be turned into usable energy. Table 3.2 and Figure 3.2 are a summary of annual biomass production and total energy harvested in the form of crops and forest byproducts. (Area in millions of hectare and weight in millions of tons.)

Table 3.2: Biomass Production

BIOMASS PRODUCTION	United States		Sweden		India		Brazil		Sudan	
	Area	Wt	Area	Wt	Area	Wt	Area	Wt	Area	Wt
Arable land and production crops	192	1083	3	18	165	990	30	216	7	42
Pastures and grazing land	300	783	0.5	1.5	13	45	167	584	24	84
Forests	247	988	22.5	90	655	262	511	2044	9.5	366
Other	310	163	18.5	9	84	42	137	68	127	63
Total Area (ha)	**1049** 10^6		**45** 10^6		**328** 10^6		**851** 10^6		**250** 10^6	
Total biomass (tons)	**3017** 10^6		**118.5** 10^6		**133.9** 10^6		**2912** 10^6		**555** 10^6	
Total biomass harvested (tons)	**1433** 10^6		**26** 10^6		**281** 10^6		**718** 10^6		**97** 10^6	

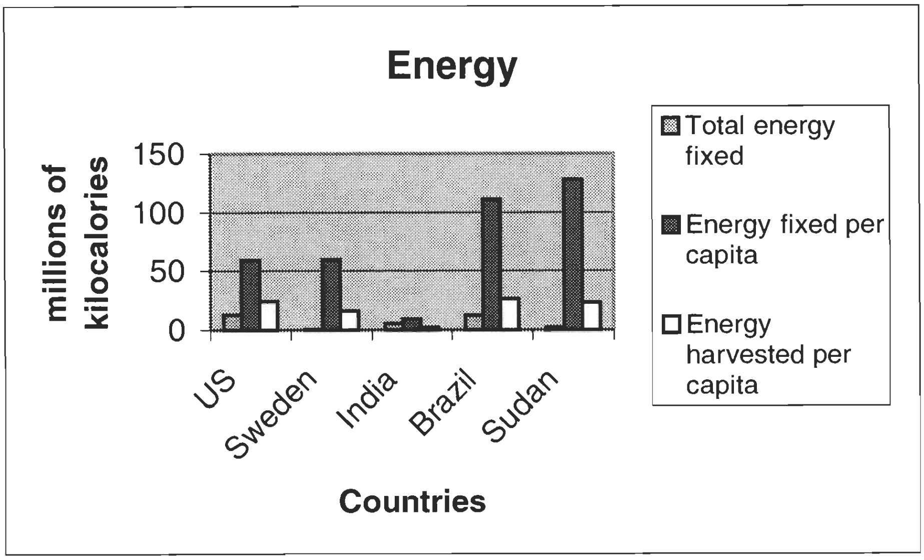


Figure 3.2: Available Energ

The energy amounts indicated in Table 3.2 and Figure 3.2 show the gross energy acquired from harvesting. The five countries that use biomass were studied in the Vergara-Pimentel Experiment to see what the net energy gained was. Table 3.3 shows net energy produced per kilogram of dry biomass.

Table 3.3: Net Biomass Energy

Biomass Substrate	Net energy produced (kcal/kg)
Livestock Manure	784
Urban Refuse	1,417 (pyrolysis) 3,393 (incineration)
Food Processing Wastes	730
Sugar Crops	1,477
Forest Biomass	935 - 3,740
Municipal Sewage	784

According to the results of this experiment, Sudan could produce six times its current energy needs and Brazil 1.5 times its needs if all the available biomass was processed and used. India's energy potential is 36.3% and Sweden's is 13.9%. Biomass can easily meet all energy requirements in Brazil and Sudan if adequately managed and developed. Factors that contribute to their great energy potential are:

- both have large areas of fertile but unused land
- both have high solar radiation
- both have large fractions of the population living in rural areas and engaged in agriculture

Biomass has the most potential of being an energy source in countries with large quantities of natural resources. Most of these natural resources should be in the form of land. In general, use of biomass resources allows countries to become more independent in terms of energy and is an effective way of maintaining a sustainable way of living. [Pyrolysis Technology, Waste Treatment Home Study, Vergara]

3.4 Deforestation

Deforestation is an issue that is crucial to the completion of this project. Simply defined, deforestation is the state of having been cleared of forests. [Merriam-Webster] This topic has raised a considerable amount of concern in the world today. In order to conduct this project successfully, it is necessary to learn about the causes and effects of deforestation, and see what has happened in other parts of the world regarding this issue.

3.4.1 Causes and Effects of Deforestation

There are many factors that contribute to deforestation. Causes of deforestation can be divided into two groups: immediate causes and underlying causes. Immediate causes of deforestation include pressure from human settlement—including agriculture and fuelwood collection—the timber trade, and atmospheric pollution. Some important underlying causes of deforestation include consumption levels in industrialized countries, regional poverty, and overpopulation.

3.4.1.1 Underlying Causes of Deforestation

The world consumes a high percentage of forest resources today. The majority of resource consumption is concentrated among the most industrialized parts of the world. A toll is incurred upon the forest due to increasing demand for consumer products, which require the use of timber. Industries, such as the oil-drilling industry and the logging industry, rely on forest resources for their progress. Consumption by industries also forces local farmers off good farmland and into the forests. By forcing local farmers to use the forests for farming, livestock will graze on forest byproducts, and other activities will take place that drain forest resources. This is a contributing factor to deforestation.

Poverty is another contributor to deforestation. Approximately 2 billion people worldwide are living in poverty. People who live in poverty have no choice but to use the resources that are immediately available to them. In many situations, that resource lies in the forest. Often, the poor resort to the illegal harvest of wood for heat and for shelter. People who are in poverty often exploit the forest resources in order to survive. Their first priority is to survive. People in that situation are not concerned with proper forest management or with sustainable development. This underlying cause is not easily helped by itself. Governments that wish to stop deforestation may wish to consider the people who are in poverty.

Another issue that causes concern is overpopulation. As more and more people inhabit an area, more resources are necessary to keep them alive. It takes more food and fuel to supply a growing population. Sometimes the land in the forest is turned into additional farmland to accommodate the population's needs. This leads to a decrease in forest area and an increase in forest use. There will be fewer resources and more demand for them. This combination yields deforestation. [Underlying Causes of Deforestation and Forest Degradation]

3.4.1.2 Effects of Deforestation

A combination of all the causes of deforestation, both immediate and underlying, amounts to disastrous effects. Problems that arise with deforestation include soil erosion, ozone depletion, acid rain, and finally, global warming. The loss of bio-diversity and habitats of indigenous people are also likely to occur. When deforestation starts to occur, a cycle of effects tends to follow.

According to studies done of deforestation in the Amazon River Basin, the cycle of deforestation starts with the loss of fuelwood. This means depriving soil of nutrition, which leads to a receding forest and an increase in soil erosion. Water will first flood the area and then totally disappear because there are no trees to support the soil to hold the water. A loss of trees also amounts to more CO_2 and other greenhouse gases in the atmosphere that cause an increase in temperature. Forest fires are more prone to occur due to dry air, releasing even more CO_2 into the air. The land eventually becomes uninhabitable, and if nothing is done to prevent total loss, that entire area will become barren and desert-like. It is apparent that if this cycle continues endlessly, inhabitable parts of the Earth will disappear. [Kawasaki, Habibabadi]

3.4.2 Deforestation Case Studies

In order to comprehend fully the process of deforestation for this project, it is necessary to look at similar cases of deforestation that have taken place in the past. Several case studies have been found having to do with the type of deforestation in question. Some of them bring hope and shed light upon the problem. The first case study involves the nation of Ghana. The second case deals with deforestation in China.

3.4.2.1 The Case of Ghana

Ghana is a nation that lies in the western part of Africa. Since the cocoa industr started in the early 1900s, immigration into the region has been extensive. The current population has a growth rate of about 3.5% a year. Due to the increasing population, its forests suffer from excessive tree felling, declining land productivity, and increased obstruction of waterways. Women of the households in Ghana take it upon themselves each year to gather fuelwood for the winter.

The case of Ghana proves that sustainable fuelwood use can be achieved through the creation of woodlots and the increased productivity of natural forest through proper management. In 1988, the government of Ghana started a forestry project. Free tree seedlings were given to 19 groups of women farmers, who were encouraged to plant them. Three thousand four hundred women participated in the project, and together they have planted thousands of trees. As a result, soil fertility has been improved, farmers are spending less money on fuelwood, and there is an overall better quality of life.
[Fairhead, Njie]

3.4.2.2 The Case of China

China is a nation in eastern Asia with a population of about 1.2 billion. China is the third largest consumer of energy in the world. Two thirds of the population reside in rural areas. Fuelwood, straw, and other types of biomass accommodate approximately 80% of the energy requirement in rural China. China consumes more of these fuels than any other country in the world—about 500 million tons per year.

Until the 1940s, the forests had completely disappeared in most of China because the trees had been felled for use as fuel. The government has since developed an energ program in the interest of improving the quality of life as well as the condition of the forest. This program is based on the seven following principles: popularizing coal- and fuelwood-saving stoves

1. developing high-grade biogas
2. developing small hydropower
3. exploiting and utilizing solar energ
4. developing fuelwood forests
5. developing and utilizing wind energ
6. developing and utilizing geothermal energ

It was discovered that inefficient wood stoves, which gave off intoxicating smoke fumes, were a big part of the problem. Improved efficiency of heating stoves has been achieved through this program. Today, two thirds of the rural population use stoves that are at least 30 percent more efficient than the older stoves. In addition to reducing the demand for fuelwood, such stoves have the beneficial effect of reducing health hazards due to smoke inhalation. [Njie]

3.5 Forest Management

Proper management is crucial to maintaining the sustainability of woodland resources. In order to insure that forests are managed appropriately, a plan governing and directing that management should be drafted and followed. Good forest management is difficult to define, because it is specific to a given forest. Viable forest management plans must take into account environmental, economic, and social impacts that management may have on specific woodlands, and find a suitable balance.

