Energy / Climate Change

Challenges and Opportunities

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ENERGY

- “Turbine” by Michael Spiller
- “Powerlines” by Peter Hellberg
- “Windpower all sizes” by Janie Hernandez
- “Rooftop Photovoltaik” by Bernd Sieker

CLIMATE CHANGE

- “Drought Texture” by Sander Hoogendoorn
- “Flooded River in University Park” by Chris Northwood
- “Katrina” by NOAA USA
- “Forest in Wisconsin State natural area” by WackyBadger Photography

Color Pallette: The World is Colorful by C.T. Dohrman

The map “Die Welt ist bunt” (The World is Colorful) divides the earth’s surface into 10 climate categories. The reddish orange describes the hot, burned soil of the desert. Yellowish orange depicts semi-desert and desert steppe. Green tones, varying between a green-brown (coniferous woodland), green-yellow (agricultural land) to a green-blue (rainforest), stand for humid areas. The Pallette was sampled from the following map:

”Die Welt ist bunt” (section), 1963 © Falk Verlag. 1:40 mio. Relief shading by F. Hölzel, colors by W. Dylewski.

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Table of Contents

Forward

This publication is the product of a graduate seminar sponsored by Fulbright and the Teresa Lozano Institute of Latin American Studies of The University of Texas at Austin. Dr. Oswaldo Lucon, a Fulbright Scholar from the Universidade de São Paulo, organized the course which challenged students to research and discuss ongoing initiatives to address the challenges posed by climate change.

The course had two sections, first learning the tools and methods in energy and climate change research and the second applying these methods to produce scholarly work. Topics ranged from the Science of Energy (physics, renewable and non-renewable sources, available resources) to the social and economic development as it is related to energy (GDP, human development index, energy access, social welfare, vulnerabilities).

The core of the course was a focus on policy. National and sub-national policies were analyzed from both OECD countries (developed nations or nations who are members of the Organization for Economic Cooperation and Development) and non-OECD countries (developing nations). Policy framework covers topics like greenhouse gas emissions mitigation, adaptation to climate change, vulnerability assessment, land use planning and ecological-social-economic zoning, integrated environmental assessment in policy making, targets and timetables in policies, financing and taxation, carbon markets, technology access and transfer, research, development and deployment, sustainable production and consumption patterns.

The following chapters of this book shows the products of the course, which is a collection of individual and group works on energy, climate change, development, and policy.

Summary For Policy Makers

The Energy and Climate Change Class of the Teresa Lozano Institute of Latin American Studies at the University of Texas created the following report, which reviews policy and research of issues surrounding energy and climate change. The group took a global perspective analyzing policy on multiple levels: regional/local, national, and global. This report outlines the challenges and opportunities that face both developed and developing nations. There is no single development pathway that works for every country, but lessons learned in one country can be applied to others.

Energy and Climate Change - Challenges and Opportunities

Energy and climate change are linked, and to address anthropogenic climate change, sustainable energy sources must be developed. Energy and development are also linked, and as the world develops and emerging economies grow, the world's energy demands will increase. These two trends pose a challenge and an opportunity for the world. The challenge is to provide the needed energy to continue development while mitigating environmental impacts. The opportunity is in developing the energy sources which can lead to improved security and access.

Renewable Energy and Efficiency Policies: Aims

Two major components of a transition to a low carbon energy portfolio involve efficiency measures to reduce demand for energy while supporting clean, renewable sources of energy production. Governments interested in promoting energy efficiency have pursued a number of policies. Indeed, a government role may be necessary to help overcome market failures and effectively introduce efficiency technologies. Some broad policies governments are currently implementing include:

- Research and development to overcome technological barriers to widespread implementation.
- Federal mandates establishing minimum efficiency standards.
- Government-sponsored consumer education programs.
- Directing incentives at manufacturers rather than consumers.
- Governments leading by example through regulations on efficiency in government affairs.

Several policy mechanisms have successfully implemented renewable energy into countries' economies. These policies hinge around financial incentives to promote renewable energy. Feed-in tariffs, renewable portfolio standards in the U.S., and renewable energy mandates have provided impetus for renewable technology and driven down costs for all users of renewable energy. Other effective measures include economic stimuli that promote education and research and development for renewable energy technology, and liberalization of energy markets to allow investment from private investors.

Renewable Energy

Though it is unlikely that renewable energy sources will comprise the entirety of a country's energy portfolio in the near future, these energy sources are becoming an increasingly important component of power generation across the globe. Benefits of renewable energy sources such as wind, solar, biomass, and hydro include decreased reliance on fossil fuels, energy independence, and decreased emissions. Countries are implementing a variety of policies to promote a renewable energy transition, including renewable portfolio standards, feed-in tariffs, tradeable green energy certificates, and targeted grants.

Sweden has been a world leader in renewable energy development and intends to be the world's first oil-free economy by 2020. The country uses 21 percent of its energy for heating, which is provided by biomass and biofuels. Sweden's shifting fuel supply has been impressive; compared to 1970, when oil was the main fuel, oil accounts for only a few percent today. More than 62 percent of district heating fuel today is biomass. A comprehensive policy mix exists with tradable green certificates as the key mechanism in Sweden. Aside from oil efficiency, a governmental mandate created the electricity certificate system which supports renewable electricity by meeting a proportioned yearly demand. The demand for electricity certificates is created by a renewable portfolio standard - an obligation that electricity suppliers and certain electricity users are required to purchase certificates corresponding to a particular proportion of their electricity sales and/or electricity use.

Iceland has a financial instrument in place called the national energy fund (NEF) that was created to aid in the development of energy for the country. The NEF, which is administered by the National Energy Authority of Iceland, gives loans and grants to entities that wish to explore potential sources. Grants from the NEF can be used to exploit any energy resources or build infrastructure that aids in the economic usage of energy. Currently, almost 100 percent of Iceland's electric power is generated from hydroelectric and geothermal sources. Iceland has also invested heavily in hydrogen development and currently has two hydrogen filling stations in the capital city of Reykjavik.

Disincentives to Renewable Energy

Nations or regions with abundant fossil fuels and a thriving conventional energy sector may not have the same natural incentives to pursue clean ener-

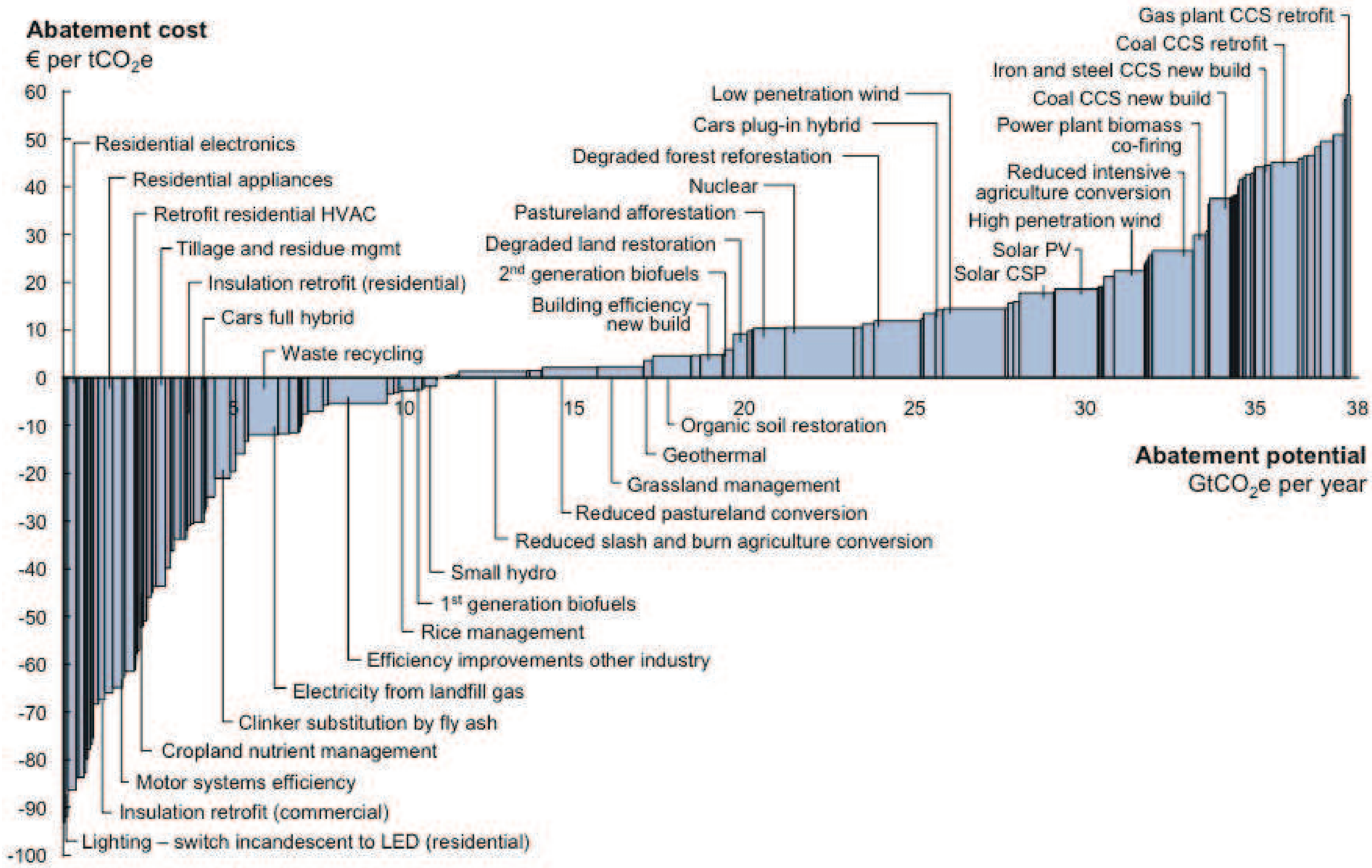

Figure 1. Abatement Costs (Mckinsey & Company, 2009)

gy. For example, Colombia has the largest proven recoverable coal reserves in South America. As demand for energy grows, more power is going to be needed to supplement the grid which is currently about two thirds hydroelectric. Although it has been shown that there is significant potential for wind power, building more coal plants is currently the most cost effective solution. Nations with abundant fossil fuels can be encouraged to develop renewable energies through polices that encourage international trade of these sources. For example Europe has renewable energy mandates that can not be meet through development of its own renewable energy potential. This policy in Europe has created a demand that will be filled by countries like Algeria which is developing concentrated solar power plants to generate electricity for Europe despite the abundant oil reserves.

Energy Efficiency

All countries, no matter their stage of development, can benefit from energy efficiency measures to reduce emissions and consumption of energy. In addition, efficiency measures often represent the most cost-effective means of meeting energy demand, when compared to adding additional production capacity. From light-bulbs to building insulation, energy efficiency measures allow countries to make incremental investments with potentially large long-term gains. As the chart below shows, much of the GHG abatement potential can be met through measures that have a positive economic impact or have no implementation cost.

United States

In 2008, residential and commercial buildings accounted for 73 percent of total electricity use in the United States and 40 percent of total primary energy use. Some analysts argue that the application of energy efficiency technologies in commercial and residential buildings in areas such as space heating and cooling, water heating, lighting, and computing, has the potential to save up to 840 terawatt hours (TWh) each year by 2020. The savings would cost less per unit of energy than the current retail prices of electricity and gas. The Energy Independence and Security Act of 2007 (EISA) established new energy efficiency standards for a variety of products, including external power supplies, residential clothes washers, electric motors, residential boilers, refrigerators, freezers, and dishwashers. In addition, EISA promotes the use of CFLs and LEDs by applying strict efficiency standards to all forms of lighting over the next decade. In establishing these regulations, the United States is effectively mandating energy efficiency improvements.

Ontario, Canada

Ontario is currently implementing legislation that will greatly increase its energy efficiency. The main policy mechanism through which it hopes to achieve these gains is through regulations and adjustments to the building code. Energy audits will be required upon transfer of a property between owners or at the start of a new lease, effectively disclosing a buildings' efficiency level and exposing the related costs to potential buyers and renters (CIELAP, 2009). In addition, public agencies will be held to a high standard of efficiency, and new government buildings may be held to a LEED Silver standard (CIELAP, 2009, Runyon, 2009). Finally, the bill will emphasize the use of Energy Star appliances at the household level and also promote efficient use of water through incentives (Runyon 2009).

One of the central concerns for implementation of energy efficiency measures is the "rebound effect," or the idea that consumers will increase use of electricity as it becomes cheaper per unit due to efficiency measures. Technologies may have various degrees of this effect (See Table 1).

Table 1. Measured Rebound Effects on Various Devices (Congressional Research Service)

DEVICE	SIZE OF REBOUND	NUMBER OF STUDIES
Space Heating	10-30%	26
Space Cooling	0-50%	9
Water Heating	10-40%	5
Residential Lighting	5-12%	4
Home Appliances	0%	2
Automobiles	10-30%	23

However, this effect can be mitigated by increased taxes so that prices reflect the externalities inherent in most electrical production.

Considerations for Developing Nations

Developing nations have, thus far, been slow to develop renewable energy and energy efficiency measures. This traction is due largely to a lack of economic resources to implement these often capital-intensive programs. Fortunately, developed nations' investments in new technology can be transferred to smaller economies, creating a "leapfrog effect." The hope is that less developed nations can bypass a carbon intensive economy and transition directly into a low-carbon economy, avoiding investment in outdated technologies and less efficient energy sources.

Energy Security

Many countries face severe threats to their energy security. Typically, nations with limited energy resources are the most concerned. Additionally, physical isolation from other nations, or political isolation from neighbors exacerbates energy security concerns. In response to energy security issues, a number of nations have created programs to aggressively reduce their energy consumption or increase domestic production.

For instance, South Korea has few fossil fuel resources, but its large manufacturing-based economy requires substantial energy consumption. Only 20 percent of South Korea's energy supply is produced domestically. Because of its relatively isolated position on the Korean Peninsula and the historic conflict with North Korea, it is difficult and inefficient for South Korea to import energy. South Korea has reacted to this energy security crisis by implementing an aggressive Green Growth program to reduce energy consumption and increase the production of domestic energy supplies. Approximately 80 percent of the South Korean fiscal stimulus was given to the Green Growth program in order to create an economy based in green manufacturing. South Korea is focused on increasing production of solar and nuclear energy, developing tidal energy technologies, and increasing energy efficiency. South Korean spending on energy efficiency research, development, and demonstration is the 4th highest in the world.

Morocco also faces significant energy security issues. The country imported nearly all its energy and lacks energy reserves. Being dependent of the world to meet energy demands, the developing economy is sensitive to fluctuations in energy prices. While the country lacks traditional sources of energy and it has many underdeveloped potential for renewable energy sources. Wind potential in coastal areas are suitable, the desert regions offer potential for concentrated solar, urban areas can utilize solar photovoltaic (PV) and thermal, and the river systems which need flood control can use hydroelectricity. The recent energy laws of Morocco are linking renewable energy with the development of the country, investing heavily with the goal to 40 percent of its energy from renewable sources by 2020.

Senegal is emblematic of the challenges unique to much of sub-Saharan Africa. Their low level of export resources, and the resulting economic challenges present a common challenge to transition to renewable energies. Commonly incomplete or inefficient power infrastructures also present both practical and financial challenges. Because of the often capitally intensive initial costs of these (wind, concentrated solar, hydro-electric, wave energy) power production facilities, these technologies have been embraced less slowly than they could be. However, with economic aid, the leapfrogging effect could aid in the further development, and increased energy security of these growth economies.

Georgia has provided a successful example in regards to energy security. In five years it transitioned from being a net electricity importer to a net exporter due to the large-scale exploitation of its hydroelectric resources. Before this shift, the country had been plagued with erratic energy supplies due to a number of converging circumstances including supply disruptions from Russia, poor-collection rates due to defective or vandalized electricity meters, and an impoverished population unable to pay for its electricity deliveries.

In the face of peak oil, even energy rich countries are looking towards policies that promote the development of clean energy and energy-efficiency. Countries such as Saudi Arabia, which is considered to have the largest proven oil reserves of any country, see renewable energy development as means to reduce domestic consumption of profitable commodities such as oil and natural gas. These countries typically have economies that are largely dependent on energy exports, and therefore, have invested interest in preserving their valuable resources to sell to other countries, rather than use it for their domestic energy needs. Saudi Arabia's economy, for instance, derives three-quarters of its governmental revenues from its oil and gas exports. Likewise, the crude produced by Pemex, Mexico's state-owned oil company, generates over 15 percent of total Mexican export revenues, and 40 percent of its government's revenues.

Although most energy exporting nations realize that waning energy reserves could be devastating to their economies, policies to reduce domestic consumption of these resources by exploiting other technologies vary. Saudi Arabia has committed to investing $400 billion by 2013 on research, education, and infrastructure improvements in order to facilitate the deployment of clean energy projects such as nuclear, solar, and wind energy. Since 2010, several large solar projects have been commissioned to exploit the county's large solar potential. Mexico, on the other hand, has depended largely on foreign investment to expand its clean energy infrastructure. It is a popular host country for Clean Development Mechanism projects, which are activities that Annex-1, industrialized countries lead in developing nations in order to offset their own domestic emissions to comply with their emission reduction targets. As of April 2011, Mexico has 249 CDM projects of varying scope, completed or under development that represent the majority of its clean energy development to date. National policies to promote sustainable energy exist, but have been relatively ineffective to date.

