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International Economic and Political Studies

Implementing Renewable Energy in Developing Countries:
An Analysis of the Possibilities as Illustrated by Croatia and Macedonia

Masters Thesis

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Abstract

The thesis investigates the implementation of renewable energy sources in developing countries. As develeping states are generally not thought to be in the financial or political position to focus their efforts on developing renewable energy technologies, this paper looks at the physical, technological and economic realities of the situation. Using Croatia and the Former Yugoslav Republic of Macedonia as examples, the paper finds that there are some realities present in developing countries which prove to be difficult obstacles. Nonetheless, these hindrances are not insurmountable, and can be controlled by the governments, to the benefit of all.

The thesis begins with a look at Croatia and then at Macedonia – a chapter for each one, focusing first on their macroeconomic situations, then on geography, next on present energy sectors, and finally on the international commitments they both belong to which require them to implement more renewable energy sources. The third chapter looks at the five main types of renewable energies available now: hydro, wind, solar, biomass and geothermal power. The fourth chapter examines the other aspects of implementing renewable systems: the financing, the foreign direct investment, R&D sectors, government deployment methods, and technology transfers. The fifth chapter combines all of the previous four to see if it is feasible for Croatia and Macedonia to implement clean energy at the present time.

The Conclusion elaborates on the trends which are unique in developing countries, as illustrated by both Croatia and Macedonia. It also looks at what developing states‘ governments can do to increment the amount of renewable energy sources in their energy sectors.

Charles University, the Faculty of Social Sciences

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Amanda Maxwell

Honor Statement

I, the undersigned, swear that the content of this study is original and my own, and that any similarity to other works is entirely unintended. Furthermore, all sources have been properly cited both in the text and in the Bibliography.

Date: 23. 5. 2007 Place: Prague

Name: Amanda Maxwell Signature: A. Maxwell

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Abbreviations

CEA	Croatian Environmental Agency
EFL	German Feed-In Tariff
EIHP	Energy Institute Hrvoje Požar
ESHA	European Small Hydropower Association
ETI	Energy Technologies Institute
EWEA	European Wind Energy Association
EUR	Euro (currency)
FDI	Foreign Direct Investment
FIT	Feed-In Tariff
FYROM	Former Yugoslav Republic of Macedonia
GBP	Great Britain pound (currency)
HEP	Hrvatska Elektroprivreda
HRK	Croatian Kuna (currency)
IEA	International Energy Association
IPA	Instrument for Pre-Accession Assistance
MKD	Macedonian denar (currency)
PV	Photovoltaic
R&D	Research and Development
RES	Renewable Energy Source(s)
SAA	Stabilization and Accession Agreement
SHP	Small Hydro Power
SHS	Solar Home System
ST	Solar Thermal
TGC	Tradable Green Certificates
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organsation
USD	United States dollar (currency)
WEC	World Energy Council

Measurements

The following charts and measures are from
"enerCEE: Units and Conversions," from Austrian Energy Agency:

Abbreviations

GJ	Giga Joule
GW	Giga Watt
GWh	Giga Watt hour
KW	Kilo Watt
kWh	Kilo Watt hour
MJ	Mega Joule
MW	Mega Watt
MWe	Mega Watt (installed electric capacity)
MWt	Mega Watt (installed heat capacity)
TWh	Tera Watt hour
PJ	Peta Joule
TJ	Tera Joule
EJ	Exa Joule
MTA	Mega Tons Annually
Mcal	Mega Calorie
toe	Tons of Oil Equivalent
ktoe	Kilo Tons of Oil Equivalent
odt	Oven Dry Tons

Equivalents

	MJ	**kWh**	**koe**	**Mcal**
1 MJ	1	0.278	0.034	0.239
1 kWh	3.6	1	0.123	0.86
1 koe	41.91	11.63	1	10.01
1 Mcal	4.187	1.163	0.1	1

Prefixes and Amounts

da	deca	10
h	hector	10^2
k	kilo	10^3
M	Mega	10^6
G	Giga	10^9
T	Tera	10^12
P	Peta	10^15
E	Exa	10^18

Introduction

In the past several months, a great deal of international attention has been paid to the increasingly alarming environmental developments reported by scientists. Studies on global warming and meetings about minimizing the negative impact humans have on the planet are making headlines and gaining an amount of awareness that is unprecedented. From the 2007 World Economic Forum in Davos, Switzerland, to the most recent report from the Intergovernmental Report on Climate Change, the pressing need to improve environmental policies and technologies is an issue that the economic, political and scientific sectors can no longer ignore.[1] This stands in remarkable contrast to the situation just ten years ago, when environmental concerns rarely warranted a place on the agendas of such international conferences. In today's world, however, environmental and political experts alike realize the worldwide need to move away from the dominance of fossil fuels in favor of alternative and renewable energy.

The wealthier countries and organizations of the world are presently investing in a variety of possible alternatives to traditional energies, which is logical as they have the finances and resources to do so, and this is an admirable endeavor. Consequently a myriad of possibilities are appearing in an effort to stem global warming and reverse some of the alarming environmental trends documented in the recent UN report. Solar power, wind power, nuclear energy, hydropower, biomass and geothermal power are just a few of the new systems that scientists are working on. But what about countries that have neither the money nor the stability to make the environment a priority? In countries which lack economic strength and/or political strength, the emphasis on acquiring and implementing ecologically-friendly technologies is clearly not very strong. Instead they must spend their resources elsewhere, to secure political firmness or economic growth.

Yet are these ideas—a growing economy and political system—mutually exclusive with environmentally-minded energy developments? Is it possible for developing countries to implement renewable energy sources (RES) successfully? It is precisely this question that this study will address. By looking at two different countries

[1] Information on this topic abounds, but specific sources can be found at "Climate Change 2007: The Physical Science Basis," *Intergovernmental Panel on Climate Change*; Geneva, Feb. 2007; available at www.ipcc.ch/SPM2feb07.pdf; and "The International Conference on Climate Change," Hong Kong, 2007; available at http://www.hkie.org.hk/iccc2007.

as primary examples, the thesis will examine the realities of implementing renewable energy technologies in developing countries. In doing so, it will look at the various kinds of technology available at the present time as well as the necessary conditions to install them in each of the two particular countries. To properly do so, it will be necessary to first look at the current situations in each state, including the economic, political and environmental conditions. Additionally, the international agreements with significant environmental and energy restrictions to which each country is a party will be analyzed.

The two chosen countries are Croatia and the Former Yugoslav Republic of Macedonia (hereafter referred to simply as Macedonia or FYROM). They have been selected for various reasons, first and foremost being their relationship to the European Union. Both were greatly affected by the conflicts in their neighboring countries during the 1990s, yet both came out of that decade well enough to officially be granted EU candidate status. This special status increases the availability of documentation and research resources for the purposes of this paper. It also provides each country with the EU requirements that it must attain in order to be granted full membership. Their geographic proximity to each other will also allow for some similar environmental comparisons. However, the choice of these two countries is also rooted in their differences, which will hopefully provide for some interesting contrasts. Though both are indeed candidate countries, their present political and economic paths are extremely divergent. Croatia's thriving economy has granted the political system a certain amount of stability, a relationship which Macedonia's less successful economic and political sectors do not share.

The first two chapters will each be dedicated to one of the example countries. They will first succinctly present the countries' current economic conditions. Then they will look at the state of the environment there, including basic geographic features, natural resources, and ecological obstacles, before moving on to examine their current energy uses and trends. Equally important will be the need to address any international agreements to which the countries are committed and that might influence energy developments there. Of course, primary sources will be used as much as possible in order to assure the most accurate results. However, due to language restrictions and the occasional difficulty in finding specific information in English, secondary sources will be helpful as well.

The third chapter will look at the current alternative and renewable energy methods developing around the world today. This will include what is available to states, what is feasible to use on a mass scale, and which are being favored among countries and scientists around the world. Moreover, it will highlight a successful example of each renewable energy technology, as a means to illustrate the various options available. The scope of this work will be limited to a specific range of renewable energies: hydro, solar, wind, biomass and geothermal sources. Of course others, such as hydrogen power, do exist; these five, though, are the most common and generally seem to be accepted as the most promising ones. In addition, this study will only look at RES that are used for electricity and heat, thus omitting any bio-fuels used in transportation. The reason for this is simple: such an extension would warrant another entire investigation, which there simply is not room for presently.

The fourth chapter will describe the other aspects of implementing RES, essentially the logistical requirements of doing so. This includes both financial and political factors: foreign and domestic investment, deployment strategies governments can use to encourage the use of RES, public and private investment in the research and development sector (R&D), legislation, and technology transfers. The fifth chapter will then synthesize all the previous information and try to analyze both the possibilities and the realities of implementing the alternative and renewable energy systems in each of the two focus countries. This will mean matching the geographic and environmental conditions of each country with the appropriate energy technologies to maximize all possible benefits. It will also establish Croatia and Macedonia's present logistical abilities to promote and implement clean energy systems. The final results of these two chapters will hopefully be a clear, thorough evaluation of advances each country could make in their energy sectors which would be beneficial to their environments as well as their economies, aiding them on their developmental paths and resulting in the best possible energy systems for the people there. The conclusion will summarize the preceding five chapters, and present the final findings of the entire work.

Chapter 1

An Overview of the Republic of Croatia and Its Energy Development

"Energy consumption is a good indicator of a country's development. A higher development level means higher energy consumption."[2]

The simple and concise statement recently published by the Croatian Environment Agency (CEA) is a seemingly logical assertion to make, and it highlights the Croatian government's current emphasis on growth and modernization. Undoubtedly, over the past several years the country has made sizeable changes and enormous strides in many aspects of its development, notably in its energy sector. In fact, if one follows the logic of the above statement, then Croatia's general development has been both steady and impressive over the past decade, as evidenced by the data given in the same report. According to the information listed there, energy consumption has been consistently on the rise since 1998 and increased 4.1% from 2003-2004. Additionally, CEA stresses the rise of hydropower. However, at 46.6% the Republic's total energy consumption per capita is still lower than the European Union's average.[3] From this single page of the CEA's environmental report, one can glimpse several important insights into the priorities and ideals of the government. First, as mentioned earlier, energy consumption is clearly equated to, or at least highly indicative of, economic progress. Second, the note regarding hydropower suggests that the use of renewable energy sources is valued and a point of pride. Third, the comparison to the EU alludes to the importance that a connection to the EU holds for Croatians.

This chapter will look closely at all of these ideas as part of the examination of Croatia's general energy development to date. This will include a review of current policies, regulations and laws that affect and shape the energy situation in the country. Equal attention will be paid to international commitments regarding the energy situation as well as to national strategies. It also will introduce the major players in the country's energy landscape and map the present energy systems, networks and resources. Of course, special consideration will be given to the presence of renewable energy sources,

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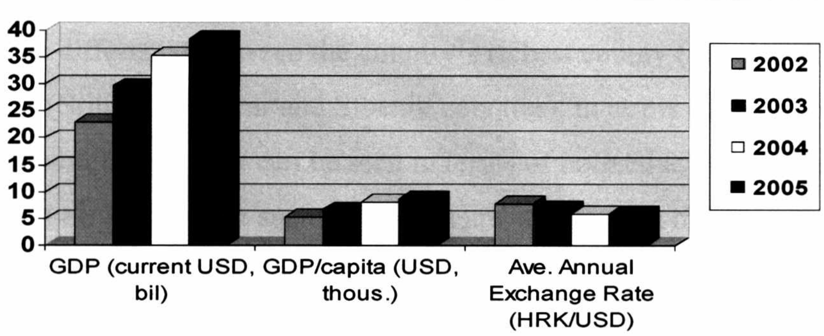
[2] "The Environment in Your Pocket I – 2006," CEA Croatian Environment Agency; Zagreb, 2006; pg. 5.
[3] *Ibid.*

specifically where they are and how much they contribute to the overall energy scheme. This will not be possible without looking at the country's physical landscape—its natural attributes and obstacles—to gain a sense of the terrain and natural resources available for renewable energy technologies. All of this is intimately connected to the country's economic situation, as research, manpower and financing for energy development and infrastructure are undeniably essential ingredients to the entire picture. Therefore, the chapter will begin with a brief survey of the national macroeconomic indicators which most plainly affect the energy situation, before moving on to an assessment of the country's geography. Then the bulk of the chapter will focus on all of the energy-specific factors listed above in an effort to paint a concise, accurate and up-to-date picture of the current Croatian energy system.

Macroeconomic Indicators

The conflicts which devastated much of former Yugoslavia in the mid 1990s undoubtedly affected Croatia's economy during that period and left the country with many obstacles to overcome throughout the rest of the decade.[4] Since the beginning of the 21st century, however, economic statistics indicate that the economy has stabilized and is in fact growing.

Table 1 – Basic Macroeconomic Indicators in Croatia, 2002-2005[5]



[4] Since a detailed account of the events of that decade is immaterial to the economic analysis of this work, the reader can find more historical information in Benson, Leslie; *Yugoslavia: A Concise History, Revised and Updated Edition*; Palgrave Macmillan Press; New York, NY; 2004.

[5] The information used in this Table is from "Statističke Informacije 2005 / Statistical Information 2005," and "Statističke Informacije 2006 / Statistical Information 2006," Republic of Croatia, Central Bureau of Statistics; Zagreb 2005.

Though Table 1 shows three different indicators of vastly different values, it is useful in illustrating the overall trends of the past four years. As reported by the Croatian Bureau of Statistics, the country's GDP (listed here in current market prices by billion USD) has grown consistently. In a related trend, the GDP per capita (here in current market prices by thousand USD) has experienced similar growth. At the same time, the average annual exchange rate of the Croatian Kuna (HRK) to the USD has steadily been falling. According to the latest information available, the 2006 GDP was roughly equal to 37.35 billion USD, a 4.4% real growth rate over the previous year.[6] This first financial glimpse at the latest information is rather positive.

Several noticeable challenges do of course remain, namely the rather high unemployment rate, the unbalanced development of the country's different regions and an increasing trade deficit. The official unemployment rate for 2006 was 17.2%, a remarkably high number for a country aiming to join the European Union. To put this in perspective, the two most recent additions to the EU, Romania and Bulgaria, have unemployment rates of 6.1% and 9.6% respectively.[7] Nor was this an exceptional year, but rather a persistent trend: in 2003, the rate reached 20.6%; in 2004 it was 18.9%; and in 2005 it remained at 19%.[8]

The uneven socio-economic status of the various regions has been identified by the Croatian government as a key problem in its overall development. It has recently reported that the difference between the country's richest county (the city of Zagreb) and its poorest ones (Srijem, Vukovar and Sibenik counties), in terms of GDP per capita, is three to one. A similar inequity can be seen in terms of both education and employment. This same report also states that such disparities are widening in most cases.[9] The reasons for such inequalities are myriad, and range from geography, to industrial development, to whether or not the area has been affected by war. The Ministry also stresses several factors that perpetuate the situation, specifically a lack of direction from the local and county levels, and a lack of basic infrastructure. These factors combine to

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[6] The 2006 information is courtesy of CIA World Factbook; "Croatia;" April 2007; available at www.cia.gov/cia/publications/factbook/geos/hr.html.
[7] All the information about unemployment rates is a 2006 estimate, from the CIA World Factbook.
[8] "Statističke Informacije 2006 / Statistical Information 2006," pg. 83.
[9] "Strategy and Capacity Building for Regional Development," September 2005; from Ministry of the Sea, Tourism, Transport and Development; pg. 12.

prevent any intended aid from being effective: "Despite constantly rising public expenditure, domestic and foreign investments, the growing disparities in the country indicate that the resources have disproportionately ended up in more prosperous regions, while a relatively small amount has gone to disadvantaged areas."[10]

Developments in Croatia's trade deficit can also be briefly identified here. In 2004 the coverage of imports by exports was 48.5%, while in 2005 it dropped slightly to 47.5%. In 2004 the imports per capita in USD equaled $3733, while the exports didn't reach half of that amount, totaling only 1806 USD. In 2005 the situation was similar, with imports per capita coming in at 4178 USD against the export calculation of 1984 USD.[11] It is clear, therefore, that the Croats are importing over twice as much as they export. This dependency on external actors is far from ideal, and the situation will appear again later in the chapter during the analysis of imported fuels used for electricity and energy consumption.

Another noteworthy group of economic indicators worth mentioning here are those involving the tourism industry in Croatia, since it is a vital and vibrant part of the economy which is also fundamentally tied to its environment. In 2006, 10,384,921 foreign and domestic tourists spent over 53 million nights in the country. Of these tourists, just over 1.7 million were local Croats while the other 8.6 million were foreigners from all parts of the globe, although the large majority are from EU countries.[12] With 5,835.3 km of coastline, 1,185 islands (47 of which are inhabited), a total coastal area of 31,067 km² and six World Heritage sites protected by UNESCO, the holiday attraction is clear.[13] During 2006, the Ministry of the Sea, Tourism, Transport and Development expected approximately EUR 500 million to be invested in hotels, campsites and resorts.[14] It is unmistakable, then, that not only is this industry a very important part of the economy, but that its relationship to the geographical environment is

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[10] *Ibid.* pg. 14.

[11] "Statističke Informacije 2005 / Statistical Information 2005," pg. 5; and "Statističke Informacije 2006 / Statistical Information 2006," pg. 7.

[12] "Tourist Traffic 2006," from *Tourism*, Ministry of the Sea, Tourism, Transport and Development; Zagreb, 2006; available at www.mmtpr.hr/default.asp?id=360.

[13] "Tourism: Facts and Figures 2005," from *Tourism*, Ministry of the Sea, Tourism, Transport and Development; pg. 2.

[14] "Croatian Tourism 2005/2006," from *Tourism*, Ministry of the Sea, Tourism, Transport and Development; pg. 10.

of utmost importance. Without its beaches and natural resources, the tourism sector would be but a fraction of its current size, which would have profound economic consequences.

Geography

A country's geography is integrally connected not only to its tourism, but to its energy systems as well; the natural resources it has and is able to use are some of the most valuable elements in its energy development. Consequently, it is important to describe the Croatian geography to gain a fuller picture of what options the people there are presented with to have access to energy. With a brief look at a regional physical map, one can immediately see the importance of the country's location. Situated between more developed EU countries in the North, such as Austria, Italy, Slovenia and Hungary, and fellow former-Yugoslav countries in the South and East, such as Bosnia-Herzegovina, Serbian and Montenegro, it is clearly an important crossroads for international travel. Its position on the Adriatic Sea also makes Croatia an advantageous connection between Central Europe and the Mediterranean.[15]

The country itself can be divided into three distinct geographical areas. First is the aforementioned coastal region, which runs then length of the country from the northwest to the southeast, and is accompanied by numerous islands the entire way. Following the coastline southward, "there is a regular rise of the annual temperature and a fall of the amount of precipitation. The climate is sunny and warm; temperatures rarely fall below zero, which is good for the growing of high-quality Mediterranean crops, such as olives, figs etc." Overall, then, "the geographical location determines the region as a specific, complex natural environment in which there are island, mountain and coastal regions."[16] The main sources of revenue in this area are tourism, commerce, traffic, telecommunications, construction, and agriculture and fishing. It is a rather dynamic region, then, with various types of industry and varying levels of development.

The second region is the central mountainous area stretching from the Alps in Slovenia to the north and into the Dynamic Alps near the Adriatic coast, as well as

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[15] Any reliable physical map will show these characteristics; the map used here is "Physical Map of Croatia," from Free World Maps, 2006; available at www.freeworldmaps.net/europe/croatia/map.html.

[16] "SAPARD Program – Agriculture and Rural Development Plan 2006;" Ministry of Agriculture, Forestry and Water Management; *Government of the Republic of Croatia*; Zagreb, 2007; available at www.mps.hr; pg. 2.

tapering to the east in the form of rocky hills. Though the terrain is quite heterogeneous, it does have a typical mountainous climate, with 2500-3500mm of rainfall annually, much of which is snow. Therefore, the agriculture there is limited to small-scale private farms, which rarely use unnatural fertilizers or other chemicals. Forests, nature preserves, and clay deposits as well as diverse flora and fauna also dominate the landscape. Appropriately, most economic revenues in the mountainous expanse come from forestry, agriculture, wood processing and tourism. One problem this region faces is its remoteness, which is a major obstacle to harnessing the abundant natural resources there.[17]

Third is the Pannonian Plains, the large area tucked into the south side of the Carpathian Mountains and extending to the easternmost border of the country – past the city of Osijek to Serbia and Hungary. It is the largest of the three with about 47% of Croatia's total area and 64% of the total Croatian population, and has the highest potential for agricultural diversity, complimented by a continental climate. According to the Ministry of Agriculture, Forestry and Water Management,

> *The soil, climate and favourable yearly circulation of precipitation give this area good natural potential for efficient agricultural production. Large parts of this region are covered with forests and provide a favourable basis for the development of forestry, and a strong timber industry. The production capacities of the primary sector of agriculture make large parts of the Pannonian Region the major Croatian granary, and good results are being obtained in the wine-growing and wine-making industry. The Pannonian Region is rich in deposits of oil and natural gas, quartz sand, clay, hot water springs and other natural wealth.*[18]

This region has the vibrant economic possibilities to encompass a wide range of industries, and enjoys the resulting effects. However several parts of the area still suffer from war damage, including physical destruction, extant land mines, and questions of ownership and property usage.[19]

In addition to the land, four rivers in Croatia are significant: the Drava River which forms part of the Hungarian border in the North; the Dunav River (Danube) along

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[17] *Ibid.*
[18] *Ibid.*, pg. 1.
[19] *Ibid.*, pg. 2.

the Eastern border; the Sava River, which forms the Southern border with Bosnia-Herzegovina before flowing inland and up toward Zageb; and the Krka River, which runs out of Bosnia-Herzegovina through the mountains into the sea approximately halfway between the cities of Zadar and Split.[20] To summarize all of this information, one can clearly say that the geography of Croatia is extremely heterogeneous. Its location among its neighbors and next to the Adriatic makes the country integral to international transportation and communication. Its diverse types of landforms yield a multitude of climates and natural resources, which in turn nurtures a wide spectrum of industries and economic opportunities. Yet the enduring effects of the wars during the mid-1990s, problems with remoteness and a broad lack of infrastructure create obstacles to development which influence the energy sector, as will be seen shortly.

Energy Sector

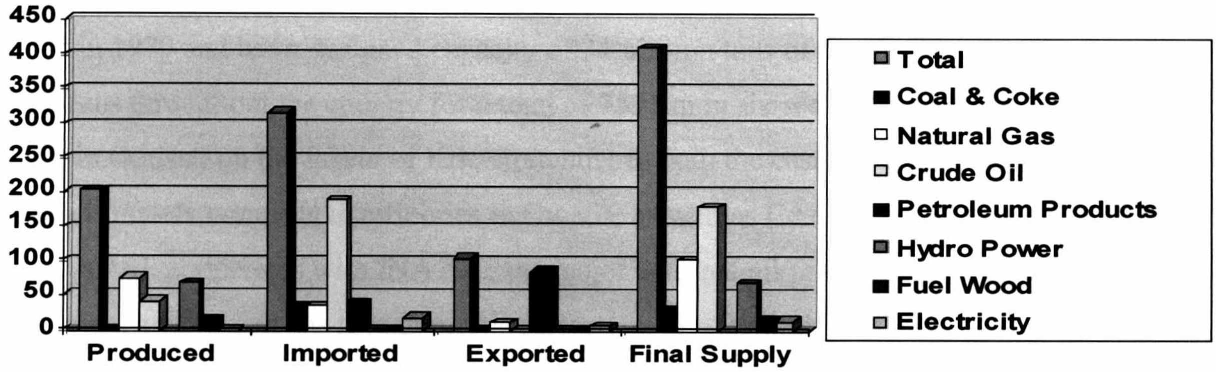
With so much information to cover, it seems best to start this section with a look at the fundamentals of Croatia's current energy situation – the main fuels it consumes, produces, imports and exports, where these fuels come from, and who the major actors in the sector are. Then it will be pertinent to look at current legislation and regulations connected to energy policy. There have been a number of changes in the past few years, so this is necessary component to review. Finally, a discussion of future energy commitments and possibilities will conclude the chapter.

The Central Bureau of Statistics reported that in 2004 the total amount of primary energy production in Croatia was 204.40 Peta Joules (PJ). The largest type of fuel to contribute to the whole was natural gas with 77.08 PJ, followed by hydro power's 69.00 PJ, then crude oil with 42.44 PJ, and finally fuel wood's 15.88 PJ.[21] This domestic production is not enough to maintain the country, however, and Croatia has to import a great deal of the energy it consumes. It imported a total of 318.12 PJ of energy in 2004, the majority of which was crude oil (189.49 PJ). It also imported other petroleum products (40.01 PJ), natural gas (35.82 PJ), coal and coke (33.73 PJ) and electricity (19.07). Despite the imbalance, Croatia still exports several types of energy, trading out 86.71 PJ of petroleum products, 11.82 PJ of natural gas, 5.88 PJ of electricity and 1.28 PJ

[20] The rivers are described as seen on "Physical Map of Croatia," from Free World Maps, 2006.
[21] "Statističke Informacije 2006 / Statistical Information 2006," pg. 55.

of coal and coke in 2004 for a total exported amount of 105.69 PJ.[22] When adding the produced energy to the imported, and subtracting the exported, Croatia's final energy supply for 2004 was 412.04 PJ, most of which came from crude oil (179.61 PJ) and natural gas (104.66 PJ). Following both were hydro power, coal and coke, fuel wood and finally electricity.[23] Table 4 provides a visual comparison of all these numbers.