3.5.1 Sustainability

An essential issue in forest management is sustainability. Forest sustainability depends upon several factors, particularly growth rate and felling rate. These two factors effectively determine whether particular woodlands are sustainable. A sustainable forest needs to stay relatively constant in size, with small increases or decreases in the average tree population spread out over an extended period of time.

Sustainability implies that the resources of the forest will continue to be available well into the future. In order to ensure the availability of resources, trees must be replaced at least as fast as they are lost. The growth rate of the forest, therefore, is an effective indicator of how quickly its tree population is growing. The felling rate, obviously, measures how many trees are cut down per acre. However, the felling rate only measures man's influence on the forest, and natural tree mortality and natural disasters are not accounted for. Therefore, the growth rate needs to be more than the felling rate by a significant enough margin to account for natural tree population decreases. This balancing requires monitoring the state of the forest, and modifying the management plan to account for any changes that may occur. [Fazio]

3.5.2 Methods of sustaining forests

An important part of any forest management plan is maintenance. The forest must not be let grow too thick, as this will result in a generally smaller and weaker population of trees. Neither must the forest be cut too thin; else, it will be difficult to get the forest to grow back. The goal of forest management is to find a sustainable middle ground and work to maintain that sustainability through selective thinning and regeneration, and other appropriate actions (weed clearing, maintaining water supplies, soil nutrients, etc.). When designing a forest management plan, one should also take into account whether the primary goal is profit though lumber harvesting or sylvan conservation. This decision greatly affects the way the forest is managed.

If the primary use for a forest is as a source of timber, then maximizing the yield is of prime importance. Often, timber farms have multiple harvests during the year, but fell fewer trees during each harvest. This provides the forest's owner more frequent income from his forest, and tends to leave the forest more fully populated at any given time. Alternatively, extensive felling can be carried out on a less frequent basis, yielding generally higher income from the forest, but making efficient and timely regeneration more important.

When a forest is being maintained for the purposes of ecological conservation, the general health of the forest is most important. Trees are allowed to grow uninterrupted, and timber is not harvested. Occasional thinning is necessary to prevent crowding and diseased trees from infecting healthy ones, but this does not provide enough quality timber to make money selling it as lumber. Additionally, dead trees are often left in the forest as they provide nutrients to the solid and serve as habitats for various animals and plants. Conservation concerns often also dictate that different tree species be encouraged to grow in the same area to foster biological diversity. Having a variety of tree species serves to improve the quantity of nutrients in the soil, provides suitable habitats for a greater variety of animals and other plants.

Regeneration is paramount to sustaining a woodland area. Natural regeneration is usually preferred if possible. By using natural regeneration, it is possible to grow the healthiest trees, since only the healthiest standing trees will produce sufficient fruit capable of maturing into seedlings. When conditions are not well suited to natural regeneration, timely artificial methods of regeneration (planting seedlings or direct seeding) is necessary to maintain tree populations. Artificial regeneration is also used when the forest management plan calls for introduction of new tree species or when the main purpose of the trees is timber harvesting.

Another important factor to consider when managing a forest is exactly how much wood will be used. If the timber will primarily be used for firewood, then a good estimate is that an acre (.4 ha) will provide between 1 and 2 cords or between 3.5 and 7 stere [one or two, 0.5m (20") diameter trees] of firewood per year, with minimal intervention, and as many as 5 cords (17.5 stere) per acre if an active artificial regeneration program is in place. The number of trees per cord and stere, relative to Diameter, Breast-High [4.5 feet (1.4 meters) from the ground] is listed in Table 3.4.

Table 3.4: Trees Per Cord and Stere

D.B.H (inches / centimeters)	**Trees to make a stere**	**Trees to make a cord**
2 / 5.08	47.5	170
4 / 10.16	14.0	50
6 / 15.24	10.6	38
8 / 20.32	7.5	27
10 / 25.40	4.2	15
12 / 30.48	0.9	3.3
16 / 40.64	0.6	2.2
18 / 45.88	0.5	1.9
20 / 50.8	0.4	1.6
22 / 55.88	0.4	1.3
24 / 60.96	0.3	1.0

If the harvest is to be used as timber, however, many more trees can be felled per acre, under the assumption that the acreage is being properly managed. However, the difference between commercial lumber and firewood is significant. The timbers used for lumber are of higher quality than those used for firewood, and significant portions of lumber-grade timber are actually discarded when processing logs. An estimate of between 200 and 300 board feet (1000 board feet is roughly equivalent to 1.8 cords, based on volume) per acre per year is the average for many commercial plantations (this same acre can yield about 10 cords of firewood under the same management conditions). And while clear-cutting often yields between 4000 and 6000 board feet per acre, it is important to note that it takes about 75 years for a clear-cut forest to fully regenerate.

Whether a forest is used as a source of timber, is maintained for conservation purposes, or its use lies somewhere in between, proper management is essential to ensure its sustainability. [Fazio, Forest Management Goals and the Means to Achieve Them]

Chapter 4 - Methodology

The previous two chapters presented background information on the project. The methodology chapter contains the goals and objectives of this project, as well as a detailed description of the procedures and steps taken to collect and analyze the data for this project.

4.1 Project Goal

There is a problem concerning the depletion of the forests in and around the town of Ifrane. The region uses wood as their main source of fuel because it is inexpensive. Large amounts of wood are used by households, *hammams*, *farans*, and bakeries each year. The wood supply comes directly from the forests in the region. These forests are being threatened with deforestation by the region's dependency on wood for fuel. There are many economic, social, health, and environmental issues surrounding this problem.

The goal of this project is to propose methods to improve the sustainability of the local forests by improving the efficiency of current methods—and/or proposing new ways—of home heating and energy use in Ifrane. To accomplish this, we will provide a preliminary assessment of the total wood energy used in town and an evaluation of living conditions and energy use of the residents. With these assessments, we will make recommendations for reducing the impact the town has on the local forests. After the recommendations are finalized, we will present our findings to Dr. Raissouni and the interested members of the community.

4.2 Objectives and Tasks

In order for us to generate recommendation to improve the sustainability of the local forests, we have to understand the economic, health, environmental, and cultural issues involved with energy consumption. Our recommendations must reflect a balance between the economic and environmental issues as well as take into consideration the health hazards and cultural issues involved with the different ways in which energy is consumed. The completion of the following objectives and subtasks is necessary for our understanding aforementioned issues and the completion of our project.

<u>Objective 1</u>: Conduct survey of the residents of Ifrane
Reason: It is necessary to survey the residents of Ifrane to gain information on how they use energy. This information provides both confirmation of the problem, and specific data needed to accurately analyze the situation.

Tasks:

- Make appointments to interview residents.
- Interview residents.
- Take pictures of heating stoves.
- Record temperature of home.
- Observe relevant housing conditions.

<u>Objective 2</u>: Obtain information on local forests.
Reason: Data on current forest conditions provides further proof that deforestation is a problem, and allows us to predict the impact current energy-use trends will have on the state of the forest in the future.

Tasks:

- Interview local Forestry Department.
- Research the ecological, economic, and social importance of the forest.

<u>Objective 3</u>: Ascertain the costs of available energy sources.
Reason: It is important to know the cost of energy, because any recommendations related to energy use need to be affordable by all members of the community.

Tasks:

- Interview local and regional wood suppliers.
- Interview local gas suppliers.
- Interview local Electric Company
- Research regional coal prices.

Objective 4: Determine potential environmental impact of available energy sources.
Reason: Deforestation and environmental impact are currently of major concern. Therefore, it is preferable that any alternative energy sources that are suggested be non-hazardous to the environment.

Tasks:

- Research environmental impact of butane.
- Research environmental impact of coal.
- Research environmental impact of propane.
- Research environmental impact of wood.
- Research environmental impact of other available biomass fuels.

Objective 5: Determine health risks associated with energy-use methods.
Reason: It is important to know the health risks of the various methods of using energy, because any recommendations that are made should be safe to implement.

Tasks:

- Interview local pharmacists.
- Interview doctor at local hospital.
- Obtain statistics from local hospital.

Objective 6: Assess total wood energy used in Ifrane.
Reason: Knowing the total amount of wood consumed by the town allows us to determine the impact it has on the forests.

Tasks:

- Query *hammams*, hospital, bakeries, and *farans* regarding the types and amounts of energy resources used.
- Publish assessment in final IQP report

Objective 7: Evaluate living conditions and heating methods in homes.
Reason: Having information about heating methods and housing conditions makes it possible for us to assess the situation and the needs of the residents. We can use this assessment to make recommendations that suit the lifestyle of the town.

Tasks:

- Analyze data collected from residential survey.
- Publish evaluation in final IQP report

Objective 8: Make recommendations to reduce the impact of Ifrane on the forests.
Reason: This is the goal of the project.

Tasks:

- Analyze and compare all collected information.
- Develop recommendations based on completed analysis
- Present findings to interested parties in Ifrane.
- Publish findings in final IQP report.