Political Instability as an Energy-Climate Challenge

Political uncertainty and conflict can generate serious challenges for existing and future climate change and energy policies. This is the ongoing situation of North Africa, where political unrest has exploded across the region and destabilized Libya with armed conflict and Egypt and Tunisia with revolution. The situation in Sudan remains precarious as the country will become two independent nations this July and divided along a line of contended oil fields. Even Algeria is unlikely to remain peaceful in the wake of neighboring violence. How these countries regain stability, promote their energy and address climate change will have implications for states and markets worldwide.

Localized instability that began with a political revolt in Tunisia set off a chain of events that have reshaped the Energy-Climate nexus in North Africa. Egypt followed closely behind with its own revolution that removed a president with political alliances to the West and possibly set that country on a course to align more with the Arab League. Libya remains embroiled in civil conflict that has nearly halted all production of the country's oil. A post-Qaddafi regime would present numerous opportunities to investors in Europe. Sudan, after many decades of civil war, finally passed a referendum for Southern secession that takes effect this July. Many eyes are now turned to Algeria, where conditions against the militant government are ripe for revolt despite miraculous calm.

North Africa represents a key strategic position in the global production of oil and natural gas and each country has unique energy challenges as production in this region has been a prime target for foreign investment. It is critical to understand how such violence has impacted energy production and policies in these countries. Trading partners in Europe, China and Israel, which are heavily dependent on production across North Africa have a vested interest in seeing these countries return to conciliation and peace. In Algeria and Sudan, the production of oil in recent years has presented opportunity as expanded discoveries and drilling have attracted a trading partner in China and led to a boost in state income that should address infrastructure and poverty. Libya and Tunisia remain key exporters to Europe and recent violence has threatened stability of energy in that market. Egypt's declining oil resources have led to a strategic shift to natural gas production for export. However, revolution in Egypt has called into question the Egypt-Israel peace agreement and officials that brokered the deal to export natural gas to Israel and Jordan are now being prosecuted for selling this resource too cheaply. How these countries respond to these challenges and maintain their strategic partnerships will be critical to future energy policies.

Climate change presents another major challenge for these countries, yet it is uncertain how political violence will impact policy makers as attention is drawn away from environmental policy to respond

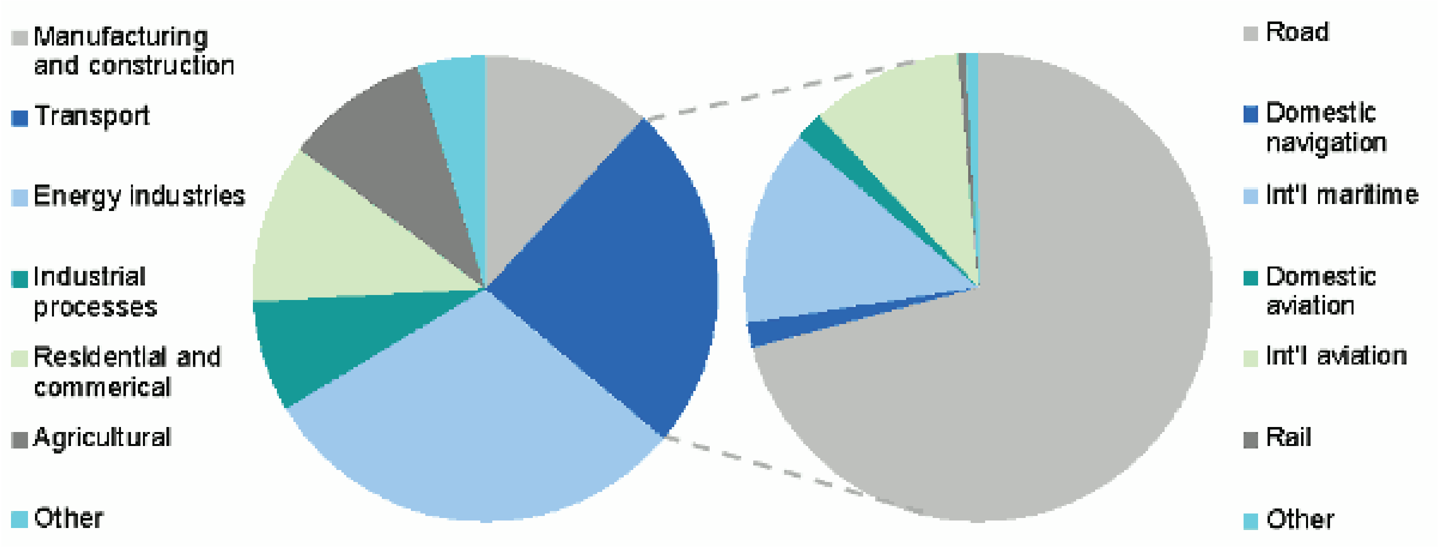

Figure 2. EU greenhouse gas emissions by sector and mode of transport, 2007 (European Commission)

to the socioeconomic factors that have started the violence, such as unemployment and repressive governance. However, the International Panel on Climate Change reports that many of these countries will be among the most severely affected by climate change on the African Continent. Each of these countries will face a unique set of environmental challenges from water security in Egypt, drought and desertification in Sudan, Libya and Egypt and possible sea level rise across the North African Mediterranean coastline.

Going forward, there is much uncertainty in these nations with regards to energy and environmental policy. Among other things, it still is unclear how policies and practices in these nations will change as a result of the recent political turmoil and who emerges as the leaders in these countries. In all likelihood, maintaining peace in this nations will become the top priority for political leaders in the foreseeable future and energy and environmental concerns are likely to play, at most, a secondary role in North African policy-making.

Transportation

The transportation sector is responsible for the second largest amount of greenhouse gas emissions, behind the energy sector. The promotion of more sustainable transportation fuel use is integral to mitigating the impacts of climate change in the world today. However, promotion of these policies is not without obstacles. Central challenges to reducing dependence upon greenhouse gas-emitting fuels in the transportation sector include primarily both the centrality of transportation to nations' infrastructures, and the economic role of the transportation sector in many economies. In addition, transportation's need for portable fuel is a logistical challenge to its use of renewable fuels. Regulating the transportation sector in terms of energy usage and consumption, the creation of sustainable systems of public transport, and the reduction of emissions are some ways that countries are changing their transportation policies. Portugal, for example, has set guidelines for energy policy through a national action strategy that deals with the problem of climate change by focusing on reducing emissions in the public transportation sector. In order to mitigate the effects of climate change both locally and globally, further cooperation and discussion around more sustainable transportation policies are necessary in order to mitigate the impacts of climate change and create sustainable energy usage policies.

Transportation has a definite impact on global climate change. The transportation sector is re-

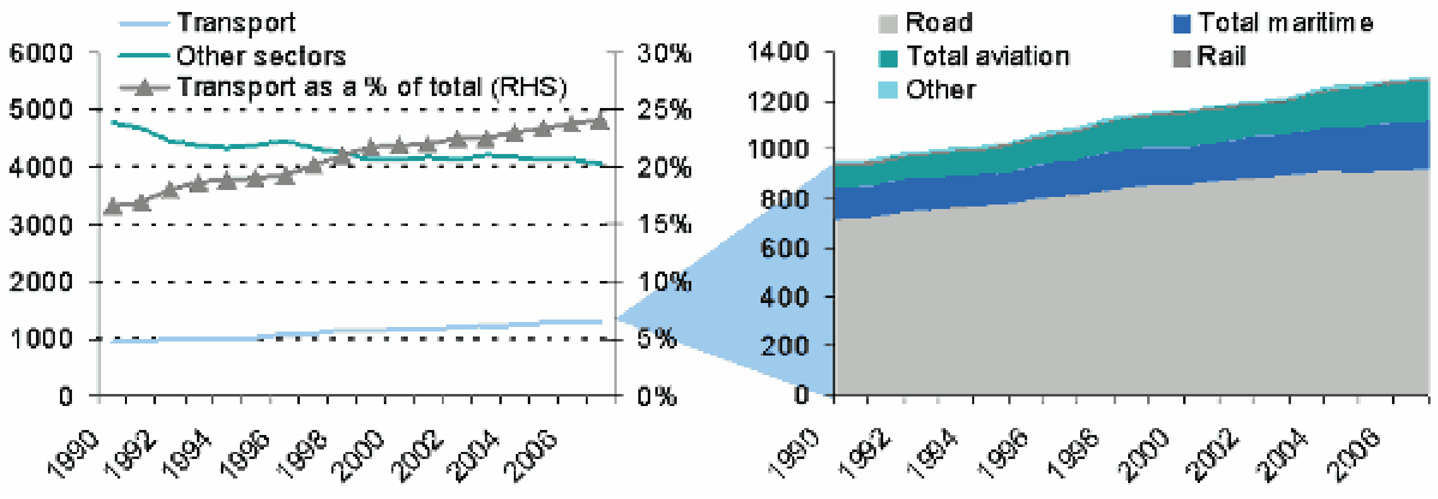

Figure 3. : EU greenhouse gas emissions from transportation and other sectors and by mode of transport, million tonnes of CO2 equivalent, 1990-2007 (European Commission)

sponsible for around 25 percent of the greenhouse gas emissions in the European Union, and more than two thirds of transport-related greenhouse gas emissions are from road transportation; this relationship is clearly visible in the graph in Figure 2 Aviation and maritime transportation also contribute significantly to greenhouse gas emissions throughout the world, visible in Figure 3, requiring that countries produce multi-modal transportation policies to reduce the impacts of climate change in our world.

Increasing automobile ownership is a major barrier to reducing greenhouse gas emissions all over the world, but the number of private cars is definitely increasing in many developing countries. In Brazil, private automobile ownership is a major problem: at about 150 vehicles per 1,000 people, it is more than three times higher than the average for the rest of Latin America. Car ownership in Brazil is projected to rise to over 335 per 1,000 people by 2030, roughly three-quarters the ownership in Europe today. In São Paulo, the largest Brazilian city, the vehicle fleet recently surpassed the 7 million mark. 73 percent of this fleet are private automobiles. Transit experts in the city estimate that the actual number of vehicles on the road daily is closer to one-third of that number, however there are still congestion and air quality issues in the city due to the high number of vehicles.

In the US, 81.8 percent of trips take place in a personal vehicle, and 0.9 percent of trips take place on public transportation. Private vehicles are the largest contributor to the average household carbon footprint, at 55 percent, and if one car per household switched to public transit for transportation the household emissions would be reduced by 1/3. The transportation sector makes up 29 percent of the energy consumption in the United States, and the focus on construction of more highways for private automobiles constitutes unsustainable transportation policy: the country spends 11.6 percent of our GDP on transportation, as total of $1.5 trillion, and about $1.3 trillion of that money is spent on the private sector particularly highways.

Adaptation to Climate Change

How individual nations respond to global climate change is a central challenge. We identify several adaptive elements: response to changing precipitation and sea level rise, changing energy production due to changing local conditions, food security, and weighing domestic concerns against global ambitions for mitigation.

Climate change effects can be seen in both biophysical and social spheres, where activity in one sphere generally has a direct effect on the other. For example, extreme environmental events like floods or droughts have direct effects in migration patterns and food security. In this way, adaptation of social systems to climate change involve involuntary and spontaneous reactions, but also deliberate and planned mechanisms. Adaptation is a dynamic process; it is not enough to focus on the initial impacts and try to develop strategies for scenarios in the future. Adaptation schemes taking place, whether they are planned or involuntary, will cause other impacts in both biophysical and social systems. If adaptation is a dynamic process, it is likely that current adaptation objectives should not necessarily reflect future adaptation plans, making it necessary to acknowledge the need for resilience, flexibility and sustainability of the systems.

Changing precipitation patterns, anticipated sea level rise and more common or more acute natural events such as typhoons and hurricanes may place enormous strain on populations, infrastructure, migration patterns and global trade patterns. In many places, dense population along coastal shores will require relocation further inland or across political boundaries. These migrations are tremendously costly in real terms and place burdens on infrastructure and sociopolitical relations, as in the case of Bangladesh. Historical strife between Bangladesh and India may be exacerbated as climate refugees from Bangladesh seek refuge in India, or relocate further inland in Bangladesh, putting strain on a poor and energy-starved country. This same phenomenon will recur elsewhere, with similar concerns. Sea level rise is also a concern for developed nations like the United States and Italy, whose flagship cities New Orleans and Venice are directly threatened by rising seas. How countries are able to respond belies critical issues of social and environmental justice and equity, namely, that adaptation is easiest for those with resources and will necessarily most directly affect the least prepared, who tend to be the poorest nations.

In many nations, poverty and lack of infrastructure hinder development plans for environmental issues and climate change. For these nations, even though there are no specific and direct policies trying to deal with climate change, its effects are already present, and communities are already implementing adaptation schemes. This situation can be seen in Central Africa, where political conflicts have added even more obstacles to the application of long term national policies. Communities in this region are extremely vulnerable to climate change, and adaptation in the form of migration is already taking place. When adaptation is foremost an instinctive survival strategy and unplanned, it is easier for this short term adaptation to present irreversible environmental impacts which become an obstacle for long adaptation plans. Deforestation is a critical issue in Democratic Republic of Congo (DRC), and it is a great example of the dynamic consequences of adaptation. As mentioned before, migration is a consequence and response to climate change effects, but it also induces changes in ecosystems. Instinctive adaptation of social systems to climate change and the extremely vulnerable scenario in Central Africa is causing damage to ecosystems at an even higher rate. These kinds of acute needs may act counter to global mitigation goals. Meeting basic needs such as clean water, food and energy may oppose global efforts to combat deforestation, prudent agricultural practices and strategic population distribution.

Adaptation policies should take into account local and global effects. Interconnections between nations are always latent, and in some way, climate change effects cannot be isolated to geopolitical borders, as they could replicate throughout a region. If an extremely vulnerable community without adaptation opportunities is forced to leave its location in order to survive it could migrate to another region where supposedly climate change effects were still not present. The arrival of the second community makes it necessary to try to find a new equilibrium in order to maintain sustainability.

Climate change, and the resulting changes in weather patterns, precipitation and extreme weather events, has the potential to significantly alter the composition of energy resources in many countries. As sources dependent upon changing weather patterns become more limited, some countries may have no choice but to explore alternative, potentially dirtier, means of providing energy. Namely, those countries that rely upon glacier-powered hydroelectric energy will likely suffer from the retreat of glaciers with increased temperatures, a reduced snowpack decreased summer runoff, and increased winter runoff. In addition, as temperatures continue to increase, reservoirs will suffer increased evaporation and hydropower production will become more variable.

In the case of Peru, the country's high dependence on glacial melting and annual snowpack runoff has become a problem in the last decade due to the changes in rainfall distribution patterns due to climatic conditions caused by La Niña and El Niño. As a result of the increasing instability of hydropower, Peru has turned to natural gas reserves to fuel the expanding electricity needs of its growing industrial sector.

Effects of La Niña and El Niño are also seen in Philippines and South Eastern Asia. Over the past two decades, there has been an increment in frequency and intensity of extreme weather events. This type of extreme events in Philippines have caused crop failure, water shortages, and forest fires, affecting several vulnerable communities. These forest fires also contribute to climate change, realising large amounts of carbon dioxide.

The global population is expected to reach nine billion by 2050, an estimate that implies an increasing concern over food security, the adaptation of production methods to climate change, and the need to address the potential loss of crop yields that will be associated with higher temperatures in some of the world's most vulnerable regions. Research shows that there will be a large disparity in agricultural vulnerability to climate change between developed and developing nations. This disparity is due not only to estimated temperature changes but also to the increased presence of CO2 in the atmosphere and future water availability.

For many countries, agriculture is one of the main economic activities. In many cases, agriculture is primarily based on small scale farmers with a small production aimed to their own families consumption. Climate change effects in agriculture are present both in large producers that export everything they harvest and in these small-scale farmers. However, a higher vulnerability is seen in the latter, because it is not just about the fall in net revenues, but if crop yields fall, their access to food would be at a high risk.

Increasing temperatures may have the positive effect of lengthening the growing season in middle and high-latitude countries, lower latitude countries, largely still developing, will likely see a shortening of its growing season and a shift away from traditional cereals and other crops. CO_2 levels are important when estimating the potential impact of climate change on crop production, as crop growth has been shown to benefit from increased levels of CO_2.

Although, in general, temperature changes to developing countries are predicted to be lower than the global average, scenarios show that yield changes are predominantly negative in these regions. In upper to middle latitudes, where the majority of developed countries lie, crop yields are projected to be mildly positive. This has major implications for global food security, and speaks to the importance of distribution through global trading schemes.