Table 4 – 2004 Primary Energy Supply in Croatia, in PJ[24]



Several important conclusions can be gleamed from this information. First, it is noteworthy to remark that over four times as much crude oil is imported than produced, which has serious economic effects as it has the highest percentage of the final supply. On the other hand, the country produces a good deal of hydro power, relatively speaking, but exports none of it. The final implication underlying all of these numbers is the fact that the country's entire production of energy is only approximately half of the total supply the country consumes. Nor was 2004 an exceptional year; in fact the statistical report has a nice graph illustrating precisely the same trend in both 2002 and 2003.[25]

This is a trend that the Croatian government has noticed and would undoubtedly like to change. A document adopted by the administration and signed by Prime Minister

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[22] *Ibid.*

[23] *Ibid.* pg. 56. The mathematics do not exactly match the results listed in the report, possibly due to small amounts of consumption and / or loss of energy during the overall process. The figures listed here are those published in the report, not those reached by the author's own calculations.

[24] Table is by the author from the information presented from "Statističke Informacije 2006 / Statistical Information 2006." 'Petroleum Products' was not listed in either the 'Production" nor the 'Final Supply' categories.

[25] *Ibid.* pg. 56.

Ivo Sanader in August 2006 states that "today, Croatia's own production meets only about half of its energy requirements, where Croatia's own supply of primary energy is in constant decline and expected to decrease further."[26] These are dire predictions considering the rising price of oil globally, which is the largest component of the primary energy supply and much of which must be imported. Because natural gas and crude oil are the two biggest sources of primary energy supply, it will be useful to briefly look at these sectors in more detail.

The oil produced in Croatia is transported via the JANAF oil pipeline, which was constructed in 1979 and has a designed capacity of 34 million tons of oil annually (MTA). It runs throughout the country for a total of 759 km in six sections, starting from its terminal in Omišalj on the Island of Krk, stretching to both the eastern and northern borders. It ultimately connects to refineries in Croatia, as well as Central and Eastern Europe.[27] JANAF cooperates with INA d.d., the major national oil production and processing company, which has four domestic refineries. Interestingly, the same company owns the majority of the country's petrol stations (selling points): 414 of the 715 in 2004 were owned by INA d.d.[28]

The natural gas sector also has a well-established network of production and transportation. The Pannonian Plains have the most-developed system, with development spreading eastward through the mountainous area and down along the coast. Additionally, new gas fields are being growing in the northeast, predominantly along the Hungarian and Serbian borders. The natural gas transportation system is owned by PLINACRO d.o.o., a member of the INA group, which transports to both domestic and foreign destinations.[29] Approximately 39 companies are licensed to distribute natural gas around the country, and the total distribution network is comprised of about 15,531

[26] "Strategic Development Framework for 2006-2013," Central Office for Development Strategy and Coordination of EU Funds; Government of the Republic of Croatia; Zagreb, 2006; pg. 36.
[27] "Company Profile," *Jadranski naftovod, Joint Stock Company* (JANAF, Plc.); Zagreb, 2006; pg. 6; available at www.janaf.hr. Page 8 of the same report has an excellent map of the pipeline in Croatia.
[28] "*enerCEE: Croatia*, Supply: Energy Sources," from Austrian Energy Agency; Vienna, 2007; available at www.energyagency.at/enercee/hr/supplybycarrier.en.htm.
[29] "Plinsko gospodarstvo Hrvatske 2004 / Gas Industry in Croatia 2004," Energy Institute Hrvoje Požar; Zagreb, 2004; available at www.eihp.hr. The same report has an excellent map of the distribution network and developing gas fields in Croatia on page 18.

kilometers of pipeline.[30] Although Croatia produces a good deal of its natural gas, the percentage it imports—almost entirely from Russia—is increasing every year.[31]

From the aforementioned information, one can see that hydro power is also a key factor in the Croatian energy scheme. When the focus is turned away from primary energy supply and instead towards electricity, it is immediately evident exactly how big of a role this source of energy plays. Hydro power constitutes approximately 52% of the country's entire installed capacity of about 4012Mega Watts (MW). It is important to note that due to the hydrological conditions at any given time, the capacity fluctuates; thus the hydro plants can produce anywhere from 40-60% of the entire national supply of electricity.[32] With 25 plants currently active, and others in development, hydro power contributes a great deal to the national grid—more than any other single source. Control of the grid is dominated by Hrvatska Elektroprivreda (HEP), which meets 95% of the national electricity demand – everything from generation, transmission and distribution to operation and control are run by HEP. The company also prides itself on being the largest renewable energy producer in the country, a valid claim considering it owns all 25 of the hydro plants, and is currently planning three more which will add a capacity of 122 MW to the system.[33]

Other renewable sources of energy are also contributing to the national electricity supply, namely wind, solar and geothermal energy. The first wind farm was built in August 2004 on the island of Pag. It has seven wind turbines, and a total capacity of generating 15 million kWh of electricity per annum. Two other wind parks opened in late 2005: one near the city of Sibenik, in a location called 'WP Trtar,' and the second, 'WP Jasenice,' is near the town Obrovac. Their combined annual output is 52.2 million kWh. HEP also plays a large role in this sector, if not owning then at least selling and distributing the electricity these plants generate.[34] Despite the relatively recent start, wind power produced almost 2 GWh of electricity in 2005. Moreover, multiple new

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[30] "*enerCEE: Croatia*, Supply: Energy Sources."
[31] *Ibid.* pg. 16.
[32] Vrhovčak, Maja B.; Tomšić, Željko; and Debrecin, Nenad; "Potential and use of renewable energy sources in Croatia," *Renewable Energy*; Vol. 31 (2006) pg. 1868.
[33] Kennedy, Dr.sc. Malcolm W. and Stanic, Mr.sc. Zoran; "The Role of Renewable Energy Sources in Future Electricity Supply;" from *Energija: Journal of Energy*; Hrvatska elektroprivreda d.d., Zagreb; Vol. 55 (2006) No. 3; pg. 321-323.
[34] *Ibid.* pg. 324.

projects up and down the coastal region are planned in the coming years, which will undoubtedly strengthen wind power's place in the market by adding a combined capacity of 189.6 MW. The financing for these projects comes from a mix of foreign and domestic investors, reflecting both the increased international interest in the country as well as a local confidence in the industry.[35]

The solar industry has also started relatively recently in Croatia, but is gaining momentum. According to the Energy Institute Hrvoje Požar (EIHP), they presently estimate approximately 12-15,000 m² of solar thermal collectors operating in the country.[36] The majority of the installed photo-voltaic (PV) systems are off-grid, which makes them difficult to measure and monitor. This is a characteristic somewhat unique to PV energy, and it will be discussed in greater detail in the third chapter. The three systems that *are* connected to the electricity grid are all located in the northern part of the country, and have a combined total capacity of 48.84 kW.[37] EIHP also published, for the first time, a solar radiation handbook which gives thorough solar data for 43 locations around the country.[38] Furthermore, a pilot project called 'Solar Roof Špansko-Zagreb' has been installed and run in recent years, as a test to see if a normal household can be effectively reliant on solar energy. Solar collectors and PV cells have been placed on the roof of the house to maximize exposure to the sun, and the house is equipped with a storage unit to save unused energy. Any surplus electricity is contributed to a network. If there is a lack of solar energy, sensors can siphon electricity off of the same network or use the system's backup gas for heating and warm water. The entire project is designed to be self-sufficient and sustainable, and thus far the results are positive.[39]

The other renewable energy sources that deserve mention at present are geothermal power and biomass. As stated above in the geographical summary of Croatia, the Pannonian region is rich in a variety of natural resources, and this certainly includes geothermal energy. In fact, a quick look at a map of the country's geothermal sources shows that the majority of them are in this area, with some also extending westward into

[35] "*enerCEE: Croatia*, Supply: Energy Sources."
[36] Energy Institute Hrvoje Požar; Zagreb, 2006; available at www.eihp.hr.
[37] "*enerCEE: Croatia*, Supply: Energy Sources."
[38] "Solar Radiation Handbook of Croatia," Energy Institute Hrvoje Požar; Zagreb, 2006; available at www.eihp.hr.
[39] "Pilot Project Solar Roof Špansko-Zagreb," Energy Institute Hrvoje Požar; Zagreb, 2006; available at www.eihp.hr.

the mountains.[40] Most of the electricity yielding from these sources is used for domestic purposes, such as space heating, balneology and the heating of swimming pools. EIHP estimates the total potential at 839 MWt of thermal energy, and 47.9 MW of electric energy.[41] Also noted in the geography section is the abundance of forests that cover the country. More than 40% of Croatia is forested, which means that there is a significant potential for the development of biomass. At present, as seen in Table 2 above, the contribution of biomass is minimal; however, the national agency for biomass, BIOEN, estimates that by 2030, 15% of total energy consumed could potentially come from biomass and be used for production of both thermal energy and electricity.[42]

BIOEN is just one of several agencies recently established by the Croatian government in an effort to improve its environmental and energy situations. Actually, each type of renewable energy has its own agency, as will be described shortly. In the past decade lawmakers have been particularly active in passing regulations and laws, as well as adjusting the organizational structure of the administration in these two specific areas. It has also signed several high profile international commitments which oblige Croatians to make great strides in the types and efficiencies of their energy system, among other things. As stated earlier, the large-scale development of renewable energy sources has been a fairly recent one. One dominant reason for the delay was the war that ravaged the Balkan Peninsula during the 1990s. During that period, resources—financial and other—were diverted to the conflicts, infrastructure was destroyed and, generally speaking, national focus was elsewhere.[43]

After realizing that they were under-utilizing their natural resources for clean energy and electricity, the government established five new programs in 1997, each dedicated to a different type of renewable energy. As a result, SUNEN works today to increase the utilization of solar energy, ENWIND promotes wind energy, BIOEN focuses on the development of biomass, GEOEN's mission is to stimulate geothermal energy, and MAHE works on the development of small-scale hydro power plants. That same year,

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[40] An excellent map can be found at Energy Institute Hrvoje Požar, specifically at http://www.eihp.hr/hrvatski/geoen-ep.htm#geoen.
[41] "*enerCEE: Croatia*, Supply: Energy Sources."
[42] Vrhovčak, Maja B.; Tomšić, Željko; and Debrecin, Nenad; pg. 1870.
[43] "Back to Kumanovo," Chapter 9 in Leslie Benson's *Yugoslavia: A Concise History* has a nice summary of the events that unfolded throughout the Balkans during the conflict. See Benson; pg 155-178.

the government also started four other agencies whose purpose is to increase energy efficiency, each with a different focus. The national MIEE energy program focuses on the industrial, services and public sectors, while KOGEN's purpose is to stimulate the growth of cogeneration plants. KUENcts tries to increase efficiency in household premises, and KUENzgrada aids in reducing energy waste in the design and construction of new buildings and the renovations of older ones.[44]

Another factor affecting the overall energy schema in Croatia is the fact that, like its neighbors, the country has been transitioning from a socialist system towards a market economy, and consequently undergoing the difficult processes of liberalization and privatization. As described by Granic Goran from EIHP, these processes were,

> *aggravated by the social conditions of the majority of population, low energy consumption intensity, the problem of inefficiency of inherited organisational, management, supervision and partly technological structure, undeveloped legislative and institutional systems, especially as regards market functioning, stimulation of free enterprise, competition, protection of consumers and freedom of choice.*[45]

Given these factors, it is no wonder that the country is still dealing with the consequences of this transition. For example, even though the largest energy companies—INA and HEP—became public in 1990, they then turned into join-stock companies owned by the state in 1993-4. This feigned-decentralization was a point of contention between Croatia and the EU countries, who raised the issue of competition in their relations with the former. Even though the liberalization was started in the early 1990's, the government had to pass new regulations as late as 2002 to continue to assist with this process. In March 2002, the Parliament passed both the "Law on Privatization of INA," and the "Hrvatska elektroprivreda d.d., Privatization Act." Both of these precisely stipulate how and how much these companies should both privatize, as well as how much of each the state should continue to own (in INA's case, the government will hold on to 25% of the shares; for HEP the state will keep 51%). Also, in an interesting nod to the EU, both documents declare that only once Croatia joins the Union will the EU aid in

[44] The overview of each of these programs is found in Granic, Goran; "Energy Sector in Croatia after the Year 2000;" Zagreb; from the World Energy Council; London, 2007; available at www.worldenergy.org/wec- geis/publications/default/tech_papers/17th_congress/2_3_26.asp.
[45] *Ibid.*

deciding what the state should do with its shares.[46] Clearly this is a long, drawn-out process that still has effects today.

Perhaps recognizing the need to modernize its energy regulations, the Croatian Parliament passed several specific laws to deal with the various sectors in 2001. In July of that year, the national "Energy Law," "Law on Electricity Market," "Law on Gas Market," "Law on Oil and Oil Derivatives Market," and "Law on Regulation of Energy Activities" were all signed and enacted.[47] Since then, however, the "Energy Law" was amended in 2004 to regulate in entirely new ways, "renewable energy sources and cogeneration, environmental protection measures, energy efficiency, public services in energy activities, prices and tariff systems."[48] In the same year, the government also passed new laws on electricity and on energy regulation, proving again that energy legislation is constantly in flux and needing adjustments.

One reason for these modifications is the fact that Croatia is increasingly becoming involved in international organizations and is thereby committed to the goals and restrictions of each. The foremost of these is its obligations under the EU accession criteria. As the Croatian government constantly stresses its goal of becoming a member state, it is undoubtedly aware of the EU's ambitious energy and environmental objectives, which it must strive to achieve. These include the most recent EU declared goal of achieving 20% renewable energy by the year 2020. In its November 2006 review of Croatia's status as a candidate country, the EU reported that Croatia had made good progress, "in terms of security of energy supply and the internal markets in electricity and gas," yet still, "efforts need to be made in addressing energy efficiency, nuclear safety and strengthening regulatory capacity."[49]

Croatia is receiving large amounts of money from the EU in order to manage the Stabilization and Accession Agreement (SAA), a fact which clearly

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[46] Both documents are available under "Legislation" at Energy Institute Hrvoje Požar; Zagreb, 2006; available at www.eihp.hr.

[47] These are all also available at "Legislation" at www.eihp.hr.

[48] Vrhovčak, Maja B.; Tomšić, Željko; and Debrecin, Nenad; pg. 1871.

[49] "Croatia: Adoption of the Community Acquis – Energy," 2006; from *The European Union*, "Energy" available at europa.eu/scadplus/leg/en/s14000.htm#REN; and "EU Enlargement" available at ec.europa.eu/enlargement/index_en.htm;

puts a good deal of pressure on the government. For example, the Phare program, whose purpose is to assist in candidate countries' preparation for membership, gave a total of 167 million Euros to Croatia over 2005-2006.[50] SAPARD, which concentrates on achievement of agricultural and rural accession goals, gave 25 million Euros in 2006. And ISPA, the EU's pre-accession body that finances infrastructural projects to improve transportation and the environment, contributed 35 million Euros. With such a large budget, it is plainly necessary for the government to make the appropriate adjustments—legislative, structural and otherwise—to accomplish the acquis communautaire.

Among other international responsibilities Croatia faces are the Kyoto Protocol (it signed the agreement, but still has yet to ratify it), which obliges participants to curb climate change. The so-called "Athens Memorandum" or the "Memorandum of Understanding" signed in 2002 by Southeast European countries is a commitment to integrate the regional electricity market, and eventually in the general European market. Its aim is to reduce energy waste and the fragmentation of the energy supply and demand network.[51] The Energy Treaty signed between the EU and the Stability Pact for South Eastern Europe established an Energy Community in October 2005, requires the signing parties to cooperate on integrating the region's full energy market into that of the European Union, in an effort to maintain peace in the area.

Conclusions

Throughout this chapter, a picture of the Republic of Croatia has emerged that includes a precursory look at its economic situation, a brief survey of its geography, and a more thorough review of its present energy sector, including the international agreements it has committed to that affect energy development. What conclusions can be gleaned from all of this information? First, as seen in the macroeconomic indicators, the economy of Croatia has stabilized over the past

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[50] "Pologne et Hongrie – Aide á Restructuration Economique," from Central Office for Development Strategy and Coordination of EU Funds; Zagreb, 2006; available at www.strategija.hr.

[51] "Memorandum of Understanding on the Regional Electricity Market in South East Europe and its Integration into the European Union Internal Electricity Market: 'The Athens Memorandum – 2002'," *Economic Reconstruction and Development in South East Europe*; European Commission & The World Bank; Athens, 2002; available at www.seerecon.org/infrastructure/sectors/energy/index.html.

decade or so, and is growing. Although its average GDP per capita is below that of the EU average, its progress is noticeable and its stable currency is promising. Unfortunately, it continues to be plagued by remarkably high unemployment, very unequal regional development and a serious trade deficit. While it is apparent that the wars in the early 1990's are to blame for a great deal of the devastated infrastructure that contributes to much of these problems, the country's location as the crossroads of Central and South Eastern Europe, and of the Adriatic and the interior makes this an obstacle of utmost importance to remedy.

This leads to the geography of Croatia, which is varied with a myriad of topography, climates and resources to use to its advantage. The coastal area provides not only access to the sea and an attractive destination for tourists, but also an environment that has been proven as conducive to the implementation of wind farms. The mountainous region has its own attractions: forests, virtually (if not completely) organic agriculture and mountain retreats. Unfortunately, its remoteness and rough terrain isolate much of its resources from being harnessed to their full potential. The Pannonian Plains are the most diverse of the three regions, and they are home to most of the Croatia's geothermal resources, agriculture and population. It is clear, therefore, that all solutions to any given problem—constructing infrastructure, connecting an electricity grid or harnessing local energy sources—must take into account the specifics of each location. Any attempt to create one overall, general solution to a national problem would be extremely difficult to implement effectively.

The energy sector today is certainly making progress towards developing renewable energy sources, yet still is overwhelmed by the abundance of fossil fuels in its primary energy supply. One reason for this is the well-established networks and pipelines for the production, transportation and distribution of oil and gas. Despite any damage they incurred during the conflicts, their system is presently functioning and thriving under the increasing demand for their products. The renewable energy sources in Croatia, on the other hand, are only just beginning to take off as an industry. With hydro power currently leading the way, wind, solar, geothermal and biomass technologies are in development in various parts of the country. Interest in them is on the rise as the government and its agencies promote their development in order to meet its international promises.

The governing bodies that study, regulate, control and report on the energy sector are perhaps more numerous than the types of energy they were formed to study. Aside from the nine programs developed in 1997 which were listed above, the state has delegated the task of managing energy development to several ministries. As a consequence, any researcher must consult the Ministry of Economy, Labor and Entrepreneurship; the Ministry of Agriculture, Forestry and Water Management; the Ministry of the Sea, Tourism, Transport and Development and the Ministry of Environmental Protection, Physical Planning and Construction to gain a complete view of the present state of energy in Croatia. Moreover the CEA, EIHP and the Central Office for Development Strategy and Coordination of EU Funds are all institutions which produce reports and information used by the government to make decisions. On one hand, this wealth of information can be a huge benefit. On the other hand, the sheer number of sources of literature and policy mean that Croatia's strategies about renewable energy sources and energy development in general are coming from different places, resulting in a rather scattered and un-harmonized overall outcome. Furthermore, none of the legislation to date sets up exact quantitative goals for energy production or usage, but instead focuses on the more general, over-arching ideas and ideals. A specific, cohesive, all-inclusive and decisive policy is still lacking.

When, in the next chapter, this paper performs the same type of analysis for Croatia's neighbor, Macedonia, it will be interesting to see how many, if any, of these trends and conclusions can be found there as well.

Chapter 2

An Overview of the Republic of Macedonia and Its Energy Development

The Former Yugoslav Republic of Macedonia stands on the threshold of a new and decisive phase in its history as it looks to emerge from the turmoil of armed conflicts and to begin reconstruction and development. It is at this moment that the opportunity must be seized to base plans for economic growth on the principles of sustainable development... While this vision can only be achieved by the people and Government of FYR of Macedonia, the international community has a vital role to play. Not only in the provision of funding and technical support, but also in pressing for environmental issues to be at the top of the development agenda.[52]

This introduction to the 2001 United Nations report assessing the environmental status of the Republic of Macedonia highlights a number of concerns which were facing the country as it embarked on its journey towards European Union membership. Of course, like its fellow former-Yugoslav state, Croatia, Macedonia endured years of violence and hardship during the 1990s which continue to have serious consequences even today. The destruction of that period will take a long time to clean up and get past—physically, economically, socially, politically, etc. It is clear, as this statement points out, that any such movement forward fundamentally requires economic growth to stimulate the rebuilding process. And it is also certain that the country will need help from its international neighbors and partners to attain the level of reconstruction it hopes for. However, with the current global awareness of climate change and environmentalism which was noted in the Introduction, the standards Macedonia must meet to satisfy its international donors are dramatically different than they were just ten years ago, and environmental goals now sit atop the agenda with financial and social ones.

Though not explicitly stated in this excerpt, Macedonia's energy policy and status are intricately connected to all of the above ideas. Physical destruction of infrastructure, economic growth, international relations, funding and technology and environmental objectives all affect—and are affected by—the country's energy sector. To gain a proper overview of this sector as it is today, it will be necessary to take a look at FYROM in

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[52] "Strategic Environmental Policy Assessment – FYR Macedonia: Final Report," United Nations Environmental Program & United Nations Development Program; Nov. 2001.

much the same way as Croatia. Therefore, first the pertinent economic indicators will be identified and discussed, followed by a brief description of the country's geography. Then, as before, the energy sector will be dissected to identify the major industries, actors, policies and potentials influencing Macedonia. Throughout the entire analysis, both similarities and differences with Croatia will appear, aiding in a more well-rounded vision of these two countries. Hopefully it will become evident how much FYROM has accomplished in its efforts to attain the goals the UNEP and the UNDP set for it almost six years ago.

Macroeconomic Indicators

According to the State Statistical Office's latest information, the real GDP growth rate of Macedonia in 2005 was 3.8% over 2004.[53] In fact, after the difficult times in the 1990s which led to annual negative real GDP growth rates, the GDP has been increasing yearly since a notable drop in 2001.[54] Thus, as in Croatia, one can see a steady rise over the past four years:

Table 3 – Basic Macroeconomic Indicators in Macedonia, 2001-2005

Year	GDP (current prices, in million denars)	GDP real growth rate	GDP/capita (USD)
2001	233841	-4.5%	1830
2002	243970	.9%	1859
2003	251486	2.8%	2243
2004	265257	4.1%	2382
2005	284226	3.7%	--

The information here undoubtedly illustrates that the country's economy, generally speaking, is growing for the present. The top three sectors contributing to the GDP from 2003-2005 were consistently (in decreasing order) 1. manufacturing, 2. wholesale and retail trade of motor vehicles, motorcycles and personal and household goods, and 3.

[53] "National Economy and Finances: Gross Domestic Product;" State Statistical Office; *Republic of Macedonia*; Skopje, 2007; available at www.stat.gov.mk/english/statistiki_eng.asp?ss=09.01&rbs=1.. The Office notes that this information is preliminary.

[54] The reasons for the negative numbers in 2001 are most concisely explained in the CIA World Factbook; "Macedonia;" April 2007; available at www.cia.gov/cia/publications/factbook/geos/mk.html. There, the authors note that, *"the leadership's commitment to economic reform, free trade, and regional integration was undermined by the ethnic Albanian insurgency of 2001. The economy shrank 4.5% because of decreased trade, intermittent border closures, increased deficit spending on security needs, and investor uncertainty."*

agriculture, hunting and forestry.[55] It is necessary to note that, as reported by the United States government, "Macedonia has an extensive gray market, estimated to be more than 20 percent of GDP, that falls outside official statistics."[56] If these unreported earnings were added to the official numbers, the totals would increase significantly. For example, to calculate solely from this vague estimate, the GDP in 2005 would have been 341071.2 million denars (MKD) if the gray market were included.

One of the plagues of the Croatian economy also appears to be a problem in Macedonia, as the unemployment rate is very high as well. In 2004 the rate was 37.2% and in 2005 it worsened slightly to 37.3%, although a 2006 estimate is 36%. This is an extraordinarily high figure for a country aspiring to join the EU, and puts it in the similar level as Yemen, Afghanistan and Swaziland.[57] The three industries listed above which contribute most to the GDP also employ the most people, in the same respective order. Again, however, it is essential to raise the issue of the informal sector. If the estimated size of the gray market is correct, then it is possible to assume that many of the officially 'unemployed' people in fact do work, but work in the informal sector and consequently go unreported.