4.3 Research Methods and Techniques

To achieve the objectives of this project, data for this project was collected from a range of sources including libraries, the Internet, government offices, residents, and businesses. This data was gathered using a combination of surveys, interviews, and general literature research.

4.3.1 Survey of Residents

The first task in evaluating the energy consumption among the residents of Ifrane was to conduct a survey of the population. The purpose of this survey was twofold. The first objective was to evaluate the total energy consumption of the households. The total energy consumption takes into account heating, cooking, heating water, and electricity usage. From the survey, we obtained information regarding the logistics of buying and using wood, total amounts of wood consumed in a heating season, the average monthly usage of butane, the average monthly electric bill, and the use of other energy sources such as propane, coal, and diesel. The second objective of this survey was to get a qualitative assessment of the demographics, living conditions, and lifestyles of the population.

To gather an accurate view of the total energy consumption of the town of Ifrane, this survey targeted representatives from the entire socioeconomic spectrum. A general breakdown of the economic class, by income, is provided in Table 4.1.

Table 4.1: Economic Class by Income, with Example Occupations

Economic Class	Income Range (DH per month)	Example Occupations
1	> 30,000	University Administrators, High Government Officials
2	15,000 – 29,999	University Professors, Doctors
3	5,000 – 14,999	High School Teachers, Lab Technicians, Pharmacists
4	< 5000	Government Workers, Public Workers, General Laborers

Our initial starting sample was provided by Dr. Raissouni, and consisted of his various contacts in the university and the town and their respective contacts among the town's residents. This sampling by networking gave us a pseudo-random distribution within each economic class, but failed to provide an overall random sample of the entire population. It should also be noted that a complete list of the town's residents was unavailable for true random population sampling. Following a meeting with the mayor and governor discussing our project, a program was set up to provide our team with subsequent samples. The program entailed the government developing a list of residents to survey, and providing government employees to guide our team, including a translator, to each of the selected residents.

This survey was designed as an interview or face-to-face style survey. This style was chosen because, financially, it is the least expensive type of survey compared to telephone or mail surveys, and also allowed us to get a first hand account of how people are living. The questionnaire was generated within the first two days on campus. Some ambiguities were found in the survey, partially due to translation and comprehension issues. Ambiguities were found in the phrasing of questions regarding the relationships of the residents (Q1 and Q2) and the heating of water (Q9 and Q23), and whether or not the stovepipe is a part of the chimney (Q22). People often asked for clarification of these questions, or gave answers that did not make sense within the context of the question (e.g. giving a number when asked if they lived in town all year). We attempted to fix these ambiguities by rewording some questions and providing clarifications during the interviews; the revised survey is contained in Appendix A. In addition to the questions regarding fuels used for cooking and baking (Q19, Q21, and Q23), we inquired about the quantities of the fuels used.

The residents of Ifrane speak a combination of Moroccan Arabic, Berber, and French. To overcome the language barrier we worked with two translators, Dr. Zahra Bouya and Professor Abdelghani El Asli. Zahra Bouya is a lab technician in the physics department and Abdelghani El Asli is a professor of biology and chemistry at AUI. The surveying was conducted as a group effort. A guide brought our team to the home of each family to survey. Our translators would then explain the project to the family. The translator would ask a member of the family the questions from the survey and translate the answers into English. One of the members of the team would record the responses onto an individual copy of the survey. The other two members of the team would take notes on their observations of the house, such as temperature, floor and wall coverings, window and door materials, and any other relevant information. Occasionally, with the permission of the families, pictures were taken of the various types of wood and butane stoves.

4.3.2 Interviewing

In addition to surveying the population of Ifrane, a series of interviews was also conducted. These interviews were conducted in much the same way as the residential survey. With the assistance of a translator, we would introduce ourselves and explain our project. We then asked a series of questions through the translator.

4.3.2.1 Hospital and Pharmacies

We interviewed a doctor at the local hospital and a pharmacist from each of the four pharmacies in the town to gain information regarding any health problems or issues related to the current methods of heating and cooking. The doctor and pharmacists were asked questions about the number of people that get sick each year from the inhalation of smoke or gases (CO, CO_2, butane, etc.) or any other injuries caused or related to heating and cooking. In addition to the types of sickness or injuries, we asked for the basic demographics of the patients (e.g. men, women, children, visitors, locals, etc.). This data was compared and summarized to get a qualitative view on the frequencies and types of health hazards involved with the current methods of heating and cooking. This information is important when considering possible alternatives because alternative methods should not only increase the efficiency of the energy use, but also lower the overall heath hazard.

4.3.2.2 Business Energy Consumption

A series of interviews was conducted among businesses in Ifrane that are major consumers of energy. We interviewed two bakeries, one *faran*, and three *hammams*. Each of these businesses was questioned on the different types of energy sources that were used, their applications, and the average amounts used during the year. In addition to interviewing these businesses, we collected information on the amount of electricity consumed by AUI. The purpose of these interviews was to gather information regarding the general energy consumption in the town. The data was summarized for each of the different types of businesses and was used as part of the preliminary assessment of the total energy consumption in Ifrane.

4.3.2.3 Forestry Department

Our intent for interviewing the Forestry Department was to gather information on the state of the local forests and how they are managed. We asked about the populations of the various species of trees in the forests in the Ifrane region, the rates at which each species was being felled, and the how the wood from each species was being used (e.g. firewood, furniture, construction, etc.). The questionnaire also asked about the existence of any forest regeneration programs, and their success rates. Additionally, we sought some general information regarding the number of trees—of a given average size—required to yield a ton of wood, and the Forestry Department's estimate of the amount of wood used by an average household each year. All of this information was used to determine the current state of the forests and to predict the impact current fuel use methods might have on them.

4.3.2.4 Local Energy Distributors and Suppliers

An important part of determining the feasibility of alternative fuels is analyzing their costs and comparing those costs to what people are currently spending for fuels. To this end, we interviewed the local wood distributors to find out exactly how much people were being charged for wood. These interviews also gave us an idea of the types of wood being sold, how much of each type was being sold, and whether or not there was a different price for each type. We also interviewed a local gas station to ascertain the exact amount of butane in both the large and small bottles and their respective costs. The local Electric Company provided us with the costs of electricity for residents. The cost of coal was determined from an invoice provided by a resident.

4.3.3 General Research

In addition to gathering first hand data through interviews and surveys, it was necessary to collect second hand data and general information. This information has been gathered from several sources including the Internet and libraries from the following universities: Worcester Polytechnic Institute, Clarke University, UMASS Medical, and Al-Akhawayn University

Bac ground research was done in order to prepare ourselves to tackle the problem presented in the project. Specifically, background information on the nation of Morocco was found in order to understand the environment in which we would be working. Knowledge of the Ifrane region was especially pertinent to our project. This information was obtained through a government document acquired from Dr. Bachir Raissouni of AUI. Sustainability is an important factor to know about because the project deals with finding a sustainable way of heating homes in Ifrane. Information on sustainability was obtained from a combination of AUI's library, WPI's library and the Internet. Research on converting English measurement units into metric units was done via Internet. This was necessary in order to measure consistently the area of the forest and the masses of the trees. Several uncommon units of measure had to be clarified.

Information directly leading to the accomplishment of our project goal was also researched. In particular, facts about insulation, forest management and biomass were obtained in order to familiarize ourselves with the options that appear before us in the attempt to complete our project. This research was done with a combination of WPI's library, Clark University's library, and AUI's library. All relevant research was gathered and organized into what are now Chapters 2 and 3 of this document.

4.4 Analysis of Data

In order to develop suggestions that are beneficial to the community of Ifrane, it is necessary to analyze the data that resulted from the surveys and the interviews. Appropriate methods of analysis must be used to draw significant conclusions. First, we will present each piece of the data and then we will discuss the results and conclusions.

4.4.1 Residential Survey

The residential survey provided information that was grouped into three categories: demographics, energy consumption, and basic housing conditions. Data was extracted from the survey by looking at responses of individual questions, combinations of questions, and the combination of question answers and information gathered outside of the survey. Analysis was conducted on the entire surveyed population as a whole as well as on each individual class.

4.4.1.1 Demographics

To develop practical, affordable recommendations, it is necessary for us to acquire an understanding of the families and their financial situations. Several questions from this survey provide the basic demographic information on the household, such as household size, income, and basic family information (e.g. sex, occupation, and relation). From this basic information about each family, we developed the following statistics on population:

- Average Age
- Number of people living in a house
- Number of adults and children per household
- Number of generations per household
- Number of people working per household
- Average age of employed persons
- Gender Percentages of workforce
- Level of unemployment
- Distribution of occupation
- Income per household
- Income per person in each household

These statistics were used in conjunction with the statistics on energ consumption, housing conditions, and energy costs to develop an evaluation of energ use and living conditions of the residents of Ifrane, as explained in Chapter 6.

4.4.1.2 Energy Consumption

The majority of the questions in the survey deal specifically with energ consumption within the home, specifically the types and quantities of sources used, as well as the application in which they are used. From these questions, we developed a better understanding of the energy use of typical households from each class. This information is one of the principle sources used in developing our recommendations.

4.4.1.3 Basic Housing Conditions

In addition to the couple of questions on the survey regarding information on the structure of the house, many observations on the homes were made and recorded during the survey process. These observations included information on floor and wall coverings, window coverings and composition, location of heating stoves, door materials, temperature, whether or not doors or windows were open while heating, and any other information relating to building materials, insulation, or energy use. This information was collected and compared, to find trends for each of these observations and any correlation with energy use.