Two important responses can be identified as consequence of decreases in crop yields (as a climate change effect). Communities whose main activity is agriculture are having shifts in their economic activities, which could also be expressed as migration to already densely populated regions. A second response is looking for physical or biological solutions to the low crop yields. Many small scale farmers have adopted fertilizers and other chemical products as an option to increase crop yield. In many cases yield is increased for some short periods after which land becomes even more infertile. As a corollary to this problem, communities become economically dependent to external actors, making them even more vulnerable. The problem with economic dependence, which can also be experienced if farmers need to buy genetically modified seeds, is that the (social) system becomes even less resilient to unexpected changes relaying completely on acquiring these products, and reducing sustainability of the original agricultural activity.

Another pressure on the agricultural sector has emerged in land use competition between food security and biofuel resource production. Especially where arable land shortages or land ownership policies reduce food security, intense debates have arisen. An example of this, Senegal has embarked on recent projects to both grow Jatropha and exploit the use of its oil for biodiesel, for both domestic use and export. To address these issues, the European Union Energy Initiative published a paper (for all of sub-Saharan Africa) in 2010 regarding the food versus fuel conflict. They urged the nations to put in place policies for responding productively to pressure from industrialized nations to shift production toward biofuel crops. The EUEI noted that these policies would facilitate responses more beneficial for sub-Saharan Africa, as they would put planning in place for the situation before pressures could create less favorable de facto policies. The contention likely will continue, but it seems that more arable land is available than currently is being used for food crops.

In addition, socioeconomic changes can occur as a secondary effect of climate change, shifting the division of labor in affected communities. In Peru, for example, climate change has already caused socioenvironmental shifts in the Andean region of Puno, near the Bolivian border. The impact of climate change in rural regions is especially acute due to the large percentage of the population dependent on pastoral livelihoods, a fact that is compounded by minimal access to institutions. Between 1990 and 2000, there were large decreases in permanent ice and increases in area covered by wetland. Responses to these changes have largely depended upon farm-level adaptation, the resources available to each family, and their perception of these biophysical changes.

Image Sources

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“EU greenhouse gas emissions from transportation” from Towards the decarbonisation of the EU’s transport sector by 2050; Skinner, I., Van Essen, H., Smokers, R. & Hill, N. (2010)

Climate change: bridging Texas and São Paulo

Oswaldo Lucon

Arriving from Brazil to lecture on Energy and Climate Policies at the Teresa Lozano Long Institute of Latin American Studies, I have found in Texas interesting possibilities for long-term research and collaboration with my home State, São Paulo. Both have a huge policy influence in their countries, what makes comparisons inevitable. Texas has the second economy in the US, with a gross product equivalent to two-thirds of that of Brazil. São Paulo has the largest economy and population in the Brazil, indicators that make it comparable to Argentina (Table).

Considering the advantages of a new and greener economy, Texas and São Paulo have ahead many possible opportunities for change and collaboration, mutually showing and offering their best practices, creating new and durable jobs, leapfrogging experiences and developing a positive

Table: Texas and São Paulo, basic information (2008 data from SSE, 2011; 2005 CO_2 SP emissions from CETESB unpublished; US DoE, 2011b; ranking as if a country by Wikipedia, 2010; vulnerabilities from IPCC, 2007, Pew Center, 2007, Environmental Defense et al, 2000 and SMA, unpublished)

		
Area 1,000 sq km 1,000 sq mi	 696 269	 249 95
Population Total mln Capital, mln	 25 Austin, 0.8	 42 São Paulo, 10
Gross Product Total $ bln share of country's 1000 $ per capita	 1,224 8% 48	 550 34% 13
Fossil-fuel CO_2 emissions Total million tonnes Ranking in the World Per capita, tonnes Per dollar GDP	 630 6th 25.2 0.51	 85 43rd 2.1 0.15
Energy consumption Total tons of oil equivalent (toe) Per capita, toe	 300 12.0	 58 1.4
Typical environmental impacts associated with climate change	Hurricanes, severe droughts and water shortages, flash floods, heat waves and cold blasts, sea level rise, losses in crops and fisheries, climate-induced migration from other countries	Severe droughts and floods, sea level rise, landslides during thunderstorms, heat islands in cities, epidemics of dengue fever and other weather-associated diseases, agricultural losses, enhanced air pollution episodes

environment for state-of-art technologies. If this happens, there may be significant positive spill-overs to the national contexts.

URGENT ACTION

Pursuing economic growth coupled with increased carbon emissions poses a threat to mankind. Through following pathways derived during the Industrial revolution and with the idea that they have a right to pollute based on historical and/or per capita contributions (Figure 1), countries like China, India, Brazil, and other emerging economies are now emitting as much or more carbon into the atmosphere as their developed counterparts (Figure 2). According to the US Department of Energy (2011a), non-OECD (developing nations) energy-related emissions of carbon dioxide exceeded OECD (developed countries, or literally the Organization Economic Cooperation and Development) for emissions in the year 2007 by 17 percent. In their reference case scenario, energy-related carbon dioxide emissions from non-OECD countries in 2035 are about double those from OECD countries. These projections are to the extent possible based on existing laws and policies, but may change significantly if laws and policies aimed at reducing greenhouse gas emissions are changed or new ones are introduced. Discussing the effect of global warming on the world economy, the UK Stern Review (2006) states that the window of opportunity to reduce emissions at the expenses of 1%-3% of the GDP is open only for the next two decades, otherwise economic losses may reach up to 20% by 2050. From conceiving a policy to having its ultimate environmental goal – that is, to stabilize global carbon atmospheric concentrations at safe levels (around 450 parts per million CO2) and to reach an average temperature of no more than 2 degrees Celsius there are several delays to consider. There is a long and inertial way from raising awareness to proposing, enacting and enforcing legislation, then to developing and implementing the necessary technologies at large scale, then to effectively reduce emissions and stabilize temperatures (Goldemberg and Lucon, 2009).

RULES HAVE CHANGED

Moreover, taking into consideration that growing in a global market requires being innovatively competitive, this approach seems not to be much effective. After a rise of 9.2 percent in 2009, China's economy grew 10.3 percent in 2010, and is expected to increase 8 percent this year. India's favorable demographics with over 30 percent of its population below age 15 and a comparatively higher intellectual level look set to support the country's consumption and economic growth in the long run. The Brazilian economy rebounded robustly in 2010 with a 7.5-percent growth thanks to strong domestic demand and heavy government investment (Fei et al, 2011). In the US, President Obama has rightly said in the State of the Union Address that rules have changed (White House, 2011). Beyond a threat to the US welfare, indeed and for worse, limits to growth have now exceeded the Earth's carrying capacity, bringing new and still not well understood rules to the economy's game. Public expenditures are also higher with effects from climate change (e.g. induced migration control, responses to natural disasters and increases in healthcare costs). Moreover, oil producing regions are not rarely instable in geopolitical terms, entailing additional burdens to governmental budgets all over the world.

CROSSROADS AHEAD

Many regions in the world are are vulnerable to extreme weather events and other associated impacts. Unfortunately this is the case of Texas and São Paulo, where agriculture, cities, coastal areas and ecosystems are environmental hotspots where adequate policies will necessarily have to address accordingly and with a growing intensity (IPCC, 2007). São Paulo Metropolitan Region has around 25 million people within a 75-mile distance from the city center, exposed to air pollution, heat

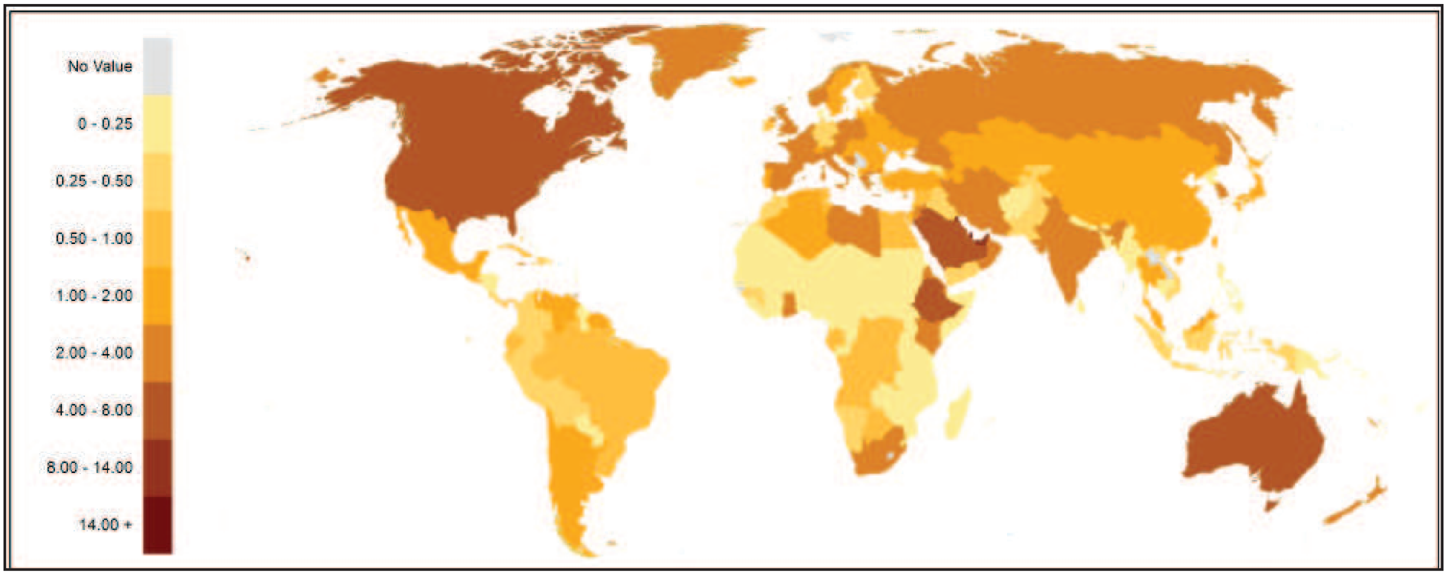

Figure 1. Countries by per capita carbon dioxide emissions from burning of fossil fuels (tonnes of CO2), year 2007. Data from CDIAC (Boden et al, 2011)

islands, flash floods and dengue fever outbreaks. Many of Texas' urban regions were designated as having some of the worst air quality in the nation (Pew Center, 2007). Houston area is a perfect laboratory for climate change: wetlands, buildings and infrastructure exposed to sea level rise, floods and hurricanes. Forest fires and water deficits are now widespread in both States. Biodiversity losses are impossible to valuate in monetary units. Texas, the leading crude oil producing State in the Nation, is becoming a net importer of such fuel; natural gas may also not last for long.

The role that Texas and São Paulo can play in this game can be prominent if they opt for pathways alternative than those based on maintaining or increasing the addiction on oil. This is not an easy task. The Lone Star State produces and consumes more electricity than any other State, and per capita residential use is significantly higher than the national average (Pew Center, 2007). In São Paulo offshore coast were recently discovered massive oil and gas fields - with a magnitude comparable to those from Iraq or Venezuela – this may lead to a more carbon-intensive economy (Lucon and Goldemberg, 2010). If Texas and São Paulo were countries, they would be the 7th and 43rd respectively on the global list of top fossil fuel related CO_2 emitters (Table).

GOOD WINDS BLOWING

Our States can exchange their best. Deliberative opinion polls conducted across Texas demonstrated unexpectedly strong public consensus for a new commitment to renewables. Electric vehicles and car sharing schemes, common in Austin area, may contribute to reduce urban pollution and greenhouse gas emissions. While wind energy in São Paulo is virtually unexplored (especially offshore), Texas leads the Nation in wind-powered generation capacity, with over 2,000 wind turbines in West Texas alone. Despite the historic role of Texas in fossil fuel development and use, the Renewable Portfolio Standard (RPS) enacted in Austin in 1999 is widely viewed as having launched a new chapter in energy development in the Lone Star state, triggering a massive increase in the supply of renewables that is being provided at prices highly competitive with conventional sources. The program has proven so successful and so popular that the Texas Legislature overwhelmingly endorsed a major extension and expansion of the legislation in 2005 (Pew Center, 2007).

São Paulo can contribute with expanding the Texan fleet of alternative-fueled vehicles (100 thousand, or 12.9 % of US total in 2008. The Brazilian State produces one-fifth of the world's ethanol, with surpluses that could raise the average blend of 6.7% in Texas (in 2009 ethanol consumption was 19.2 million barrels, while motor gasoline's was 289.5 million barrels, according to the US DoE, 2011b). Biomass-based electricity technology (e.g. sugarcane in São Paulo) can benefit mutually our States as well, increasing energy security, improving air quality and mitigating carbon emissions via the substitution of fossil fuels. This will benefit both regions, curbing greenhouse gas emissions and providing energy security.

CLEANER FOSSIL FUELS

With a significant part of the economy depending on fossil fuels, a long term view cannot leave apart the possibilities of reaping the benefits of new technologies, such as hydrogen associated to carbon capture and storage (CCS). More than for local use, these technologies have a huge potential for enhancing added-value exports of goods and services from Texas and São Paulo. Local benefits include especially urban air pollution abatement and an improved-clean energy security through better use of coal, oil and gas.

ABOUT THE SKEPTICS

Obviously such challenges are often seen by many as barriers to be avoided through the elimination of environmental regulations (a lassez-faire thinking), or through the idea of a certain "right to emit", because other nations have caused in the past damages to the Earth's climate system (the differentiated responsibilities view). Under these perspectives, a race for unsustainable growth is happening in many parts of the world. Unfortunately, global warming is a problem which denial is leading to serious risks to mankind. There is no environmental room for such controversy, since there is no other Planet Earth as a laboratory control while this one bears the consequences of an ample and accelerated consumption footprint. Man-made climate change skepticism is a good topic to sell paperbacks and to lobby against supposedly "job slashing" legislation, but is also a head-in-the-sand option with long-term effects that are economically risky and inconsistent scientifically. The scientific community has reached a consensus with sceptical scientists reaching similar conclusions. This was the case of the Berkeley Earth Surface Temperature project, financed by the Koch Foundation (Krugman, 2011) skeptical scientists have been reaching similar conclusions than NASA and other groups analyzing climate trends. Benefits from the business-as-usual economy do not last for long and are counteracted by upscaling hidden costs (externalities paid by the society as a whole). Jobs, for example, are not armored against competitiveness losses to other markets that have opted by a high added value and low-carbon economy. This is the path that China is pursuing aggressively, as demonstrated by the country's 5-years plan (Seligsohn and Hsu, 2011).

THE ROLE OF ADAPTATION

Adapting to extreme weather events is a whole new topic where the Texan experience could make a significant contribution to São Paulo, Brazil and the whole Latin America and the Caribbean Region. I have invited my students from the UT to write for PORTAL a special article on this topic, covering best practices from Austin area. It was a great satisfaction to find such a proactive environment here.

INSTRUMENTALIZING COOPERATION

Collaboration can happen through several different forms. A good and reasonable first step in the area of Climate Change could be through institutional departments, (e.g. LILLAS and the University of São Paulo's Instituto de Eletrotécnica e Energia). Furthermore, it could be expanded to the whole of UT and USP, as well as to other universities. A more ambitious step would be an agree-

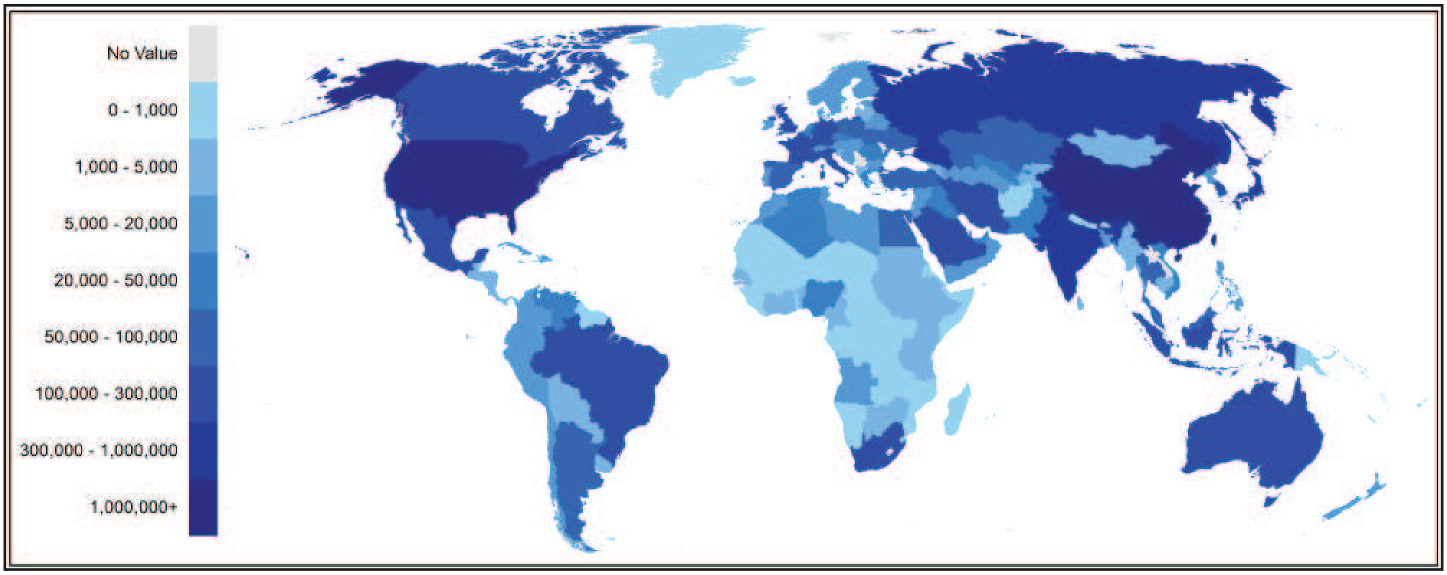

Figure 2. Countries by carbon dioxide emissions from burning of fossil fuels, thousand tonnes of CO2, year 2007 (Boden et al, 2011)

ment between the States of Texas and São Paulo, as did the Brazilian region with California in 2005 and 2007 (Reid et al, 2005, SMA, 2007). São Paulo and California have adopted ambitious climate policies – including emission targets. This may not be seen as a recipe for Texas, but without any doubt considerations to diversification of energy supply and improved economic competitiveness would be a major driver for mutual interests.