The negative trade deficit in Macedonia is also a difficulty that needs to be balanced. The latest annual report from the State Statistical Office is for 2004; in that year the country exported the equivalent of 1,675,855,000 USD, but imported approximately 2,931,626,000 USD – over twice as much.[58] The external deficit as of November 2006 is estimated at 2.285 billion USD.[59] The major product exported from FYROM in 2004 was "blouses, shirts and shirt-blouses, women's or girls, not knitted or crocheted;" the major product imported was "petroleum oils and oils obtained from bituminous minerals, crude," the value of which totaled more than twice as much as the blouses.[60]

[55] "National Economy and Finances: Gross Domestic Product."
[56] CIA Factbook, "Macedonia."
[57] The 2004 and 2005 figures are from "Labor Market: Active Population," State Statistical Office, available at www.stat.gov.mk/english/statistiki_eng.asp?ss=07.01&rbs=1. The 2006 estimate and the information about the other three listed countries is from the CIA Factbook.
[58] "Foreign Trade," State Statistical Office; www.stat.gov.mk/english/statistiki_eng.asp?ss=13.01&rbs=1.
[59] CIA Factbook.
[60] "Foreign Trade."

Besides the high unemployment rate and international trade imbalance, another obstacle that Macedonia must overcome on its path toward EU membership is a low rate of foreign direct investment (FDI). Understandably, this is something the government is keen to change since FDI is one proven way to boost the economy and stimulate growth. Unfortunately, the amount of FDI in 2005 dropped to 116.2 USD from 139.5 million USD in 2004. Of the total amount, 55.3 million USD came from EU countries; the specific countries investing the most in FYROM in 2005 were Saint Vincent and the Grenadines, Italy, Switzerland, Greece, Austria and Russia. The latest estimates also report that 69.4% of the total amount invested went to 'Manufacturing' and 'Mining and quarrying.' Macedonia's government was pleased to announce that, despite the decrease in overall FDI from the previous year, in 2005 it had a "positive impact on the realized annual financial results. In the business subjects with foreign direct investments, in 2005 the total profit is 4665.6 million denars, [opposed] to the profit realized in 2004 in [the] amount of 1001.9 million denars." The greatest profit occurred in the category titled "Transport, storage and communication."[61] From all of this information, it is clear that the FDI in FYROM is presently lower than hoped, although some industries are making a profit from the international funds they receive—even if their sector is not receiving the majority of the total investments.

One last sector deserves note here in order to maintain the comparison with Croatia, and that is tourism. In 2006 a total of 499,473 tourists visited FYROM. Of these 297,116 were domestic tourists and 202,357 were foreigners.[62] This is an important difference between the two countries, as this total is less than half of Croatia's. Equally important is the fact that in Croatia, the large majority of tourists were from abroad, and only a handful were Croats. Conversely, in Macedonia only 41% were from other countries while roughly 59% of the tourists visited their own country last year. With less foreign tourists visiting FYROM, there will naturally be less foreign investment their and less income generated by the tourist industry itself. As described last chapter, Croatia's scenic coastline is a major attraction for tourists, so Macedonia's lack of sea access is a

[61] "Foreign Direct Investments," State Statistical Office; available at www.stat.gov.mk/english/statistiki_eng.asp?ss=09.03&rbs=1.
[62] "Macedonia in Figures," State Statistical Office; available at www.stat.gov.mk/english/glavna_eng.asp?br=01.

serious drawback in the tourism industry. In a landlocked country, where do the tourists go? Most go to Skopje, the capital city, and others go to the various types of resorts the Macedonians have developed, namely spa and mountain resorts.[63] Without a coast and beaches, people built their tourist sector around the natural resources they *do* have, in other words their mountains and natural spas. Again it is apparent how much geography influences people's lives, and how essential it is to the national economy.

Geography

The geographical character of Macedonia is very different from Croatia, not only because it lacks a coastline, but also because it does not have a large, central flat area like the Pannonian Plains. Any physical map of FYROM quickly reveals the country's major characteristic: mountains. It is, in essence, a mountainous country, with valleys, basins and some small plains woven among the tall ridges. Several ranges run through the country: the Skopska Tsrna Gora Range to the north, the Pindus Range to the west, and the Western Rhodope Mountains in the east. A good percentage of these mountains is forested with deciduous and coniferous forests, while other parts contain more low-lying brush due to the rockier soil. About 37% of the total land area is officially categorized as forested. In the south, several lakes dominate the view – the two largest being Ohrid Lake and Prespa Lake, both lying on the southwest border with Albania. On the southeast border with Greece, lies a third large lake, Dojran Lake. These three are natural lakes, while the country has approximately 50 other man-made lakes as well.[64]

Another important feature of Macedonia's geography, this time similar to Croatia, is its rivers. The Vardar River very nearly dissects the country, going from Kosovo in the northwest to Greece in the southeast, and is predominantly hugged by two fertile banks as it flows from one border to the other. Skopje, the capital, lies on the river in the north. Another large river runs near the southwest border, and is called the Crni Drim. There

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[63] "Transport, Tourism and Other Services: Tourism," State Statistical Office; available at www.stat.gov.mk/english/statistiki_eng.asp?ss=14.02&rbs=1.

[64] The geographical information is taken from the relief map at "Macedonia on Maps," *Macedonia.org*; Skopje, 2003; available at www.macedonia.org; the physical map at "Macedonia," from Maps of the World, 2007; available at www.atlapedia.com/online/maps/physical/Greece_etc.htm; and the information courtesy of the government, found at "General: Country," Ministry of Environment and Physical Planning; *Republic of Macedonia*; Skopje, 2007; available at www.moepp.gov.mk/default-en.asp?ItemID=A6059048839FCC4C8DFD6F8D16ABA09B/.

are about 33 other smaller rivers inside FYROM as well.[65] The river system has historically been used as a means of transport, since Macedonia is in the middle of the Balkan Peninsula and therefore is an excellent route from Western or Central Europe to South Eastern Europe or the Aegean Sea, and vice versa. In accordance with this type of landlocked terrain, the climate of the country is, "characterized with sharp winters, long and w[a]rm summers and certainly a lot of sunny days during the year."[66] The rocky earth limits the amount of arable land, which is estimated to be around 22%, and from which farmers produce grapes, wine, vegetables, tobacco, milk and eggs.[67]

Around 60% of the country's inhabitants live in the urban areas. Three of the top four most populous cities are in the northern half of the country: Skopje in the north-central Vardar River area, Tetovo almost directly west of Skopje, and Kumanovo slightly to the northeast of the capital.[68] Bittola, on the other hand, actually is in the south, close to Prespa Lake. It was mentioned earlier that Manufacturing and Mining are two industries which receive a great deal of FDI. The resources native to Macedonia in which foreigners would invest are low-grade iron ore, copper, lead, zinc, chromite, manganese, nickel and tungsten.[69] It is extremely important to realize that crude oil and natural gas are nowhere on this list. These two fossil fuels are not found in Macedonian soil, and consequently must be imported for use in energy and electricity production. If FYROM's citizens, then, consume these fuels heavily, it puts the country at a serious disadvantage, as far as the idea of energy security is concerned. This fact will be discussed in much more detail in the next section, when attention is changed from geography to the energy sector of Macedonia.

Energy Sector

With such dissimilar overall geographies, it follows that Croatia and FYROM also have different natural resources to use for energy and electricity. While Croatia's system produces some (though not nearly all) of its consumed fossil fuels, Macedonia's does not. Croatia's renewable energy technologies are fairly diverse and are relatively growing in both investment and application; Macedonia's renewable energy situation, as will be

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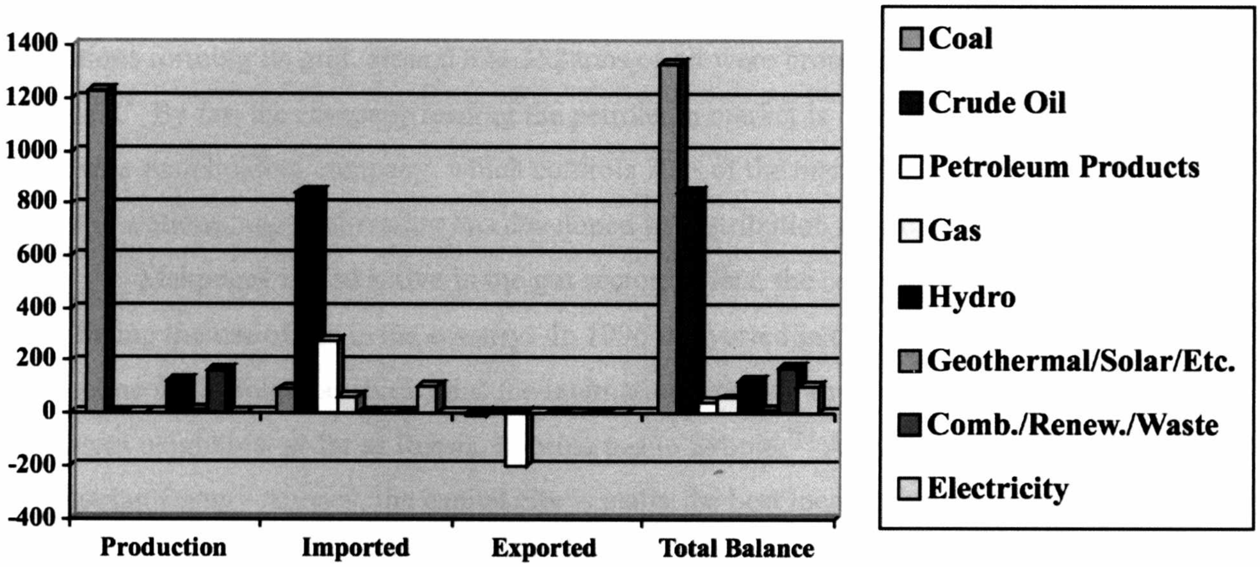
[65] "General: Country;" Ministry of Environment and Physical Planning.
[66] *Ibid.*
[67] CIA Factbook, "Macedonia."
[68] "General: Country;" Ministry of Environment and Physical Planning.
[69] CIA Factbook, "Macedonia."

seen, is neither quite so varied nor so dynamic. The aforementioned geographical particularities offer the latter country a much different schema of options to work with. Like the previous chapter, this one will begin with an overview of the general total energy supply of Macedonia before focusing on its fuel-specific sectors. Then an inward look at the government's relationship with the domestic energy industry—its changes over the past few years, its current laws and policies, and its present difficulties—will be essential before looking outward to the international arena. The treaties and pacts which Macedonia committed to are, by and large, the same as Croatia, yet FYROM's status in relation to these attachments is very different and will be explored as well.

In 2004, the International Energy Agency reports that Macedonia produced 1536 ktoe (thousand tons of oil equivalent) of all different types of fuel. The large majority of this was coal, which consisted of 1232 ktoe, followed distantly by the general category combustible / renewables / waste with 165 ktoe, Hydro power with 127 ktoe, and finally Geothermal / Solar / Etc. with 12 ktoe. The country imported an additional 95 ktoe of coal but no more of its other natural sources. Instead, other imports were crude oil (844 ktoe), petroleum products (275 ktoe), electricity (101 ktoe), and gas (59 ktoe). The total imports of that year equaled 1374 ktoe. The main exports were petroleum products, and a slight amount of coal and combustibles / renewables / waste, for a total export amount of 212 ktoe.[70] Overall, it is evident that FYROM's primary energy comes from a very few and specific number of its own products, while it must import a great deal of oil to maintain its consumption. Furthermore, it exports very little; especially remarkable is that its chief export is a product it must import in the first place. The combined total supply of renewables is significant, yet it pales in comparison with the fossil fuels. Also noteworthy is the complete absence of nuclear energy from this balance; Macedonia uses no nuclear energy in its energy network. As before, a visual comparison of these numbers may aid in understanding the relationship between them:

[70] "Macedonia, The Former Republic of: Statistics," *International Energy Agency*; OECD/IEA, 2007; available at www.iea.org/Textbase/stats/index.asp. The source notes that the total numbers may not add up due to stock changes and rounding.

Table 4 – 2004 Primary Energy Supply in Macedonia, in ktoe[71]



Since a discussion of the oil sector has already begun in the previous section, and because it is undeniably an important source of energy for the Macedonian population, a more specific look will help to understand the situation. The fact is quite simply that the country does not have any crude oil in its own territory, and it thus must bring in every ounce it consumes from its trading partners. In 2005, FYROM utilized approximately 20,000 barrels of oil per day.[72] Thus it also imported the same amount. Of course, this is a geographic trait of the region that can not be changed, and both Albania and Bosnia-Herzegovina are in the same situation. On the positive side of the situation is the fact that "the country's domestic demand for petroleum products is relatively stable at around 800,000-1,000,000 tons per year."[73] Hence, although the cost of oil is rising worldwide, the prices in Macedonia will not rise as much as other countries whose consumption is also steadily increasing.

Even though it does not produce any of its own oil, FYROM does have a refinery on its soil called OKTA, located near Skopje and connected via pipeline to Greece.

[71] The table is the author's own, though the source of information is the *International Energy Agency*.
[72] "Balkans: Profiles," *Energy Information Association: Official Energy Statistics from the U.S. Government*; Washington, D.C., 2007; available at www.eia.doe.gov/emeu/cabs/Balkans/Profile.html.
[73] "Energy Proflile: Macedonia," *enerCEE,* from Austrian Energy Agency; Vienna, 2007; available at www.energyagency.at/enercee/mk/index.htm.

Eighty percent of the pipeline itself is owned by Hellenic Petroleum, and the other 20% is owned by the government of Macedonia. With a full system of terminals and service stations forming its grid, around 824,352 tons of oil were brought into the Macedonia in 2006.[74] By far, the company leading the petroleum market is Makpetrol, a completely private shareholding company, which controls 70% of the market share. It also owns 114 petrol stations, and so therefore has developed its distribution network.[75]

Makpetrol is also active in the gas sector; in fact, the company credits itself with initiating the use of gas in the country. In 1996 it invested in the construction of the gas pipeline from Bulgaria which joins the international network running through many of its eastern neighbors, as far as Russia, to bring gas to Skopje.[76] As pointed out by the Austrian Energy Agency, the capital city is really the best location at this point in time to bring gas as a fuel, since it has the best network prepared for that particular fuel. To distribute gas to other parts of the country would require new pipelines and a good deal of construction, as well as international agreements and cooperation from neighboring countries. Current negotiations are underway with Turkey, Bulgaria, Greece, Albania, and Serbia, among others, to try to find a cheaper way to import gas than from Russia.[77] At the present, as seen in Table 4, the present use of gas in FYROM is not nearly as high as oil or coal, or even the renewables.

Unlike oil or gas, Macedonia has a relatively large native supply of coal and lignite. Its total reserves equal approximately 941 million tons, about 752.8 million of which (80%) are proven reserves. There are four production mines deserving note: Suvodol was opened in 1982, has a yearly production of 6.3 million tons (mt) of coal, sends its products for electrical generation and contains reserves estimated to be available until 2014. Oslomej produces 1.05 mt annually, opened in 1980, also is used to generate electricity, and has available reserves until 2012. RIK Berovo's yearly output is .08 mt; it was opened in 1986, produces coal used primarily for industrial purposes and household heating, and has reserves available until 2010. The fourth, Piskupstina, was opened last, in 1988, and produces 0.1 mt every year, also for industry and home heating; its reserves

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[74] *Ibid.*, under the sub-section, "Supply: Energy Sources."
[75] Specific information found under "Services" and "About Us" at Makpetrol; Skopje, 2007; available at www.makpetrol.com.mk/index_en.asp.
[76] *Ibid.*, under "Services."
[77] "Energy Proflile: Macedonia," *enerCEE.*

are estimated to be available until 2026. In 2006, the Ministry of Economy measured the total consumption of coal to be 6,943,506 tons, mostly used by thermal power plants and industry.[78] The sheer quantity of coal coupled with its relatively low price makes it an attractive fuel, and according to one estimate it accounts for about 72.8% of the country's total energy potential.[79]

Aside from coal, Table 4 also shows that the renewable energy sources have something to contribute to the national energy scheme, the single most productive at this time being hydro power. In fact, many estimates put the total current exploitation of hydro power at far less than its potential. There are seven large hydro plants running on both rivers and reservoirs in Macedonia, which have a total capacity of 480 MW. Several small plants contribute about additional 50 MW, which brings the total to approximate capacity to 530 MW of energy.[80] Most of these plants were commissioned in the 1950s and 1960s, which shows an interesting early initiative to make use of the country's rivers. Indeed, the system of rivers described in the geography section provides excellent water flow for hydro plants. Estimates for the country's total hydro potential, however, are much higher than the current output, and can be anywhere from 4.085 GWh/yearly to 5.483 GWh/yearly.[81] In the past three years, several projects and tenders have begun to encourage the industry's development more and more. Yet progress remains rather slow due to limited financial resources as well as 'institutional constraints,' i.e. water rights issues.[82] These two issues create formidable obstacles for potential investors and developers.

The climate of Macedonia should offer a perfect market for the solar industry, as the country has one of the highest irradiation rates in Europe. The Ministry of the Environment and Physical Planning was noted above as describing the state's long, warm summers with lots of sunny days. At the present, however, the solar potential remains seriously underexploited, and solar collector energy use is confined to heating small numbers of households, commercial and public premises. Photo voltaic (PV) apparatuses

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[78] *Ibid.* The source contains more thorough charts about both the coal mines and total 2006 consumption.
[79] Donevski, Bozin; "A Survey of the Energy Situation in Macedonia," *University of St. Clemet Ohridski*, Bitola; available at www.mef.unsa.ba/ce/izdanja/Donevski-XX.pdf; pg. 3.
[80] "Energy Proflile: Macedonia," *enerCEE.*.
[81] The first estimate is from Donevski's "A Survey…" and the second is from *enerCEE*'s "Energy Profile."
[82] *enerCEE*'s "Energy Profile" lists several specific projects in the works, but also notes the difficulties that lie ahead in actually constructing and implementing the plants.

are used mostly for research and remote areas, and telecommunications. Another extremely important factor in the eyes of the consumer is the fact that solar energy from PV equipment is 3-5 times more expensive than fossil fuels.[83] Several foreign companies have expressed interest in the Macedonian market—from Spain, Germany, Greece and Austria—and are currently conducting studies to check the viability of investing there.[84]

The geothermal sector has a long history in Macedonia, when "about 20 years ago, Macedonia was the first country to prove that geothermal heating of a large greenhouse complex could prove a commercial success."[85] Since that time, unfortunately, the sector's development was not maintained, and today the assessment of its potential contribution to the nation's energy supply is, like hydro and solar power, higher than its current production. In 2003, the wells produced about 543 TJ of heat, while the total potential is approximated at 22 MWth.[86] The majority of the geothermal wells are found in the East and Northeast of the country, and they are used for heating, not electricity. About 81% of the heat is used in greenhouses, with the rest going to space heating (i.e. households, commercial buildings, etc.), industry, agricultural drying, and balneology and swimming pools.[87] Also similar to solar and hydro power, the geothermal energy of FYROM is a growing sector, with several plants—in Kocani, for example—being renovated and reconstructed, while others are under new construction.[88] Encouragingly, the revitalization of this type of renewable energy seems to be proceeding without the hindrances of the hydro sector.

Because 37% of Macedonia is covered with forests, it is logical to consider biomass to be a growing part of the energy sector. However, its uses are fairly narrow and don't seem to be expected to expand anytime in the near future. Presently, wood is chiefly used for heating homes, and is not used for electricity at all.[89] The Macedonian State Energy Balance (SEB) calculates that wood provides 8.9% of the total primary

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[83] *Ibid.*
[84] *Ibid.*
[85] Popovski, Kiril; Vasilevska, Sanja Popovska; "Prospects and problems for geothermal use in agriculture in Europe," *Geothermics*; Vol. 32 (2003) pg. 549.
[86] *enerCEE*'s "Energy Profile."
[87] Popovski, "Prospects and problems…" Popovski has a nice pie chart on page 550 of the different uses of geothermal energy compared to Hungary and Bulgaria.
[88] Both Popovski and *enerCEE* discuss the current construction and renovation happening on these geothermal plants in much more detail.
[89] Donevski, "A Survey…" pg. 5.

energy source, contributing 2.660 GWh/year of energy to the country's sum. It also estimates a 'Theoretical Potential' of 6000 GWh/year, which would equal 20% of the total primary energy. However, it also expresses doubts that growth of the industry will ever reach that number, with few, if any, projects currently in development.[90]

Wind energy, which showed so much potential in Croatia, exists under much different circumstances in Macedonia. With so many mountains and high peaks, it is possible to assume that there are plenty of consistently windy locations in the country where wind turbines could effectively produce energy. An estimate by Econet International showed a potential output of 15 PJ/year. In spite of this, recent ethnic conflicts and political tensions have diverted the necessary funds away from research. Thus most assessments of wind potential in Macedonia actually take place in the near-by Greek wind farms, and quantities are assumed to be similar across the border.[91]

One common thread that is visible among the various types of renewable energy sources is the fact that their estimated potential is much higher than what is currently being realized today. The natural resources Macedonia has seem to be conducive to each of these sectors. Yet they are continually left unexploited by lack of financing, unstable political situations, geographic remoteness or damage from the conflicts of the 1990s. In his survey, Bozin Donevski identifies several of the lingering past difficulties facing the energy sector in general: "the split of the former Yugoslav Republic in 1991, the war in Bosnia and Herzegovina, the crisis in the region of Kosovo, the blockade of Macedonia by Greece and the UN embargo on the Federal Republic of Yugoslavia."[92] To add to this list—or maybe instead to specify further—one could also add the decentralization and liberalization processes the country faced after the collapse of communism, which are also problematic in Croatia. The need to encourage liberalization and, in particular privatization, is a specific stipulation of Macedonia's Partnership Agreement with the EU.[93] Another challenge identified by the government is the present state of the country's infrastructure. Acknowledging this, the new "Program of the Government of

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[90] *enerCEE*, "Energy Profile..."
[91] *Ibid.*
[92] Donevski, "A Survey…" pg. 1.
[93] "European Partnership with the former Yugoslav Republic of Macedonia," *The European Union*; Brussels, 2007; available at www.europa.eu/scadplus/leg/en/lvb/r18013.htm.

the Republic of Macedonia, 2006-2010" stated boldly, "investments in infrastructure are vital to the reduction of unemployment and poverty, the competitiveness of the national economy, the economic growth and more balanced regional development..."[94] It then pledges huge financial investments into infrastructure projects to help stimulate development – specifically in construction, water supply, sewage systems, irrigation systems, transportation, the gas pipeline network, and energy supply.

This Program is very wide-ranging in scope, and addresses numerous issues; everything from macroeconomic and microeconomic policies to science, from tourism to 'European perspective for young people,' receives a good deal of space and attention. In the energy section, specifically, FYROM's government promises to assist financially and otherwise projects to develop the country's hydro energy potential, to re-define existing regulation and to accept and implement the EU's directives, to "revitalize, modernize and adapt parts of the current thermo-production capacities," to introduce more clean-burning natural gas into electricity production, and to construct new energy facilities.[95] The Program is very idealistic and ambitious, but ultimately outlines no quantitative goals or concrete benchmarks by which to measure progress.

On the other hand, the government has made tangible changes in its legislation during the past five years or so. The Ministry of Environment and Physical Planning lists a Law on Environment passed in 2005, and a Law on Ambient Air Quality, a Law on Waste Management and a Law on Nature Protection, all passed in September 2004.[96] Additionally, in 2006 the new Law on Energy was passed in order to effectively update the old one, which had been enacted in 1997.[97] Similar to Croatia, the Macedonian government has multiple Ministries and agencies tasked with various aspects of its energy policy. Thus, the Ministry of Environment and Physical Planning, the Ministry of Economy and the Ministry of Transport and Communications each influence the energy sector in different ways. The Ministry of Economy also has several subordinate organizations which focus on energy, including the State Energy Agency, founded in

[94] "Program of the Government of the Republic of Macedonia: 2006-2010," *Republic of Macedonia Government*; Skopje, 2006; available at www.vlada.mk.
[95] *Ibid.*
[96] Ministry of Environment and Physical Planning; *Republic of Macedonia*; Skopje, 2007; available at www.moepp.gov.mk.
[97] "Law on Energy," *Official Gazette of the Republic of Macedonia*; No. 47/97; available from South East Energy; Vikyrovice, Czech Republic, 2007; at www.seenergy.org.

2004, and the Energy Efficiency Commission, founded in 2003.[98] There are also a number of other energy-concerned organizations and NGOs, most have been established since the turn of the millennium, and all have specific niches and specializations. Indubitably, interest in the energy sector is growing with government and non-government groups increasingly becoming involved in the energy development of FYROM.

This raised level of interest could certainly be connected to Macedonia's increased participation in international organizations, much like Croatia. Also like Croatia, FYROM's status as a candidate country to the EU means that it must take the conditions of its Stabilisation and Association Agreement (SAA) very seriously if it hopes to become a member state. The SAA, which became active in April 2004, outlines both political and economic criteria which must be achieved, as well as concerns regarding Macedonia's ability to meet the Community aquis, to adopt a wide-range of legislation and to co-operate across a spectrum of areas. The SAA also highlights the economic assistance candidate countries receive to help fulfill their goals. From 1992-2005—starting before it ever applied for candidacy—FYROM received a total of approximately 767 million EUR from the various agencies of the EU.[99] The CARDS Program, focused on assisting candidate states in South East Europe, gave Macedonia 298.2 million EUR from 2000-2006. As of 1 January 2007, CARDS was replaced by the Instrument for Pre-Accession Assistance (IPA) which is presently the only financial aid organization for candidate countries from 2007-2013.[100] The responsibilities facing Macedonia are serious, though, as the EU warns that "Community assistance is conditional upon recipient countries abiding by the essential elements which govern their relations with the EU, particularly effective implementation of the reforms… Otherwise, financial assistance may be suspended by the Council."[101] Undoubtedly it is in everyone's best interest for the government of FYROM to earnestly try to attain the energy and environmental goals outlined by the EU.