The information from these three categories was collected together and summarized to form our evaluation of the housing conditions and energy use of Ifrane's residents. These statistics were also used in developing recommendations to improve the current methods of heating and the understanding of the residential impact on the environment.

4.4.2 Health Risks

The information obtained from the local pharmacies and hospital—as well the question from the survey concerning any health problems related to energy use—was collected and summarized. We considered this information when developing recommendations to improve heating methods.

The responses given by the hospital and the local pharmacies allowed us to determine health hazards by gathering and analyzing the overall statistics of people who have taken ill or who have suffered from injuries incurred by current methods of heating. Since any new methods or modifications to existing methods should be at least as safe as current methods, we looked at the current health risks and considered how our suggestions might exacerbate the situation. Any suggestions that would present the possibility of increasing the danger of heating were noted as such.

4.4.3 Energy Sources

By interviewing the various energy suppliers, we were able to obtain information about the costs of wood, butane, propane, and coal. With this information, and researched information about the calorific capacity of the fuels, we were able to compare the energy content (in Megajoules per kilogram) of each per Dirham. We used this data when making our recommendations, to provide the most cost-effective suggestions.

4.4.4 Analysis of Wood Data

Initially, we used data from the CDF presented in Table 5.11 to find the average amount of wood felled each year, from 1995-1999. We then estimated the number of years until the forest would be depleted, assuming that the rate of felling remained the same and that no new trees were planted. To get an approximation of the amount of wood being sold by the wood distributors, first, we calculated the average amount of wood sold over the given, five-year period from the data provided in Table 5.11. We then used the median values of the data found in Table 5.12 to determine the percentage of wood sold that comes from the distributors interviewed.

4.4.5 Analysis of Data Combined

After each piece of data was analyzed, we put it all together and analyzed it as a whole. We began looking at the problem as a chain of supply and demand that starts from the forest and ends with the residents of Ifrane. We analyzed each part of the chain and saw how it contributed to the whole problem. Our analysis of the entire problem then allowed us to formulate conclusions and make recommendations for improvement.

4.5 Summary

In this chapter, we restated our goal and presented our objectives and tasks for completing it. We also gave details on how we completed each task and objective, and how we analyzed all our collected data. The next chapter specifically presents all of our data and analysis.

Chapter 5 - Results

In the previous chapter we described the methods and techniques used for the collection of data. In this chapter, we present all of the collected data and the information that resulted from it. (Note: In this chapter, the word ton specifically refers to a metric ton, or 1000 kg.)

5.1 Residential Survey Results

The results from the residential survey were broken down into three categories: demographics, energy consumption, and housing conditions. The demographic section gives us information about the family composition and income. The information in energy consumption category gives specifics on the types and quantities of energ sources that are being used. Finally, housing conditions are observed to gain information on the physical state of the house that is being lived in. 104 surveys were collected, and the social classes were as shown in Table 5.1.

Table 5.1: Class Breakdown of Surveys Collected

Class	Number of Surveys Collected
Class 1	4
Class 2	4
Class 3	16
Class 4	80

This data is included in all of our results unless otherwise noted. Whenever possible, results are broken down into classes and given as a total (weighted average) distribution.

5.1.1 Demographics

The demographic information that was obtained from the residential surveys was collected and summarized. Demographic information includes the follows

- Average Age
- Number of adults and children per household
- Number of people working per household
- Gender Percentages of workforce
- Distribution of occupation
- Income per person in each household
- Number of people living in a house
- Number of generations per household
- Average age of employed persons
- Level of unemployment
- Income per household

First, the most general demographics, including ages and family members, were summarized. Table 5.2 shows the household members' average age by class, and is also broken down into generations, adults (people over 18), and children (people 18 and under).

Table 5.2: General Demographics

Per Household	**Overall**	**Class 1**	**Class 2**	**Class 3**	**Class 4**
Average # of People	5.48	4.0	3.5	4.25	5.9
Average Age	28.11	29.69	27.86	28.12	28.06
Average # of Generations	2.13	2.0	1.75	1.63	2.21
Average # of Adults	3.57	2.25	3.33	2.73	3.80
Average # of Children	2.49	1.75	2.0	2.3	2.59

Next, results on employment and income were grouped together. Table 5.3 shows information on who is working in each household and the average income being made by the working members.

Table 5.3: Employment and Income

Per Household	**Overall**	**Class 1**	**Class 2**	**Class 3**	**Class 4**
Average # of People Working	1.54	2.0	1.75	1.94	1.40
Average Age of People Working	39.67	43.50	36.71	35.06	41.18
Average Income Per Person (DH/mo)	1563	9146	8911	2751	393
Average Income Per Working Person (DH/mo)	4129	27356	13808	6368	1543
Average Income (DH/mo)	5283	35000	17667	8147	1974

Employment data was collected on each household and is presented by gender. To do this, we first divide the total population surveyed into males that are able to work and females that are able to work. Table 5.4 shows the gender employment breakdown and the percent employed in each class.

Table 5.4: Gender Employment Breakdown

# / % of	**Overall**	**Class 1**	**Class 2**	**Class 3**	**Class 4**
Able Females	189	5	6	22	156
Able Males	153	4	4	20	155
Workforce that is Female	26.1%	50%	42.9%	35.5%	19.3%
Workforce that is Male	73.9%	50%	57.1%	64.5%	80.7%
Unemployed Females	81%	20%	50%	50%	89%
Unemployed Males	35%	0%	0%	0%	43%
Total Unemployed	61%	11%	30%	26%	69%

5.1.2 Energy Consumption

The resulting energy information is detailed in this section. Energy sources include wood, butane, propane, coal, and electricity. Households in Ifrane use these sources of energy for various purposes such as heating, cooking, baking, and bathing. Results were taken for each source of energy and compared to cost. A comparison between the yearly cost of fuel per household and each household's yearly income was also made.

First, the amount of energy used was tabulated from the survey results. In particular, butane, wood, and electricity were considered. A majority of the households surveyed use butane for cooking and wood for heating. Table 5.5 shows the percentage of residents surveyed who use the specified fuel for the specified purpose (e.g. wood for baking, butane for heating water, etc.). The survey resulted in only three households using coal for heat and one household using propane. The residents who use wood for cooking are not using it as their main source but only occasionally as a complement to other energy sources.

Table 5.5a: Percentage Surveyed Using Wood for Specified Purpose

	Overall	Class 1	Class 2	Class 3	Class 4
Heating Home	95	100	75	81	99
Cooking	15	25	0	13	16
Baking	0	0	0	0	0
Heating Water	56	0	0	31	61

Table 5.5b: Percentage Surveyed Using Butane for Specified Purpose

	Overall	Class 1	Class 2	Class 3	Class 4
Heating Home	21	75	50	50	11
Cooking	99	100	75	100	100
Baking	89	50	75	63	96
Heating Water	57	50	75	50	58

Table 5.5c: Percentage Surveyed Using Electricity for Specified Purpos

	Overall	Class 1	Class 2	Class 3	Class 4
Heating Home	9	75	50	25	0
Cooking	1	25	0	0	0
Baking	2	50	0	0	0
Heating Water	5	25	0	13	3

It is also important to consider how much of these energy sources are being consumed by the local residents. Tables 5.6a and 5.6b show the breakdown of this information by fuel and by class.

Table 5.6a: Fuel Use by Quantity*

Per Household	Overall	Class 1	Class 2	Class 3	Class 4
Average Wood (tons per year)	3.7	2.8	2.6	3.3	3.9
Average Butane (kg per month)	36.2	58.0	64.0	37.1	33.9
Average Electricity (kWh per month)	285.5	696.3	431.4	470.3	193.0

Table 5.6b: Fuel Use by Cost*

Per Household	Overall	Class 1	Class 2	Class 3	Class 4
Average Wood (DH per year)	1860.0	1400.0	1300.0	1635.0	1935.0
Average Butane (DH per month)	120.8	193.7	213.8	123.9	113.1
Average Electricity (DH per month)	258.6	937.5	425.0	463.3	174.7
Average Total Cost (DH per year)	6081.9	14974.6	9498.5	7029.2	5346.0

Following the breakdown of energy use, we compared the cost of each individual energy source and the total annual energy expenditure with each household's yearly income. Table 5.7 shows these comparisons.

Table 5.7: Percentage of Annual Income Spent on Energy

% of Annual Income Per Household Spent on Energy (DH/DH)	Overall	Class 1	Class 2	Class 3	Class 4
Wood	7.5	0.3	0.6	1.9	9.6
Butane	5.5	0.5	1.2	2.4	6.7
Electricity	8.4	2.6	2.7	2.9	10.4
Total Energy	21.4	3.5	4.5	7.2	26.7

5.1.3 Housing Conditions

Details on the types of heating stoves used and construction of the homes is contained in this section. The majority of the buildings in Ifrane are constructed with a combination of concrete blocks or stone and cement mortar. The survey indicates that

* These quantities only take into account those who are using the specified fuel. Wood is used by 99 of the households surveyed, butane by 103, and electricity by all.

46% of the houses were made of concrete blocks. The remaining 54% of the homes are constructed with stone. The only roofing materials used in Ifrane are the red tiles for which Ifrane is noted. With the exception of windows, no exterior sources of ventilation were observed. Out of the homes surveyed, 57% had wood storm shutters on their windows. With the exception of a few upper class homes that use wood, most exterior doors were made of steel.