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Adaptation to Climate Change

A prospective collaboration between the UT at Austin and Latin American institutions in flood control

M. Anwar Sounny-Slitine, Jennifer Alexander, Kelly Twomey, Julia O'Rourke, Eva Hershaw and Scott Moorhead

Amoung the many contributions from the University of Texas at Austin (UT) to Latin America, collaborative research on adaptation to climate change is an area of study ready for expansion. UT has expertise in climate modeling, the human environment relationship, environmental engineering, and regional planning that could suit to the growing needs caused from extreme weather events. In this article, an invited group of students from the Fulbright sponsored course "Energy and Climate Change - Policies and Challenges" will explore climate adaption in the two regions. UT can serve in North-South adoption of adaptation techniques as well as a catalyst for South-South adoption of adaptation techniques.

Introduction

While the world debates which greenhouse gas emissions mitigation policies are finally implemented, there still exists a high risk that the climate is going to change due to historic anthropogenic activities, no matter what is done. Thus, climate change solutions will require both mitigating any future damage and adapting to inevitable changes. Climate adaptation is finding ways to live with the consequences of global warming. A warmer average temperature means more energy in the atmospheric system, leading to more extreme and frequent weather events, increase effects of natural disasters, changes in raining seasons, and rising sea levels (IPCC, 2007). Societies in both the developed and the developing world are still not fully prepared to deal with these changes and have much to learn from each other.

Vulnerability to impacts of climate changes is a function of the exposure to climate conditions, sensitivity to those conditions, and the capacity to adapt to the changes (USAID, 2007). It is often stated that those who are the most vulnerable are the poor from the developing world. Most economic activities in the developing world are sensitive to climate, and infrastructure used to regulate environmental extremes is not well developed. While developing nations may face challenges that developed countries are better suited to handle, there is much to learn from those nations that historically have dealt with harsh environments long before concerns over anthropogenic climate change. On the same note, communities in the developed world are well situated to adapt to many aspects of climate change and have a responsibility to share adaption techniques developing countries. Thus, technology transfer is bidirectional and can benefit both people living in developed and developing countries. Institutions like The University of Texas at Austin (UT) can serve as a catalyst, learning and developing climate adaption techniques that can be transferred from some parts of the developing world to others. Latin America offers a great laboratory for studying climate adaption, and UT has many opportunities to build collaborative research and projects in the region that will both benefit "North-South" and "South-South" cooperation.

Climate Adaptation in Texas

Much of Texas' success in flood control management has been its ability to implement such mechanisms without compromising livability. Linear parks have been a popular means of adding value to floodplains that would otherwise be risky for urban development. A linear park is a landscape corridor that cuts through urban developments often connecting undeveloped areas cutoff by urbanization. These parks provide functionality, as well as beauty, in many of the state's most densely populated urban centers. In Austin, the Lady Bird Lake hike and bike trail has transformed the lake's once barren floodplains into a beautiful recreational area for outdoor enthusiasts, leading to development and higher quality of life for Austin urban core. In Dallas, The Trinity River Corridor Project began in 1998 to extend the city's flood protection through a complex network of levees, wetlands, downtown lakes, recreational parks, hike and bike trails, and equestrian centers. Once completed, this project is anticipated to be among the United States' largest urban parks.(TRCP, 2011)

The San Antonio River Walk, along the banks of the San Antonio River, is one of the most famous of Texas's linear parks and currently the number one tourist destination in Texas ("The Official Website of the San Antonio River Walk," 2011). Although the River Walk is home to many of the city's most popular bars, restaurants, shops, museums, and cultural centers, its dams and floodgates also provides critical flood protection to the city above. The concept of the River Walk began in the 1920's in response to a decade of devastating floods. However, recently variable water flow made the River Walk unsustainable. Beginning in 2000, recycled water from the city's water treatment and reuse

Figure 1. In downtown Austin, a floodplain is convertd to a recreation linear park that gives vistors the chance to escape the urban environment. (Larry D. Moore)

system replaced the Edwards Aquifer as the main water source of the River Walk in efforts to slow the aquifer's depletion and to provide constant flow for the attraction. A valuable resource, the aquifer provides 99% of the city's municipal supply (Glennon, 2002). Other recent environmental initiatives aim to protect indigenous plants and animals, remove invasive species, and improve the hydrology of the river, using principles of fluvial geomorphology to maintain adequate flow, reduce flooding potential, and enhance water quality in the system (SWA, 2001).

Austin, located in the Central Texas "Flash Flood Alley" is prone to flooding events due to frequent and intense storms. Flood policies are determined in Austin through detailed studies by the Federal Emergency Management Agency (FEMA) which runs the National Flood Insurance Program. NFIP's studies result in delineation of 100-year and 500-year floodplains, which are floodplains that represent a 1% and 0.5% chance of flooding in a year respectivly. Compounded, however, this represents different risk. For example, in a 30-year period, a property within the 100-year flood plain has a 26% chance of being flooded sometime in the period. Cities like Austin have regulations that prevent building within 100-year floodplains as a way to live with the natural process of flooding. Through flood control structure, floodplains can be modified, making these areas available for development. Austin is adopting a similar approach as San Antonio's to provide flood control near downtown. Normally, Central Texas streams flow slowly or sparsely, but during heavy rain events these creeks quickly flood, putting lives and property at risk.

An example of one such project underway is the Waller Creek Tunnel project in downtown Austin. Like other Austin streams, Waller Creek frequently overflows its banks. Its location along the eastern edge of downtown prevents adjoining land from being developed because of flood hazards. Current flood policy and flood dangers limit development along Waller Creek. According to the City of Austin, ilf flooding hazards were controlled, an additional 11 percent of downtown would become available for development. The City of Austin is pursuing a flood control project that will control water by diverting flows under ground. The flood water will bypass creeks, and flow through a tunnel system directly into Lady Bird Lake. This flood control system will modify the floodplain both to reduce the flood hazards and increase land available for development.

Texan linear parks, is only one example of adaption techniques that can serve as a model for implementable framework for floodplain management and development in urban areas worldwide. Many example exist of environmental management and monitoring that can have an impact and serve as a model. Another example often taken for granted in Texas is weather monitoring from the National Weather Service (NWS). Providing the public with warnings and watches helps keep people prepared for severe and inclement weather. Monitoring weather also provides data-sets to better delineate floodplains, which leads to better accuracy of floodplain mapping. These technologies like doppler radar, satellite imagery, and weather gauges help in alert systems. In an age of uncertainties these systems and the people at the NWS are a great asset in dealing with climate change.

Climate Challenges for Latin America

Latin America provides an excellent laboratory fro the study of climate change adaption. Currently there are many UT researchers working in the region, this next section provides an example of research happening in the Andes which exhibits how multiple disciplines are working on different aspects of climate adaption. Exchanges between UT and Latin American universities through different channels of information exchange, technology transfer, and capacity building could expand this type of study to other regions of Latin America at a great benifit to both UT and Latin American Universities.

The tropical glaciers located in the Andes offer an example of natural buffers in Latin America ecosystem. Glaciers in Ecuador, Peru, and Bolivia have all been observed to be rapidly shrinking, and given IPCC climate change scenarios these glaciers are expected to continue to retreat in the coming century (Vuille, 2008). Daene McKinney, professor of Civil Engineering at the UT Center for Research in Water Resources, is studying how structural systems can be installed to reduce the urban flooding impact of variable runoff resulting from glacier loss and melt. According to models created by Professor McKinney and his student, the main impact of glacier loss is lower flows during the dry season and more unpredictable flows in general. In the end there will not be the smoothed filter of accumulated ice slowly melting. Regions in the Andes will be regulated by rainstorm events and precipitation. This creates challenges for rural populations in the Rio Santa Basin of Peru, putting them in situations where they must adapt. The UT Chapter of Engineers without borders is working on installing water retention structures that will be used to store water during the raining season for use in the dry season. These small scale projects have a smaller impact on the environment and can be replicated throughout the region bringing a reliable water supply to the rural populations. While these technology solutions play a big role, understanding the social aspects of climate change can remove social barriers to adoption. This team project has also consulted professors at UT who specialize in the region to learn more how a system will work with human operators. What needs do locals have in water storage and in what ways will they use the water.

Kenneth Young, Professor of Geography at UT Austin, is studying the different scales of climate adaptation in Latin America, spanning household, community, regional, national, and multinational levels. Professor Young has highlighted in his research the differences in the ways people adapt in rural mountain communities is very different than how mega-cities like Lima and other adapt. For example people on small community levels in Peru and more generally in Latin America are well adapted to climate variability and live with flood hazards, droughts, and other climatic variations. They find ways to diversify crops planting over 80 species of potatoes for example, thus reducing the risk of climate variations. They plant crop in multiple regions taken advantage of elevation difference to ensure crop production during droughts, floods, or infestations of insects. These techniques have been developed over generations, however new trends are threatening this indigenous knowledge with globalization draw the younger generations to opportunities in mega regions. It is important to document and understand these indigenous methods, not only for scholarship but for South-South transfer of methods. What works in the Andes can have major benefits to other rural areas in the developing world. UT can serve as a catalyst learning these techniques and spread them a long technological solutions.

While flooding is a major problem in Latin America, it can be seen as both a positive and a negative. Mario Cardoza, a Ph.D. Candidate in Geography and The Environment studying indigenous people, the Iquitos in the Peruvian Amazon. Through his

Figure 2: Water storage tank above Yanamito village at about 3800 m. (courtesy of Daene McKinney)

field work, Cardoza has seen how the local populations have adapted to flooding regimes, using it to both sustain their livelihoods and profit economically.The farmers are adapted to flooding and plant their crops based on flooding sequence. For example crops that grow faster are in areas lower in the flood plain and longer developing crops in the upper portions. Cardoza points out that the floodplains are the most fertile lands in a region with predominantly poor soils, but the sediment and nutrients delivered by the alluvial deposits have sustained these cultures for generations. They can also provide lessons in living with flooding.

On a regional scale, climate adaptation is difficult in Latin America, where rapid urbanization is occurring and economies are closely linked to climate sensitive resources. Latin America is the continent with the highest urbanization rate of all developing world regions. At the same time, Latin American annual rainfall accumulates at a volume equal every year to that of hurricane Katrina. This has an immense impact on dense urban areas, with flooding killing thousands annually. Urban and rural flooding are expected to become more severe with climate change, as the buffers--such as glaciers--that exist in the natural system are slowly disappearing, or the land use land cover changes increase runoff.

Throughout Latin America, from Mexico to Argentina, megacities flood every year. This is a combination of pavement systems, largely brought from Spain and Portugal, and the high amounts of rain that fall onto that pavement. Climate change models predict longer droughts and stronger rains. Fernando Lara, a professor in the UT School of Architecture is researching ways to adapt architecture to respond to rainfall levels greater then 40 inches per year or more. Professor Lara is a founder of Studio Toró, an non-profit studio mainly concerned with the threat of flooding. He is looking at how the urban environment can be built to adapt to the hazards of flooding. Through his experience in Latin America he has lessons learned for Austin in that as it continues to grow and increase density, it needs plans for a city that will be facing much longer droughts and worse flooding as temperatures continue to rise. It is understood that Austin is particularly vulnerable, and urban areas in Latin America can serve as a model on living with hazards if solutions are figured out in the region.

Conclusions

Climate change adaptation is about more than learning how to live in harsh environments. It instead is about how we can both modify our systems fast enough to handle rapid change, and modify them successfully for the type of changes that will come. People have lived and thrived in all environments of our world, so the knowledge exists on how to adapt. Studying, adapting, and sharing this knowledge across boundaries in both technology and know-how is the solution moving forward, thus establishing trans boundary connections are vital to everyone.

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Real Time Collaborative Work Using the Cloud

M. Anwar Sounny-Slitine

Collaborative work can be a challenge especially when working in large groups. It often results in work being segmented, and reconstructed at the end. True collaboration means people all working on the same document at the same time. This was not possible in the past where technology sometimes hurt the collaborative process. For example e-mailing word documents back and forth cause bottlenecks. Often a collaborative work would take longer than a single authored work and process followed the model that each author would take his/her turn at writing and editing the document. Internet solutions and cloud computing is opening up the possibilities for new methods of collaboration.

To do real time collaborative the class used cloud computing technologies of Google Docs. Google Docs is a web-based word processing software that works off of cloud computing or software and data that resides within webserver and not

Figure - The Cloud referring to the common workplace in cyberspace

on individual computers. Bringing laptops to the classroom, the students were able to work as a group all on the same document at the same time. Some minor issues arise with compatibility of older systems or personal devices like the iPad, but overall the experience was smooth across different platforms.

The collaboration transcended cyberspace and in class room discussion formed around the table. Methods of review process, team meetings, and issues were all worked out in the classroom. When questions arise, the students were all around the same table and were able to overcome any issues within minutes. Cloud computing gave the ability to have the same document on everyone's screen and the same time, which lead to a fully participatory process resulting in productive work.

The following three articles are a complete collaborative work. The group of 18 people broke up into 3 working groups; each group selected a question about energy and climate change, and answered it as group producing a single document. This document was then reviewed by the other working groups, giving it a 12 person peer review, and returned to the originally working group which finalized the draft. The final product was submitted as follows to the Professor as a final report. This took place over three hours.

Abstract illustration of the complex multiple pathways of human development featured on cover of 2010 HDI Report

What is the Human Development Index (HDI)?

Dylan Malcomb, Colleen McGue, Scott Moorhead,
Dushyant Palejiya, Molly H. Polk, and M. Anwar Sounny Slitine

The Human Development Index (HDI) grew out of the Human Development Report (HDR) provided by the United Nation's Developmental Programme (UNDP). The algorithm, created in 1990, is intended to measure development by combining indicators of life expectancy, educational attainment, and income. The intended aim was to create a single scalar statistic for both social and economic development. It is derived by the following formulas.

Dimension Index (I) = (actual value - minimum value)/(maximum value - minimum value)
HDI = (Life/3+Education/3+Income/3)

The HDI looks at three representative, equally-weighted dimensions of a society's profile to offer a determination of growth and general societal well-being: health, education and living stan-

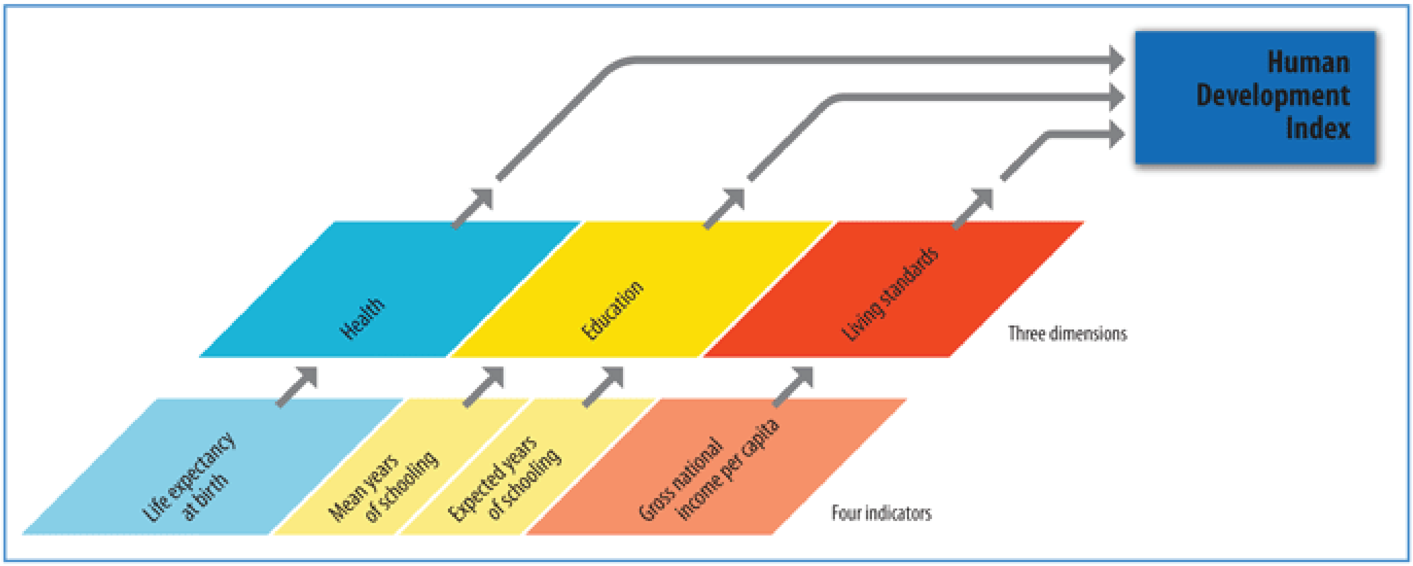

Figure 1 - The Three Dimension and Four Indicators of HDI (Source: HDRO)

dards. The index is used to measure the statuses of the following three indicators, and as illustrated in Figure 1:

- Health = Life expectancy at birth
- Education = Mean Years of Schooling/Expected Year of Schooling
- Living Standards = Gross National Income per capita

Correlation between Energy and Development

One of the most pronounced relationships between energy and development is the correlation between the HDI and per capita energy consumption. Developed countries exhibit high energy consumption in both direct and indirect usage. Direct energy usage (such as owning a vehicle or operating residential appliances) and indirect usage (such as energy used to produce goods and services) are both factors that increase with development. While this relationship is relatively unsurprising, it illuminates that consumption rates at the individual or household level reflect lifestyle disparities between developed and developing countries. However, earlier models depicting long term energy consumption (toe/1000 USD) make it appear that developed nations are consuming less energy than their industrializing partners. This relationship between HDI and per capita consumption best illuminates the increased reliance on energy (down to individual level) as a result of greater development. This correlation (based on HDI) calls into question the capacity to sustain such high energy usage as more nations develop under the model of non-renewable based energy.