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[98] for all information regarding these groups, see Ministry of Economy of the Republic of Macedonia; Skopje, 2007; available at www.economy.gov.mk.
[99] "EU – The Former Yugoslav Republic of Macedonia Relations," *The European Union*; Brussels, 2007; available at www.ec.europa.eu/cgi-bin/etal/pl.
[100] "European Partnership with the former Yugoslav Republic of Macedonia," *The European Union.*
[101] *Ibid.*

The other international commitments that Macedonia is bound to are the same as Croatia: the Kyoto Protocol, the "Athens Memorandum," of the Southeast European countries, and the Energy Treaty between the EU and the Stability Pact for South Eastern Europe. Subsequently, the government must strive to meet these obligations by, among other things, further developing its energy sector.

Conclusions

The Republic of Macedonia is certainly, as stated by the UNEP and UNDP's report in the beginning of the chapter, at a turning point in its development. After the tumultuous decade of the 1990s, it has emerged with a hopeful outlook on its future, as evidenced by the way it committed itself to ambitious international promises and the scrutiny that follows. This chapter's succinct look at its economy yielded a picture that despite recent troubles has rebounded into what might just be a period of steady growth. With the GDP and its correlating indicators stable and growing annually, Macedonia's national income looks promising. Unfortunately, it does have several blaring negative spots which mar the overall picture, namely the extremely high unemployment rate, the trade imbalance, and its low rate of foreign direct investment. Also problematic is the reported, but difficult to assess, informal sector that exists and drags down other macroeconomic indicators. If it truly is at 20%, as mentioned above, then the results on both employment and trade could be quite substantial. The lack of FDI is also an important issue the government wants to remedy; its 2006-2010 Program specifically highlights the need to make the country more attractive to foreign investors.[102]

While Croatia's FDI is partly attracted by its growing seaside tourist industry, Macedonia's geography is quite different—thereby offering different resources for exploitation. A fundamentally mountainous country with a network of rivers flowing between the ranges, the countryside's abundance of varied forests, lengthy rivers and high, windy regions offer a distinct set of possibilities. Tourists going to Macedonia spend time in mountain, spa or lakeside resorts, which tend to be more remote than the network of cities along Croatia's coast. One serious problem facing the country, as far as its natural environment is concerned, is pollution. The Ministry of Environment and Physical Planning notes that, "some of the crucial environmental issues in the country are

[102] "Program of the Government of the Republic of Macedonia: 2006-2010;" available at www.vlada.mk.

poor air quality… polluted surface water due to discharge of untreated wastewater, and inadequate solid and hazardous waste management system."[103] The industry of FYROM is equally affected by the physical shape of the land, with limited agricultural possibilities, and a focus on manufacturing textiles and mining a variety of metals. Thus the materials the country has available to export are remarkably dissimilar from those it needs to import—in essence, crude oil and natural gas.

Because much of the Balkan Peninsula naturally lacks oil and natural gas, Macedonia must import both to meet the consumption needs of its population. It also produces a great deal of coal, which is also used for general energy purposes due to its cheap and easy accessibility. Unfortunately for the government of FYROM, oil and coal are not the cleanest of fuels, and the international commitments it is bound to require more environmentally-friendly sources of energy. As a consequence, the government needs to look carefully at the variety of renewable energy resources it has available. As the previous survey of these options shows, the country is actually quite rich in hydro, solar, biomass, geothermal and even possibly wind energy. The potential for all of them is much higher than the current level of use would indicate, thus illustrating a part of the energy sector that is underdeveloped and likely inefficient as well. With hydro power already contributing more to the energy grid than any other RES, it is logical that the government chose that one to pledge its support to in the "2006-2010 Program." However, it has been seen that the other possibilities also have projects in the works, and only need to hurdle certain obstacles to start the path towards growth.

These obstacles, chief among them a lack of infrastructure and not enough financial support, could both be drastically reduced if Macedonia is able to meet its international goals and thereby continue to receive economic assistance. Having recently passed a new set of legislation and established several environmental and energy-related organizations, both inside and outside the government, the possibility is there for the government to make some good progress. According to the November 2006 Progress Report from the EU, Macedonia has already made "notable progress in parts of the energy sector, in particular as regards internal energy and energy market related

[103] "General: Country," Ministry of Environment and Physical Planning.

legislation."[104] It has, on the other hand, a lot more work to accomplish regarding the actual implementation of said legislation, which the same report calls "a matter of priority." So FYROM has the political and legislative framework in place for energy growth, and having overcome a difficult recent history, now must look to its environment and natural resources to meet the demands of the international community.

[104] "Enlargement Strategy and Progress Reports," *The European Union*; available at ec.europa.eu/enlargement/key_documents/reports_nov_2006_en.htm.

Chapter 3

Current Renewable Energy Technologies

During the past two chapters, the various types of renewable energy sources were mentioned in the context of their present development in Croatia and Macedonia. Yet in each situation the descriptions were brief. This chapter will focus on more detailed illustrations of the renewable energy technologies available today, including the costs, requirements, benefits and drawbacks, and outputs associated with each. In addition, it will be advantageous to look at successful examples of functioning projects from different locations around the globe, in order to gain a more complete picture of what solar, wind, hydro, geothermal and biomass technologies are capable of contributing to the energy sector.

Solar Energy

The sun's rays are the most abundant form of energy available; they shine on all countries of the world, they can be harnessed even on cloudy days, and they are free. The sun provides more than enough energy for the entire global population. In fact, the amount of sunlight that hits the earth's surface is 2850 times as much energy as humans can consume. Of course it isn't distributed evenly around the world, and so some regions clearly receive more light than others. While the worldwide average square meter of land gets enough energy to produce 1700kWh annually, Europe's exposure equates to approximately 1000kWh/year and the Middle East has an average of 1800kWh/year.[105] Despite these differences, the large majority of the habitable parts of the earth are appropriate for solar energy use.[106] According to 2001 data, just 1% of the world's unused land receives enough sunlight to generate 3.7 times the amount of energy as the current primary energy consumption.[107] If this percentage of unused land is raised to ten, then the amount of possible energy collected is 117 times the current primary consumption. These numbers are remarkable, but they don't tell the whole story, for this sunlight must be collected and transferred into a usable form.

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[105] "Global Energy [r]evolution: A Sustainable World Energy Outlook," *European Renewable Energy Council* and *Greenpeace International*; Stuttgart, Jan. 2007; pg. 72.
[106] Figure 11.10 is a map of the area the WEC deems appropriate for solar energy, from "Solar Energy," *Survey of Energy Resources*; World Energy Council; London, 2007; available at www.worldenergy.org.
[107] *Ibid.*

There are two main ways the sun's energy can be harnessed for human use: via photovoltaic systems (PV) or via solar thermal (ST) systems. The first case is the one most people are familiar with, and it involves the installation of solar panels to absorb sunlight.[108] When the rays hit solar cells in these panels, they excite electrons in semiconductor material (usually silicon) which create a current of electricity. What happens from there depends on the specific type of PV network being used. If a unit is grid-connected, any excess electricity not used by the building is directly sold to the power company and then imported during non-daylight hours. If the system is "grid-supported" it contains a back-up battery which is charged completely before any electricity is sent to the grid. Then it can take electricity from the battery if necessary, before importing from the grid. The third PV option, or the "off-grid" system, operates independently and stores the energy in a large battery. Via an AC inverter the energy is able to power all of the building's needs. Generally, however, solar literature refers to systems as either 'grid' or 'off-grid.'

Solar thermal systems, on the other hand, collect the sun's rays using various methods and focus the energy to generate heat, which can then be used in several ways. While PV systems generally are smaller and are used for individual buildings, or a small group of buildings, ST systems are used more often in large power plants. There are three designs of these power plants, all which essentially operate on the same principle. In systems using parabolic troughs, rows of trough-shaped mirrors focus the sun's rays onto a tube of thermal transfer fluid, heating the substance which then is pumped to produce superheated steam and subsequently can be used in steam-powered cycles. The central-receiver method uses a circle of mirrors that can individually track the sunlight and redirect it on a central receiver in the middle, where it is concentrated as heat. The third method, the parabolic dish, is a large dish-shaped mirror with the receiver located at the centre. The shape catches the sunlight and sends it to this receiver, which again creates heat that is transformed into electricity.[109]

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[108] "Energy [r]evolution," pg. 72; all of the following technical descriptions of PV and ST solar systems comes from this source.
[109] *Ibid.*, pgs. 72-4 contain excellent illustrations of both PV and ST systems, as well as the variations of each.

Of the three, parabolic troughs are the most developed, largely due to the nine plants constructed in Southern California from 1984-1991. These plants have approximately 2 million square meters of troughs, which are connected to the electricity grid to produce 800 million kWh annually. The world's leading region of solar power is Asia, where China and Japan have a combined ST capacity of over 50 million m^2.[110] Four of the top ten leading companies producing solar cells and modules are Japanese, and they produced 49% of the world's total in 2003.[111]

In Europe, Germany has the largest amount of ST systems with 7,109,000 m^2 installed in 2005 (or 4976.3 MWth), followed by Greece and Austria. In the EU, over 17 million m^2 were installed in 2005 (or 12,000 MWth), up about 12% from 2004.[112] Even with this increase projections indicate that the EU will not be able to match a white paper's 100 million m^2 goal by 2010. Germany is also the leader of PV systems in the EU, with a total of 1537 MWp (both off-grid and grid) installed at the end of 2005. The next country is Spain, whose total capacity is 51.8 MWp, followed by The Netherlands' 50.776 MWp.[113] The EU total is 1,791.712 MWp, which means that Germany alone has over 85.8% of the PV market and roughly 40% of the ST systems in the EU. While this is great for the solar market in Germany, it forces the entire market to be extremely sensitive to just one country's developments. In 2002, for example, there was a lag in the Germany solar sector, and the whole market suffered for it.[114]

Nor are these numbers stagnant. In the beginning of 2007, Germany announced that it will build a new solar plant at the end of 2007 in its Saxon region that will generate 40 million kWh/yr.[115] Projects totaling 1000 MW are being planned in all parts of the globe, including Greece, Italy and Spain.[116] In fact over the past decade, the global production of solar cells has jumped approximately 32% every year and 45% in 2005,

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[110] "Solar Energy," *Survey of Energy Resources.*
[111] Zahedi, A.; "Solar photovoltaic (PV) energy; latest developments in the building integrated and hybrid PV systems;" *Renewable Energy*; Vol. 31 (2006), pg. 712.
[112] "Innovation and technological development in energy;" from "Energy," European Commission; Brussels, 2007; available at ec.europa.eu/energy.
[113] *Ibid.*
[114] "2004 Annual Overview Barometer," *Renewable Energy Journal*; No. 14, Dec. 2004; EurObserv'ER; pg.48.
[115] "First Solar to Supply Modules for 40 MW Solar Plant in Germany," *Renewable Energy Access*; Feb. 16, 2007.
[116] "Solar Energy," *Survey of Energy Resources.*

highlighting the growth associated with this multi-billion US Dollar industry.[117] As technological improvements of all forms of solar energy continue, the price of purchasing and operating solar systems will decrease and the worldwide market is expected to keep on growing.

At the present, however, the price of solar systems is considered to be one of its main drawbacks. The reason for this is the cost of development and production of the silicon in solar cells is rather high. Scientists have experimented with other materials, but their outputs are not nearly as efficient as silicon. Consequently, the price of solar energy is significantly higher than other renewable sources and much higher than traditional fossil fuels. As a result it is difficult for a developing country to invest in this technology, since the initial costs would be much more than for other options.

This trend is changing rapidly, though, given the pace of solar energy research. In 2002, the World Energy Council estimated that PV systems could cost anywhere from 4-18 USD per Watt.[118] Yet in 2005 scientists at the United States Department of Energy's National Renewable Energy Laboratory believed that it would not be long before PV cost less than 3 USD.[119] Different companies around the globe are working together to develop new types of solar cells which could be less expensive. For example, two large solar companies announced in April 2007 a joint venture to produce a newer, thinner and more flexible silicon panel.[120] At the autumn 2006 meeting of the American Chemical Society, scientists revealed no less than three exceedingly different techniques to improve solar cells made of non-silicon material.[121] Even more recently, scientists announced a significant increase in the efficiency of a plastic solar cell, up to 6%. While its output is nowhere near that of silicon (presently just over 40%), it is fast approaching the marketable line, and could be competitive with silicon in a matter of years.[122] If successful, the plastic solar panel would be much lighter in weight and more flexible in terms of where it could be applied. There is even discussion of it being painted onto houses. These few telling examples illustrate not only how much research is conducted

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[117] "Powering Up," *The Economist*; Sept. 16-22, 2006; pg. 91-92; and Zahedi, A.; pg. 712.
[118] "Solar Energy," *Survey of Energy Resources.*
[119] "Cost-Competitive Solar Called 'Imminent'," from *Renewable Energy Access;* July 21, 2005.
[120] -"Sunfilm Plans to Reduce the Cost of Solar Panel Manufacturing," from *Renewable Energy Access;* April 6, 2007.
[121] "Powering Up," *The Economist.*
[122] "Plastic Solar Cell Efficiency Hits 6% in U.S. Lab," from *Renewable Energy Access;* May 4, 2007.

daily to decrease the price of solar energy, but also how varied the methods are that scientists are exploring.

The other traditional drawbacks of solar energy include the fact that they are fruitless at night and on cloudy days, and that they are very heavy. Fortunately, these issues are also constantly being improved on, and most solar panels still collect energy on days when the sun isn't shining. Of course, they cannot possibly still receive energy during the night, but the back-up batteries and grid systems available now can counter that obstacle. Finally, as seen in the previous paragraph, the weight of silicon solar panels is being adjusted, either by cutting the amount of silicon or by using a different material altogether.

Proponents of solar energy are quick to point out its benefits, of which there are admittedly many. First, evident from the descriptions above, there are a number of ways in which solar energy can be harnessed, thus allowing for flexibility and a wider range of applications. Second, PV units have proven to be particularly practical technology in remote areas that have no access to an electricity grid. With so much of the world's population still without electricity, "off-grid PV electricity supplies, such as PV-driven water pumping systems, small solar home systems (SHS), and small village grids are suited to greatly alleviate this situation."[123] Small systems can be used for a variety of functions, while bigger units can be coordinated to provide energy to a small community or group of buildings. Additionally, solar systems can be used for remote industrial purposes, often with back-up batteries.[124]

Third, they produce no noise or combustion, and do not disturb the environment in any particularly intrusive way. This is a complaint about other sources of energy, as will be seen later. Moreover, the new flexible technologies for panels mean that in addition to being mounted on roofs and in fields, solar cells will eventually also be painted, rolled and generally applied to a much broader spectrum of surfaces, thereby decreasing the space they consume and becoming less space-consuming.

As an example of a particularly interesting, unique and successful solar energy program, it would perhaps be best to look to Europe's leader in the sector, Germany.

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[123] Hoffmann, Winfried; "PV solar electricity industry: Market growth and perspective," *Solar Energy Materials & Solar Cells*; Vol. 90 (2006), pg. 3290.
[124] *Ibid.,* pg. 3289.

Judging from the aforementioned statistics, one could easily assume that the Germans have been employing solar technology on a large scale for decades. In reality, the sector struggled until 1998—the German solar 'boom' has been around for less than a decade. Early advocates pushed to develop the market in the early and mid-1990s, but to no avail. It wasn't until the "100,000 roof" program launched in 1998 that the industry started to take off. Grassroots initiatives plus the threat of two U.S. solar companies to close their German plants pushed the program into being. Two years later, in 2000, the German feed-in law (EFL) was revised so that users of renewable energy would receive remuneration from power companies for 20 additional years.[125] These combined techniques caused the solar sector to grow exponentially in just four short years from 1999-2003.[126] Now, as evidenced above, Germany is far and away the leader in solar energy capacity in Europe.

Wind Energy

Like the sun, the earth's wind resources are capable of producing more than the worldwide consumption of electricity. As a resource, it is spread across all continents regardless of the climate. Although it does experience some periods of lower intensity—due to seasons or local weather patterns—wind is not at the whim of day/night cycles. These characteristics have encouraged the development and use of wind energy in all parts of the globe for decades, and thus there is currently a myriad of models and sizes of wind turbines to accommodate a variety of geographical and weather conditions.

As a result, the wind industry is the "world's fastest growing energy source."[127] According to the European Wind Energy Association (EWEA), the growth of the wind market reached new levels last year, with 7588 MW of wind power capacity installed in 2006. This is a jump of 23%, represents a cumulative investment of 9 billion EUR, and brings the EU total wind capacity to more than 48,000 MW. This much energy equates to 100 TWh of electricity per year, or 3.3% of the total consumption of electricity among all Member States.[128] The EWEA also estimates that during 2006, the EU generated

[125] Jacobsson, Staffan; and Bergek, Anna; "Transforming the energy sector: the evolution of technological systems in renewable energy technology;" *Industrial and Corporate Change*; Vol. 13, No. 5, 2004; pg. 834.
[126] Hoffmann, pg. 3299.
[127] "Energy [r]evolution," pg. 74.
[128] "European Market for Wind Turbines Grows 23% in 2006," *European Wind Energy Association*; Brussels; February 1, 2007; available at www.ewea.org.

roughly 50% of the entire world's installed capacity. The leading country in this sector? Again, Germany is ahead of the other Member States, followed closely by Spain. These two together account for 50% of the entire EU market.[129] Behind them are France, Portugal, the UK and Italy. Notably, in the EU-10 wind installations increased threefold during 2006, thanks largely to Poland, Lithuania and Hungary. While the total capacity doesn't approach that of the leaders, it is clear that the newer members are also joining this market. The report also notes that Romania and Bulgaria installed some, albeit a small number, of wind turbines last year.[130]

Not only are Germany and Spain the leading countries in Europe in terms of total installed capacity, they are also at the head of the *global* wind sector. The global total installed capacity at the end of 2006 was 74,223 MW. Of this, 11,603 MW came from the United States, putting it in third place, followed by India and then Denmark. France and Canada both joined 11 other countries to now have over 1000 MW of installed wind capacity. New projects in China helped that country to more than double its 2005 capacity and added to Asia's overall growth. Canada, young African countries and the Middle Eastern market all grew considerably in 2006 as well compared to their previous wind energy abilities.[131]

Wind technology has been used for decades, first as simple windmills and then as more developed turbines. Most of the commercial turbines of today have three blades, attached to a rotor that connects and transfers power to a generator via a gearbox. The electricity then travels down the shaft and is connected to a grid. Generally, a modern wind turbine works in a wind range from 3-4 meters/sec up to 25 meters/sec. If the wind happens to be too strong at a given time, the machines can do one of two things: either "stall" or reduce the electrical output so as not to overload, or to change the angle of the blades so the simply no longer resist the wind (called "pitch control"). Turbines can be set to turn at a constant rate, or at a variable speed that depends on the strength of the wind.[132] Since the essential principles of wind technology remain the same, engineers have been able to develop various sizes and strengths of turbines to use in a range of

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[129] "2006 New Installation: EU 25," *EWEA*.
[130] "European Market for Wind Turbines Grows 23% in 2006," *EWEA*.
[131] "Global wind energy markets continue to boom – 2006 another record year," *Global Wind Energy Council*; Brussels, 2007; available at www.gwec.net.
[132] "Energy [r]evolution," pg. 74.

conditions. In the 1980s in California, installed units varied from 20-60 KW outputs; in 2005 the average was 1282 KW, while the largest unit operating today has a capacity of 6 MW.

Turbines of this enormous size are targeted for offshore use, which is a special segment of the industry. Presently, the existing offshore wind farms account for only approximately .4% of the total wind market, yet there is a new focus to develop this emerging sector.[133] The International Energy Association (IEA) estimates that by 2030, over 40% of OECD's wind power could come from offshore sources, comprising around 80% of the global total offshore wind capacity.[134] Offshore wind farms are being harnessed because the wind is generally stronger and more constant at sea. Accordingly, larger and stronger turbines must be built there, as the typical ones used on land would never last. The implementation of offshore wind energy obviously requires additional materials and construction methods, not only to build and erect turbines capable of withstanding the natural elements, but also to connect these turbines to an electricity grid.

In fact, this highlights one of the two main drawbacks of wind energy, which contribute to its price. The IEA estimates that at a good site the costs are similar to conventional technologies, yet moderate sites can cost between 45-55USD per MWh—a significantly higher price than fossil fuels.[135] The first cause of this price increase is the need, and sometimes the difficulty of connecting the turbine(s) to a grid. Unlike solar power's small, independent systems that can be used for one building, a wind turbine must be connected to a grid. If the wind farm is located quite far from the grid, extra costs are incurred during the transportation of the electricity. Of course, if the turbines are close to the grid the costs are less.

The second factor adding to this cost is the fact that wind patterns are unpredictable, and can not be known earlier than 36 hours in advance. The result is that sometimes wind power can be intermittent. During instances when there is not enough wind to provide enough energy to the grid, alternative methods must be called upon to

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133 *Ibid.*, pg. 75.
134 "World Energy Outlook 2004," *International Energy Agency*; Paris, 2004; available at www.iea.org; pg. 235.
135 *Ibid.*

make up the difference. On short-term notice, this can be an expensive step.[136] These two factors can add anywhere from 11-33% more to the price of electricity at a moderate site, and 9-27% at a good location.[137]

Other disadvantages of wind turbines focus more on their physical attributes: their size, the noise they generate, and their effect on the surrounding wildlife, specifically birds.[138] The machines must inherently be large to reach the necessary wind – that is an unavoidable characteristic. While older models were indeed very noisy, any newly designed model produces much less noise during operation. A quick look at the webpage of any turbine manufacturer will tell how quiet their turbines are. There has been a large amount of concern among environmentalists, especially among zoologists, for the bird populations where wind farms are erected. Many fear that the local birds will be killed or at least greatly affected by this large imposition on their habitat. Interestingly, a recent study showed that in the U.S., wind facilities are causing no "measurable changes in bird populations."[139]

As specific example of successful wind energy implementation, Denmark is the perfect candidate. Often considered to be something of the 'darling' of Europe's wind market, the Danish had 3129 MW of installed wind power at the end of 2005—a substantial number considering its geographical and population size. A report released in December of 2006 stated that 20% of the Danish electrical consumption comes from wind energy.[140] Denmark is perfectly situated for offshore wind development; surrounded on three sides by the sea, it is a geographically ideal location to exploit this resource. Two large offshore wind farms, Horns Rev and Nysted, are the result of a 1997 government action plan to encourage wind development. Since 1999, however, these two have been criticized for disrupting the marine environment in which they were constructed. In the eight years since, a collaboration among the Danish Energy Authority, Danish Forest and Nature Agency, Dong Energy and Vattenfall (the owning firms of Horns Rev and Nysted) studied the ecological effects of these two offshore

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[136] *Ibid.*
[137] *Ibid.*, pg. 236.
[138] For an interesting take on the wind market, and a thorough discussion of its negative aspects see Pasqualetti, Martin J.; "Morality, Space and the Power of Wind-Energy Landscapes," *Geographical Review*; Vol. 90, No. 3 (Jul. 2000); pg. 381-394.
[139] "Wind Turbines Not a Threat to U.S. Bird Population, Says Study," *Renewable Energy Access.*
[140] "Denmark to Increase Wind Power to 50% by 2025, Mostly Offshore," *Renewable Energy Access.*

farms. The optimistic findings were released in December, and an evaluation by the International Advisory Panel of Experts on Marine Ecology was extremely positive as well. As a consequence, the Danish government is already planning to double both Horns Rev and Nysted in efforts to increase the national and EU percentage of electricity produced by wind energy.[141]

Hydro Energy

Hydropower is similar to wind in that it has been around for a long time. Humans have been harvesting water to create energy for over a century. Presently, hydropower provides about one-fifth of the world's electricity.[142] While this sounds impressive, it is essential to note that not all hydropower is considered to be 'good.' Much of this output comes from large concrete dames, built to stop the flow of a river entirely and subsequently control the amount that flows out. These structures are actually harmful to the environment around them, drastically altering their local ecosystems via flooding, often with negative consequences. Thus, when referring to hydropower as a renewable resource, what is implied is the smaller "run-of-the-river" type technologies, often called small hydropower, or SHP.