In the interior of the houses, the walls and floors were all made of concrete. The majority of the rooms where the interviews were conducted had some type of floor covering ranging from a thin plastic mat to thick wool rugs. The interior walls of some homes are covered with ceramic tile from the floor to half way up the wall. Most of the walls were simply painted. There were no heavy drapes or curtains found covering any of the doors or windows, although a few doorways were covered with drapes, usually light bed sheets. All the windows observed were single-pane. We were given the opportunity to look at a few attics; none of them showed signs of any insulation.

Out of all the homes visited, 17 homes were heating the room in which the survey was conducted and 7 of them had exterior windows and doors in the room open while they were heating.

For the most part only one room of the house is being heated. The heating stoves were usually located in the center of the room, if space allowed. Otherwise, the stoves were placed in a corner. Most of the wood stoves were made from formed and welded sheet metal. These types of stoves appeared to contain many air gaps, which causes the stove to be less efficient. Most of the households surveyed clean their chimneys at least once a month. Figure 5.1 shows the frequency of chimney cleaning among households surveyed.

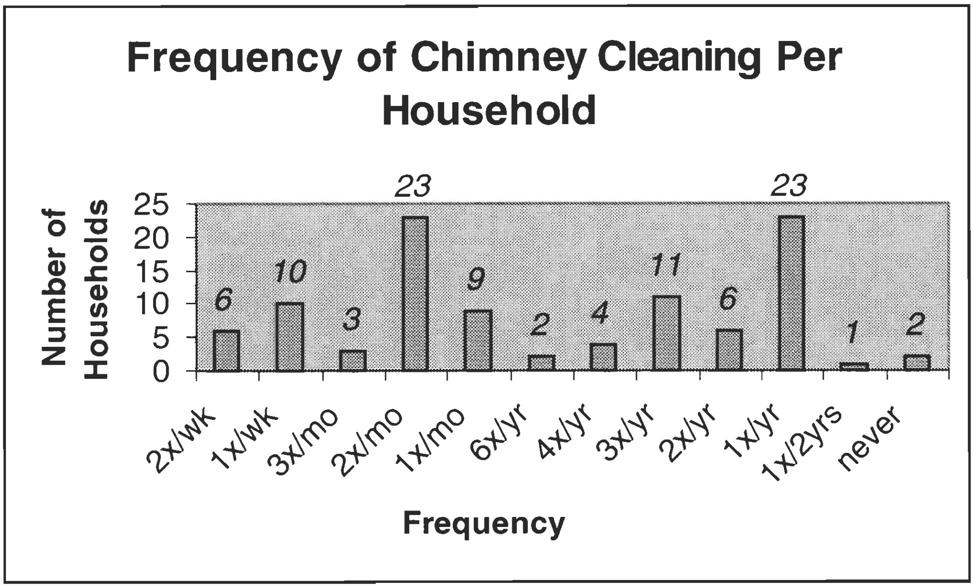


Figure 5.1: Frequency of Chimney Cleaning Per Household

A few people had factory built wood stoves or butane heaters. Four different examples of wood stoves are shown in Figure 5.2. This information will be used when considering recommendations to improve the overall heating efficiency.

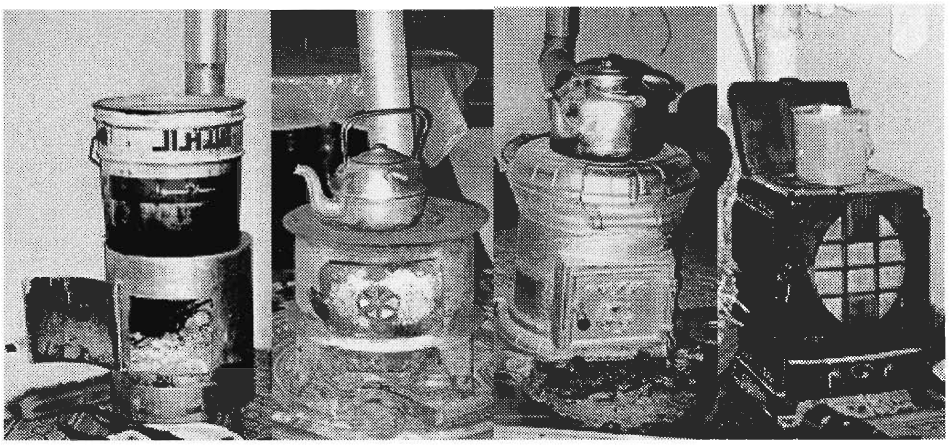


Figure 5.2: Pictures of Various Wood Stoves

5.2 *Hammams*

There are three *hammams* in Ifrane. Interviews were conducted at all three of these businesses on October 29, 1999. In addition to the interviewing, we were given the opportunity to make observations of the wood stock and boilers.

All three of these *hammams* use wood—delivered from Azrou—as the main source of fuel for their boilers. On average, each of these *hammams* uses 20 tons (44,100 lbs.) of wood per month. The average monthly consumption of wood for each of these *hammams* is displayed in Table 5.8. Cumulatively, the *hammams* in Ifrane use approximately 732 tons (1,614,060 lbs.) of wood each year.

Table 5.8: *Hammam* Statistics

	Average Amount of Wood Consumed per Month (tons)	Average Number of People per Day
Hammam 1	28	No Response
Hammam 2	20	45
Hammam 3	13	50
Total	61	95
Average	20	50

Hammams are an important part of Moroccan society. Therefore, it is important to look at the population's frequency of use for each *hammam* in addition to the quantities of wood used by each. The average daily number of people that use the *hammams* is also shown in Table 5.8. Among the residents surveyed, 95.2% attend the *hammams* regularly. The frequency of use among regular users ranges from once a month to twice a week as illustrated in Figure 5.3.

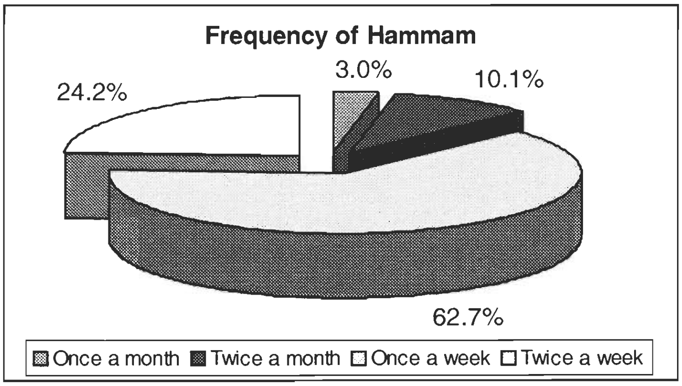


Figure 5.3: Frequency of Hammam Use

All three *hammams* are used by both sexes, although only one of the *hammams* is designed with separate areas for men and women, so that both may make use of the facility at the same time. The other two *hammams* use a set schedule to determine when males and females can attend; the men go from 5am-noon, women from noon to 8pm and the men from 8pm to midnight.

5.3 *Faran* and Bakeries

The interviews conducted with the *faran* and bakeries were conducted on two days, October 29,1999 and November 4, 1999. There are two bakeries and one *faran* in Ifrane. Both of the bakeries are also cafés, and one is also a restaurant. The *faran* in Ifrane is a public oven, used by members of the community, as well as a bread bakery. These three businesses use a combination of fuel sources including wood, propane, diesel, and electricity.

Bakery 1:

- This bakery is also a café.
- Wood is used for all baking
- On average 700 kg of wood is used per day, with a maximum of 1200 kg.
- Wood is purchased from Azrou

Bakery 2:

- This business is a bakery, café, and restaurant
- Wood is used for baking pizzas only
- 18 tons of wood are used per year
- Propane is used for cooking meals in the restaurant
- 13 containers (455 kg) of propane are used per month
- Diesel is used for baking and cooking for the bakery
- No more than 30 tons of diesel is used per month

Faran:

- Wood is the fuel used for baking bread.
- 1500 kg of wood is used per day (30 tons every 20 days)
- The wood is purchased from Azrou
- 600kg of flour is used in a 24 hour period
- All the kneading, and shaping of the loafs is done by electric machines
- The average monthly electric bill is 2000 DH
- Bread is sold directly to families, and to stores

Combined, these three business are using approximately 67.5 tons (148,837.5 lbs.) of wood per month. This is around 810 tons (1,786,050 lbs.) of wood per year. The owner of bakery two commented that he uses several different fuel sources because he is aware of the deforestation problem. He also commented that breads and pastries baked with wood are of higher quality because the wood improves flavor of the food.

5.4 Pharmacies

Interviews were conducted with pharmacists from each of the four pharmacies in Ifrane on two days, October 28, 1999, and November 4, 1999. None of the pharmacists reported any cases of sicknesses or intoxication due to the inhalation of smoke or gases caused from heating and cooking. All four of the pharmacists mentioned that the most common injury that they see relating to heating and cooking is burns to the face and hands. They all mentioned that the burns were mainly on women and children. Three out of the four pharmacists mentioned that mainly visitors to Ifrane suffered from burns, and not the permanent residents.

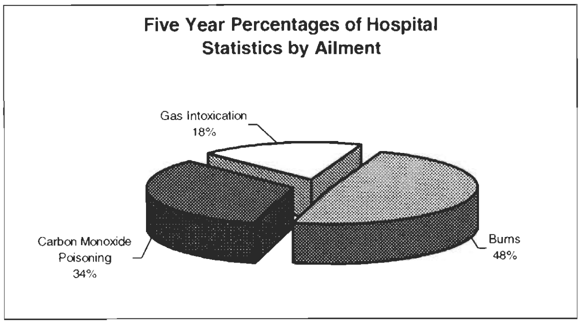
5.5 Hospital

We interviewed a doctor at the local hospital in Ifrane on November 11, 1999. The doctor provided us with information regarding the method of heating used by the hospital as well as information on illnesses related to heating and cooking.