Criticisms of HDI

Criticisms of limitations or misrepresentations of the HDI have been somewhat persistent since its introduction. Methodological improvements to the HDI have been made over the years; recently, the Inequality-adjusted HDI (IHDI) has emerged, which seeks to account for inequalities in HDI dimension by discounting average values according to levels of inequality. Effectively, the IHDI becomes the "true" measure of human development, while HDI remains the "potential" developmental capacity. However, persistent criticism of this crude indicator remains.

HDI vs. GDP

In contrast to GDP, the Human Development Index is a more nuanced index that measures a country's development. Figure 2 describes the

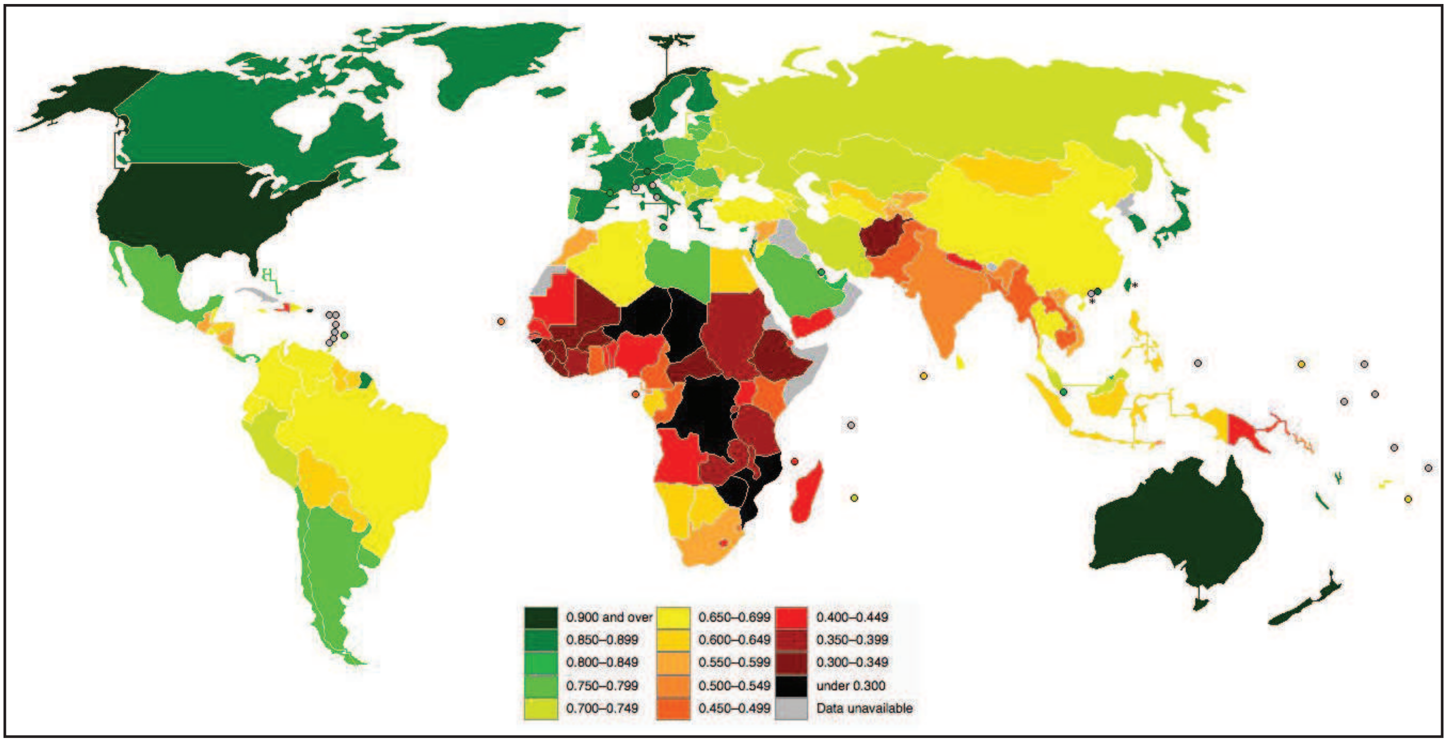

Figure 2: World map indicating the Human Development Index in 2010 (Source: Human Development Index (HDI) - 2010 Rankings, United Nations Development Programme)

2010 global HDI. The intent of the HDI was to better address the inherent problems of the use of income per capita as a development measure. For instance, income per capita may not capture the inequality of a society. Effectively, it distilled various concepts that had been raised in earlier development discussions into a unified theme of 'human development'. GDP and GNP per capita are measurements that do not take social indicators into account (Sagar and Najam, 1998). HDI includes life expectancy, literacy and total fertility rates. To give an example of this shortcoming in GDP, Qatar has the highest per capita GDP (PPP adjusted) but it ranks 35 in HDI. On the other hand, Cuba, which has higher HDI ranking than its GDP ranking is the example at the other end of the spectrum (UNDP 2010 rankings, IMF 2010 rankings).

While HDI may be considered an improvement over GDP, it still does not account for ecological considerations like pollution, climate change, human impacts on biodiversity and sustainability. In light of increasing concern about climate change and subsequent need to address it, lack of ecological measurement criteria may need to be accounted for.

While HDI presents an interpretable number to view the overall development of a country, it may also present a distorted picture of the world. The index ignores the environmental dimensions of development, especially the relationships between the performance of countries on the environmental and human development dimensions. An appropriate example might be the education component, which fails to account for differences in educational systems and cultural expectations for education. Namely, ten years' education in one country is not directly comparable to ten years in another system.

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Pumpjecks in Texas

Why does the price of oil fluctuate?

Eric Borden, Graeme Burrows, Omar Diaz,
Colleen McGue, Ani Krishnan, and Paul Ward

Oil is traded on a global market and its value is determined by many competing factors. There are several contributing factors which work concurrently to influence oil price fluctuations: supply and demand market forces, market speculation, geopolitical factors, market control through OPEC, and extraction. Figure 1 illustrates how these factors have affected the volatility of oil prices since 1973.

1. Supply and Demand

The primary drivers of oil prices are supply and demand. In general, when supply of crude oil outpaces demand, prices fall; when demand outpaces supply, prices rise. Disruptions in supply can cause oil prices to fluctuate. For example, crude prices shot to a record of approximately $147 a barrel in July, 2008, mostly because supply failed

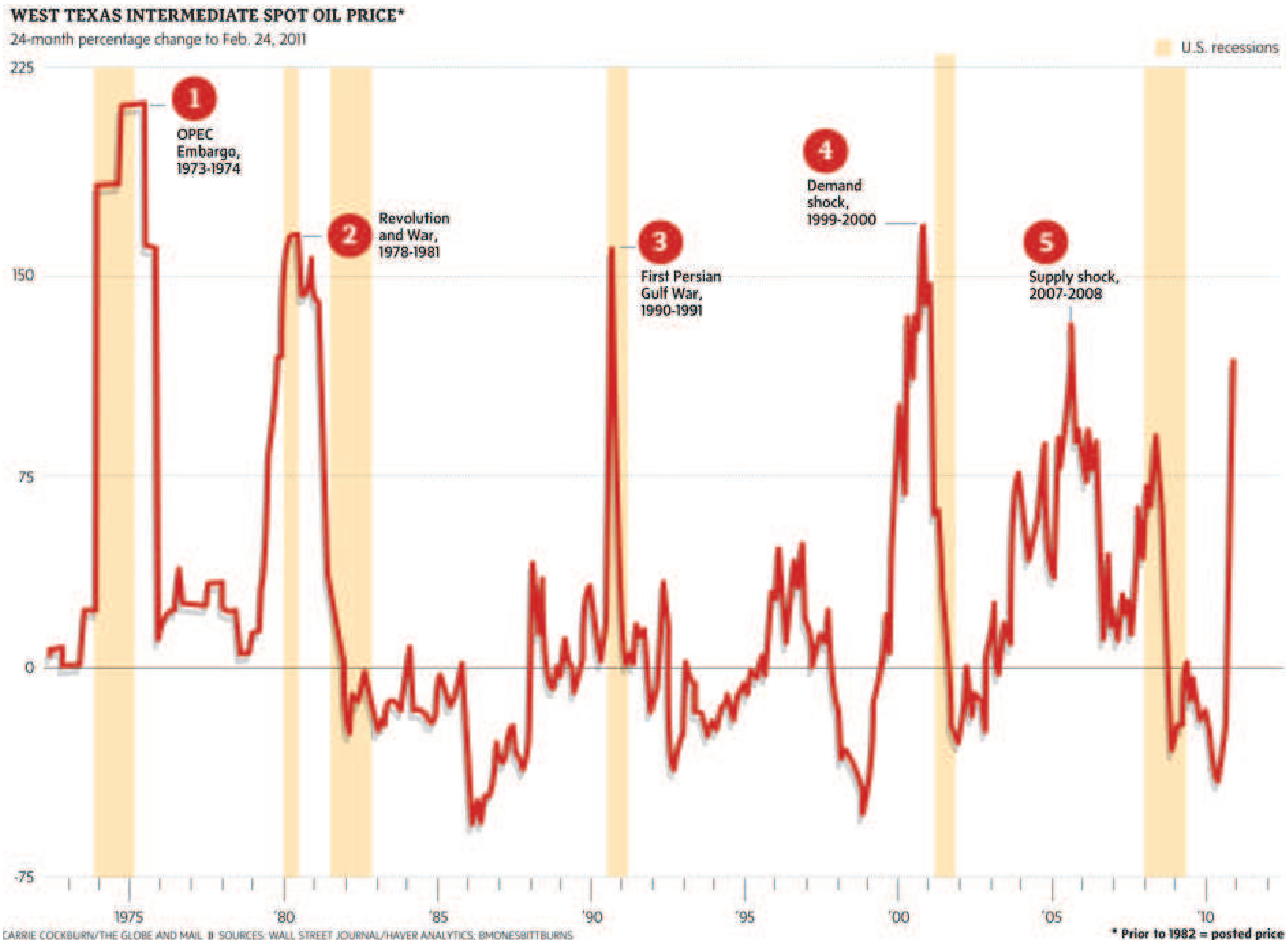

Figure 1 - The Fluctuation of Oil Prices since 1975 (Source: Global and Mail/ The Wall Street Journal)

to keep pace with the rise in demand from China and other emerging market countries. Figure 1 shows some additional factors, including geopolitical factors, which affected the price of oil from 1973 to 2011 . In addition, natural disasters, such as hurricanes, may cause supply disruptions and thus affect the price of oil. Economic recession can have the reverse effect, decreasing demand for oil as economies produce less. Locally, subsidies and tariffs may also play a role. The total amount of subsidies in the non-OECD countries is roughly 250 billion USD/year (one quarter of the energy sector) (Goldemberg and Lucon p. 353).

2. Market Speculation

Another reason that oil prices fluctuate is due to oil trading in futures markets, where contracts for delivery of crude are bought and sold. Arbitrage ensures that future prices and spot prices—what's paid for oil delivered today—generally move together. If investors pushed up the price of crude for delivery in six months' time and the spot price stayed put, entrepreneurs could buy on the spot market, put the oil into storage, and deliver it in six months at the higher future price. Everybody in the market knows this, so when future prices rise, spot prices do too. There doesn't have to be any actual hoarding of crude; the threat alone is enough to make the prices move together (Cassidy, 2008). OPEC (discussed below) also wields tremendous strength in manipulating the market.

Currency fluctuation also has an influence on oil prices. Crude oil prices are denominated in U.S. dollars, and thus fluctuate with the relative strength or weakness of the dollar. In addition, refining capacity of respective countries affect the price of gasoline .

3. Geopolitics

Much of the world's oil supply is concentrated in few countries, some of which have historically been involved in regional conflict and/or been subject to volatile governments. Supply can be used as a political weapon or bargaining tool by governments, while the threat of domestic unrest or military conflict in a major oil producing nation can drive worry in the market, pushing oil prices up. Even the threat of supply disruption, as we have seen in the Libyan example in recent months, can cause fluctuations in price. Oil price spikes have coincided with Middle-Eastern conflicts including the Yom Kippur War and Oil Embargo on Israel's allies, the Iran/Iraq war, and the First Gulf War. Such world events can have a direct impact on global supply and may result in energy insecurity, or a nation's inability to control its own energy consumption resources.

Geopolitical events can also contribute to the access of key supply chain locations such as the Strait of Hormuz, which if restricted can impact the ability to export oil and oil base products. Hormuz is the world's most important oil chokepoint due to its daily oil flow of 15.5 million barrels in 2009. The Strait handles the world's largest crude oil tankers, with about two-thirds of oil shipments carried by tankers. "Closure of the Strait of Hormuz would require the use of longer alternate routes at increased transportation costs." (US EIA)

4. OPEC

The Organization of Petroleum Exporting Countries (OPEC) was founded in Baghdad, Iraq in 1960 with the signing of an agreement between five countries: the Islamic Republic of Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. These founding members were later joined by Qatar (1961), Indonesia (1962), Libya (1962), United Arab Emirates (1967), Algeria (1969), Nigeria (1971), Ecuador (1973), Gabon (1975-1994), and Angola (2007). The organization is currently made up of twelve countries.

OPEC's objective is to coordinate and unify petroleum policies among Member Countries, in order to secure fair and stable prices for petroleum producers; an efficient, economic and regular supply of petroleum to consuming nations; and a fair return on capital to those investing in the industry.The OPEC Statute declares that member countries have the inalienable right to exercise sovereignty over their natural resources in order to further their national development. The member countries thus have a significant influence on the price of oil (OPEC).

5. Extraction

The price of oil is also affected by the cost to extract it. For instance, shale oil is a more difficult and expensive method of extraction and can only be supported by high prices of oil. Another example is extraction of oil in the Canadian tar sands. In turn, supply may increase due to increased technological investment and cause a subsequent decrease in the price of oil.

Additionally, as easily accessible, shallow-depth oil reserves are exhausted, extraction of previously uneconomical reserves at greater depths becomes necessary. Though the price of oil could increase due to the difficulty of extraction, the potential for large increases in supply could negate the extraction-related price increases. Cambridge Energy Research Associates supports this theory, predicting that oil supply may increase by as much as 25% by 2015 (Deep Oil Drilling, 2006).

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Images

“Texas Pumpjeck” photo by ErgoSum88 - Wikimdeia Commons


Energy Losses in the form of steam released from Nuclear Power Plant Cattenom, France

What are energy losses?

Jennifer Alexander, Peter Backlund, Will Phillips, Julia O'Rourke, Valerie Thatcher, and Kelly Twomey

Energy losses are forms of converted energy that are not used for useful power or work. According to the First Law of Thermodynamics, energy cannot be created or destroyed. During the conversion of energy from one form to another (such as potential energy in coal burned to chemically transfer energy to a coal burning electricity generator), energy losses are experienced due to heat creation and transfer, overcoming friction, and other losses (though losses are due largely to heat and friction). Further examples of losses include friction, waste heat generation, incomplete combustion, vibrations, and resistance in electric power transmission. Energy efficiency is achieved through overcoming energy losses in systems. In energy transmission, energy loss is estimated as the difference between energy produced and the energy sold and consumed.

Examples of losses:

- Heat not captured in a heat generating (often combustion-based) power generation system (Cogeneration power plants capture part of this heat for use--for heating and for further driving of turbines, and through this process improve efficiency) (See Example 1 below)
- Aerodynamic drag and rolling resistance (or fluid resistance for water vehicles) to movement of automobiles and other forms of transportation
- Losses within internal combustion engines like heat loss, engine friction, use of energy for air pumping
- Thermal and cooling losses in badly insulated homes (heat and cold air are produced by energy-based systems, and insufficient insulation causes heat to radiate towards the cooler areas, and approach the temperature of outside air).