Of course, with different systems it can be difficult to distinguish, and as of now there is no international definition of what the limit is on an SHP. For instance, in China a plant can qualify as an 'SHP' if it has a capacity up to 25 MW, while in India the cap is 15 MW, and in Sweden the maximum SHP has 1.5 MW. Despite these discrepancies, the 10 MW benchmark is becoming accepted in Europe.[143] Perhaps the reason China's limit is so high is that the Asian continent has such an incredibly high potential for hydropower, followed distantly by Latin America. Asia, especially with developments in China, is expected to become the world leader of hydro-electric generation. By the year 2010, the WEC estimates that the entire global output of hydropower will be 55GW (in 2000 SHP output was 37 GW), with China leading the way in new installations.[144]

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[141] *Ibid.* The full 144-page report can be read at "Danish Offshore Wind: Key Environmental Issues," DONG Energy, Vattenfall, The Danish Energy Authority and The Danish Forest and Nature Agency; Nov. 2006; available at www.ens.dk/graphics/Publikationer/Havvindmoeller/havvindmoellebog_nov_2006_skrm.pdf.
[142] "Energy [r]evolution," pg. 77.
[143] "SHP in the World," European Small Hydropower Association (ESHA); Brussels, 2007; available at www.esha.be.
[144] *Ibid.*

SHPs don't stop an entire river's flow, but rather only use a portion of the free-flowing water to generate energy. Specifically, when a hydro-station is constructed, the engineers find a location of a strong river where a sort of artificial head can be created. From this, the water is temporarily diverted to run by a turbine, where the electricity is generated. In this situation, unlike the dam, the water is neither contained nor held for a long period of time before flowing back out into the river.[145] There are two types of turbines, each designed for a different scenario on the river. If the location has a high 'head' (the term for the amount the water falls) and a 'small' discharge, it will probably use an impulse turbine. Here, a jet of water works counter to the runner blades, thereby creating momentum which is converted into energy and sent to a grid. In the second option, with medium- to low-heads and medium to large discharges, the reaction turbines "run full of water and in effect generate hydrodynamic 'lift' forces to propel the runner blades."[146] From there, again, the energy is converted and sent out of the hydropower plant.

In Europe, the European Small Hydropower Association (ESHA) reports that the potential for SHP is drastically underutilized. In 2004 the EU-15 Member States had about 14,000 SHP plants operating, at an average size of 0.7 MW, with a totaled installed capacity of 10,000 MW and generating 40,000GWh/year of electricity. The EU-10 New Member States had 2800 active plants at a size of 0.3 MW, for a total installed capacity of 9820 MW and generating 2300 GWh/year of electricity. The leading country in SHP was Italy, followed by France and Spain; of the new Member States both Poland and the Czech Republic had 2% of the total EU-25 capacity, far above the other newcomers.[147] While the EU-15 has already exploited nearly 65% of its potential SHP resources, the EU-10 has only made use of roughly 20%.[148] Interestingly, according to the same report, the EU Candidate Countries have a higher potential SHP capacity than the current Member States (at the time of the report, 2005; Romania and Bulgaria were not yet Members of the EU).

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[145] "Energy [r]evolution," pg. 77.
[146] *Ibid.*
[147] "SHP in Europe," ESHA.
[148] "Small Hydropower," European Small Hydropower Association with European Renewable Energy Council; Brussels, 2005; available at www.erec.org.

Supporters of hydropower are quick to point out the sheer abundance of water as one reason for its development. Additionally, the length of time it has been used means that SHP technology is proven and reliable, with well-developed systems and established grids. This increases confidence of investors and consumers alike. Because SHP plants are located on rivers, there is little land usage. The small size of SHP means they can be built on small rivers as well as large ones, i.e. they do not require a large space and can therefore be constructed virtually anywhere there is a river and a nearby grid. These small plants are thusly useful in the electrification of isolated areas. When the peak consumption is satisfied, the electricity can be sold back to the national grid, bringing revenue to a small, remote location.[149] Another interesting point about SHP is that they draw users' attention to maintaining the conditions of their rivers. As noted by the World Energy Council,

> *With good planning and good management, hydropower is a catalyst for the sustainable improvement of people's lives... Hydropower stands at the crossroads of two of these key areas: water and energy. The integrated use of water and energy is an important component of sustainable development. Wherever suitable sites are available, hydropower offers the possibility to assist in meeting both of these basic human needs.*[150]

It is clear that environmentalists would support SHP even though they may shun its much bigger, much less sustainable relative described above. The WEC also comments on the cost of hydropower, and points out that normally the operation costs of an SHP are only 1% of its investment costs, thus making it a financially secure long-term investment.

The most often-cited disadvantage of hydropower is its effect on the environment. This is a major obstacle to Europe's developing its full hydro potential that *EurObserv'ER* highlights: "despite the existence of real potential, any new project clashes almost systematically with local opposition that heavily weighs down on the sector's dynamism."[151] Although the effect of SHP on the local habitat is minimal, especially compared to large dams, the inevitable fact remains that rivers flow downstream, and any use of the river in one location will influence the area downstream. Furthermore, because hydropower has been used for so long, a deal of the plants are old

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149 "2004 Annual Overview Barometer," *Renewable Energy Journal*; pg. 48.
150 "Hydropower," *Survey of Energy Resources*; World Energy Council.
151 "2004 Annual Overview Barometer," *Renewable Energy Journal*; pg. 49.

and outdated, requiring renovation or even complete overhauling. In the EU-25, almost 70% of SHP plants are over 40 years old.[152] This leaves a big hole in the industry where efficiency is concerned, since obviously anything built 4 decades ago will not be nearly as efficient as the new models.

The case of SHP in Slovenia is an interesting example to look at, because despite the country's small size and limited resources, it is one of the most successful of the EU-10 countries when looking at its hydropower statistics. Since 1990, the industry has grown steadily every year, with forecasts continuing in the same direction. During that period, the number SHP has nearly grown one and-a-half times over, with the country adding about 29 MW of capacity. In 2002 there were 478 SHP plants operating with a combined capacity of 110 MW and electricity generation of 259 GW/year.[153] Behind large hydro plants, SHP is the second largest contributor of renewable energy in the country. Equally important as the quantity of plants is the age of the plants. Of the 400 total plants used in by ESHA's 2004 study, 353 are less than 20 years old. This means that 88% of the SHP is new, reliable and efficient, and is striking when compared to other states. For example, the Czech Republic also has an impressive amount of SHP, but only about a fourth of its plants are under 20 years old, while the majority are between 40-60 years old.[154] The total SHP potential of Slovenia is 1400 GWh/year of energy, although the feasible potential is half of that. To the time of the report, 40‰ of these resources had been exploited. Unfortunately, the past decade has been difficult for the Slovenian small hydropower industry, and presently the biggest obstacle to further development is local opposition and bureaucracy. If these can be overcome, ESHA believes SHP in Slovenia will be able to make a good comeback.[155]

Geothermal Energy

When the phrase 'geothermal spring or well' is mentioned in a normal context, usually the first thing to come to mind is a spa or bath house. Yet geothermal energy reaches far beyond this blissful picture. Unlike the previous three forms of renewable

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[152] *Ibid.*
[153] "Small Hydropower Situation in the New EU Member States and Candidate Countries," *Lithuanian Hydropower Association*, *ESHA*, *IT Power Renewable Energy Consultants*, and *ADEME*; Sept. 2004; available at www.esha.be.; pg. 10.
[154] *Ibid.*, pg 56.
[155] *Ibid.*, pg 56.

energies, geothermal is inherently different because it is not nearly as prevalent as sunlight, wind or water. In fact, geothermal resources only exist in specific places on the earth, and if a country does not happen to be sitting on top of them, then this technology is not an option for it. Geothermal sources are concentrated in the west of the U.S., Iceland, Asia, New Zealand, and West and Central Europe.[156] Moreover, the use that energy goes to depends on the temperature of the geothermal source, further limiting the options for its employment. The acknowledged categories are high temperature (above 150°C), moderate (90-150°C), and low (less than 90°C). Only high temperature is used for electric power plants. The moderate temperature energy is utilized in direct use technology, e.g. agriculture, industry, commercial greenhouses, building heating, balneology, etc. Low temperature geothermal sources are usually tapped to provide space heating, although some can also function in the same way as moderate temperature.[157] Although geothermal sources can only be used for particular purposes, these sources of energy provide enough output to be seriously considered among the others RES.

In truth, the quantity of heat available from the earth is "enormous," according to the WEC. They estimate that "more than 100 million GWh of heat energy is conducted from the earth's interior to the surface." The problem is that this heat diffuses on its way to the surface, and so the only locations with direct streams of heat are those lying on Teutonic Plate fault-lines.[158] This explains why Italy, California, the East Coast of Asia and the South Pacific have so much geothermal output, while, for example, Kansas or Ghana do not. The Geysers in California are presently the most powerful geothermal sources on the planet, and they have been tapped for use since 1960. Wairakei field in New Zealand predates that by two years, and Lardarello field in Italy has been running since 1913.[159]

When comparing geothermal outputs and potentials, it is useful to discuss two separate categories, electricity and heat, since only countries with access to high

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[156] "Energy [r]evolution," pg. 77.
[157] "Energy Efficiency and Renewable Energy," *U.S. Department of Energy*; Washington, D.C.; 2007; available at www1.eere.energy.gov. This webpage provides an excellent and thorough summary of how the various types of geothermal sources and plants work.
[158] "Geothermal Resources," *Survey of Energy Resources*; World Energy Council.
[159] "Energy Efficiency and Renewable Energy," *U.S. Department of Energy.*

temperature sources can produce electricity. In 2003, there were only five such countries in the EU. They were, in descending order, Italy with the lion's share of 790.5 MWe, Portugal, France, Austria and Germany. That is an impressive turnout for Italy, with over 95% of the EU total of 822.98 MWe.[160] The heat sector embodies both moderate and low temperature sources, which allows many other countries to participate. Italy was again the top producer, with 486.51 MWth, while France followed closely with 330 MWth. The EU total in 2003 was 1130.61 MWth—a 75% growth from 2002—spread over 12 countries. However, in the lowest temperature category, which produces geothermal heat pumps, Sweden was by and far the biggest producer, generating 212,000 units with a 1270 MW capacity. It was followed by 11 other EU Member States, in second place Germany and third France. The EU total was 435,350 units with a 4153 MW capacity.[161] In 2005, geothermal energy accounted for 5.5% of all EU renewable primary energy production, and 1.2% of all renewable electricity generation.[162]

Very different technologies must be employed to utilize the geothermal sources, because of their extreme (or not so extreme) temperatures, as well as the depth to which some of the sources lie. Also important is the use for which the source is tapped. Therefore high temperature sources being used for electricity are tapped at three different types of power plants: dry steam, flash steam and binary cycle. Dry steam plants are the most basic and the oldest of the three, yet are still very effective. Flash steam systems are especially good for extremely high temperature wells, while binary cycle plants are better for temperatures closer to the moderate range. Because moderate temperature sources are the most plentiful, it is likely that this type of power plant will become the most popular in the future.[163]

The direct-use systems used to tap moderate geothermal sources reflect the variety of purposes that they serve. Each of the functions of this category have different optimal temperatures, thus industrial and commercial uses may require a different intensity of energy than space heating, which could be different from greenhouse and aquaculture needs. This setup is interesting because it allows for what is called a

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[160] "2004 Annual Overview Barometer," *Renewable Energy Journal*; pg. 49.
[161] *Ibid.* pg. 50.
[162] "Innovation and technological development in energy;" from "Energy," European Commission; Brussels, 2007; available at ec.europa.eu/energy.
[163] "Energy Efficiency and Renewable Energy," *U.S. Department of Energy.*

'cascade' system, whereby the geothermal energy is used for one purpose, after which it has cooled a bit and can be used for a different purpose, and so on and so forth. Popovski and Vasilevska's study of geothermal potential in agriculture has an excellent diagram of the multi-faceted potential of temperature cascades.[164] This drawing depicts how energy can leave the plant at an extremely high temperature to be used by industries for their own purposes as well as water and space heating; then it moves at a slightly cooler temperature to the town district heating scheme, then, cooler again, to an agriculture centre where it can heat greenhouses, dry produce and be used for open field heating; then it moves to a balneology and recreation are to heat pools and spas; the next stop is an aquaculture tank to be used appropriately; and finally the cooled energy is taken to the re-injection well to be used again.

Low temperature sources are used mostly for heat pumps, also called ground level heat pumps. They can be used for both space heating and cooling, proving useful all year long. The basic principle of these heat pumps is to use the earth's own heat to either warm or cool a building. By relying on the fact that the earth's own temperature is rather constant, the heat pump pulls the heat out of the ground into the building during the winter and pushes the warm air out of the building and back into the ground during the summer. Therefore, it works as a sort of cycle or loop with the earth, always using concentrated natural heat to accomplish the task, instead of fossil fuels.[165]

This highlights a true benefit of geothermal energy, the fact that it is clean and operates without any need for combustible fuels. Some geothermal fields release carbon dioxide, but the amount is a fraction of that emitted by a clean natural gas fuelled plant. Binary cycle plants, described above, release almost zero emissions, since their entire cycle is looped and nothing escapes except the electricity. In addition, any minerals or salts that are left after the process are reinjected into the well, ultimately recycling and replenishing the source.[166] So the total environmental impacts are minimal. Also, the energy is available all day long, and is subject neither to the whims of weather patterns nor to the earth's daily rotation.

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[164] Popovski, Kiril; and Vasilevska, Sanja Popovska; pg. 552, Figure 1.
[165] "Energy Efficiency and Renewable Energy," *U.S. Department of Energy.*
[166] *Ibid.*

Clearly, one of the disadvantages of geothermal systems is the fact that as a global source of energy they are far from ubiquitous. The geographical limits prevent many countries from being able to use this type of RES. Also, it is possible that the source is more than a mile below the earth's surface, requiring intensive initial labor and high initial costs to set up the plant or facility. Fortunately, geothermal atlases are available now that can assist future developers in choosing and measuring locations for their projects. The specific temperature of each source is also problematic, as it limits the ways in which they can be tapped—if at all. Like solar energy, scientists are constantly working on a variety of ways to maximize this source and overcome current obstacles to efficiency. For example, in Alaska, geologists are working to try to lower boiling temperature of the wells there so that the presently-too-cool water will boil earlier and thus produce steam. In Iceland, scientists have found themselves in the opposite situation, and are trying to harness steam that is naturally too hot for use.[167] If these scientists, and others like them, are successful, they may be able to further expand the usage of geothermal sources around the globe.

It is no surprise that Iceland has geologists trying to improve the geothermal potential there, since Iceland is one of the most geothermally-prolific countries in the world. In 2002, the IEA estimates that the small island country was the third country in the world as far as its share of geothermal power in its total electricity generation. Geothermal electricity comprised about 16.5% of its total, behind the Philippines and El Salvador. Its geothermal resources are so well known that in March of 2006, Alcoa announced its intentions to build an enormous aluminum smelter just outside Husavik, in the north of the country, which will run predominantly on geothermal energy.[168] The site was chosen after an extensive and thorough study of nearly everything related to the environment there. For its part, Iceland welcomed the announcement, as it complimented its own desire to expand its geothermal capacity and broaden the scope of uses for its natural resources.

Biomass

[167] "Blowing hot and cold," *The Economist*; Sept. 16-22, 2006; pg. 92.
[168] "Alcoa & Iceland Study Geothermal-Powered Smelter for North Iceland," *Renewable Energy Access*; Mar. 7, 2006.

'Biomass' is an extremely broad term that is difficult to define, although one fair definition is "material of recent biological origin that can be used as a source of energy."[169] Further, domestic biomass resources include agricultural and forestry residues, municipal solid wastes, industrial wastes, and terrestrial and aquatic crops grown solely for energy purposes."[170] There is no one set of categories to divide this heterogeneous list into smaller groups, but rather it depends on the criteria used. The most common refers to the different type of fuels it comes from: wood, agro-fuels, and urban waste. Alternatively, one could also categorize them per their technological applications, i.e. traditional use (such as firewood) versus modern use (such as electricity).

Regardless of the chosen classifications, the amount of biomass available on the globe for human use is nearly uncountable. The WEC reports that "biomass resources are potentially the world's largest and most sustainable energy resource." The numbers that follow are astounding, as it continues to say that this RES "compris[es] approximately 220 billion oven-dry tons (odt) (or c. 4500 EJ) of annual primary production; the annual bioenergy potential is about 2900 EJ, although realistically only 270 EJ could be considered available on a sustainable basis and at competitive prices."[171] It emphasizes the imprecise numbers associate with measuring biomass when it expresses estimates of its future potential as anywhere from "67 to 450 EJ per annum."[172] Evidently this source of energy is difficult to assess.

What is possible to do right now, however, is to look at how this energy is harnessed for electrical and energy use. All power plants function much like those of natural gas, only the biomass must be processed before being burned. After that, the combustion engines, generators and grid connections are quite similar. The differences between the types of power plants, then, lie in the ways in which the biomass is prepared for combustion. For dry materials, liquids or gas, one of three different thermal systems is chosen; the most common of these is direct combustion, making up 90% of biomass processing globally. A more advanced process is called gasification, which is being used

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[169] "Energy [r]evolution;" pg. 75.
[170] "Energy Efficiency and Renewable Energy," *U.S. Department of Energy.*
[171] "Bioenergy," *Survey of Energy Resources*; World Energy Council.
[172] *Ibid.*

more frequently due to increased efficiency and decreased emissions. The third type is pyrolysis, which essentially 'speed-decomposes' the biomass by subjecting it to high temperatures in the absence of air. For very wet (but not liquid) biomass, two biological systems are employed to aid in the preparation: anaerobic digestion and fermentation.[173]

Although some consider wood to be separate from other biomass sources, this study will include it in the analysis because both Croatia and Macedonia have a large supply of forested areas which could be interesting to harness (see Chapter 5 for that particular discussion). In 2003, France was the EU's leading producer of primary energy from wood, with 9.28 million toe. Behind the French was Sweden and then Finland, with 7.92 million toe and 6.31 million toe respectively. The EU 15 produced 43 million toe in total that year.[174] The size of power plants can vary, according to their purpose and source, but it is generally noted that they are more efficient if located close to their source material. The average size is 15 MW, although there are some much bigger plants ranging up to 400 MW as well. The IEA estimates that by 2030 biomass will account for 2% of the worldwide electricity production, and will triple over the next thirty years. Interestingly, it also states that the largest increase will happen in OECD Europe, which will jump to 4%.[175]

One reason for this expected rise is that biomass is an excellent way to curb carbon dioxide emissions, and current concern in light of the global warming trend discussed in the Introduction. It can be used in conjunction with or in place of fossil fuels if the right technology is present. As government policies encourage a move away from oil, coal and natural gas, biomass products (including biofuels) will be an affordable and bountiful option for the general population to make use of. It is precisely their abundance that adds to their appeal, for there are not many corners of the earth where some type of biomass is not available. The IEA also predicts that in the future, traditional uses of biomass will be replaced by the modern ones, and thusly the growth will be in the electricity and power sectors.[176]

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[173] "Energy [r]evolution," pg. 76.
[174] "2004 Annual Overview Barometer," *Renewable Energy Journal*; pg. 52.
[175] "World Energy Outlook 2004," *International Energy Agency*; pg. 234.
[176] *Ibid.*

This is good news for the environment, as one of the drawbacks of biomass energy is that it is used very often, especially in less developed countries, for traditional purposes with traditional methods, i.e. cooking and heating. Without taking the proper steps, the process will not be CO^2 neutral. This is why advocates stress the need to keep plants close to their sources: harvesting, collecting, storing and transporting the materials from one place to the power plants expends a lot of energy. And if these steps are aided by carbon dioxide emitting machines, the efficiency and net benefit is lost. Another difficult aspect of this sector has already be discussed above, namely that the sheer number of the materials and their purposes make it a difficult source of energy to measure and predict. Of course, measurements and predictions are both made, but often with big discrepancies and uncertainties. It is challenging to effectively be aware of the industry if one study includes wood and excludes biofuels, but another excludes wood and includes biofuels. The inconsistencies make any thorough study difficult.

One thing that is perfectly clear, however, is that the Scandinavian countries are noted for making particularly good use of their wood bioenergy sources. Finland, for example, "covers 50% of its heating needs and 20% of the primary consumption of its 5.1 million inhabitants through the use of wood energy."[177] Those numbers both imply that Finland must have a large amount of forested area, as well as reflect an impressive commitment by the Finnish people to capitalize on their natural resources. Indeed, the country contains the globe's largest biomass fuelled power plant. It was built in 2001 in Pietarsaari, and is still running effectively today. It is an industrial plant that produces both steam (100 MWth) and electricity (240 MWe), supporting the local forest industry and heating towns nearby at the same time. The plant can generate its energy from a variety of materials, including wood by-products (barks, sawdust, wood chips and residues) as well as commercial bio fuel and peat.[178] In December 2005 the Finnish government released its new renewable energy program in which it announced its strategy to achieve its commitments to both the EU and the Kyoto Protocol. Foremost among the goals listed was to increase the total consumption of renewable energy to account for approximately one-third of its primary energy consumption by 2025. To

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[177] "2004 Annual Overview Barometer," *Renewable Energy Journal*; pg. 52.
[178] "Energy [r]evolution," pg. 76.

accomplish this, the government stressed the need to raise the use of logging waste biomass, in addition to field biomass, recycled fuels and biogas.[179] Finland's successful use of the variety of their local biomass sources is evidently a huge advantage for them to gain energy security, save money and be environmentally-conscious at the same time.

Throughout this chapter, a more detailed description of each of the major sources of renewable energy was provided to illustrate the scope of options available to developing countries today. It is apparent that each energy source has its advantages and its disadvantages, and it is precisely these characteristics which make them applicable or not to specific locations. Also, various countries within Europe were selected and described for each type of RES to give an example of a successful venture in each of the sectors. However, the success of an RES in any given country depends on a range of factors, including government policies, financing options and the availability of the necessary technology. These topics will be addressed in the next chapter.

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[179] "Finland Announces Renewable Energy Ambitions," *Renewable Energy Access*; Dec. 8, 2005.

Chapter 4

Practical Applications of RES: Government Policy, Financing and Technology Transfer

Renewable energy technologies are only one side of the entire implementation process. Equally essential are the practical applications of getting these systems up and running, and thus effectively contributing to a country's energy supply. While a variety of issues can fall into this category, this chapter will take a look at three of the most important ingredients. First, government policies and the specific tools which governments can use to encourage the growth of RES in their respective states will be reviewed. Feed-in tariffs, quotas, tax exemptions and grants are some of the schemes used to boost the renewable industry in countries today. Of course, governments can also affect progress by investing in the research and development (R&D) sector, which is the second topic of discussion. R&D financing, in both the public and private sectors, has long been recognized as a productive way to foment economic growth. This chapter will look specifically at this relationship in the energy sector, to see if this positive correlation between investment, innovation and development still applies. Another way innovation is created is simply by a transfer: countries that already have technology can bring them to countries that do not. The final part of this chapter, then, will consider this idea of technology transfer, and whether or not it could function in bringing RES to developing countries.

Government Policy

As mentioned above, there are various tools at the disposal of governments to help the renewable sector gain a firm footing in the market. Given the overwhelming dominance of fossil fuels at the current time, these state instruments are, by and large, a necessity if clean energy is going to be a competitive part of any economy. Because—compared to oil, natural gas and nuclear energy—RES are new as legitimate, large-scale sectors of the market, governments need to implement some policies to help them grow. In fact, in their study on RES policies in Germany, Sweden and the Netherlands, Jacobsson and Bergek noted that, *the first and overall policy challenge is to create conditions for processes of cumulative causation to appear in a variety of new energy technologies. Such processes are necessary for the transformation process to eventually become self-sustained, i.e. increasingly driven by its own momentum, instead of being dependent on repeated policy inventions.*[180]

The purpose of these 'inventions' is to form a market where those exact inventions are no longer necessary.

How are governments today trying to achieve this goal? One technique, the feed-in tariff (FIT), is widely regarded as the most effective option.[181] It is largely credited with making Germany's RES sector so successful and stable, and is employed in a number of other countries around the world, from Canada to the Czech Republic to China. FIT laws are at heart, a very basic concept. They require conventional utilities to allow renewable installations to use their grid, as well as buy electricity from those same renewable installations at a fixed, premium price. What makes this program so successful is that it can be tailored in any number of ways to fit a particular country's (or state's, as in the U.S.) situation. The length of time that the price of the tariff is fixed can be short-term or long-term. The tariffs can be specified to each type of renewable energy source, so that solar PV, for example, has a different tariff than wind power. Or, in the case of tariff digression, the laws are designed to reduce the amount of the tariff if the person or company installing renewable energy does so next year instead of this year, encouraging both faster establishment of RES as well as indirect technological innovation.[182] Additionally, these laws may stipulate that the renewable programs can be reviewed every few years to ensure that they are productive enough to warrant the tariff law, which can be adjusted accordingly. In Germany programs are reviewed every three years, while in France and Ontario the period for review is every two years.[183] This guarantees that the installations are efficient, maintained, and deserving of the tariff.