The hospital heats with a forced hot water central heating system fueled by coal. The system is powered by a coal boiler located in the basement of the hospital. Heat is used at night from 3pm until morning, unless the days are especially cold, at which point heat is then used 24 hours per day. The hospital uses approximately 3 kg of wood each day to start the boiler, and then burns about 100 kg of coal per day to keep the system running.

Table 5.9: Hospital Statistics of Burns and Intoxications
(1999 statistics are through 11/99) [Ifrane Hospital]

		1995	1996	1997	1998	1999
Burns	Children	12	7	8	7	13
	Women	8	5	8	11	5
	Men	5	5	11	2	9
Carbon Monoxide (CO)	Children	5	0	0	3	0
	Women	2	5	7	8	32
	Men	2	5	4	5	2
Gas (Butane)	Children	0	4	1	0	2
	Women	2	2	3	0	14
	Men	3	2	2	4	4



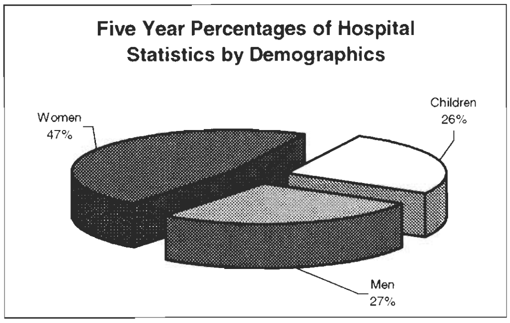


Figure 5.4: Five-Year Percentages of Hospital Statistics

Approximately 60 patients are seen per day. Generally, one can find between ten and fifteen patients being hospitalized on any given day. There are three main ailments caused from heating and cooking: burns, carbon monoxide poisoning, and intoxication from the inhalation of butane. The hospital provided us with the statistics of these ailments from 1995 through 1999. The statistics are displayed in Table 5.9 and illustrated in Figure 5.4.

5.6 Forest Conditions and Management

During an interview with the Forestry Department, on December 2, 1999, we gathered information regarding the conditions and management of the local forest. All forests in Morocco are protected by law and managed by the Ministry of Forestry. Local forests in the Province of Ifrane are managed by the *Centre Développement Forestière* (CDF). It is illegal for anyone not involved with the forestry department to cut down trees.

The Province of Ifrane contains 115,920 hectare of forestland. The density ranges from 800 to 2000 trees per hectare. The distribution of species can be seen in Table 5.10.

Table 5.10: Composition of Forest [Royaume du Maroc]

Species	Land Area (ha)	Percentage of Total Forest
Cedar	48,687	42%
Holm Oak	44,290	39%
Portugal Oak	2,938	2.5%
Maritime Pine	2,320	2%
Other	17,676	15%

The two main types of trees being felled in the Province of Ifrane are cedar and Holm Oak. Almost 100% of the Holm Oaks cut down are being used as fuel wood. One hectare of Holm Oak forest will produce 15 to 110 steres of fuel wood depending on the density of the forest. One stere (st) is equal to a cubic meter, and one metric quintal (qx) is equal to 100 kilograms. A stere is also the equivalent of 3-4 qx. Table 5.11 presents the statistics on the volume of oak put on the market, sold, and used. In addition to Holm Oaks, cedar tree branches are also being used for fuelwood. Cedar logs are used only for woodworking (making furniture, doors, windows, etc.).

Table 5.11: Volume Statistics of Holm Oak Usage [Department of Forestry, Azrou]

Volume	1995	1996	1997	1998	1999 (through 11/99)
Wood put on the market to be sold (st)	39,725	30,505	28,200	37,820	48,160
Wood sold (st)	32,490	27,655	28,200	33,840	48,160
Wood consumed (st)	23,210	10,682	18,260	22,588	22,027
Charcoal produced (qx)	11,582	4,280	16,456	32,423	18,055

To manage the forest, the CDF uses an approach that consists of dividing the forest into several areas known as zones. The CDF assesses each zone and then develops an individual 24-year plan of development for each of these zones. This plan includes all areas of forest management from soil and water conditions, to management of the trees and wildlife.

Two different methods of Holm Oak management and felling are used, *Dépressage* and *Coupe à blanc étoc*.

1. *Dépressage* is used in the dense forests to stimulate new growth. This method simply entails the cutting of every other tree, to give the remaining trees room to grow.
2. *Coupe à blanc étoc* is the method used to harvest Holm Oak, and is simply the method of clearing all the trees in an area.

Three different methods are used for the cedar forests, *Coupe d'hygiene*, *Coupe de regénération*, and *Coupe d'amelioration*.

1. *Coupe d'hygiene* is the same as the method used on the Holm Oaks, *Dépressage.* It is used in the dense cedar forests and involves cutting down every other tree to thin the forest and allow for new growth.
2. *Coupe de regénération* involves cutting down very old or very sick trees that are at risk of falling down and possibly damaging other trees.
3. *Coupe d'amelioration* is a method used to improve the health of the forest b cutting down trees from really dense parts of the forest to allow for new growth, as well as cutting down diseased trees.

The CDF uses two methods of forest regeneration. The first method used is called *crochtage.* This method is used only where the soil is rich and full of nutrients. When this is the case, seeds are sown, and the entire area is surrounded by a fence made out of barbed wire. The other method used, *reboesement*, is used where the soil is not as rich and full of nutrients. When areas such as these are found, seedlings are planted instead of seeds. The success of these methods range from 20% to 80% depending on the weather.

Other forest byproducts are harvested from the forests of the region. Lichens are harvested for use in the perfume industry. Tar is also extracted from the cedar trees using a distillation process to be used in bug repellant. Acorns from the Holm Oak trees are used mainly as fodder for grazing herds. The average Holm Oak tree produces 25 kg of acorns each year. The forests of this area are also used by the tourism industry. Common uses by the tourists include hunting, fishing, skiing, and hiking.

5.7 Wood Suppliers

There are 10 fuel wood suppliers in the region of Ifrane. Interviews were conducted with five of these suppliers located in Azrou on November 27, 1999. The data gathered from these interviews are summarized in Table 5.12.

Table 5.12: Data from Wood Suppliers

Supplier	Types of wood sold	Price per ton	Cost of Delivery (DH/ton)	Quantity of Wood Sold per Year in (tons)			
				Azrou	Ifrane	Outside of Region	Total
1	Holm Oak Cedar	500 DH to residents 250 DH to *hammams*	50	150	150	200-250	600
2	Holm Oak	500 DH	50	500		200	700
3	Holm Oak	500 DH	50	450-500	100-150	400-500	1000
4	Holm Oak	500 DH	N/A	740	10	250	1000
5	Holm Oak Cedar	500 DH	Free	1200	1300-1500	2000	4700

One of the suppliers interviewed purchases logs from a logging company then splits and distributes them. The remaining four suppliers each own a plot of land—purchased from the CDF—and do the felling themselves. All five of the suppliers indicated that the wood is harvested within a 75km radius of Azrou. The information acquired from the wood distributors provides us with knowledge of the cost of buying wood, including cost per ton and cost of delivery. This information also gives us an idea of how much wood is being supplied to the towns of Ifrane, Azrou, and other towns outside of the immediate region.

5.8 Energy Source Comparison

There are five main sources of energy used in Ifrane: wood, coal, butane, propane, and electricity. We gathered information on the size and cost of propane and butane containers from the local Shell™ gas station, as shown in Table 5.13. It should be noted that both butane and propane gas are sold by mass (in kilograms).

Table 5.13: Gas Containers and Costs

Gas	Size	Cost
Butane	3kg	10.10 DH
	12kg	40.10 DH
Propane	35kg	250.00 DH

We visited the local Electric Company on November 24, 1999 and gathered information on the cost of electricity for the local residents. The cost of electricity in Ifrane is dependent on the amount of electricity consumed. The electricity tariffs are broken up into four levels of use as shown in Table 5.14.

Table 5.14: Domestic Electricity Charges

Amount of Electricity	Charges
0-100 kWh	0.8420 DH/kWh
101-200 kWh	0.9055 DH/kWh
201-500 kWh	0.9851 DH/kWh
> 500 kWh	1.3464 DH/kWh

The cost of wood was determined in the interviews with the wood suppliers. We found that the undelivered cost of wood was consistently 500 DH/ton among all five suppliers interviewed. The cost of coal was determined to be 1750 DH/ton from an invoice provided to us from one of the residents we interviewed.

To compare all of these different fuels, it was necessary for us to research the calorific value of coal, oak, butane, and propane. Calorific value is the quantity of energ released as a combustible material is burned.[Lide] The comparisons made in Table 5.15

are based upon the complete and 100% efficient combustion of oak, coal, butane, and propane. The calorific values in Table 5.15 were obtained from the CRC Handbook of Chemistry and Physics. Ideally, wood provides the most amount of energy per Dirham, as can be seen in Table 5.15.

Table 5.15: Energy Cost Comparison of Available Energy Sources

Energy Source	**Calorific Value (MJ/kg)**	**Cost of Material (DH/kg)**	**Cost of Energy (MJ/DH)**
Anthracite Coal	34.3 – 37.2	1.75	19.6 – 21.25
Oak Wood	19	0.50	38
Butane	49.509	3.34	14.82
Propane	50.325	7.14	7.05
Electricity	3.6 MJ/kWh	0.8420 – 1.3464 DH/kWh	2.67 - 4.28

Chapter 6 – Analysis

In the previous chapter, results from our surveys and interviews were discussed. From those results, we conducted an analysis of what was found. Recommendations were then made from this analysis.