Losses in Energy Transmission

Joule demonstrated in the 19th century how mechanical work might transform into heat. In high voltage electricity transmission, less energy is lost due to resistance due to a reduction in the current and resistive losses in the conductor. Losses, called corona discharges, can be larger at extremely high voltages that lower resistance loss; these losses can be offset through large diameter line conductors that are frequently hollow in order to weigh less or bundled with another conductor (California Public Utilities, 2005).

While most lines have relatively short spans to maintain cost effective transmission, the longest distance is 4,300 miles for DC current energy. For AC current, reactive power current create additional losses in transmission. Increases in reactive current cause the power factor to decrease and the reactive power to increase. Various components such as capacitor banks can be added to the AC transmission system to help reduce losses and stabilize system voltage. (US EIA, 2009).

Connection Between Energy Losses and Energy Efficiency

Highly efficient systems have low energy losses, allowing large proportions of the energy entering the system to be used to perform work. For example, LED bulbs are more energy efficient than incandescent bulbs because a greater proportion of the energy entering LED bulbs is converted into light. Conversely, a smaller proportion of the energy entering LED bulbs is converted into heat, meaning that much less energy is lost to heat, which is unusable by the system.

The Second Law of Thermodynamics places a limit on the maximum theoretical efficiency of a thermal energy system. The limiting factors are the temperature of the heat that enters the system and the temperature of the surrounding environment to which heat is ejected. Even a perfect steam plant in which 100% of the thermal energy is transferred to the working fluid cannot approach 100% efficiency. The maximum theoretical efficiency is given by the Carnot Cycle Efficiency equation:

$$\text{max efficiency} = 1 - T_c/T_h$$

where T_c is the temperature of the surrounding environment and T_h is the temperature of the heat that is put into the engine.

In the real world, many systems have much lower efficiencies than what could be achieved theoretically. The energy efficiencies of actual products can increase substantially with improved technology. For example, from 1712-1970 the steam engine increased substantially in efficiency due to improvements in engine design. In 1712, the Newcomen engine had an efficiency well below 10%; by 1970, a compound turbine at very high temperature and pressure achieved just below a 50% efficiency (Goldemberg & Lucon, 2010).

Example 1: Energy lost during steam-driven electricity production

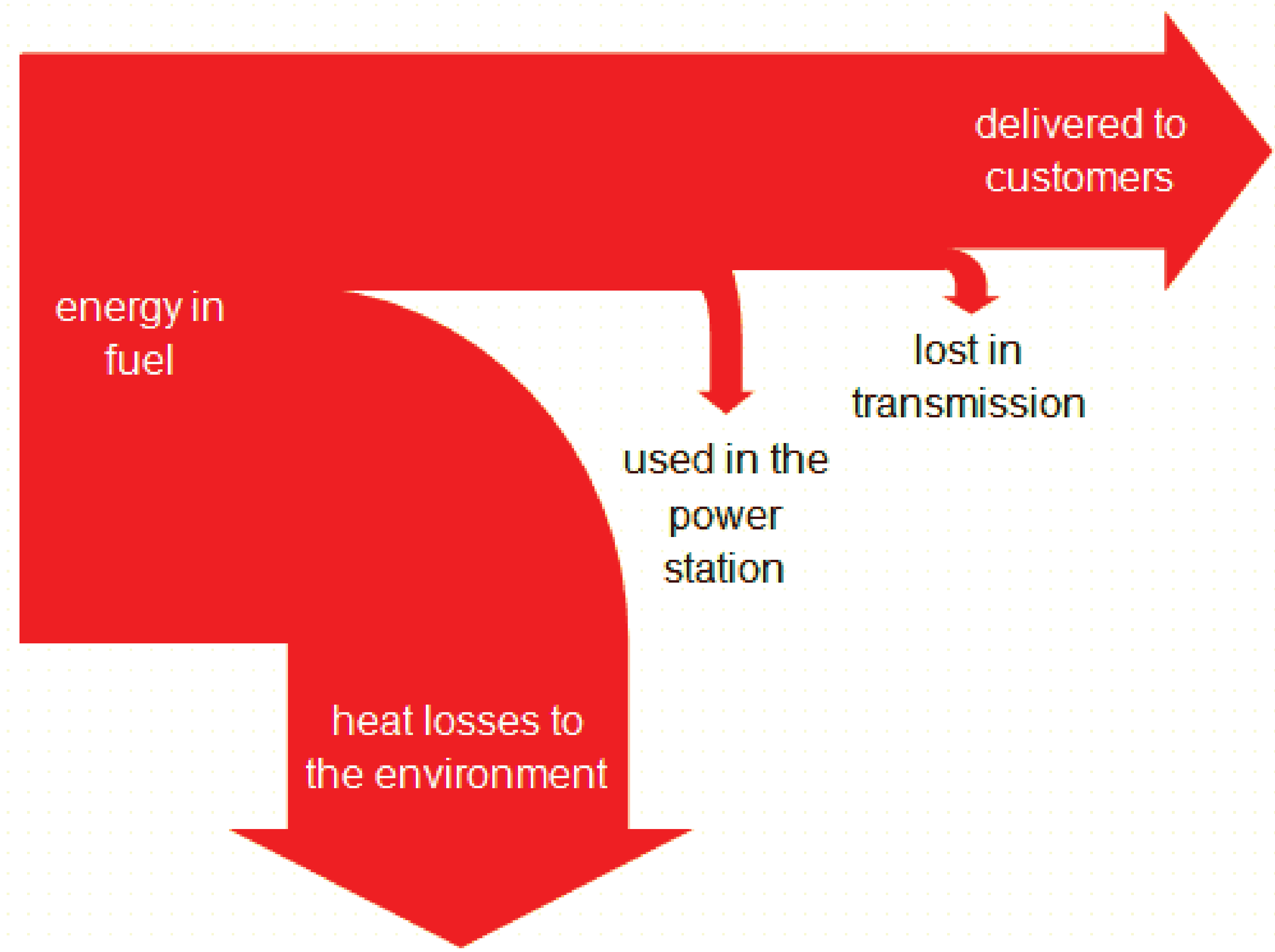

Figure 2: Energy losses during steam-driven electricity production (BBC, 2011)
Figure 1 is an illustration of a Sankey Diagram, which is a flow diagram in which the arrows are different sizes representing the sizes/volumes/amounts of the flows.

Losses During Fossil Fuel to Thermal Power Conversion

Thermal power plants use a primary energy input such as coal or natural gas to provide heat to water to create steam. The steam is used as a working fluid to turn a steam turbine which drives an electrical generator to produce electricity. The hot steam is cooled in order to condense it into water and is cycled again through the plant.

This cycle, referred to as a Rankine cycle, has a limited efficiency as governed by the laws of thermodynamics. The Sankey Diagram in Figure 1 shows the losses experienced by the system during the Rankine cycle explained above. Most of the energy is lost when the primary fuel (such as coal) is converted into heat energy to generate steam. Much of the heat that is generated from the coal during combustion is not directly transferred to heat the water. Rather, a percentage of this heat energy is lost to the environment. (Note: In some thermal power plants, such as gas-turbine combined cycle plants, a portion of these heat losses can be recovered to make superheated steam to drive another cycle to produce additional electricity.) These heat losses might be transferred to through walls surrounding the system through conduction, through flue gases by means of convection, or through radiation to the environment. Once the electricity has been generated by the power plant, other losses occur by means of transmission losses, and often at the house when electrical devices such as lamps create waste heat.

Fossil fuel generation in the United States had an average heat rate of 9,854 British thermal units (BTU) per generated kilowatt-hour (kWh) in 2009. Dividing 3413 BTUs, which is the number of BTUs in a kWh when losses are not accounted for, by this heat rate indicates that the efficiency of fossil fuel generated electricity in the United States has an average efficiency of 35%. Thus, average losses are 65% (EIA, 2010).

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Images

Nuclear power plant in Cattenom, France by Stefan Kühn

Blood Hill Windfarm, Norfolk, East England

UK's Renewable Energy Targets: Ambitious or Achievable?

Dushyant Palejiya

The role of fossil fuels as primary energy sources has been crucial for advancing the human society since industrial revolution. Today, over 80 % of the world's energy needs are supplied by oil, coal and gas (IEA 2010). This large-scale use of fossil fuels over the last few centuries has given rise to adverse side effects like climate change that could threaten many of the planet's species and even human lives. Greenhouse gas (GHG) emissions resulting from the fossil fuel combustion is the main culprit behind climate change. Renewable energy sources that do not emit GHGs and are not limited in nature - unlike, fossil fuels - could be better alternative to fossil fuels.

Additionally, fossil fuels like oil and gas are concentrated in relatively few nations unlike renewable energy sources like solar radiation, wind and hydro, which tend to be more widely

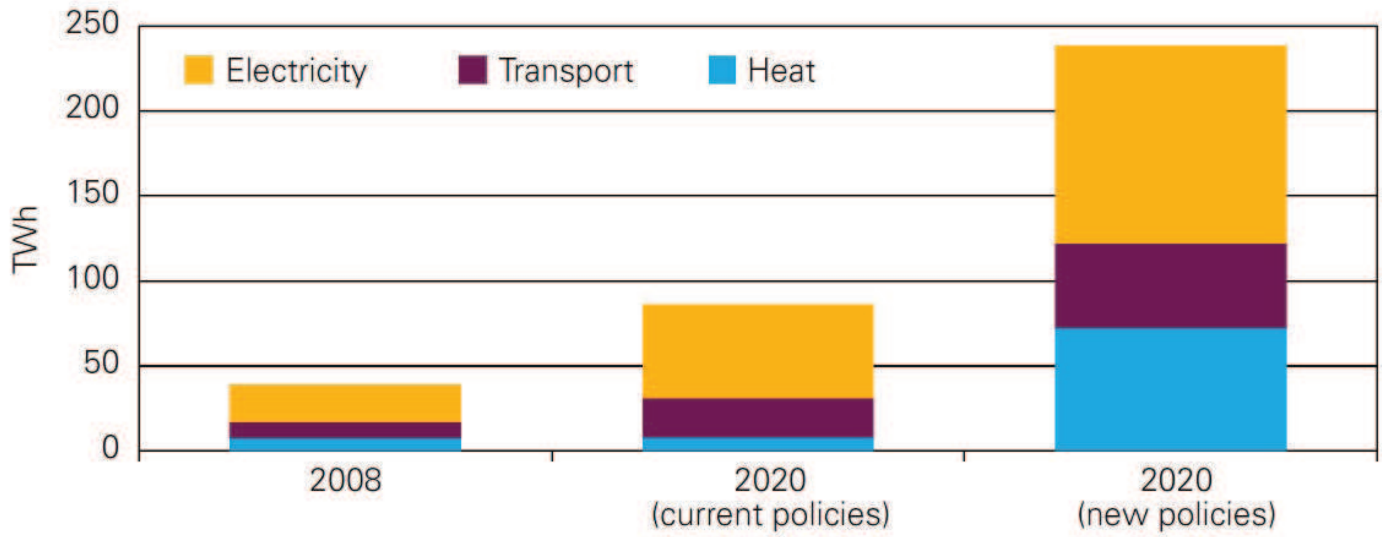

Chart 1: The size of the challenge: A potential scenario to reach 15% renewable energy by 2020 (RES 2009)

available. For majority of the nations that import fossil fuels, increasing use of renewable energy means improving their energy security.

Today less than 15 % of the world's energy is from renewable sources (IEA 2010). So there is a vast opportunity to increase that share by investing in renewable energy research and developing an industry around it. A growing renewable energy industry can spur economic growth and "green" jobs in foreseeable future not unlike the current fossil fuel industry that significantly contributes to economies of many oil and gas exporting nations.

Many nations have recognized renewable energy's significant benefits to their environment, economy and energy security. It is not uncommon to see ambitious goals set by governments to increase the share of renewables in their energy mix. For example, The UK has set target of achieving 15 % energy from the renewable by year 2020, a remarkable goal in light of the fact less than 3 % of its energy was generated from renewables in 2009 (EU 2009). This steep target of five-fold increase in scarcely more than decade would undoubtedly require much more commitment on part of the government, private sector and consumers than has been evidenced in last few years; From 2005 to 2009, the country increased its share of renewable energy from 1.3 % to modest 3 %. While it is impossible to foresee the precise breakdown of this target, the country must impart radical changes in the ways it generates electricity and heat and powers its transport sector. The following chart illustrates the scale of challenge by showing a lead potential scenario on energy mix in 2020 from a government study (RES 2009).

While the successive UK governments, over the last few years, have taken an array of steps to facilitate the renewable energy target - e.g. Renewable Obligation, Climate Change Levy, and Feed in Tariffs - the scale of challenge is such that more must be done to realize it. The UK parliament's Committee of Public Accounts has recently made clear that the UK is making "unacceptably slow" progress and that "there was no clear understating of the cost and success of some alternative technologies" (BBC 2010). Even industry in the UK has recognized that it "must do more on climate change" (Richard Lambert 2010). The UK government's technology-neutral policy which relies on free market to find a "winning" combination among multiple renewable technologies has come under serious criticism in view of success of governments that bet heavily on one technology such as Denmark and Germany (Jha 2010; Gross and Watson 2010). Also, the recent decision by the government to cut feed in tariffs – a worldwide proven policy - for large scale solar power plants have caused concerns that it might hinder the growth of solar power in its infancy (Irranca-Davis 2011; Hartnell 2011).

As the chart in previous page shows, electricity generation would contribute close to half of the renewable energy by 2020. Offshore and onshore wind is expected to supply most of the renewable electricity (RES 2009). This ambitious goal in wind power has been matched by its progress so far; . The UK is the largest offshore wind producer with 5.2 GW installed capacity and 3.8 GW under construction comprising both onshore and offshore wind. Further 14 GW of wind power is in various stages of planning (RenewableUK 2010). But recent dramatic cost increases in offshore wind could hinder its rapid deployment as envisioned by the government and industry. The capital expenditure – the major component in overall wind power cost - of a typical offshore wind turbine doubled from £1.5m/MW to £3m /MW in the last five years due to number of factors such as commodity (especially steel) prices, currency movements and supply chain constraints (Greenacre, Gross Robert and Heptonstall 2010). Some of these factors are obviously beyond government's control but it could do lot more to incentivize the domestic manufacturing and innovation, which in long term would decrease the cost. While it is not surprising for an evolving technology like offshore wind to experience cost escalations before they mature, the challenge is to continue its rapid expansion for the next decade in face of rising costs.

As with any ambitious targets, financial commitment by an organization/country is crucial to determine their success or failure. The country's current investment in the renewable energy, at £6 bn to £7 bn, is nowhere near £20bn to £30bn required to meet its renewable energy goals as estimated by the independent Committee on Climate Change (Jha 2010). Though it is expected that the private sector would contribute majority of the required investment, the government is set create Green Investment Bank with seed funding of £3bn in 2012 to attract private sector money (Morales and Bakewell, 2011) towards renewable energy.

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Clean energy policy in Saudi Arabia
Is the oil giant trying to get off of oil?

Kelly M. Twomey

Energy demand in Saudi Arabia has increased dramatically in the past decade, especially in regards to electricity generation. Unfortunately in the arid Middle East, population and economic growth has had an exaggerated effect of energy demand, as people require more energy, as well as more water, for their daily activities. Water, in particular, comes at an energy and economic premium since most water demand is met by desalinating seawater. Despite a relatively small population of 24.6 million people, Saudi Arabia was 15th in the world in terms of primary energy consumption in 2008. In that year the country consumed an average of 2.4 million barrels of oil per day, an increase of 50% from the year 2000 (EIA, 2010), although recent wiki-leaks of confidential US diplomatic cables suggest that electricity demand has been increasing a rate as high at 10% annually.(Gallucci, 2011)

Projections regarding future population growth in Saudi Arabia indicate that the country will grow at a rate of about 3% per year with a corresponding annual growth in per capita electricity demand of 5%, levelling off around the year 2035.(Said, 2011) On the whole, domestic power demand is expected to triple over the next two decades, which is concerning considering that today, 75% of the country's domestic oil consumption is used for electricity production, the least efficient means of fossil-fuel generation. Although natural gas is cleaner and more efficient, Saudi Electric Utility claims that it does not have the natural gas resources to satisfy its electricity demand. (Said, 2011)

Leaders in the country fear that this dramatic increase in energy consumption in recent years could lead to domestic demand in excess of 8 million barrels of oil equivalent per day by 2030, which could potentially cut its oil revenues in half. The country would have to boost its oil producing capacity to at least 15.5 million barrels a day to make up for the lost revenues due to its domestic growing consumption. Increasing its capacity by this much would require as much as $700 billion in investment.(Said, 2011) This article explores Saudi Arabia's current energy conundrum and how its government is addressing these issues through clean energy development and energy-efficiency policies.