The German feed-in law was originally passed in 1991, a result of the efforts of a coalition of environmental groups, different political parties and the infant hydro and

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[180] Jacobsson, Staffan; and Bergek, Anna; "Transforming the energy sector: the evolution of technological systems in renewable energy technology;" *Industrial and Corporate Change*; Vol. 13, No. 5, 2004; pg. 838.
[181] Mendonca, Miguel; "Energy, Ethics and Feed-in Tariffs," World Future Council; 30 April 2007; available at www.renewableenergyaccess.com.
[182] *Ibid.*
[183] Gipe, Paul; "Electricity, Electricity Feed Laws, and Advanced Renewable Tariffs," Wind-Works.org; 2003; available at www.wind-works.org.

wind power industries. It was so successful in expanding the wind turbine sector that in the mid 1990s the Parliament considered rescinding it. During that time, the strength of the wind sector was mirrored in its newfound lobbying powers, and so the attempts to revoke the law met hostile counter-forces.[184] Ultimately it was kept, and in 2004 it was amended and updated. Today, it covers hydro, offshore hydro, wind, geothermal, solar and biomass energies, and gives specific tariffs for each type of power. The Bundestag states that this law will encourage energy sustainability, environmental protection, energy security and the facilitation of energy technologies. Finally it stipulated that by 2010 at least 12.5% of Germany's power supply would come from RES, and 20% by 2020. Today, the German feed-in law is credited with propelling it into its current position as one of the world's leading RES countries.[185]

Another instrument that some governments choose to employ to promote their RES sectors is a quota, often set or pitted against the FIT. Quotas are currently used in the UK, Italy and Denmark, for instance, and are often coupled with a tradable green certificate (TGC) system. Instead of focusing on the *price* of RES that utilities must use like the feed laws do, quotas specify the *amount* of RES they must use within a certain period. The utilities fulfill the quotas by getting the designated energy from a renewable installation and then receive green certificates, which they can bundle and sell to consumers. Theoretically, this tool is considered to be more efficient economically as well as in promoting competition and in lowering costs, in other words, more market-oriented.

The Netherlands was the first country to implement a quota system in the EU, in 1998, even though it changed to a more tax exemption-oriented system in 2001. During that period, six other EU countries introduced quotas, and presently quotas plus TGCs are used by Belgium, Denmark, Italy, Poland, Sweden and the UK.[186] From 1998-2001, twice as many European countries adopted quota systems than feed-in tariffs, although presently the latter option is much more prevalent in the EU. In their study comparing

[184] Jacobsson & Bergek; pg. 833.
[185] Morris, Craig; *Energy Switch: Proven Solutions for a Renewable Future*; New Society Publishers, British Columbia, Canada; 2006. Morris's book discusses Europe's, and particularly Germany's, success in implementing renewable power, and spends a good amount of space on the feed laws in Germany.
[186] Bechberger, MIscha; Reiche, Danyel; "The spread of renewable energy feed-in tariffs (REFITs) in the EU-25;" 2006; available at www.wind-works.org.

quotas and FITs, Bechberger and Reiche highlight three reasons why, during those three years, public confidence in FITs was very low, and hence the popularity of quotas. Since then, however, the situation has reversed, and now 17 EU Member States favor feed laws as a means to promote their RES sectors.[187]

Of course, countries have other options as well, and although the quota / tariff issue seems somewhat dichotomous and has sparked debate in the EU, these other possibilities are often used in conjunction with them and with each other. These include special tax programs, capital grants, subsidies, and procurement policies. Tax exemption programs, like the one the Netherlands chose over their previous quota-based one, are fairly simple, though, logically the specifics depend on the countries putting them to use. For example, in China wind power generators receive exemptions on import duties on wind farm equipment.[188] India's policy has a variety of tax plans to help bolster their wind sector, including a "concessional import duty on certain components of turbines, excise duty exemption, ten years' tax holiday on income generated from wind power projects, benefit of accelerated depreciation and loan from Indian Renewable Energy Development Agency (IREDA) and other financial institutions."[189] Germany, the UK, and some states in the U.S. provide tax exemptions for biofuels and renewables.

Capital grants are another type of program available for governments' use, when they financially back specific programs and prototype projects. These are most common in the demonstration phase of development but can also be seen in long-term projects. Perhaps the most obvious example of these is the numerous PV 'rooftop' programs in countries like Germany, Japan and the U.S. Germany's "100,000 Rooftops" program is believed to be the dominant factor in that state's remarkable surge in PV installations since its inception in 1999. Another option is subsidies, provided to reimburse, for example, the infrastructure costs of connecting new technologies to local grids. Yet another possibility are procurement policies, by which governments can 'hire' renewable technologies for national or local entities. In this instance, a town may provide business for a local geothermal company by using their electricity for municipal buildings.

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187 *Ibid.*, Table 1.
188 "China: Renewable Energy Policy Set in Motion," 17 Nov. 2005; available at www.renewableenergyaccess.com.
189 "India Reflects on Yearly Wind Power Growth," 28 July 2006; available at www.renewableenergyaccess.com.

Another example is the national government commissioning solar cells for aerospace facilities.

Clearly, there is a myriad of ways in which states can procure business from clean energy companies, thereby supporting the domestic renewable industry.[190] What's more, they don't have to choose just one instrument. The reader may have noticed that Germany was mentioned multiple times in the examples above. It is a prime example of a country whose policy is diverse and touches all types of RES, in order to promote as much growth as possible and not favor one or two technologies. Policymakers can choose to instate a quota system, for instance, and still award grants, give subsidies, design tax exemptions and procure work from RES suppliers to maximize their efforts to eventually create a market in which these means are no longer necessary. Yet there are still more ways in which governments can speed up this process.

It is necessary for governments to do more than just create benefits for people and companies that use RES if they want to achieve the aforementioned market scenario. They must also write and enforce policies which regulate the day-to-day aspects of the industry. What is the good of giving a capital grant to a clean energy demonstration project if there is no mechanism in place to ensure that it uses the money appropriately and legitimately? Why create tax exemptions for solar energy users if there is no regulation of the competition? And if a hydropower firm wants to build a new plant, is it worth the subsidy if they can't connect to the local electricity grid? These issues also fall into the realm of government policy: institutions, frameworks, regulation and enforcement mechanisms.

The importance of developing reliable institutions and good regulation methods, particularly in developing countries that are going through privatization, is at the forefront of important government policy according to the Stability Pact. As seen in the previous two chapters, both Croatia and Macedonia have recently experienced privatization and decentralization – and both are still feeling the effects of these processes. In the next chapter their present and future experiences with this situation will be analyzed, but for now it is important to point out that although these processes seem

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[190] Stern, Nicholas; *The Stern Review: The Economics of Climate Change*; 2006; available at www.hm-treasury.gov.uk; pg. 366.

immaterial for much of the developed world, they are still major issues in developing and transition countries. This is especially relevant to the energy sector, since it is commonly energy companies that are large and centralized, and that often have monopolies. If not handled correctly, privatization can have disastrous consequences on the economy in general, or on specific industries in particular.

Thus, when a government embarks on this journey, it should carefully consider its steps:

> *Privatizing network industries in transition countries in advance of competition enhancement and proper regulation poses great risks to efficiency gains, consumer welfare and the political acceptance of reform. But delaying divesture until good regulatory structures are in place might also be very costly, especially in the light of the slow pace of institutional reform in many SEE countries.*[191]

It is best to have a clear, medium- to long-term strategy with defined goals and overall clarity. Next, the state should set up regulatory frameworks be to ensure transparency, efficiency, competition and accountability. Only after these first two steps are complete does the Stability Pact recommend actually commencing the privatization process by restructuring state-owned companies for a market economy.[192] Naturally, these steps are all somewhat linked, and will probably overlap. Indeed, Jacobsson and Bergek note that "the legitimacy of a new technology and its actors, their access to resources and the formation of markets are strongly related to the institutional framework."[193] And the EU's 2006 Green Paper on energy states, "actions to accelerate technology development and drive down the costs of new energy technologies must be complemented by policy measures to open the market and to ensure the market penetration of existing technologies that are effective."[194]

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[191] "Regulatory Authorities in South East Europe," *Stability Pact: South East Europe Compact for Reform, Investment, Integrity and Growth*; OECD Public Governance and Territorial Development Directorate; October 2003; pg. 13.
[192] *Ibid.*
[193] Jacobsson and Bergek; pg. 821.
[194] "Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy;" 8 March 2006; from *European Union*; Brussels; 2007.

Not only do the actors and institutions need to be in place to optimize the RES industry, but the regulatory tools need to be functioning as well. This includes everything from permits and inspectors, to data collections systems and archives. Without these integral reinforcement pieces, the system could very easily be taken advantage of, and the subsequent market failure(s) would detract from the overall economy. For example, a study about the environmental regulatory mechanisms of South East European countries had some interesting conclusions. It began by confirming that most of the states had the proper laws and regulations "adjusted to the new political reality," which is good news. However, the investigation continued to report that ministries communicate with each other on a personal level instead of on official levels. It also cited that most Defense ministries barely contribute to environmental dialogue despite being among the worst contributors to environmental pollution and destruction. Furthermore, the study concluded that inspections are not regulated and data is kept in paper archives, not in electronic form.[195] Evidently, these countries have a lot of work to do before any RES technology will have the foundation and infrastructure to grow and thrive in a market economy. To merely pass legislation is not enough; the laws and regulations must be enforced if a new sector will develop.

Financing

In an extensive survey conducted by Reddy and Painuly in 2004, five groups of stakeholders were identified and interviewed about barriers to renewable energies, specifically about wind and solar power. The results showed that among both the residential and policy-maker categories, the number one barrier they perceived to investing in RES was 'economic and financial.' The industrial sector, on the other hand, believed that 'technical' barriers were the most deterring, while the commercial sector felt that 'the market' was the biggest obstacle, followed closely by the economic and financial problems. The final group was wind energy developers, but they had a different set of

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[195] Dimovski, Mihail and Glaser, Rob; "Environmental Enforcement and Compliance in South Eastern Europe;" BERCEN and The Regional Environmental Center for Central and Eastern Europe; Hungary; Feb. 2002; pg. 9.

options from which to choose, and consequently reported that the biggest problem they faced was 'land acquisition' followed by 'lack of infrastructure.' [196] In all, the data revealed that each group of stakeholders measured the possibility of RES in comparison to conventional energy, specifically to its low price. They also all expressed hesitancy to invest in renewables because of the risk involved; none wanted to engage in an enterprise they viewed as uncertain and risky.[197] This study illustrates that not only does the actual amount of investment in clean energy matter, but that popular perception of its financial viability plays a significant role as well. It is pertinent, therefore, to look at both public and private investments into RES to see first how much money is being devoted to energy, and then how the financing is understood by stakeholders.

Worldwide, approximately $10 billion (USD) was spent in 2004 on renewable energy deployment, i.e. the FIT, quota, grant, etc. programs described earlier. This seems like a considerable amount, yet it is only a fraction of the $150 - $250 billion spent every year on those for fossil fuels.[198] Logically, it seems that the renewables are at a serious disadvantage. This is stressed by Jacobsson and Bergek when they discuss the characteristics of the energy sector that make it so difficult for new markets to form:

> *New technologies often have a cost disadvantage in comparison to incumbent technologies and they many not offer any direct benefits for the individual buyer or investor (but reduce society's costs in terms of e.g. CO^2 reduction). In addition, incumbent technologies are often subsidized. This refers not only to R&D subsidies in the past, which were substantial, but also to other forms of direct subsidies... Incumbent technologies are also subsidized indirectly as there are various types of negative external economies associated with the use of conventional energy technologies.*[199]

Moreover, the amount spent on all sectors is only going to increase each year. The IEA estimates that from 2001-2030, the total world energy investment in oil, gas, coal and electricity will be $16,481 billion (in USD at 2000 levels).[200] Of that amount over 70%

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[196] Reddy, Sudhakar; and Painuly, J.P.; "Diffusion of renewable energy technologies—barriers and stakeholders' perspectives," *Renewable Energy*, Vol. 29 (2004); pg. 1439-1442.
[197] *Ibid.*, pg. 1443.
[198] Stern, pg. 367.
[199] Jacobsson and Bergek, pg. 816.
[200] World Energy Investment Outlook: 2003 Insights; *International Energy Agency (IEA)*;

will go to the electricity sector (11% to transport and 18% to 'other users').[201] Thus it is plain that over the next two decades energy investments will play an enormous role in the shaping of the sector.

When the state invests in its research and development (R&D) sector, it is best done in a variety of disciplines so as to create a broad portfolio instead isolating one or two industries. The German federal R&D program is designed to encourage all sorts of renewable development and promote a general 'creation of knowledge'; the results have been very positive with a wide range of knowledge and progress. The Dutch policies have been similar, with R&D directed in many directions. In the case of the Swedish wind sector, however, research investment was initially spent almost entirely on the development of (very) large turbines, and consequently stunted the growth of other technologies. Coupled with several other situational obstacles, this inhibited the entire industry, and the Swedish wind sector took much longer to take off than it theoretically could have.[202]

By investing in any industry in non-discriminate way, a state realizes that not every item in the portfolio will succeed. On the contrary, the fundamental nature of innovation and the market is marked by the fact that some technologies will succeed and others will fail – and, importantly, that it is near impossible to predict these outcomes. It follows then that the more types of innovation the portfolio contains, the better the chances of success. Taken in this light, it seems as if the bottom line of government investment is to merely spread money around to as many programs as possible. This is not entirely wrong. According to *The Stern Review*, the purpose of public energy R&D is to supply the knowledge that has less direct commercial applications and is thusly considered a 'public good.'[203] Such knowledge will attract little to no private investment because its economic rewards are minimal. Yet if the government can contribute to the general knowledge and to the basic, non-excludable, non-rival aspect of innovation, private research can use the results to create something more specific. The resulting new technological advances, "can further economic growth because they contribute to the

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Paris, 2003; pg. 42.
[201] *Ibid.*, pg. 44.
[202] Jacobsson and Bergek, pg. 830. These examples appear throughout the paper, used to illustrate the various characteristics of each.
[203] Stern, pg. 360.

creation of new goods, new services, new jobs, and new capital. The application of technology can improve productivity and the quality of products."[204] State R&D should, by and large, be wide-ranging, focused on 'public good' projects, and generally stimulate an atmosphere of creation and diffusion of knowledge.

The private side of R&D is, plainly, where the commercial success lies. In effect, the state's contribution creates a selection of possibilities and a pool of knowledge from which private investors can choose to direct their own personal efforts. Generally private investments go to more applied science and specific technologies, as that is where the financial rewards lie. For example, the first PV cells were designed in the 1950s by the state's space program. They were incredibly costly and inefficient, able to convert less than 2% of the total solar energy into electricity. Over the decades since then, private investments have built upon the initial technology and today's solar cells are both much cheaper and much more productive.[205] Additionally, a study by Norberg-Bohm found that,

> *of 20 key innovations in the past 30 years, only one of the 14 they could source was funded entirely by the private sector and nine were totally public. Recent deployment support led the PV market to grow by 34% in 2005. Nemet41 explored in more detail how the innovation process occurred. He found that, of recent cost reductions, 43% were due to economies of scale, 30% to efficiency gains from R&D and learning-by-doing, 12% due to reduced silicon costs (a spillover from the IT industry).*[206]

It is undeniable that both sides of the R&D investment coin have a lot to offer the RES industry. One more important point, that is implied above but that deserves explicit mention, is the fact that these two 'sides' do not need to compete. *The Stern Review* notes that especially in the energy sector, cooperation between public and private innovation investments is the essential to maximize growing potential.[207]

In developing countries, private investment in RES is understandably a risky venture. Considering that the governmental policies listed earlier in the chapter are not

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[204] Wohlgemuth, Norbert; "Energy Security In Least Developed Coutnries," United Nations Industrial Development Organization (UNIDO); 2006; available at www.unido.org; pg. 27.
[205] *Ibid.*, pg. 361-2.
[206] Norberg-Bohm, V; "Creating incentives for environmentally enhancing technological change: lessons from 30 years of U.S. energy technology policy;" *Technological Forecasting and Social Change*; Vol. 65 (2000); pg. 125-148, available at csia.ksg.harvard.edu/publication.cfm?program=CORE&ctype=article&item_id=222.
[207] Stern, pg. 362.

quite stable yet—despite the presence of both legislative and strategic frameworks—it is evident that the institutional alignment still needs progress. Countries going through or just coming out of privatization have added difficulties, since their entire market system is in flux. Furthermore, if these governments do not have enough funds to spend on clean energy R&D, the basic non-excludable, non-rival knowledge which forms the foundation for private financing, will not develop. Consequently, private investment in technology will be minimal. Recently, however, several interesting new sources or techniques of financing RES have emerged that could lead to the development of new financial models that may help alleviate this problem.

The first of these appeared in May 2006 when Goldman Sachs & Co. invested 27 million USD in Iogen Corp., a biofuel company based in Ottawa. Following its own new eco-friendly green policies, the financial giant became the first major Wall Street firm to invest in renewable technology. Goldman Sachs & Co.'s highly regarded global reputation helps this type of investment to be a model for others around the world.[208] The second example also emerged in 2006, this time in the UK, when the new Energy Technologies Institute (ETI) was announced. What makes this institute remarkable is that it is funded half by the public sector and half by private companies, with an initial endowment of one billion GBP over ten years. Its purpose is to accelerate the speed of investments and developments in alternative fuels by selecting, funding, managing and sometimes conducting research and various projects.[209]

The final innovative model to emerge recently is the Q7 offshore wind farm in the Netherlands. Located further offshore and in deeper waters than any other wind farm, its notable characteristic is its funding. Q7 is entirely financed by a group of international banks on a non-recourse basis. This means that these banks will depend entirely, "on the project to generate the revenues needed to service the interest costs and principal repayment of the financing with very limited additional sponsoring support."[210] The details of the strategy have a number of specifically designed features to lower investors' risks. Funding covers the construction phase as well, thereby avoiding one of the typical problematic phases when chances are good that they project will stall. Not only is

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208 "Goldman Sachs & Co. Invests in Cellulose Ethanol," 4 May 2006; *Renewable Energy Access.*
209 Stern, pg. 363.
210 "Q7 wind farm wins Euromoney Deal of the Year Award," 13 Mar. 2007; *Renewable Energy Access.*

construction going smoothly, but as of March 2007 it was actually ahead of schedule. Q7's investment strategy has gained international notice, winning several international finance awards and much praise. Ultimately it created a new, successful model that other investors may follow in order to participate in RES innovation.

Technology Transfer

These three novel examples illustrate how the typical rules for investment and funding are changing in order to accommodate the new possibilities and challenges that are arising everyday. Another solution to the dilemma that many developing states face regarding their lack of fundamental energy knowledge is actually quite old: import it from abroad. Technology transfer is an important tool for bringing both physical and intangible goods to a country that cannot afford to create its own. Then it can be applied and used to boost the domestic economy.

> *A key element of a developing country's technology strategy is to acquire foreign technology cheaply and effectively and then to adapt it to local conditions. Developing countries that want increased access to foreign technology thus need to remove restrictions on formal arms-length technology import transactions, such as FDI, technology licensing agreements, technical assistance, and imports of capital goods.*[211]

Yet if it was always such an easy, straightforward process, state-sponsored R&D would only exist in the richest countries of the world and all the others would merely bring it to their own markets after development. Obviously, this is not the case, since the top wealthiest countries are clearly *not* the only ones contributing to innovation research.

What complicates the transfer? As seen in the United Nations Industrial Development Organization (UNIDO) quote above, there are several elements involved in the transaction. In order to import foreign technologies, a government must create the appropriate environment in which the new knowledge can grow. It must create policies conducive to importing various types of goods, attracting foreign investors, licensing and training of its own people. The overall environment must be attractive to foreign investors first to bring them to the country, and then to convince them that their investments will not be too risky or

[211] Wohlgemuth, pg. 28.

mismanaged. Therefore, all the elements of a stable economy and business sector must be in place, including proper regulations, enforcement of policies, uncorrupt systems, and physical infrastructure, to ensure investor confidence.

Moreover, sufficient human capital must be present in the receiving country if the new technology is to be successfully adapted and implemented. A wind power firm from one country, for example, may decide to build a wind farm in a developing state, bringing with it the latest designs and innovations for wind turbines. They will invest in the construction of the wind farm, connect it to the grid and generally have the most modern, most efficient wind farm ready to produce energy. Yet if there is no one with the technical knowledge of how to run and maintain these turbines, the whole endeavor will be in vain. Study after study has highlighted the importance of training, education and overall human capital development when transferring technology.

Fortunately for the clean energy sector, much funding for projects comes from the private sector and sort of follows the specific natural resources it chooses. If a US-based solar company sees an opportunity in Mexico, it will probably not let the Rio Grande limit its plans. Likewise in Europe; companies and private investors are constantly investing in renewable projects in other states and even cooperating with other international investors. As mentioned in Chapter 2, Austrian companies are viewing Croatia's RES potential and starting to invest there. And Goldman Sachs chose a Canadian company for its milestone investment, while the Q7 wind farm's main contributors were all international banks based in different countries. This type of 'borderless investment' is important in creating investor confidence; positive prior experience is one of the most persuasive ways to convince firms to invest in a new place or new market. And it can have highly successful consequences:

> *The creation of significant new national markets for a technology attracts foreign investors directly. For example, India's commitment to the expansion of wind power created the conditions for a successful joint venture between Vestas, the largest Danish wind turbine manufacturer, and India's RRB Consultants. This led to the creation of Vestas RRB, a wholly Indian owned company.*[212]

[212] Stern, pg. 497.

The international nature that already exists in the renewable energy industry can be extremely beneficial, for both the investor and the country in which the new technology is transferred.

It is worth noting that the idea of bringing technology and knowledge from one location to another is not a novel concept. Its benefits have been demonstrated in the past, most easily seen in the example of Green Revolution. In South and East Asia in the 1950s-1970s, Western markets brought agricultural technology to help increase output in developing nations. Tools like irrigation techniques, pesticides, etc. aided in boosting the food supply and alleviating hunger. With the proper mechanisms and willingness on both sides of the transaction, the period was successful, and it therefore is a worthy illustration of the possibilities of technology transfers.[213]

Conclusions

Government policies and deployment programs, the R&D sector and financing of clean energy projects, and technology transfer are all, of course, extremely essential elements. But one final aspect of practical implementation of RES needs to be considered in this chapter: public perception. The Stern Review notes the importance of popular acceptability in its discussion of government policy.[214] In Jacobsson and Bergek's study, they claim, "a prerequisite for appropriate incentives to come into place, and for firms to enter the new area, is that renewables are seen as legitimate in broad segments of society."[215] To illustrate this point, they contrast the German and Swedish experiences with nuclear power. In Sweden during the 1970s and early 1980s, there was a heated debate about ending the country's large nuclear power program. Hence, every other option that came up for discussion—namely small types of RES—was pitted against the strong capabilities of nuclear plants, and the public viewed renewables as weak and inefficient. In addition, any pro-RES sentiment was also viewed as anti-

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[213] I will not go into any more detail here, but for further reading about specific cases of successful Green Revolution experiences, see Manning, Chris; "Rural Employment Creation in Java: Lessons from the Green Revolution and Oil Boom," *Population and Development Review*; Vol. 14, No. 1 (Mar. 1988), pg. 47-80; and Goldman, Abe; and Smith, Joyotee; "Agricultural Transformation in India and Northern Nigeria: Exploring the Nature of Green Revolutions," *World Development*; Vol. 23, No. 2 (1995), pg. 243-263.

[214] *Ibid.*, pg 370.

[215] Jacobsson and Bergek, pg. 830.

nuclear and thus portrayed as anti-Swedish by the pro-nuclear contingent. In the end of the debate, "the supply of resources was constrained, the market did not grow and few firms entered the industry supplying renewable energy technology."[216]

On the other side of the spectrum, the fallout after the Chernobyl disaster in 1986 convinced Germans to focus their efforts on renewable energy instead of nuclear.[217] And today their RES programs, as seen throughout both this chapter and last, is one of the strongest in the world. In the next chapter, Croatia and Macedonia again become the focus of the analysis, as all of the information discussed up to this point will be applied to see what types of RES are most appropriate in each, as well as what the economic costs and consequences of implementing them could be.

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216 *Ibid.*, pg. 827.
217 *Ibid.*, pg. 831.

Chapter 5

The Future of Renewable Energy in Croatia and Macedonia

After looking at the various renewable energy sources available on the market today, as well as at the myriad of practical measures necessary to implement them successfully, it is time to return to the two example countries. In this chapter the information of the previous four chapters will be compiled to see what kind of conclusions can be drawn from them about the future of RES in Croatia and Macedonia. First, the practical applications of implementing renewable energies in Croatia will be analyzed in the context of its current clean energy sources, its geography and its legislation. Then the same will be done for FYROM. Finally, the chapter will close by comparing the two and extracting any similarities that appear.

Croatia

As Chapter One discussed already, the current energy situation in Croatia is far from being independent, or even secure, considering the current trends forecasted by such organizations like the IEA. They expect the price of oil and natural gas (since they are inherently connected) to increase constantly over the next two decades, as well as the global population and the demand for energy.[218] Croatia imports more than half of its entire primary energy supply, the majority of which are fossil fuels. The amount of oil it produces is a mere fraction of what is bought from abroad, and the amount of natural gas imported is about half as much as it produces. Furthermore, nearly all of the imported oil comes from just one other country, Russia. There is a danger in relying so heavily on only one other actor. If the supplier decides to stop sending fuel, the purchasing country will be left without energy for its population, as the gas controversy between Russia and the Ukraine in 2006 illustrated.[219] On a more positive note, the substantial contribution that hydro power makes to the primary energy supply—both produced and total—illustrates that the state is interested in RES and can see the potential there.