Wood that is used and distributed to the residents of Ifrane comes from the forests of the province. To analyze our data we followed the cycle in which wood is distributed to determine the toll that consumption is taking on the forest. We began by looking at the entire forest and then moved on to how the wood is being used in the town of Ifrane.

The forest consists of 115,920 ha of woodland today, in 1999. From the information that was obtained through the CDF, we determined that an average of 36,882 st/yr was felled for fuelwood over the past five years. Given that a hectare of Holm Oak forest yields between 15 and 110 steres—depending upon tree size and population density—this level of consumption is equivalent to clear-cutting between 335 and 2459 hectares of Holm Oak forest each year.

The local forest is logged by both the forestry department and private entities, which are granted logging privileges by the department. Private entities include wood distributors. From the data gathered from the Forestry Department, shown in Table 5.11, we derived that the average amount of wood sold per year over the past five years is 34,069 stere. We calculated that the five wood distributors interviewed sell an average total of 22,500 st per year—using an average value of 3.5 metric quintal per stere—which makes up 66% of the average amount of wood sold. These five wood distributors sell approximately 60% of their fuelwood to the Azrou-Ifrane region and the other 40% is exported to other parts of the country.

Some of the wood sold by these distributors to the town of Ifrane is used by the businesses of the town, including the *hammams*, the *faran*, and the bakeries. Taking into account only these businesses, we calculated that about 4400 st/year of wood is consumed by the businesses alone. Comparing this number to the average amount of wood sold per year (Table 5.11), we determined that these businesses consume approximately 13% of the total.

Hammams are an important part of Moroccan culture and therefore are an important aspect to take into account. As discussed in section 5.2, 95.2% of the residents surveyed make use of the *hammams* on a regular basis. Frequency of *hammam* use can be seen in Figure 5.3. The number of people that use the *hammams* can be seen in Table 5.8. Table 5.8 also shows that the *hammams* are major consumers of wood, consuming roughly 61 tons (~ 174 st) of wood each month. When compared to the amount of wood used by households, as displayed in Table 5.6a, it can be seen that on average, the three *hammams* in Ifrane consume more wood in a month than 16 families consume in a year. This shows that there needs to be research done into improving the way of heating water in the *hammams*.

Like the *hammams*, the *faran* and bakeries are also major consumers of wood in Ifrane. As discussed in section 5.3, the *faran* and bakeries consume a total of 67.5 tons (~ 193 st) of wood each month. Using the same method as we used for the *hammams*, we calculated that these facilities consume as much wood in a month as 18 families consume in a year. The bakeries and the *faran* are an important part of the community. They supply the community with bread, although a majority of the residents surveyed bake at home. As seen in section 5.3, approximately 600kg of flour are used per day for baking bread by the one *faran* in Ifrane. Given that a single baguette uses less than 250 grams of flour, it is obvious that the *faran* bakes a great deal of bread. In Moroccan culture, bread is an essential part of the meal. We also observed that the bakeries, which are also cafés, are frequented by both members of the community and tourists.

The people who make use of these businesses are mostly residents of the town. Like the businesses, the residents of the town are also dependent upon wood for energy. As seen in Table 5.6a, the average amount of wood used by surveyed households per year ranges between 2.8 and 3.9 tons (~ 8.0 to 11.1st) depending on class. This table also shows that, on average, the members of Class 4 use more wood per year than any of the other three classes. This information is important because 80% of the population of Ifrane falls in Class 4 (see section 2.2). Of the total population surveyed, we determined that 95.2% of the households use wood for heating the home, cooking, baking, or heating water. This demonstrates that fuelwood is in high demand among the residents because it is inexpensive to use.

As noted in section 3.1, housing conditions affect the amount of energy used to heat the home. Almost half of the residents interviewed who were heating had their windows and doors open, allowing heat to escape. This may be due to the commonly held notion that drastic temperature changes can adversely affect one's health. We also observed that no residents were taking any active measures to retain heat within the home. Coupled with the high thermal mass of the buildings themselves, this lack of insulation makes heating the homes very difficult. Most of the stoves used to heat also appeared to be very inefficient. Combined, these factors tend to greatly increase the costs of heating the homes.

It is important to analyze cost of energy, and wood in particular, for the residents surveyed. After laying out the energy costs in section 5.1.2, we made a comparison between energy costs of 1998 and energy costs of 1999. In 1998, the government of Ifrane sold one ton of wood at half cost, 250 DH, to 2027 households in town. This information is from a government-produced table that is included as Table E.1 in Appendix E. Assuming household income, the cost of butane, and the cost of electricity stayed the same, we can figure that Class 4 residents are spending over 1% more of their income on energy in 1999 than they did in 1998. By comparison, Class 1 residents experienced just a 0.05% increase in energy expenditures from the previous year. This demonstrates that wood costs significantly affect the lower classes, and therefore significantly affect the majority of the population. This effect was only taking into account the cost of wood. In general, any increase in the cost of fuels will effect the majority of the population, the lower classes, most considerably. Since the government gave one ton of wood at half price to over 2000 families in 1998, we can conclude that already, home heating is one of the most significant uses of fuelwood.

Along with cost, it is also necessary to consider health hazards. In sections 5.4 and 5.5, it was determined that over the past five years, the vast majority of the cases seen by the hospital were cases of burns. Furthermore, it can be seen in Table 5.9 that mostly children were victims of these burns. It is probable that this is because children are careless when playing around the stoves. This shows that it may be beneficial to educate children about the dangers of playing around stoves.

From Figure 5.4, it can be seen that women are treated the most by Ifrane's hospital for energy-related ailments. The results from the residential survey indicate that most women are unemployed (see Table 5.4) and presumably stay at home. Therefore, women are the most exposed to any risks found in methods of heating, cooking, and overall energy use.

Taking into consideration what was discussed in this chapter, we were able to develop a few recommendations. To come up with these recommendations, we looked at the whole situation involving wood consumption from the forests to the residents of the town. We decided that the recommendations should involve the residents of Ifrane, because the majority of them are using wood as a main source of energy for heating. Table 6.1 is a list of some possible recommendations, with reasoning for each, broken down into economic, social, environmental, and health categories. Our conclusions and recommendations are presented in Chapter 7.

Table 6.1: Recommendation Possibilities

Recommendations	Economic	Environmental	Social	Heath
Purchase new, more efficient wood stoves	Expensive initial investment. Save money in the long term by purchasing less wood	Use less wood to heat. Reduction in smoke exhausted into the air.	If new stoves are larger, space consideration	Lower levels of CO through more complete combustion Stoves stay hot longer after fire is extinguished increasing exposure time for burns. Less smoke escaping from stove into house
Modify current stoves to improve efficiency	Initial cost may vary depending on type of modification Save money in the long term by purchasing less wood			
Put a shield or fence around heating stoves	Initial cost is not significant No additional cost i necessary	NONE	Might take up floor space.	Makes it safer for children to pla around the stoves, thus resulting in less burns or injuries.
Increase use of butane heaters.	Large initial investment of new stove (~1000 – 2000 DH) More expensive cost for fuel. Reduction in business for the fuel wood industr	Not using wood as fuel. Using a nonrenewable resource	Using gas heaters are perceived to be more dangerous	Increased possibilit of gas intoxication
Insulate Window using blanket or heavy material	Small initial investment for purchasing materials. (~50DH per window)	Possible small decrease in amount of energ used to heat.	Increase in temperature of room. Less drafts People may not want to have the windows covered	Reduction in ventilation from the windows
Insulate interior doors of heated rooms using a blanket or heavy material	Small initial investment for purchasing materials. (~100DH per doorway)	Possible small decrease in amount of energ used to heat.	Contain heat in roo better Restricts heat flo into other rooms	NONE
Insulating Walls and Roof	Potentially large initial investment depending on method of insulation Long term it will save on energy bills	Reduce the amount of energ needed to heat the room to desired temperature	Hassle of making major modification to the house If exterior method used, the exterior appearance of the building must be unaffected	NONE
Use alternative fuel source such as acorns	Inconclusive	Lower the demand on the trees of the forest for wood	Possible odors or storage issues	Inconclusive
Closing all exterior doors and windows	Possibly save on energ bills	Possibly save on the amount of wood consumed	Less drafts Improved heat retention	Restriction of ventilation

Chapter 7 – Conclusions and Recommendations

The information presented in Chapter 6 are the findings that came from our data and observations. In summary, there seems to be a major problem with wood consumption in the Ifrane region, which is caused by the lifestyles of the people. Many components contribute to this problem.

The businesses and households in Ifrane contribute significantly to this problem. Ifrane uses 20% of wood sold by wood distributors per year. As the forest becomes less dense, the availability of wood decreases. It is likely that this will lead to an increase in wood cost, adding to the financial burden on the residents of Ifrane. An increase in cost will inevitably affect the entire population, especially the lower class. Wood is the cheapest way (assuming at least 50% stove efficiency, see Table 5.15) to heat homes in Ifrane, and this method already consumes 9.6% (see Table 5.7) of the lower class's yearly income.

This brings us to the point that there needs to be a better way of heating homes. The current contraption for heating homes is often an inefficient, hand-welded wood stove (see Figure 5.3). Based on these findings and after contemplating the possible suggestions listed in Table 6.1, our first recommendation is to research methods to improve the efficiency of stoves.