Current oil and gas dependence reduces national export revenues

Prior to 2010, Saudi Arabia's domestic energy demand was met entirely by oil and natural gas as the country rich in these fossil resources. As of 2010, the country had an estimated production capacity of as much as 12 million barrels per day. Worldwide oil reserve projections indicate that Saudi Arabia has more than 267 billion barrels of unexploited oil (Aljarboua, 2009), roughly one-fifth of the world's proven reserves and more than any other country in the world.(EIA, 2010) Between 1991 and 2009 Saudi Arabia was the largest crude oil producer but has since fallen to Russia in terms of crude oil production.(EIA, 2010) Many analysts believe that Saudi Arabia's unproven and undiscovered oil reserves could dwarf those of other high-producing nations and suggest that reductions in the production rate since 1988 might be strategic, and thus, might not be representative of the size of the Saudi Arabian reserves that are yet to be produced.(Aljarboua, 2009) In addition to its petroleum reserves, Saudi Arabia also has the 5th largest natural gas reserves in the world according to 2010 estimates.(CIA, 2010) Two-thirds of this natural gas is termed "associated" gas because it is a by-product of petroleum production, thus, prior to 1982, this gas was simply flared at the site of extraction. (Aljarboua, 2009) Today natural gas and natural gas products are a significant part of the country's economy.

Despite its vast fossil resources, recent concern over declining oil production in the face of an increasing global population has prompted Saudi Arabia to place more interest in preserving its oil resources for lucrative export to other nations, as over three-quarters of its government's revenue is based on petroleum sales alone.(Al-Shehri, 2011) Accordingly, the Saudi government has expressed interest in shifting its domestic energy consumption away from fossil-fuel based energy towards sources such as solar, wind and nuclear energy to meet its burgeoning domestic energy demand.(Haroutunian & DiPaola, 2011) Saudi leaders plan to invest as much as $400 billion by 2013 on education, energy, and transportation infrastructure to support the growth of these new industries. One-hundred billion dollars of this money will likely be allocated towards nuclear and solar developments to reduce domestic oil consumption.(Said, 2011)

Nuclear

Nuclear energy is a viable option for replacing some of the country's current electricity generation infrastructure, which is comprised mainly of petroleum burning thermal power plants. On April 18, 2010, governmental officials announced that the country would develop a peaceful nuclear energy program called The King Abdullah City for Atomic and Renewable Energy (KACARE). The program's first nuclear project will be sited in the capital city of Riyadh, where population and economic growth has strained existing power plants. (Hibbs, 2010) This announcement follows 3 decades of Saudi interest in nuclear energy, however, it has not been until very recently that its top leaders have been convinced that the country must diversify its energy mix. Although several countries in the Middle East have expressed interest in civilian nuclear power, no country in this region has begun generating nuclear-powered electricity. (Iran has a nuclear power reactor but has yet to generate electricity with it.(Hibbs, 2010) While the prospect of a Saudi Arabian nuclear program has made some nervous, others believe that it might reduce Iran's potential role as a regional leader in nuclear power. Although Saudi Arabia has the financial resources and stable grid to pursue nuclear power, most people agree that it lacks the necessary intellectual and legal framework to deploy the technology in order to ensure safe and modern nuclear reactor design. Thus, it will most likely have to form a bilateral agreement with technologically advanced countries like the United States, Japan, or France, which would position it as a superior to Iran's nuclear technology.(Hibbs, 2010)

Clean energy sources provide an opportunity to offset domestic oil and gas consumption

Saudi Arabia has vast solar potential. The region, situated in close proximity to the equator, has reached among the highest temperatures ever recorded and enjoys very few clouds. According to a report published in the World Academy of Science, the daily insolation incident on the country's surface would be enough to produce over 12,400 TWh of electricity, enough to meet its current domestic demand for 72 years.(Aljarboua, 2009) Studies indicate that the country receives 2,200 thermal kWh of solar radiation per square meter, twice that is received by European nations.(Al-Shehri, 2011) Analyses completed by the Saudi government suggest that solar radiation is emitted at an average rate of 7 kW per square meter for 12 hours a day. (Gallucci, 2011) These solar radiation data are comparable with those collected in such regions as the Sahara Desert, central Australia, and the Southwestern United States.(Gallucci, 2011) Consequently, it is estimated that if photovoltaic (PV) solar panels were installed to cover just one-tenth of one-percent of the country's total land area, Saudi Arabia could double its current electricity capacity, which is currently 40GW. (Gallucci, 2011)

The country's vast solar resources have attracted a lot of foreign investors interested in developing large solar projects in recent years. The first large-scale PV installation was completed in May 2010 on at the site of the country's King Abdullah University of Science and Technology which opened in 2009. The PV arrays, divided among two rooftop solar plant located on two university laboratories, have a combined generating capacity of 2MW.(REN21, 2010) In total, these buildings support approximately 12,000 square meters of solar thermal and PV arrays to generate about 3.3GWh of renewable energy a year.(KAUST, 2011) The project was developed by Saudi Armco, Saudi Arabia's national oil company, with the German based solar company CONERGY. It is estimated that this array offsets approximately 1.67 thousand tons of carbon, annually.(CONERGY, 2010)

Another 3.5MW installation is being developed by Germany's Phoenix Solar group near the capital city of Riyadh at the site of the world's largest energy research centre in the world, King Abdullah Petroleum Studies and Research Center. The project was commissioned by Saudi Aramco, so that the facility would be eligible for LEED platinum certification.(Wegner, 2010) This project precedes another commissioned by the oil giant, at its office complex in Dhahran. The Dhahran 10MW installation is the largest project being developed to date and will be the world's largest parking lot solar installation. The completed array will cover a total of 4,500 parking spaces with thin-film, copper indium selenide solar modules made by Japanese manufacturing firm, Showa Shell Sekiyu K.K. The project was recently granted to German developer, Belectric Solarkraftwerke GmbH, and is anticipated to begin generating electricity to the national grid by the end of 2011.(SNT, 2011)

In October of 2010, SolFocus, a company based in the United States, announced that it would join with Vision Electro Mechnical Company to build the first commercial Concentrator Photovoltaic solar system in the Bahra region of the country. The project, estimated to generate 300MWh of electricity a year, utilizes advanced optics in conjunction with high-efficiency solar cells to produce clean energy.(SolFocus, 2010)

Saudi Arabia's extremely limited fresh water resources, coupled with the increasing demand of a burgeoning population, have led to energy-intensive water desalination on a large scale. In fact, Saudi Arabia is home to one-quarter of the world's total desalination capacity (Hunt, 2011) At the recent 2010 United Nations Framework Convention on Climate Change in Cancun Mexico, Ali bin Ibrahim Al-Naimi, the Minister of Petroleum and Mineral Resources in Saudi Arabia, announced his country's plans to build the world's largest solar-powered seawater desalination facility. (Al-Naimi, 2010) The desalination facility project, which is projected to come online in 2013, is being completed as a collaboration between the United States' technology company IBM and the Saudi Arabian research institution King Absulaziz City for Science and Technology (KACST). Its expected production capacity is 30,000 cubic meters per day which will meet the needs of 100,000 people.(Gallucci, 2011)

The favorable environment for solar development and the availability of cheap energy in Saudi Arabia has attracted polysilicon manufacturers that wish to build plants in the country. In November of 2009, plans to develop a $1 billion polysilicon plant were announced. This plant is estimated to be able to produce 7,500 tons of polysilicon material per year. Solar analysts surmise that interest in developing polysilicon manufacturing facilities in Saudi Arabia is more a function of its cheap energy and lenient environmental regulations, which provide a relatively inexpensive environment to produce the energy-intensive material, than to expand the country's solar capacity. Much of the material is predicted to be sent to China and Taiwan, where the majored of solar cells are manufactured.(Gallucci, 2011)

Wind

Although Saudi Arabia's solar potential receives the majority of the attention in regards to renewable energy deployment, the country also enjoys windy regions along the coastal regions bordering the Persian Gulf and the Red Sea.(Al-Shehri, 2011) Mean annual wind energy density ranges between 250 and 500 kWh per cubic meter along the coast of the Red Sea, but often reaches much higher values in certain regions where conditions are particularly favourable to wind. Average wind densities in inland regions, however, are often significantly lower, averaging 50 kWh per cubic meter.(Al-Shehri, 2011) A recent study by KACST indicates that wind resources in Yanbu on the west coast of Saudi Arabia are particularly favourable as they match the electricity load curve of the surrounding community; that is wind speeds are strongest in the summer month during the hottest afternoon hours of the day, when electricity demand is at the highest.(Al-Abbadi, 2005) In general locations studied along the coast had wind speeds that matched well with electricity demand, indicating that deploying wind energy in these locations might be an effective tool for providing additional electricity when demand is highest. This concept, also referred to as "peak shaving" is a potential means to delay the need to build additional peaking power plants to meet times of high demand.

Locations inland tended to peak during night-time and morning hours, when electricity demand is lower. However, inland locations displayed less variability than coastal regions and were consistently above 5m/s in two of three of those regions studied (Al-Abbadi, 2005). In these cases, the times at which winds are highest are of less concern, as electricity could be generated consistently throughout the day and night. The difference in magnitude and wind profiles of the three inland locations studied in this analysis suggest that there are areas that are particularly good and particularly poor for inland wind development, so a site-specific analysis should coincide with any proposal for building a wind farm.

Another conclusion that the study noted with that the two locations with highest average wind speeds were also areas of low population density.(Al-Abbadi, 2005) Since producing electricity from wind is less capital intensive than building centralized thermal power plants, siting wind turbines in less-populated areas might be an effective means for Saudi Arabia to deliver electricity to more-remote regions that have not traditionally had access to the national electricity grid.

Hydro and biomass are not viable energy sources due to freshwater resource constraints

Hydropower projects are not likely to be incorporated into Saudi Arabia's future energy mix, as water bodies cover 0% of its surface and most underground aquifers are nearly or completely depleted. Total renewable water resources are only 2.4 cubic km. In fact, Saudi Arabia is the largest nation in the world that does not have a natural river flowing into the sea.(Aljarboua, 2009) Although Saudi Arabia receives only 10cm of rain annually, less than a tenth of average global precipitation, the kingdom stores 774 million cubic meters of water in more than 200 dams. Despite this infrastructure, excessive evaporation and sedimentation hinder any appreciable potential for generating electricity at these dam locations.(Aljarboua, 2009)

Two percent of Saudi Arabia's land area is used for agricultural production, but due to its very limited precipitation, 80% of this land is dependent on full-irrigation. Although the government made a significant effort in the 1970's to become self-sufficient in wheat production and eventually became a major exporter of wheat to over 30 nations, this program was stopped in 2008 on the basis that large scale food production is simply unsustainable for a country of such limited water resources. To accommodate reductions in food production, the country has invested in large-scale agricultural projects in other countries.(Aljarboua, 2009) Consequently, growing biomass for energy in a country that is cannot support its own food needs, is not viable energy policy in the near-term future.

Energy efficiency policies also intend to curb rising energy demand

Energy efficiency will be an extremely important in creating a sustainable energy infrastructure in the future. Saudi Arabia began its first large scale energy-efficiency effort in 2002. The project has an estimated budget of $909,000.(UN, 2011) The first phase of the project addresses its built infrastructure, particularly in the industrial, governmental, commercial, and residential sectors. Energy efficient building codes, lighting, electric motors, and HVAC systems are at the forefront of the effort. Labelling, to indicate the energy consumption of these devices, is being used enhance consumer awareness. To date, efficiency in the transportation sector has not been addressed, but will be in the second phase of the projects.

Despite merits, economic barriers hinder clean energy and energy-efficiency policy goals

Although the nation has not made formal commitments to clean energy goals in climate change negotiations, Saudi officials have made public statements in the past year that suggest that developing clean energy infrastructure is on the forefront of the country's national agenda. In April of 2010, the Saudi oil minister stated that his country aimed to become a major exporter of solar energy in the next three to five decades. Later that fall, country officials made a public statement indicating its goal to produce at least 10% of its energy from clean sources, primarily solar, by 2020. (Gallucci, 2011) The political unrest of 2011, which swept through Northern Africa and the Middle East, has somewhat thwarted some of its clean energy development. In attempts to prevent similar unrest, Saudi leaders invested $103 billion dollars to increase benefits to the country's people in order to address its own domestic inequity issues, which has effectively raised the breakeven price of a barrel of Saudi oil to a high of $85. reducing the potential profit margin on oil, and thus, the money available to allocate towards other initiatives such as clean energy generation. (This investment was somewhat offset by increased oil prices resulting from Libyan oil supply disruptions and the shutdown of Japanese nuclear plants after a large Tsunami in early March 2011.) (Haroutunian & DiPaola, 2011)

Despite is apparent interest in clean energy deployment, Saudi Arabia's progress is still hindered by its abundant fossil resources which are cheap to burn. Developing nuclear and solar energy comes at a premium in comparison to its domestic oil and gas resources. Its lenient environmental standards also attract foreign companies, to manufacture energy-intensive products, such as solar materials cheaply and without regard to its environmental impact. The country must negotiate if it will continue to allow foreign industries consume its cheap electricity at the expense of reduced oil exports or get serious about reducing domestic oil consumption.

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Image

"Gas Plant in Al Jubail, Saudi Arabia" by Jon Rawlinson

Personal Rapid Transit Station at Masdar Institute, UAE

Renewable Energy Policy and Technology: UAE & Germany

Ani Krishnan

Abu Dhabi, UAE

The Emirate of Abu Dhabi is the capital of the United Arab Emirates. Unlike other countries in the Gulf Cooperation Council (GCC), the political system of the UAE is a federation (Anderson, 2009). Decisions on policies relating to foreign affairs, security, and defense are handled at the federal level, whereas issues like electricity, education, and health are dealt with at the state or emirate level (Reiche, 2009). The governance structure of the UAE, however, is biased, especially on the federal level (Anderson, 2009). Abu Dhabi and Dubai enjoy more power than the other five emirates of Sharjah, Ajman, Umm al-Quwain, Ras al-Khaimah, and Fujairah. The reason for this dates back to the inception of the UAE in 1971. A power sharing agreement was reached between Abu Dhabi and Dubai, considered the two most important emirates on account of the relative abundance of resources available to them. This agreement stipulated that the ruler of Abu Dhabi would be the President of the UAE, while the ruler of Dubai would act as the Prime Minister (Davidson, 2006). In other words, the Prime Minister was the head of the UAE government and the President the head of the state, a hierarchy that is followed even today. The UAE government has also established the Supreme Council as a top policy-making body. Even though all emirates are represented by their leaders in this council, the rulers of Abu Dhabi and Dubai have a veto power over matters of national importance (Reiche, 2009).

On the local or emirate level, governance is largely centralized. Decision-making power lies mainly with the ruling families. In all the emirates, the presence of political parties or any other institutions or organizations that deal with politics is prohibited (Reiche, 2009). The constitution of the UAE further lends itself to facilitate local decision-making; for example, it stipulates that the local governments of the emirates have full legal control over oil and natural gas reserves. This kind of system, although hardly democratic, allows for effective implementation of policy decisions.

The Need for a Renewable Energy Policy

The United Arab Emirates has the world's sixth largest proven oil reserves, 94% of which exist in the Abu Dhabi Emirate ; these oil reserves, along with an abundant supply of natural gas reserves, account for 70% of the emirate's GDP (from the UAE embassy website, reference no. 23). The emirate has thus been playing an important role in the global hydrocarbon market. However, there are several factors that have driven the need to develop policies and initiatives that diversify the emirate's portfolio in renewable energy.

An increased share of renewable energy would reduce the domestic demand fossil fuels. This implies that excess oil and natural gas could be

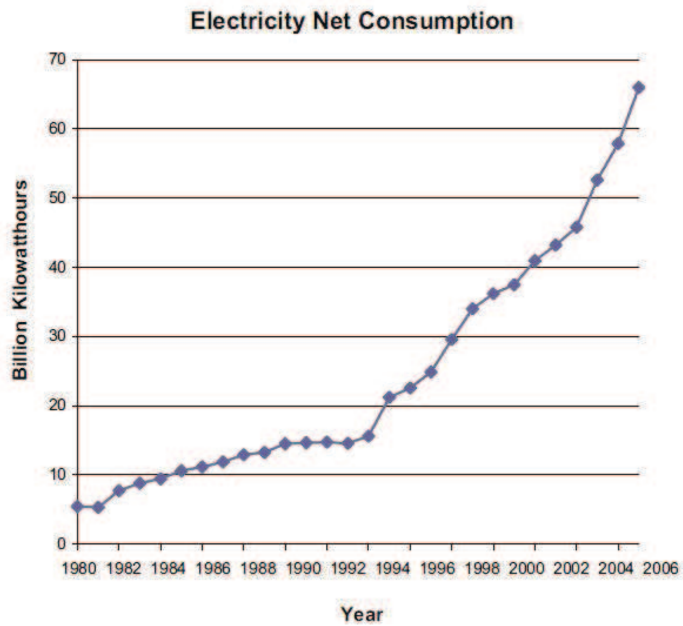

Figure 1 - Trend of UAE Electricity consumption over time. (http://tonto.eia.doe.gov)

exported abroad for financial gains. The immense potential for solar energy as a viable renewable source has already been documented. The UAE, along with other countries in the Middle East, fall under a region of between 2000 – 2500 kWh per square meter of solar potential (Alawaji, 2001). This corresponds to a very high annual mean global solar radiation (GSR), which further imply increased power production from PV cells (Harder and Gibson, 2010). The peak energy demand in Abu Dhabi is during the daytime in August and September, when air conditioning use is the highest. This peak demand coincides perfectly with the highest GSR levels in a year (Harder and Gibson, 2010). The primary energy consumption in the Middle East increased by 43 % between the years 2000 and 2007 (BP, 2008). Since the year 1980, the average electricity consumption growth rate in the UAE has been 10%, in comparison to the world average of just 3% (Reiche, 2010).