[218] "World Energy Outlook 2004," *International Energy Agency*, pg. 47.
[219] Information about the Russia-Ukraine gas conflict can be found in a variety of sources; for a brief overview see "Q&A: Ukraine gas row," BBC News; *British Broadcasting Corporation*; London; 4 Jan. 2006; available at http://news.bbc.co.uk/1/hi/business/4569846.stm.

Also, it became apparent in the first chapter that the Croatian government is fully aware of its precarious energy position. However this is hardly a new situation; it is rather the continuation of a stable trend which thus far has not experienced any forceful push from the state to change.[220] Naturally, one reason—and perhaps the major reason—for this lack of action on the state's part is financial. Not only are fossil fuels are cheaper to buy than starting renewable programs—a major attraction to letting things stay at the status quo, or at least change slowly—but they are also cheaper to process, distribute and use, as all of the infrastructure and facilities are already present and functioning. To move away from them in any significant capacity would require a complete overhaul of the system. Such an endeavor would be extremely expensive for any government, both financially and politically. The financial costs are obvious, but the political ones may be less so. Internationally, a move away from Russia's supply of oil could have unpleasant effects in diplomatic relations with Russia. Domestically, the Croatian government would certainly lose the support of the population involved in the oil and gas industries, literally thousands of employees. Furthermore, as reported in Chapter One, the state owns a significant share of INA and a majority share of HEP, the two leading companies in the fossil fuels sector. Thus, it would run contrary to its own interests if the government drastically reduced its use of natural gas and oil.

Since states are not able to change their natural resources, they can choose to work with the ones they have. That is what energy security is all about: using the renewable materials at your disposal to be as independent as possible in your energy production and consumption, and to ensure that your supply will not run out. What renewable materials does Croatia have access to that can be exploited? Its geography gives the country a variety of options, which is both an advantage as well as a disadvantage. It is positive, of course, because it provides the government with an assortment of technologies to work with and different ways to produce energy. It can be a drawback, on the other hand, because it makes having one uniform nation-wide system impossible. Instead, each particular area must have its own network, infrastructure, regulations, etc. in order to maximize the total potential.

[220] "*enerCEE: Croatia*, Supply: Energy Sources;" available at www.energyagency.at/enercee/hr/supplybycarrier.en.htm.

The range of RES that already exist in Croatia is incredibly encouraging. Appropriately, the wind farms along the coast and in the western mountains were chosen to capture the wind capacity there. The network of rivers running through the country undoubtedly contributes to the large amount of hydro power. Yet, it is essential to note that of the roughly 2 GW of electricity it produced in 2005, only 26.7MW of the installed capacity of the entire system is SHP. In fact, the majority of the electricity generated by hydro is from large power plants. The biggest, Zakucac, has a capacity of 486 MW – much more than the EU acknowledged limit of 10 MW for SHP.[221] Because Chapter Three mentioned that such large plants are actually detrimental to the environment, one must consider whether or not the amount of electricity produced by dams should count as eco-friendly.

The solar sector also took advantage of the country's coastline. With both solar thermal and PV systems currently operating, albeit in the early stages thus far, they could certainly expand as the price of solar cells decreases. The PV systems described in Chapter Three could be especially useful for coastal areas and islands that have difficulties connecting to the normal electricity grid. The off-grid model with storage batteries could be used to support the electrical needs of a smaller island. Meanwhile, geothermal energies are somewhat limited in their abilities to contribute to electricity. With very little to no high temperature geothermal sources, Croatia can only use its wells for heating purposes, which it does mostly in spas, hotels and hospitals.[222] Biomass has a high potential, with over 40% of the country being forested and waste from agriculture abundant. However, biomass plants must be located close to their sources, thus requiring that the power plants be built in the middle of the forest, and usually in the mountains. Unfortunately the infrastructure is still not in good enough condition to be able to fully utilize this resource in the best, most efficient way possible, and consequently the biomass sector remains underdeveloped.

All in all, though, Croatia's RES portfolio is growing, with diverse projects specific to each geographic region of the country. Given the right environment and proper tools, the system could potentially bloom into an impressive RES-based market.

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[221] *Ibid.*
[222] *Ibid.*

Delays in progress are largely caused by the 'other side' of the new technology equation, the government policies and practical applications of implementation. All of the topics discussed in the last chapter regarding this issue appear in Croatia's energy landscape at the present time. And all need serious consideration from policymakers if their faults are to be corrected. Croatia is clearly still feeling the pangs and consequences of privatization. The government laws and policies to promote RES are new and still a bit shaky. The size of the economy does not allow for enormous amounts of government spending on R&D, and so it could certainly use as much foreign direct investment as possible. And the RES deployment strategies are almost non-existent. The technology of the renewables most likely was not developed inside Croatia, but was transferred from abroad. So while the clean energy technologies themselves are doing well as independent entities, as a part of the larger picture they need help because they are lacking support from the implementation side.

Although privatization happened a while ago now, the Croatian economy is still experiencing some of the adverse informal institutions of the old system. Corruption is particularly bad.[223] In fact it is still such an issue that as recently as April 2007, Economy Minister Branko Vukelic announced a new anti-corruption program targeting the residual corruption from privatization.[224] He also outlined a five-step program for companies still waiting to privatize. Until corruption is under control and privatization is complete, Croatia's institutions are not going to be entirely stable, and therefore not creating a suitable environment for technology development or transfer. What's more, the EU has made this one of the deciding issues regarding Croatia's admission to the community. In Croatia's progress reports, the elimination of corruption is consistently mentioned as an absolute prerequisite for membership.[225]

Government policies and laws should contribute to this environment by outlining clear objectives, as seen last Chapter. Croatia has indeed passed many laws to help regulate the RES industries as well as the overall energy sector. However, a brief look through these laws shows that they appear as frameworks more than laws; they do not

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[223] "Croatia: Political Profile;" from *The European Union*; ec.europa.eu/enlargement/croatia/political_profile_en.htm.

[224] "Anti-Corruption Programme in Croatia," *The Journal of Turkish Weekly*; 19 Apr. 2007; available at www.turkishweekly.net/news.php?id=44354.

[225] "Croatia: Political Profile;" available at ec.europa.eu/enlargement/croatia/political_profile_en.htm.

necessarily outline specific targets, but instead set general goals. For example, the Energy Law states that "The Croatian Government shall pass a long-term and annual energy balance that will determine energy demand, sources (types) of energy and measures to be implemented for meeting the demand."[226] It provides a good idea but gives no particular numbers by which to gauge progress. Of course, some exceptions do exist, but generally they focus more on qualitative ideas over quantitative.

This can result in making regulation and accountability more difficult. Without specific measurements and with traces of corruption, the regulation system could be hurt as much as the others. In a 2006 report, the Croatian Energy Regulatory Agency assessed its work for the entire year of 2005, most having to do with the electricity sector. Of the 64 total pages, RES received the following lines:

> *In February of 2005 the first Croatian wind farm Ravne 1 on the island of Pag was put in operation, built by the German-Croatian company Adria Wind Power, of the nominal power 5.6MW, provided by seven wind generators of 850 KW.*[227]

This is fairly remarkable considering that over half of the electricity was produced by hydro power. As this indicates, if there is no information about something, there is no way to regulate it. And an unregulated market does not inspire consumer or investor confidence, which we have seen is an essential part of the market's development. Without investment, a new technology will never get off the ground.

In terms of investment, the Croatian R&D sector receives roughly 1.25% of the total GDP–an amount higher than the average of the new EU-10, but lower than most developed countries. Although this sounds favorable, in fact the situation is far from ideal, as 90% of this investment comes from the public sector.[228] "More precisely, the public sector employs 90% of all researchers, allocates almost 90% of total investments in science and research, whereas only 10% of the institutes' revenues and 6% of the

[226] "Energy Law," Zagreb, 24 July 2001; translation from *Narodne novine: Official Gazette of the Republic of Croatia*; No. 68 (27 July 2001); Article 9.1.
[227] "Report on the work of the Croatian Energy Regulatory Agency for the Year 2005,"Republic of Croatia, Croatian Energy Regulatory Agency; Zagreb, July 2006; available at www.hera.hr/english/documents/pdf/CERA_Report_2005.pdf.
[228] Strategic Development Plan, pg 25-26.

faculties' revenues come from research done for the business sector."[229] In such a scenario, none of the profit-creating and innovation-inducing development can happen. The Strategic Development Framework recommends creating a state-of-the-art research center to attract more FDI, stimulate interest in technology development funding, and keep young scientists in the country instead of leaving for foreign jobs. The Framework continues to describe how the connection between Croatia's long-standing scientific community and the economic results from the commercial applications of its research have historically been weak at best. Additionally,

> *[t]oday in Croatia, no adequate infrastructure exists for technology transfer. Without it, it will be impossible to achieve the desired transfer of knowledge from the academic sphere into the economy. The role of the state and the public sector in encouraging the transfer of knowledge and technology is necessary and justified, because innovations and the dissemination of knowledge and technologies create significant positive social effects.*[230]

The study then proceeds to list ten different actions that can be taken to stimulate not only the R&D sector in and of itself, but FDI into the R&D industry as well. Most notable among these are investing in infrastructure and knowledge transfers, encouraging alternative sources of financing, and requiring efficient use of all materials and resources.[231]

It is evident that the Croatian policymakers want to draw more FDI to their country, even though among other Southeastern European states, they are doing rather well. From 1996-2000, it received approximately 4000 million Euros; from 2001-2005 the total was just over 6000 million Euros, making it fourth highest in the area, behind Turkey, Greece and Romania.[232] From 2010-2013, the country's FDI investment is predicted to be 6% of its GDP—the same as it was a decade ago.[233] A problem with the FDI inflow, however, is that it is often spent on a concentrated number and type of products, thereby avoiding diversification in favor of safe investments.[234] Undoubtedly,

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[229] *Ibid.*
[230] *Ibid.*
[231] *Ibid.*, pg. 27.
[232] "Foreign Direct Investment in SEE;" *Southeast Europe Investment Guide 2006*; Bulgaria Economic Forum; Sofia, 2005; available at www.biforum.org/files2/pdf/ig2006/At_Glance.pdf.
[233] Strategic Development Framework; pg. 80.
[234] *Ibid.*

the government is eager for FDI to broaden its scope and give local economies and innovations a helping hand.

Another financial area where the government needs to make more progress is in the deployment schemes of RES. It wasn't until March of 2007 that the government started to offer a tariff system for people using electricity from RES sources.[235] Until then, the only such deployment strategies used in general were for the benefit of conventional energies.[236] Though the Energy Law did state that "electricity" could receive some recompense, it wasn't until this new program that RES received explicit recognition and their own types of support. For a long time, then, the renewable sector has been at a severe disadvantage in comparison with oil, natural gas, coal and petroleum products. Considering how successful such measures have proven to be in the EU over the past decade, it is surprising that it took Croatia, a country with such high hopes of joining the EU, so long to implement them as well.

Macedonia

The information in Chapter Two stated that the Republic of Macedonia's energy sector is not very heterogeneous, especially in comparison with the Croatian one. Possessing no oil or natural gas sources of its own, the Macedonian state must import all of its supply of these two major fuels. Although its consumption rate does not seem to be increasing significantly on the whole, its position of complete dependency is nonetheless a precarious one. As prices of oil and gas rise around the world, the country may find itself in a very delicate situation where it has no choice but to pay exorbitant amounts. It has stable, functioning pipelines for both gas and oil, as well as processing plants and distribution locations. So in essence, it has all of the components of a country with its own sources. If a price hike or environmental concerns, or any other reason convinces the government to drastically alter its energy scheme, it could prove difficult to disassemble the existing infrastructure. Like in Croatia, the number of employees, investors and people who depend on it could make any such strategy very unpopular. The same goes for its relations with its suppliers. So the government of FYROM must be rather careful when considering its future options.

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235 "HEP and the environment;" 26 Mar. 2007; Hrvatska Elektroprivreda; Zagreb, 2007; available at www.hep.hr/hep/novosti/vDetail.aspx?id=281&catID=3&lang=EN.
236 "Energy Law;" Article 26.1.

This is not to say, however, that Macedonia ought to stay entrenched in its current plan; on the contrary, the sooner it can attain some energy security via increased RES the better. Yet, another obstacle to this goal is the fact that the largest single source of energy it does produce is coal, as described in Chapter Two. Far and away, coal is the number one entity in FYROM's primary energy supply and its total balance (since it does not export any). Coal is far from being a clean energy. On the contrary, the smoke it produces when burned is among the most noxious gases contributing to climate change.[237] Yet, the cheap price coupled with its availability make coal a very easy and logical source of energy to utilize. Some valuable incentives must be shown as beneficial if there is to be a shift away from a coal-based economy.

Fortunately, Macedonia's renewable resources can offer some options to help alleviate the situation. The country's vast network of rivers described in the second chapter provides ample opportunity for an increase in small hydro power. Presently, the country has seven large hydropower stations with a total capacity of 480 MW. Its number of SHP plants has a combined capacity of 50 MW. The government is very aware of the benefits it can gain from incrementing its hydro power potential. In 2004, an experimental project called GEF Mini Hydro Project was implemented to see if it was possible to build some 'mini' plants on the country's smaller rivers and existing water pipelines. Its viability encouraged the government to commission 4 similar plants, sized from 0.5 – 5 MW, and 11 other mini plants, sized 0.1 – 1 MW. All have been proven technically and financially viable, but construction is held up due to various institutional obstacles.[238] When these issues are resolved, these 'mini' plants could prove a very useful new tool to bring to remote areas where rivers flow. In addition, the state asked the Ministry of Economy to commence bidding on new SHP plants throughout the country in the autumn of 2006.[239] In the next few years, it is near-certain that Macedonia's hydro power will increase noticeably, thanks to both the natural resources and to the efforts of the state.

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[237] Donevski, Bozin; "A Survey of the Energy Situation in Macedonia; pg. 2-3.
[238] "*enerCEE: Croatia*, Supply: Energy Sources;" available at www.energyagency.at/enercee/hr/supplybycarrier.en.htm.
[239] *Ibid.*

Chapter Two also described the current situation of solar energy in FYROM as having a great deal of potential, due to the country's high amount of irradiation. This opportunity cannot be taken advantage of, unfortunately, if the costs of purchasing and implementing solar technology are so much higher than other options. Presently, the uses of solar energy are rather limited, yet with some financial aid, this industry has the potential to prosper. The remote areas of the country in the mountains, where power grids are difficult to access, would be ideal for independent PV systems. If small villages or even independent houses were able to employ PV systems, complimented by storage batteries and back-up systems, they could produce their own energy without needing to invest in the expensive process of hooking up to a grid.

The potential of Macedonia's geothermal, biomass and wind sectors were both described in the second chapter, so there is no need to review it here. The important thing to note, though, is that all three of these types of clean energy have a good deal of potential, due to the presence of the natural resources required for each. Popovski even highlights Macedonia in his article as being one of the best-suited countries in the area for geothermal energy use in agriculture. Also, Chapter Three described a cascade scenario which can be used in geothermal systems to use the energy for a number of different purposes based on their specific temperature requirements. Macedonia does not have any high temperature wells, but it does contain quite a few moderate temperature ones, which produce enough heat to sustain a cascade system, including Popovski's agriculture. What is missing, then, is the infrastructure.

The same situation exists for biomass. With such a remarkable amount of forests, FYROM has enough wood and wood-related biomass to increase its electrical output significantly. Unfortunately, it lacks proper, modern plants to correctly make use of this resource. Building such plants will be expensive, considering that they must be close to the source, i.e. the forests. The reason for wind energy's slow growth, despite the mountainous regions with plenty of wind to warrant productive wind farms, is mostly international political disagreements.[240] Therefore, for these three types of RES, the natural resources are plentiful, but the variables affecting the country's lack of

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[240] See Chapter Two, page 34.

geothermal, biomass and wind have to do with the political and economic situation of the FYROM.

As a result of all this, Macedonia's renewable energy portfolio is not very diverse. Although it physically contains the necessary natural resources, it does not produce enough of most of them to claim that clean energy is a significant part of its overall energy industry. It has already been explained that diversification is an attractive quality for investment. Without this, the chances of drawing investments from both foreign and domestic sources are much smaller than it would otherwise be. And this is true for Macedonia's current FDI dilemma. The state's lack of foreign investors is a serious economic issue that it wants to remedy. In its five-year program, the government addresses its plans to attract more FDI no less than five times. Their suggestions to foment a better investment climate include, "stability and predictability of regulation, efficient executive procedure… decreasing public consumption, deregulation and liberalization, improved public services quality, improved public infrastructure…"[241] This is a particularly illustrative citation, since it connects the other practical applications of RES implementation that were the subject of Chapter Four; regulation and accountability, liberalization, services and institutions – all are connected in the ways that they create a favorable environment for investors.

Foreign direct investment in FYROM is not only small, but it is also inconsistent. After the almost desolate 1990s, the amount of FDI in 2000 was 4.86% of its GDP. However in 2003 it fell by more than half to 2.03%.[242] If this situation is going to be improved, it will need some strong methods. Fortunately, the government does have ideas in mind. While the quotation above is rather general in its language, the government does list some concrete, specific actions to take to improve the status of FDI later in the Program:

> *The new government will have two ministers…who will deal exclusively with foreign investments… Hiring 20-50 distinguished, world-known consulting agencies through a transparent public procedure in order to attract green field investments in Macedonia… For more efficient promotion and attraction of investments, following the example of Ireland, we will establish*

[241] Program of the Government of the Republic of Macedonia (2006-2010).
[242] "FYROM," Globalis; Global Virtual University; 2007; available at globalis.gvu.unu.edu/indicator_detail.cfm?IndicatorID=155&Country=MK.

a unique professional agency called Invest Macedonia, which will develop a network of more than 20 offices internationally, with contact information of all businessmen of Macedonian origin... We will abolish the possibility for stock companies to issue stocks exclusively for existing shareholders...[243]

This program is ambitious in its scope, and it is exactly this wide range of tactics which provides the promise of success. This is an important issue for the government to tackle, as it is also a key topic in EU progress reports.[244] If FYROM does not improve its FDI statistics, the accession process will surely be much slower.

The Program also stresses the importance of the scientific side of development. Research and development are recognized as important parts of economic growth, and accordingly the plan is to "support...the cooperation between scientific-research institutions and economic institutions."[245] It also acknowledges that a large majority of its young students and scientists are leaving their native land to do their work in other countries. To bring them back, the state wants to "increase investments in scientific-related infrastructure... budgetary funds for scientific-research work in function of the private sector, following the example of more developed European countries... grant favorable and stimulating loans... promotion of cooperation with scientific-institutions abroad for better knowledge transfer."[246] Macedonian policymakers plainly understand the need for both public and private R&D investments, as well as the role knowledge transfer plays in bringing new technology to the country.

Another important factor in attracting investments and innovation to FYROM that is mentioned time and time again in the sources is liberalization and privatization process. From the second chapter it is already clear that this is a problem, since the country did not begin them until relatively recently. Therefore, not only is there a problem with competition but also with regulation and its accompanying parts, i.e. licensing and permits, punishments for law-breakers, etc. Corruption is rampant in Macedonia, and, like Croatia, it has become a key issue on which the EU fixates when discussing any accession timeline. Chapter Two noted the laws which are currently in place to help solve this situation, and without them the problems of competition, privatization,

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[243] Program of the Government of the Republic of Macedonia (2006-2010).
[244] "EU – the Former Yugoslav Republic of Macedonia relations."
[245] Program of the Government of the Republic of Macedonia (2006-2010).
[246] *Ibid.*

regulation and corruption will surely not abate. Yet it is also clear that merely writing laws is not enough; these economic and social ills that exist throughout the institutions, formal and informal, of FYROM are not going to abate without the complementary legislation that implements the necessary checks. As Jacobsson and Bergek reported, institutional stability is one of the primary requirements for lasting innovation and successful technological change.[247]

One more point needs to be made, regarding the deployment strategies to encourage the spread of renewable technologies. At this point in time, and with currently available sources, it has been impossible to find information about whether or not the government has any feed-in tariffs, subsidies, grants, etc. in place for users of RES. The immediate conclusion is that the reason for this is simply that they do not exist. Yet it also must be suggested that those sources are available only in the Macedonian language, and are consequently unavailable for this study. Perhaps in the future it will come to light that they do or do not exist.

Croatia and Macedonia: Extracting Similarities

In both of the case studies, it has become apparent that each country has specific advantages and challenges that are particular to it, and make it stand out among the region. Croatia's coastline provides an entire sector of industry that its landlocked neighbors can not appreciate nor make use of. Macedonia's rich geothermal wells and network of rivers give it a great deal of renewable potential that could be exploited to help the country grow. Yet it is also clear that there are several characteristics that these countries share, and which provide lessons regarding the implementation of RES in developing countries.

First, the violent backgrounds of the entire region is something that has had an incredible impact upon their current economies, politics, infrastructure, and national identities in general. Although both Croatia and Macedonia have managed to stabilize financially and otherwise since then, the effects of this period linger on, manifesting themselves in a myriad of ways. First and foremost is the physical destruction that ensued. The current disrepair of infrastructure, roads, communications networks, etc. has direct consequences on the energy sector. This lack of connections prevents energy from

[247] Jacobsson and Bergek, pg. 818.

being transported, distributed and improved upon. What's more, it has the same effect on information and knowledge. How can people living in remote mountainous areas be aware of the technological possibilities of solar PV systems if the roads to the closest major city are a mess and the communications are inadequate? It is evident that the infrastructure is a priority item to be improved if RES will be spread.

Also a result of the wars of the 1990s is the late start both countries had on the privatization and liberalization processes. Though both Croatia and FYROM have effectively undergone them, the lingering steps and effects continue to influence their economies and investment climates. Connected to this, regulation processes in both countries need to be enforced, as do anti-corruption measures. The presence of all of these elements in both countries is indicative of stable institutional frameworks (or, perhaps a stable but *detrimental* one) which must be dealt with in order to create investor and consumer confidence.

Another shared characteristic of these two countries is their need for more FDI. Both governments are working to increase this lack of foreign funding, but they certainly have a ways to go before catching up with the EU countries. With FDI comes new funding of R&D, which both states also need to improve their energy technologies. The other financial aspect of RES that EU countries enjoy is the deployment programs which promote investment in and usage of clean energies. It was apparent in Chapter Four that feed-in laws, subsidies, procurement policies and the like all have significant effects on promoting RES. Yet their presence in Croatia is small and new, and in Macedonia, it is still unclear if they exist at all. Indubitably, any escalation in these three factors – FDI, R&D and deployment methods – would have positive effects on the states' renewables sectors.

It is clear that the natural environment has provided both Croatia and Macedonia with the resources to produce clean, renewable energy in significant and effectual amounts. The proper harnessing of the RES could truly alter the economic landscapes of both countries, providing them with independence from their current fossil fuel suppliers, increased profits from the tourist sectors, and appreciation from the European Union. The obstacles that prevent this are the practical applications that lie within the reach of the governments, which is an optimistic thought.

Conclusion

The real issue is no longer the technical potential of these (and other) renewable energy technologies, but how this potential can be realized and substantially contribute to a transformation of the energy sector.[248]

As Jacobsson and Bergek concisely state in their paper, renewable energy sources are no longer merely a hypothetical alternative to fossil fuels. On the contrary, they are now a tangible, realistic solution to today's shifting energy sector and changing climate. The technological breakthroughs scientists are continuously making with these sources of clean energy are proving time and time again that they have a great deal to offer. As each type of technology becomes more efficient, more versatile and less expensive, the RES industry gets closer to contributing 'to a transformation' of the energy market as well as the countries that implement them. If their value and capabilities are no longer theoretical, what remains to be done is devise a way to develop these renewables into widespread, fully developed and successfully functioning energy systems.

Throughout this paper, an attempt has been made to see how countries can do exactly this. Of particular interest are developing countries, which generally have neither the financial nor the political support to invest heavily in RES right now. By looking specifically at Croatia and Macedonia as two examples, an interesting picture has emerged from which one can draw some useful conclusions about developing states' current energy industries. Furthermore, several of the main obstacles which impede the practical implementation of these technologies became clear, thereby pointing out the ways in which governments can improve their situations and consequently encourage more development of RES.

One of the first characteristics of developing countries, as illustrated in both Croatia and Macedonia, is their tendency to rely on oil, gas and coal for primary energy sources. What's more, they also seem to import a large percentage of these fuels from abroad, and thus are more dependent on others for the essential products. In a stable world, this might not be a problem, yet with prices of these fuels in flux and the political climate occasionally fluctuating, it would surely be better for developing countries to be able to exploit their native sources of energy as much as possible. The World Bank notes

[248] Jacobsson and Bergek, pg. 816.

that, "removing barriers for use of these renewable energy supply options would increase the supply from indigenous energy sources, create local employment options and mitigate the adverse environmental impact of energy production."[249] So not only would states gain a certain degree of independence and security, but they would also see domestic employment rise and negative environmental impacts decline. The reasons for pursuing these technologies then are numerous and quite strong.