In addition to there being inefficient stoves within the homes, there is also a lack of insulation. Doors within the homes are mostly composed of solid steel and the windows are made of single-paned glass, usually within a steel frame. The way that these are made provides very little insulation and allows heat to escape rather easily. Since a majority of residents surveyed leave their windows and doors open, eliminating any insulation, our second recommendation is for insulation to be added to the doors and windows. In addition, it would be beneficial to educate the population on the importance and techniques of proper ventilation and insulation.

In the interest of reducing wood use, our last two recommendations deal with using other forms of energy. One of these suggestions is to research the possibility of using alternative fuels such as acorns. Acorns may potentially be a good alternative fuel because they are readily available in that 41.5% of the local forest consists of oak trees and the average oak tree yields 25kg of acorns every year. Our last recommendation is to encourage a shift away from using wood as a fuel source. We suggest that the government create programs that subsidize the cost of butane and butane stoves, so that it is at least as inexpensive as wood. In addition to subsidizing the cost, it is important that the program also educates the population on how to use this fuel safely.

All of our recommendations are based on findings from our research. This is a very complex problem, which has many issues involved with it. It is the hope of the IQP team that the research conducted as part of this project will serve as groundwork for future projects.

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Appendices

Appendix A	Glossary of Terms
Appendix B	Conversion Factors
Appendix C	Residential Surve
Appendix D	Questionnaires
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Appendix A – Glossary of Terms

Dirham (DH) – Moroccan unit of currency

Faran – public oven

Habous – a government organization which oversees religious charities

Hammam – Turkish style bathhouse

Metric quintal (qx) – metric unit of measure equivalent to 100 kilograms, used in agriculture

Souk – Weekly farmers market

Stere (st) – metric unit of measure equivalent to a cubic meter, used for measuring fuelwood

Appendix B – Conversion Factors

Length:

1 meter (m) = 1.0936 yards (yd.)
= 3.2808 feet (ft)

1 kilometer (km) = 0.62137 miles (mi.)

Area:

1 hectare (ha) = 10,000 square meters (m^2)
= 0.01 square kilometers (km^2)
= 2.4710 acres

Volume:

1 stere (st) = 1 cubic meter (m^3)
= 35.315 cubic feet (ft^3)
= 0.2759 cord

Mass/Weight:

1 kilogram (kg) = 2.2046 pounds (lbs.)

1 metric ton (mt) = 1000 kilograms (kg)
= 2204.6 pounds (lbs.)
= 1.1023 short tons

1 metric quintal (qx) = 100 kilograms (kg)
= 220.46 pounds (lbs.)

Energy:

1 Megajoule (MJ) = 0.2778 kilowatt hours (kWh)
= 238.8459 kilocalories (kcal)
= 947.8673 British thermal units (BTU)

Temperature:

1 degree Fahrenheit (°F) = [9/5*°C + 32] degrees Celsius (°C)

Appendix C – Residential Survey

Energy Consumption in Ifrane: A Survey of Ifrane Residents

Q1. How many years have you been living in Ifrane ________ years

Q2. How many people live in the house? ___ people

Q3. What are the relationships and ages of the members of the household?

Person 1: relationship ____________________ Age:______
Person 2: relationship ____________________ Age:______
Person 3: relationship ____________________ Age:______
Person 4: relationship ____________________ Age:______
Person 5: relationship ____________________ Age:______
Person 6: relationship ____________________ Age:______
Person 7: relationship ____________________ Age:______
Person 8: relationship ____________________ Age:______

Q4. What is your occupation

Person 1: ____________________ Person 5:____________________
Person 2: ____________________ Person 6:____________________
Person 3: ____________________ Person 7:____________________
Person 4: ____________________ Person 8:____________________

Q5. What is your house made of

1 cement
2 stone
3 mud
4 concrete blocks
5 adobe
6 straw
7 wood
8 other ____________________

Q6. How old is your house? _____ years

Q7. What months during the year do you use heat

1 Januar
2 Februar
3 March
4 April
5 Ma
6 June
7 Jul
8 August
9 September
10 October
11 November
12 December

Q8. What portion of the day do you heat

1 morning
2 afternoon
3 evening
4 night (while sleeping)

Q9. Do you keep water warm on the stove for tea or cleaning

1 yes
2 no

Q10. Do you find the current temperature comfortable

1 yes temperature ______°C (skip to Q12)
2 no

Q11. If no, do you like it warmer or cooler

1 warmer
2 cooler

Q12. What materials do you use for fuel to heat your home

1 wood
2 butane
3 propane
4 coal
5 charcoal
6 electricit
7 newspaper
8 straw
9 acorn
10 plastic
11 leaves
12 manure
13 spoiled food
14 other paper products
15 agricultural waste
16 diesel
17 gasoline
18 other _______________

Q13. How often do you purchase or obtain the materials used to heat your home?

1 dail
2 twice a week
3 weekl
4 monthl
5 yearly (seasonally)
6 other ____________________

Q14. On average how much of these materials do you get each time?____________________________

Q15. Where do you acquire these materials from?______________________________________

Q16. Where do you store these materials? ____

Q17. What do you do with the ashes? ____

Q18. Do you use the same heat source for heating and cooking

1 yes *(skip to Q20)*
2 no
3 occasionall

Q19. What are all the fuels you use for cooking

1 wood	6 electricit	11 leaves	16 diesel
2 butane	7 newspaper	12 manure	17 gasoline
3 propane	8 straw	13 spoiled food	18 other ______________
4 coal	9 acorn	14 other paper products	
5 charcoal	10 plastic	15 agricultural waste	

Q20. Do you bake or buy your bread

1 bake
2 bu (skip to Q22)
3 both

Q21. Where do you bake your bread

1 in a *Faran* (public oven) ______(times per week)
2 private oven
(a) wood
(b) electric
(c) other______________

Q22. How often do you clean your chimney?

1 never	3 annually	5 quarterl	
2 biannually	4 semi-anuall	6 monthl	7 other_____________

Q23. How do you heat your water? ____

Q24. Do you go to the Hemmam?

1 yes ___________ (times per week)
2 no

Q25. Has anyone had to go to the pharmacist or the doctor because they got sick from heating the house or from cooking?

1 yes how often___________ when_____________
2 no
3 not sure

Q26. What is your average monthly electric bill? ____________________________________

Q27. What is the monthly income of your household? ______________________

Appendix D – Questionnaires

Questionnaire for the Forestry Department

Q1. What is the total size of the forestland in the Ifrane region, and how much of it is available for logging?

Q2. What species of trees make up the forest in this area

Q3. What is the local population for each of these species

Q4. What species are being logged?

Q5. At what rate are these trees being felled

Q6. What is done with tree refuse such as treetops and limbs

Q7. Approximately how many trees make up a ton of wood? or
How many tons of wood are contained in a tree

Q8. What is the distribution of usage for Moroccan wood
(E.g. percentage used for firewood, lumber, furnature, etc.)

Q9. Does Morocco import any wood
If yes, How much wood is imported

What types of wood are imported

From where is the wood imported

What is the imported wood used for

Is any of the imported wood used locally?

Q10. Are there any forest regeneration programs in existence?

If yes, What types of programs are in effect and where are they taking place

How long have these programs been in existence

At what rate is the forest being restored

How successful have these programs been thus far

Q11. What are the regulations and restrictions involved with commercial and private logging

Q12. What percentage of the forest is old growth
Are these sections of the forest being protected or logged

Q13. What species of trees are used as firewood for heating and cooking

Q14. What is the forestry department's estimate on the amount of firewood used per household each year

Q15. What is the process by which wood is distributed for firewood

Q16. Are there any other forest products used or consumed? If so what types and for what purpose

Q17. What is the potential for gathering acorns as an alternative fuel for heating and cooking

Questionnaire for Wood Suppliers:

Q1. Where do you get your wood from?

Q2. What types of wood do you sell

Q3. Do you sell the different types of wood separately or in mixture? If you sell a mixture, what type of mixture do you sell? How is it determined? Does it effect the cost? If so how?

Q4. How much do you charge for a ton of wood

Q5. Who do you sell your wood to (people in Ifrane, Azrou, or other towns)?

Q6. How many tons of wood do you sell each year

Q7. How many tons of wood do you sell to each town per year

Questions for *Hammam*:

Q1. What materials are burned to heat the water?______________________________

Q2. How much of these materials do you use per month? ______________________________

Q3. Where do you get these materials from? ______________________________

Q4. On average how many people come per day;
During the high season? ____________________
During the low season? ____________________

Questionnaire for *Faran* and Bakeries:

Q1. What materials are used for energy? ______________________________

Q2. How much of these materials do you use per month? ______________________________

Q3. Where do you get these materials from? ______________________________

Q4. On average how many people come per day;
During the high season? _______________
During the low season? _______________

Q5. How do you heat your ovens
1 Wood
2 Electricit
3 Other____________________

Q6. What is your average monthly electric bill? ______________________________

Appendix E – Miscellaneous Data

Table E.1: Families benefiting from Wood in Ifrane for the year 1998
[Kingdom of Morocco, Ministry of Interior, Province of Ifrane]

Categorization of Benefiting Families	Number	Quantity	Remarks
1) Families of employees and workers	1224	1224 tons	These quantities of wood are 50% off charges.
2) Other than families of employees and workers:			
- Hay Atlas	356	356 tons	
- Hay Salam	256	256 tons	
- Hay Chabab	25	25 tons	
- Hay Riad	96	96 tons	
- Bir anzaran	70	70 tons	
Total	**2027**	**2027 ton**	