This study has also demonstrated that developing countries are plagued by several problems that do not affect developed states as much. First, the privatization and liberalization processes that Croatia and FYROM are still undergoing lend themselves to corrupt behavior and a doubtful atmosphere for investors. Also, the volatility of the R&D sector's finances burdens the states with minimal homegrown technology, forcing them to look elsewhere if they want have possess it and benefit from it. Moreover, these governments often do not employ the same strategies to attract people to use RES as, for example, Germany does. The variety of available options, ranging from feed-in tariffs to procurement policies to TGCs, provides governments with an assortment of deployment techniques that can encourage locals to use clean energy instead of fossil fuels. Clearly, these hurdles must be overcome to establish secure RES sectors.

One positive trend that came to light was the fact that both Croatia and FYROM already have the beginnings of RES industries. Depending on what is most appropriate for the geographical conditions, each country has begun to build and develop hydro, solar, wind, biomass and geothermal energies. Some of them have been working longer than others, as the strong hydro sector in Macedonia illustrates, or the growing wind industry in Croatia. Nonetheless, merely having the technology is not enough; the governments of each state must create an environment that is not only supportive of RES, but one that is also welcoming. They must create the kind of atmosphere that invites people—foreigners and locals alike—to invest in these new technologies and establish them as significant sources of their energy.

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[249] "FYR Macedonia Energy Policy Paper," Infrastructure and Energy Services Department; Europe and Central Asia Region, The World Bank; 23 July 2004; available at www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/07/26/000012009_20040726100157/Rendered/PDF/29709.pdf.

The previous discussion about the practical aspects of implementing such systems emphasized the ways in which countries can do just that. By creating a trustworthy and secure setting, institutionally stable, free of corruption and the without the ills of privatization and liberalization, a government can attract FDI, which is clearly a useful tool. Foreign investors can bring either the finances to build RES locally, or they can transfer the technology from their own countries, thereby importing knowledge to the developing country with the certainty that their investment will eventually pay off. Similarly, governments also can benefit from having a strong R&D sector, which ultimately develops the technology that creates and improves clean energy. It is essential, as seen in Macedonia, that private investments in R&D must compete with public ones if the sector is to thrive. Additionally, the myriad of deployment strategies used all over Europe and around the globe have been proven to impressively facilitate the use of renewable systems among both local people and large companies. Feed-in tariff laws, subsidies, quotas, procurement policies, grants – the list is long and varied, yet each item has the same goal: to increase the amount of RES used throughout the country. If developing states employed techniques like this, they might see more of a push in this direction. It will be interesting to watch Croatia's progress now that it has recently implemented a tariff law for RES. Whether FYROM will consider adopting similar measures remains to be seen. Finally, as both example countries demonstrated, it is not enough to simply pass legislation; the governments must take their own laws seriously and work to implement, enforce and regulate them.

It is plain that developing countries face a number of difficulties which developed ones do not. Implementing renewable energy sources as a significant part of their energy sectors may have been difficult to justify a decade ago, considering the costs involved and the obstacles present. Yet, as shown in the cases of both Croatia and FYROM, these clean energies can certainly grow given the right circumstances. With both international support and pressure, building and developing such systems is no longer a luxury for the rich states, but an imperative for all countries.

Bibliography

"2004 Annual Overview Barometer," *Renewable Energy Journal*; No. 14, Dec. 2004; EurObserv'ER; pg.44-56.

"2005 Annual Report," CEA Croatian Environment Agency; Zagreb 2005.

"Amendment of the Act on Granting Priority to Renewable Energy Sources;" as adopted by the *Bundestag*; 2 April 2004; available at www.ipf-renewables2004.de/en/dokumente/RES-Act-Germany_2004.pdf.

American Wind Energy Association; Washington, D.C.; 2007; available at www.awea.org; the following information is found there:
-"Wind Energy Fast Facts"

"Anti-Corruption Programme in Croatia," *The Journal of Turkish Weekly*; 19 Apr. 2007; available at www.turkishweekly.net/news.php?id=44354.

"Balkans: Profiles," *Energy Information Association: Official Energy Statistics from the U.S. Government*; Washington, D.C., 2007; available at www.eia.doe.gov/emeu/cabs/Balkans/Profile.html.

Bechberger, MIscha; Reiche, Danyel; "The spread of renewable energy feed-in tariffs (REFITs) in the EU-25;" 2006; available at www.wind-works.org.

Benson, Leslie; *Yugoslavia: A Concise History, Revised and Updated Edition*; Palgrave Macmillan Press; New York, NY; 2004.

"Blowing hot and cold," *The Economist*; Sept. 16-22, 2006; pg. 92.

"Census of Population, Households and Dwellings in the Republic of Macedonia, 2002: Final Data," Republic of Macedonia, State Statistical Office; Skopje, May 2005;

Central Office for Development Strategy and Coordination of EU Funds; Zagreb, 2006; available at www.strategija.hr. The following sources are found there:
-"IPA Programme"
-"Pologne et Hongrie – Aide á Restructuration Economique"
-"ISPA"
-"SAPARD Programme: Special Pre-Accession Instrument for Agriculture and Rural Development"
-"CARDS Programme: Community Assistance for Reconstruction, Development and Stabilisation"
-"Strategic Development Framework for 2006-2013"

CIA World Factbook; "Croatia;" April 2007; available at www.cia.gov/cia/publications/factbook/geos/hr.html.

CIA World Factbook; "Macedonia;" April 2007; available at www.cia.gov/cia/publications/factbook/geos/mk.html.

"Climate Change 2007: The Physical Science Basis," *Intergovernmental Panel on Climate Change*; Geneva, Feb. 2007; available at www.ipcc.ch/SPM2feb07.pdf

"Company Profile," *Jadranski naftovod, Joint Stock Company* (JANAF, Plc.); Zagreb, 2006; available at www.janaf.hr.

Courgage, Youssef; Wilkens, Ronald; "Censuses, Elections and Population: The Case of Macedonia," *Population (English Edition, 2002-)*; Vol. 58, No. 4/5 (Jul – Oct. 2003), pg. 429-450.

"Croatia Political Map," from Maps of the World, 2007; available at www.mapsofworld.com/croatia/croatia-political-map.html.

"Croatia: Statistics," from International Energy Agency; Paris, 2007; available at www.iea.org/Textbase/stats/countryresults.asp?COUNTRY_CODE=HR&Submit=Submit. The following information is found there:
-"2004 Energy Balances for Croatia"
-"Selected 2004 Indicators for Croatia"
-"Coal in Croatia in 2004"
-"Oil in Croatia in 2004"
-"Natural Gas in Croatia in 2004"
-"Renewables in Croatia in 2004"
-"Electricity/Heat in Croatia in 2004"
-"Evolution of Total Primary Energy Supply from 1992 to 2004: Croatia"

"Danish Offshore Wind: Key Environmental Issues," DONG Energy, Vattenfall, The Danish Energy Authority and The Danish Forest and Nature Agency; Nov. 2006; available at www.ens.dk/graphics/Publikationer/Havvindmoeller/havvindmoellebog_nov_2006_skrm.pdf.

Dimovski, Mihail and Glaser, Rob; "Environmental Enforcement and Compliance in South Eastern Europe;" BERCEN and The Regional Environmental Center for Central and Eastern Europe; Hungary; Feb. 2002.

Donevski, Bozin; "A Survey of the Energy Situation in Macedonia," *University of St. Clemet Ohridski*, Bitola; available at www.mef.unsa.ba/ce/izdanja/Donevski-XX.pdf.

"*enerCEE: Croatia*, Supply: Energy Sources," from Austrian Energy Agency; Vienna, 2007; available at www.energyagency.at/enercee/hr/supplybycarrier.en.htm.

"Energy," European Commission; Brussels, 2007; available at http://ec.europa.eu/energy.

The following information was found there:
-"Innovation and technological development in energy"

"Energy Efficiency and Renewable Energy," *U.S. Department of Energy*; Washington, D.C.; 2007; available at www1.eere.energy.gov.

Energy Institute Hrvoje Požar; Zagreb, 2006; available at www.eihp.hr. The following sources are found there:
-"The Development of a Pre-Commercial 750KW Wind Power System Project Code TP-01/008-03 (2003-2005)"
-Domac, Dr.sc. Julije; "Renewable Energy in Croatia: Latest Developments and Challenges"
-"Energy Sector Development Strategy of the Republic of Croatia"
-"Master Plan: Development of the Croatian Electric Power Sector 2001-2020"
-"Oil Sector"
-"Pilot Project Solar Roof Špansko-Zagreb"
-"Project 02001001 – National Energy Programmes (2002-)"
-"Project 020101 PROHES – Development and Organisation of the Croatian Energy Sector (1996-2002)"
-"Solar Radiation Atlas for the Republic of Croatia"

"Energy Law," Zagreb, 24 July 2001; translation from *Narodne novine: Official Gazette of the Republic of Croatia*; No. 68 (27 July 2001) pg. 2174.

"Energy Proflile: Macedonia," *enerCEE,* from Austrian Energy Agency; Vienna, 2007; available at www.energyagency.at/enercee/mk/index.htm.

"Energy [r]evolution: A Sustainable World Energy Outlook," *European Renewable Energy Council* and *Greenpeace International*; Stuttgart, Jan. 2007.

"Energy Treaty between the EU and South Eastern Europe," Stability Pact for South Eastern Europe; Brussels, November 2005; available at www.stabilitypact.org/energy/default.asp.

"The Environment in Your Pocket I – 2006," CEA Croatian Environment Agency; Zagreb, 2006.

"Environmental Protection," Hrvatska Elektroprivreda, d.d.; Zagreb, Croatia, 2002; available at www.hep.hr/en/environmental/index.html.

European Small Hydropower Association (ESHA); Brussels, 2007; available at www.esha.be; the following information is found there:
-"SHP in the World"
-"SHP in Europe"

The European Union, "Energy" available at europa.eu/scadplus/leg/en/s14000.htm#REN;

and "EU Enlargement" available at ec.europa.eu/enlargement/index_en.htm; Brussels; 2007; the following information is found there:
-"Candidate Countries: Croatia," 2007
-"CARDS Assistance Programme: Former Yugoslav Republic of Macedonia, 2002-2006"
-"Commission Staff Working Document: Croatia 2006 Progress: Report"
-"Croatia: Adoption of the Community Acquis – Energy," 2006
-"Croatia: Political Profile"
-"Energy"
-"Enlargement Strategy and Progress Reports"
-"EU – The Former Yugoslav Republic of Macedonia Relations"
-"European Partnership with the former Yugoslav Republic of Macedonia"
-"The Former Yugoslav Republic of Macedonia: Country Profile"
-"Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy;" 8 March 2006
-"The Stabilisation and Association Process: The Western Balkans"

European Wind Energy Association; Brussels, 2007; available at www.ewea.org; the following information is found there:
-"2006 New Installation: EU 25."
-"European Market for Wind Turbines Grows 23% in 2006," Feb. 1, 2007.

"Financial Information: Sources," Project Preparation Committee; London, 2004; available at www.ppcenvironmnet.org. The following information is found there:
-"European Commission – Phare"
-"European Commission – SAPARD"
-"European Commission – ISPA"
-"Grant Based work within World Bank Country Assistance and Regional Assistance Strategies"
-"Renewable Energy and Energy Efficiency Parntership (REEEP)"
-"USAID traditional bilateral programme support to countries and regions"

"Foreign Direct Investment in SEE;" *Southeast Europe Investment Guide 2006*; Bulgaria Economic Forum; Sofia, 2005; available at www.biforum.org/files2/pdf/ig2006/At_Glance.pdf.

Frankovic, Bernard; Hrastnik, Branimir and Jedrisko, Claudia; "Thermal Utilisation of Solar Energy," Croatian National Energy Program SUNEN, 1998-2010; from *Renewable Energy*, Vol. 16 (1999), pg. 636-639.

"FYR Macedonia Energy Policy Paper," Infrastructure and Energy Services Department; Europe and Central Asia Region, The World Bank; 23 July 2004; available at www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/07/26/000012009_20040726100157/Rendered/PDF/29709.pdf.

"FYROM," Globalis; Global Virtual University; 2007; available at http://globalis.gvu.unu.edu/indicator_detail.cfm?IndicatorID=155&Country=MK.

Gipe, Paul; "Electricity, Electricity Feed Laws, and Advanced Renewable Tariffs," Wind-Works.org; 2003; available at www.wind-works.org.

"Global wind energy markets continue to boom – 2006 another record year," *Global Wind Energy Council*; Brussels, 2007; available at www.gwec.net.

Goldman, Abe; and Smith, Joyotee; "Agricultural Transformation in India and Northern Nigeria: Exploring the Nature of Green Revolutions," *World Development*; Vol. 23, No. 2 (1995), pg. 243-263.

Granic, Goran; "Energy Sector in Croatia after the Year 2000;" Zagreb; from the World Energy Council; London, 2007; available at www.worldenergy.org/wec-geis/publications/default/tech_papers/17th_congress/2_3_26.asp.

HED: Croatian Energy Association, "15th Forum: Energy Day in Croatia;" World Energy Council; Zagreb, Croatia; 2007; available at www.hed.hr/forum_en.htm. The following presentations and papers are found there:
-Car, Prof.dr.sc. Stjepan; Firak, Doc.dr.sc. Mihajlo and Donlagic, Bakir; "Use of Hydrogen in the Power Sector"
-Granic, Goran, "Achievements and Challenges of the Croatian Energy Strategy"
-Gulbrandsen, Dr.sc. Thor Henning; "Energy Planning – A Tool for Sustainable Energy Development"
-Kalea Marijan, "Non-Conventional Energy Sources and Energy Development Strategy of Croatia"
-Keay, Malcolm, "Energy Scenarios until 2050 and Climate Changes"
-Potocnik, Vladimir; "The Croatian Energy Policy in Function of Regional Development and Job Creation"

"HEP and the environment;" 26 Mar. 2007; Hrvatska Elektroprivreda; Zagreb, 2007; available at www.hep.hr/hep/novosti/vDetail.aspx?id=281&catID=3&lang=EN.

Hoffmann, Winfried; "PV solar electricity industry: Market growth and perspective," *Solar Energy Materials & Solar Cells*; Vol. 90 (2006), pg. 3285-3311.

Horváth, László; "Will new energy regulation help wind industry to emerge in Croatia?," Energy Institute Hrvoje Pozar; Zagreb, 2006; from the European Wind Energy Conferece; Athens, 2006; available at www.ewec.info.

Hrvatska Elektroprivreda, HEP Group; Zagreb, 2007; available at www.hep.hr.

"The International Conference on Climate Change," Hong Kong, 2007; available at http://www.hkie.org.hk/iccc2007.

Jacobsson, Staffan; and Bergek, Anna; "Transforming the energy sector: the evolution of technological systems in renewable energy technology;" *Industrial and Corporate Change*; Vol. 13, No. 5, 2004; pg. 815-849.

Kennedy, Dr.sc. Malcolm W. and Stanic, Mr.sc. Zoran; "The Role of Renewable Energy Sources in Future Electricity Supply;" from *Energija: Journal of Energy*; Hrvatska elektroprivreda d.d., Zagreb; Vol. 55 (2006) No. 3; pg. 292-327.

"Law on Energy," *Official Gazette of the Republic of Macedonia*; No. 47/97; available from South East Energy; Vikyrovice, Czech Republic, 2007; at www.seenergy.org.

"Law on Regulation of Energy Activities," Zagreb, 24 July 2001; translation from *Narodne novine: Official Gazette of the Republic of Croatia*; No. 68 (27 July 2001) pg. 2184.

"Macedonia," from Maps of the World, 2007; available at www.atlapedia.com/online/maps/physical/Greece_etc.htm.

"Macedonia, The Former Republic of: Statistics," *International Energy Agency*; OECD/IEA, 2007; available at www.iea.org/Textbase/stats/index.asp.

Macedonian Center for Energy Efficiency; Skopje, 2007; available at www.macef.org.mk.

"Macedonia on Maps," *Macedonia.org*; Skopje, 2003; available at www.macedonia.org.

Manning, Chris; "Rural Employment Creation in Java: Lessons from the Green Revolution and Oil Boom," *Population and Development Review*; Vol. 14, No. 1 (Mar. 1988), pg. 47-80.

"Map of Croatia," from Tourizm Maps com, 2006; available at www.map-of-croatia.co.uk.

Makpetrol; Skopje, 2007; available at www.makpetrol.com.mk/index_en.asp.

"Memorandum of Understanding on the Regional Electricity Market in South East Europe and its Integration into the European Union Internal Electricity Market: 'The Athens Memorandum – 2002'," *Economic Reconstruction and Development in South East Europe*; European Commission & The World Bank; Athens, 2002; available at www.seerecon.org/infrastructure/sectors/energy/index.html.

Mendonca, Miguel; "Energy, Ethics and Feed-in Tariffs," World Future Council; 30 April 2007; available at www.renewableenergyaccess.com.

Ministry of Agriculture, Forestry and Water Management; *Government of the Republic of Croatia*; Zagreb, 2007; available at www.mps.hr/eng/ministarstvo/. The following information is found there:

-"SAPARD Programme – Agriculture and Rural Development Plan 2006"

Ministry of Economy of the Republic of Macedonia; Skopje, 2007; available at www.economy.gov.mk. The following information is found there:
-"Energy Efficiency Strategy of the Republic of Macedonia – Volume 1: Executive Summary," Dec. 2003.

Ministry of Economy, Labour and Entrepreneurship; *Government of the Republic of Croatia*; Zagreb, 2007; available at www.mingorp.hr. The following information is found there:
-"Energy Department"
-"Legal Regulation on Energy"
-"Strategic Planning and Energy Balance Department"

Ministry of Environment and Physical Planning; *Republic of Macedonia*; Skopje, 2007; available at www.moepp.gov.mk. The following information is found there:
-"General: Country"
-"Law on Environment"
-"Law on ambient air quality"
-"Law on Nature Protection"
-"Law on Waste Management"

Ministry of Environmental Protection, Physical Planning and Construction; *Government of the Republic of Croatia*, Zagreb, 2007; available at www.mzopu.hr/default.aspx?lang=en&id=3967. The following sources are found there:
-"Energy for Sustainable Development"
-"Report on the State of the Environment in the Republic of Croatia," *Narodne novine*; Zagreb, 19 June 1998.
-"National Environmental Action Plan," Zagreb, 29 April 2002.
-"Second, Third and Fourth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change," Zagreb, November 2006.

Ministry of the Sea, Tourism, Transport and Development; *Government of the Republic of Croatia*,; Zagreb, 2006; available at www.mmtpr.hr/default.asp?id=360. The following information is found there:
-"Croatian Tourism 2005/2006"
-"Strategy and Capacity Building for Regional Development," September 2005.
-"Tourist Traffic 2006"
-"Tourism: Facts and Figures 2005"

Miščević, Prof. Ljubomir, dipl.ing.arh., "Passive Energy Standard in Building as a Perspective of Sustainable Development – First Passive Houses in Croatia;" from *HED: Croatian Energy Association*, "14th Forum: Energy Day in Croatia;" World Energy Council; Zagreb, Croatia; 2005; available at www.hed.hr/forum_en.htm.

Morris, Craig; *Energy Switch: Proven Solutions for a Renewable Future*; New Society Publishers, British Columbia, Canada; 2006.

Norberg-Bohm, V; "Creating incentives for environmentally enhancing technological change: lessons from 30 years of U.S. energy technology policy;" *Technological Forecasting and Social Change*; Vol. 65 (2000); pg. 125-148, available at csia.ksg.harvard.edu/publication.cfm?program=CORE&ctype=article&item_id=222.

"Physical Map of Croatia," from Free World Maps, 2006; available at www.freeworldmaps.net/europe/croatia/map.html.

Pasqualetti, Martin J.; "Morality, Space and the Power of Wind-Energy Landscapes," *Geographical Review*; Vol. 90, No. 3 (Jul. 2000); pg. 381-394.

Popovski, Kiril; Vasilevska, Sanja Popovska; "Prospects and problems for geothermal use in agriculture in Europe," *Geothermics*; Vol. 32 (2003) pg. 545-555.

"Powering Up," *The Economist*; Sept. 16-22, 2006; pg. 91-92.

"Program of the Government of the Republic of Macedonia: 2006-2010," *Republic of Macedonia Government*; Skopje, 2006; available at www.vlada.mk.

"Q&A: Ukraine gas row," BBC News; *British Broadcasting Corporation*; London; 4 Jan. 2006; available at http://news.bbc.co.uk/1/hi/business/4569846.stm.

Reddy, Sudhakar; and Painuly, J.P.; "Diffusion of renewable energy technologies—barriers and stakeholders' perspectives," *Renewable Energy*, Vol. 29 (2004); pg. 1431-1447.

"Regulatory Authorities in South East Europe," *Stability Pact: South East Europe Compact for Reform, Investment, Integrity and Growth*; OECD Public Governance and Territorial Development Directorate; October 2003.

Renewable Energy Access; Peterborough, NH; 2007; available at www.renewableenergyaccess.com; the following information is found there:

-"Alcoa & Iceland Study Geothermal-Powered Smelter for North Iceland," Mar. 7, 2006.
-"China: Renewable Energy Policy Set in Motion," 17 Nov. 2005
-"Cost-Competitive Solar Called 'Imminent'," July 21, 2005.
-"Denmark to Increase Wind Power to 50% by 2025, Mostly Offshore," Dec. 5, 2007.
-"Finland Announces Renewable Energy Ambitions," Dec. 8, 2005.
-"First Solar to Supply Modules for 40 MW Solar Plant in Germany," Feb. 16, 2007.
-"India Reflects on Yearly Wind Power Growth," 28 July 2006
-"Goldman Sachs & Co. Invests in Cellulose Ethanol," 4 May 2006
-"Plastic Solar Cell Efficiency Hits 6% in U.S. Lab," May 4, 2007.

-"Q7 wind farm wins Euromoney Deal of the Year Award," 13 Mar. 2007
-"Sunfilm Plans to Reduce the Cost of Solar Panel Manufacturing," April 6, 2007.
-"Wind Turbines Not a Threat to U.S. Bird Population, Says Study," May 7, 2007.

"Report on the work of the Croatian Energy Regulatory Agency for the Year 2005," Republic of Croatia, Croatian Energy Regulatory Agency; Zagreb, July 2006; available at www.hera.hr/english/documents/pdf/CERA_Report_2005.pdf.

REVETIS: Regional Centre of Vocational Education in Sustainable Building and Renewable Energy; Čakovec, 2006; available at www.revetis.hr.

"Secretariat for European Affairs," *Government of the Republic of Macedonia*; Skopje, 2007; available at www.sei.gov.mk. The following information is found there:
-"Sector for Preparation of the National Version of Acquis Communautaire"
-"Sector for Economic and Social Integration"

"Small Hydropower," European Small Hydropower Association with European Renewable Energy Council; Brussels, 2005; available at www.erec.org.

"Small Hydropower Situation in the New EU Member States and Candidate Countries," *Lithuanian Hydropower Association*, *ESHA*, *IT Power Renewable Energy Consultants*, and *ADEME*; Sept. 2004; available at www.esha.be.

"Stabilisation and Associate Agreement between the Republic of Macedonia, of the One Part, and the European Communities and their Member States, of the Other Part;" Luxembourg, 2001.

State Statistical Office; *Republic of Macedonia*; Skopje, 2007; available at www.stat.gov.mk. The following statistical information is found there:
-"Foreign Direct Investment"
-"Foreign Trade"
-"Industry and Energy"
-"Labour Market: Active Population"
-"Macedonia in Figures"
-"National Economy and Finances: Gross Domestic Product"
- "Population"
-"Transport, Tourism and other Services: Tourism"

"Statističke Informacije 2005 / Statistical Information 2005," Republic of Croatia, Central Bureau of Statistics; Zagreb 2005.

"Statističke Informacije 2006 / Statistical Information 2006," Republic of Croatia, Central Bureau of Statistics; Zagreb 2006.

Stern, Nicholas; *The Stern Review: The Economics of Climate Change*; 2006; available at www.hm-treasury.gov.uk.

"Strategic Development Framework for 2006-2013," Central Office for Development Strategy and Coordination of EU Funds; Government of the Republic of Croatia; Zagreb, 2006.

"Strategic Environmental Policy Assessment – FYR Macedonia: Final Report," United Nations Environmental Programme & United Nations Development Programme; November 2001.

Survey of Energy Resources; World Energy Council; London, 2007; available at www.worldenergy.org; the following information is available there:
-"Biomass"
-"Geothermal Energy"
-"Hydropower"
-"Solar Energy"
-"Wind Energy"
-"Wood"

Vrhovčak, Maja B.; Tomšić, Željko; and Debrecin, Nenad; "Potential and use of renewable energy sources in Croatia," *Renewable Energy*; Vol. 31 (2006) pg. 1867-1872.

Wohlgemuth, Norbert; "Energy Security In Least Developed Coutnries," United Nations Industrial Development Organization (UNIDO); 2006; available at www.unido.org.

World Energy Investment Outlook: 2003 Insights; *International Energy Agency (IEA)*; Paris, 2003.

"World Energy Outlook 2004," *International Energy Agency*; Paris, 2004; available at www.iea.org.

Zahedi, A.; "Solar photovoltaic (PV) energy; latest developments in the building integrated and hybrid PV systems;" *Renewable Energy*; Vol. 31 (2006), pg. 711-718.