Moving towards a renewable energy portfolio in the form of PV electricity could also provide benefits to Abu Dhabi in the form of reduced emissions. The UAE, along with the rest of the GCC countries, fall into the "high category" for vulnerability to the effects of climate change (Harder and Gibson, 2010). The rapidly increasing population and rise of industry in the Abu Dhabi is contributing significantly to ambient air pollution. A recent study estimated that particulate matter and ground-level ozone cause 600 premature deaths in the UAE each year (Li et. al, 2010). Abu Dhabi's per capita GHG emission is currently among the highest in the world (Reiche, 2010). Further research has documented the two major and immediate consequences of climate change, population growth, rapid urbanization, and wasteful consumption for GCC countries, as outlined by Janardhan (2007). Firstly, marine life and coastlines will be severely affected by rising sea levels, and could impact desalination plants that are the source of water for the region. Secondly, the rising temperatures will also mean an increase in demand for water. The cost of construction and maintenance of desalination plants to accommodate for the scarcity of water supply could be mitigated to some extent if they were to be powered by renewable sources like solar energy (Tzen and Morris, 2003).

Showing an interest in developing renewable energy technology and policies would also give UAE, along with other GCC countries, a chance to gain a better reputation in the international arena. With the largest Ecological Footprint in the world according to a study conducted by the WWF (2008), the UAE would do well to begin efforts that can erase this ignominious honor. Abu Dhabi is an optimal location for investments in PV energy production. According to Reiche (2010), the emirate's increasing capacity needs, high solar potential, large capital resources, synergy between times of peak energy demand and peak solar radiation, increasing concerns about air pollution and climate change, and desire to become a world leader in renewable energy technologies are all factors that call for Abu Dhabi to make a significant foray into renewable energy portfolios.

Structural Limitations to Policy Change

Although there are many favorable reasons for the UAE to dedicate efforts into developing renewable energy policy, some restrictions could hinder its progress. For example, the fact that the UAE is not a democracy means that there is little to no role that a voter-maximizing politician can play in influencing energy policy by engaging an active society and an informed public (Spiess, 2008). As mentioned in the earlier section on governance, there is also no room for active NGOs, independent political parties, and free press, which are all organizations that could influence the kinds of issues that need to be addressed in the political agenda.
Reiche (2010) highlights another important characteristic of the UAE as a "rentier state". This is a term which is used to describe a distributive societal contract on which the government's legitimacy depends. In the UAE, cheap and subsidized energy is an integral part of the wealth transfer to the domestic population from oil- and natural gas- generated revenues. The local population complies with the rules of the royal family in exchange for the government's provision of free medical care, education, low-income housing, and high-paying public jobs. Indeed, there is no form of taxation in the UAE, and the country relies primarily on the rent made from the export of oil in order to generate revenue for financing public spending (Saif, 2009). It would be quite difficult for the UAE to implement a feed-in tariff system (explained later in the paper), which is the main instrument for the promotion of renewable energies in the electricity market in countries like Germany, Spain, and Denmark. The main reason for the UAE's unwillingness to implement such a system is that administering a tax on the domestic distribution of oil would cancel the implicit societal contract and force the governments to increase their interactions with their populations (Reiche, 2010). The current system, however, has its drawbacks. Abdelkarim (1999) argues that the absence of direct taxes, while freeing the government from any need to share power, reduces the redistributive power of fiscal policy. Without taxation-induced political bargaining, rentier states are supposed to be generally autonomous from societal demands, free to

pursue policies as they please, drawing on external resources which they aren't held accountable for.

Saif (2009) also argues that since energy prices in the GCC countries like the UAE are low, they provide a compelling reason for foreign companies to choose to operate there. He proposes that we could witness an increasing number of energy-intensive industries like aluminum, petrochemical, and steel moving to countries like the UAE to take advantage of the minimum taxation and relatively cheap labor. Although this may seem like an economically progressive step, it is in fact facilitating the creation of an economically vulnerable sector for policy instruments such as carbon taxes. Reiche (2010) furthers the ramifications by adding that energy-intensive industries would fear for their competitive advantage and act as a powerful lobby group against any policies making their business less competitive.

Current Efforts – Masdar Initiative

The UAE and Abu Dhabi in particular, have been taking some proactive steps to reshape the renewable energy area in the past few years. The economy of Abu Dhabi is still based primarily on exporting fossil fuels; the emirate realizes that these resources are finite, and has been looking for ways to diversify their economy (Reiche, 2009). On an international level, there has been a growing demand for alternate energy solutions, or "clean-tech" solutions. In 2006, the Government of Abu Dhabi decided to do something to address the increasing economic and environmental challenges it faced. This section, describing the Masdar Initiative in detail, is based primarily on Masdar (2009) and Nader (2009).

The Masdar Initiative, funded by the government-owned investment arm Mubadala, was formed in 2006. The primary goal of the initiative is to spur innovation by investing in renewable energy and sustainable technologies, along with research

Masdar units	Functions
Carbon Management Unit	Develops greenhouse gas emissions reduction projects under the provisions of the United Nations' led Clean Development Mechanism (CDM) framework of the Kyoto Protocol
Industries Unit	Invests globally and locally to establish a portfolio of production assets in renewable energy
Masdar Institute of Science and Technology	Offers Master's and Doctoral-level degree programs focused on the science and engineering of advanced energy and sustainable technologies
Property Development	Builds the carbon-neutral, zero-waste Masdar City
Utilities and Asset Management	Uses various investment models to build a portfolio of renewable energy operating assets and to make strategic investments in companies with promising technology

Figure 2 -The various components of the Masdar Initiative (Reiche, 2010).

and development (R&D) startups to commercial operations. Masdar is striving to establish joint ventures and acquire companies with promising technologies in order to stake its involvement in all parts of the global low carbon value chain. The key initiatives of Masdar are described below.

Masdar City

Masdar City is one of the Initiative's largest and most significant projects. It is described as a carbon-neutral, zero waste urban community in the heart of Abu Dhabi. One of Masdar City's defining characteristics is its large scale, integrated application of renewable energy technologies and sustainable living principles in order to achieve comfortable living with minimal environmental impact. Masdar City, covering an area of seven square kilometers once completed, is slated to be completely powered by renewable energy. This renewable energy, be it in the form of wind, solar, biomass or bio-fuels, will provide enough energy to house about 40,000 residents and play host to a commercial and business district of 50,000 more. It has been recognized that the real-world application of these technologies have been on a relatively smaller, piece-meal scale. The lack of a larger scale has also meant that there has been a difficulty to finance such renewable energy systems. As advancements in technologies have begun to drive prices down, the variation in the pattern of costs and costs of improvements have stymied the implementation of renewable energy systems on a larger, utility-level scale. Masdar City is aiming to change this pattern by attempting to integrate various applications of existing renewable technologies in order to position Abu Dhabi as a world leader in renewable energy and sustainability.

Masdar Power

Masdar Power invests both in renewable energy power projects and in companies with proven cleantech technologies – within the UAE and internationally. Through this two-pronged investment strategy, the unit helps power companies add renewable energy to their generation mix and provides cleantech companies with expertise and capital for growth.

As a renewable energy power project developer, Masdar Power adds renewable energy to the electricity generation mix on a world wide scale. The unit makes direct investments in individual utility scale projects in all areas of renewable energy and sustainability, with a focus on concentrated solar power (CSP), Photovoltaic solar energy and on- and off shore wind energy. Masdar Power is developing a 100MW CSP plant in the Western Region of Abu Dhabi Emirate, called SHAMS 1. International projects include the 1GW London array offshore wind farm and a wind farm in the Seychelles that will provide 25% of the island's energy needs. The unit also is developing a 500MW hydrogen-fired power plant in Abu Dhabi that uses advanced technologies to make hydrogen power commercially viable today by feeding the CO2 into the CCS network to be developed by Masdar Carbon.

Concentrated solar power (CSP) systems use mirrors or lenses and tracking systems to focus large amounts of sunlight on water, salts or oils. The heated water directly drives steam generators, while the salts and oils heat water, which in turn runs the steam generators.

Photovoltaic (PV) cells produce electricity as a re-

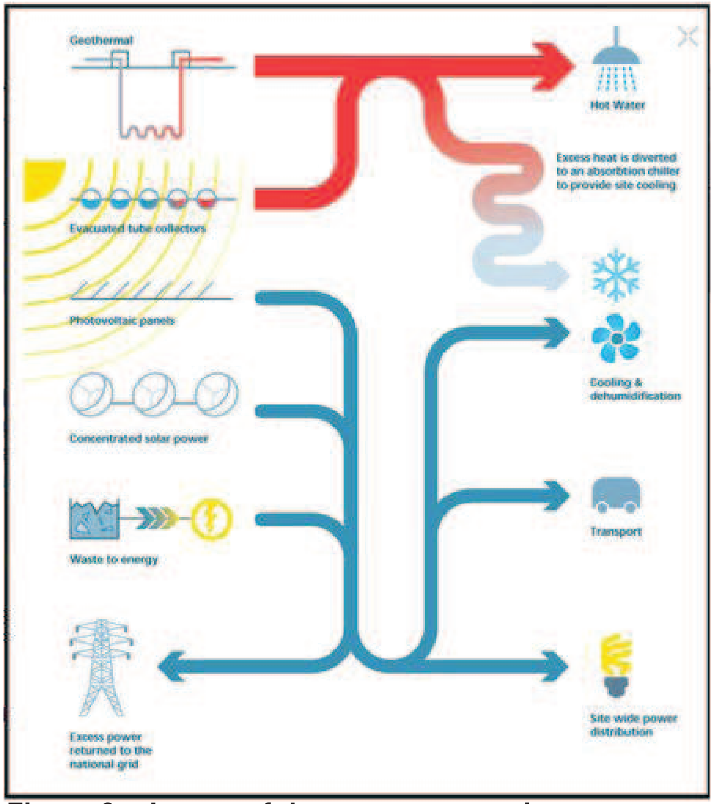

Figure 3 - Layout of the power generation structure at Masdar City (http://www.masdarcity.ae/en/index.aspx)

sult of a chemical reaction that occurs when sunlight hits the PV cells. This reaction is harnessed by the PV cells, which are constructed of two thin layers of semi-conducting materials, usually silicon, that have been treated with chemical substances. When sunlight hits the PV cells, it creates an electric field across the two layers.

Other policy-oriented initiatives – Clean Tech Fund, PV, and CCS

Being a multifaceted, regional economic development program, the utilities and asset management of the Masdar Initiative uses various other models to promote sustainable energy. One of them is the Masdar Clean Tech Fund, a $250 million venture capital fund launched in partnership with various European financial conglomerates like Credit Suisse. The Clean Tech Fund deployed its capital in 2007 and 2008, and purchased stakes in a variety of renewable energy companies like Segway, Halosource, Sulfurcell etc. On the other hand, the utilities unit of Masdar Initiative deals with making direct investments in projects in all areas of renewable energy and sustainability. According to Reiche (2010), here are some examples of these investments:

- Torreso Energy, a joint venture between Masdar and the Spanish engineering group Sener, already has three solar power plants in Spain with an approximate combined value of 800 million Euros.
- WinWinD, a Finnish manufacturer of 1 and 3 MW wind turbines, received an investment of 120 million Euros from Masdar.

The Masdar Initiative also consists of an industries unit, which invests in all markets to establish a portfolio of production assets. Masdar PV (photovoltaic) was formed in April 2008, and is Abu Dhabi's first high-tech manufacturing company. In order for this venture to be successful, Masdar has identified the need to facilitate a technology and knowledge transfer to Abu Dhabi, and has thus decided to invest $600 million in new facilities in Erfurt, Germany (Reiche, 2010).

To achieve the goals of GHG reductions in the UAE, Masdar also has plans to develop the world's largest CCS project (Nader, 2009). There is immense potential for developing a successful and technically feasible CCS project in the emirate – Abu Dhabi covers a fairly small area, and the distance between emission sources and oil reservoirs are very short. Moreover, injection of CO2 into oil reservoirs is dually beneficial. The natural gas that is currently being injected into the reservoirs can be used for more valuable purposes if substituted by CO2, and CO2 also dissolves in oil to make it less viscous, hence facilitating a more effective oil recovery process. This process is known as enhanced oil recovery (EOR). The emirate of Abu Dhabi, with the aid of the Masdar CCS project, aims to capture five million tons of CO2 from power plants and industrial facilities in Abu Dhabi by the end of 2012 (Nader, 2009).

Challenges Faced

An initiative of this magnitude has its fair share of concerns with operability and implementation. While working on a larger scale delivers a primary benefit of economies of scale, successful interoperability between the various systems involved becomes paramount. Masdar City's power infrastructure includes a range of renewable energy technologies like PV plants, a concentrated solar thermal power plant (CSP), evacuated thermal tube collectors, and a waste-to-energy plant (Nader, 2009). These systems should be able to function in a manner that maximizes their advantages and minimizes their disadvantages.

Masdar is also focusing on the problem of energy demand, and will utilize passive design elements all around the city to ensure that its energy demand is about 70% less than what is currently required by Abu Dhabi city (Masdar, 2009).

Germany

A Brief Synopsis on the Development of Renewable Energy Policy

Germany is considered by many to be the global leader in production and implementation of renewable energy technologies, especially solar. The German government launched a comprehensive series of promotions for renewable energy in the early 1990s, which has since been augmented with additional legislation and policy actions to increase renewable energy use (Bundesministerium fuer Umwelt, 2003). These policies were embedded in a larger set of environmental, economic, and security policy considerations.

Much of Germany's initial sponsorship of renewable energy was initially spurred by energy security concerns during the 1970s. Germany consumed a significant amount of fossil fuels on account of its industries, and the energy crises of 1973-74 and 1979-80 had a significant economic impact on Germany (Runci, 2005). In order to reduce this dependence on imported fossil fuels, the country set about promoting renewable sources of energy as a potential means of alleviating such risks (Bundesministerium fuer Wirtschaft und Technologie, 2002).

Broadly, Germany has relied on a combination of five primary policy instruments for the promotion of renewable energy (Runci, 2005):

- Direct investment in R&D;
- Direct subsidies;
- Government-sponsored loans;
- Tax allowances;
- Subsidies for operational costs/feed-in tariffs.

One of the most important laws, which fall under the categories of feed-in tariffs, was the federal Electricity Feed Law (StrEG). This law, adopted in 1991, became the most important instrument for the promotion of renewable energy in Germany during the 1990s. It worked by "obligating public utilities to purchase renewably-generated power from wind, solar, hydro, biomass and landfill gas sources, on a yearly fixed rate basis, based on utilities' average revenue per kWh" (Runci, 2005). The successor to the StrEG was the EEG, or Germany's Renewable Energy Law. This law was adopted in April 2000. The EEG aimed to double the renewable energy share in 1997 by the year 2010, which would be about 12.5% (Bechberger, 2002). Currently, the share of Germany's electricity provided by renewable sources is about 16.1%.

In addition to the economic impacts, environmental concerns rose in the 1990s to play a significant role as a driver of renewable energy policy in Germany. Germany has been a proponent of international policy action to address climate change and has adopted a broad set of domestic actions to curtail its greenhouse gas emissions (Wurzel, 2002). For example, as part of the European Union's commitment under the Kyoto Protocol, Germany agreed to a 21% reduction in greenhouse gas emissions from 1990 levels within the period 2008-2012. Consequently, renewable energy sources and accelerated deployment of renewable energy technologies were seen by the German government as playing a central role in meeting its voluntary greenhouse gas reduction goals (Bundesministerium fuer Wirtschaft und Technologie, 2002).

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Image

"Personal Rapid Transit Station at Masdar Institute, UA " by Masdar City - http://www.masdarcity.ae/en/index.aspx

"Layout of the power generation structure at Masdar City" by Masdar City - http://www.masdarcity.ae/en/index.aspx

Morocco
Energy dependent today, energy leader tomorrow.

M. Anwar Sounny-Slitine and Sara Bensalem

Morocco is the only country in North Africa that does not have substantial fossil fuel reserves. Unlike its neighbors Algeria and Mauritania, who have large oil and gas reserves, Morocco must rely on foreign imports of energy. In 2010, Morocco imported 97 percent of its energy making it the largest energy importer in Africa and economically sensitive to energy prices of the global market (Oxford Business Group, 2011). While the country lacks traditional sources of energy, it has large underdeveloped potential for renewable energy. In 2008, the government enacted a new energy strategy with focus on developing renewables as a way to continue broader development (Fritzsche et al., 2011).

Morocco has an emerging economy experiencing steady growth of 4 to 5 percent between 2000 and 2010 (Qxford Business Group, 2011, Page 186). As the economy grows, Morocco becomes more de-

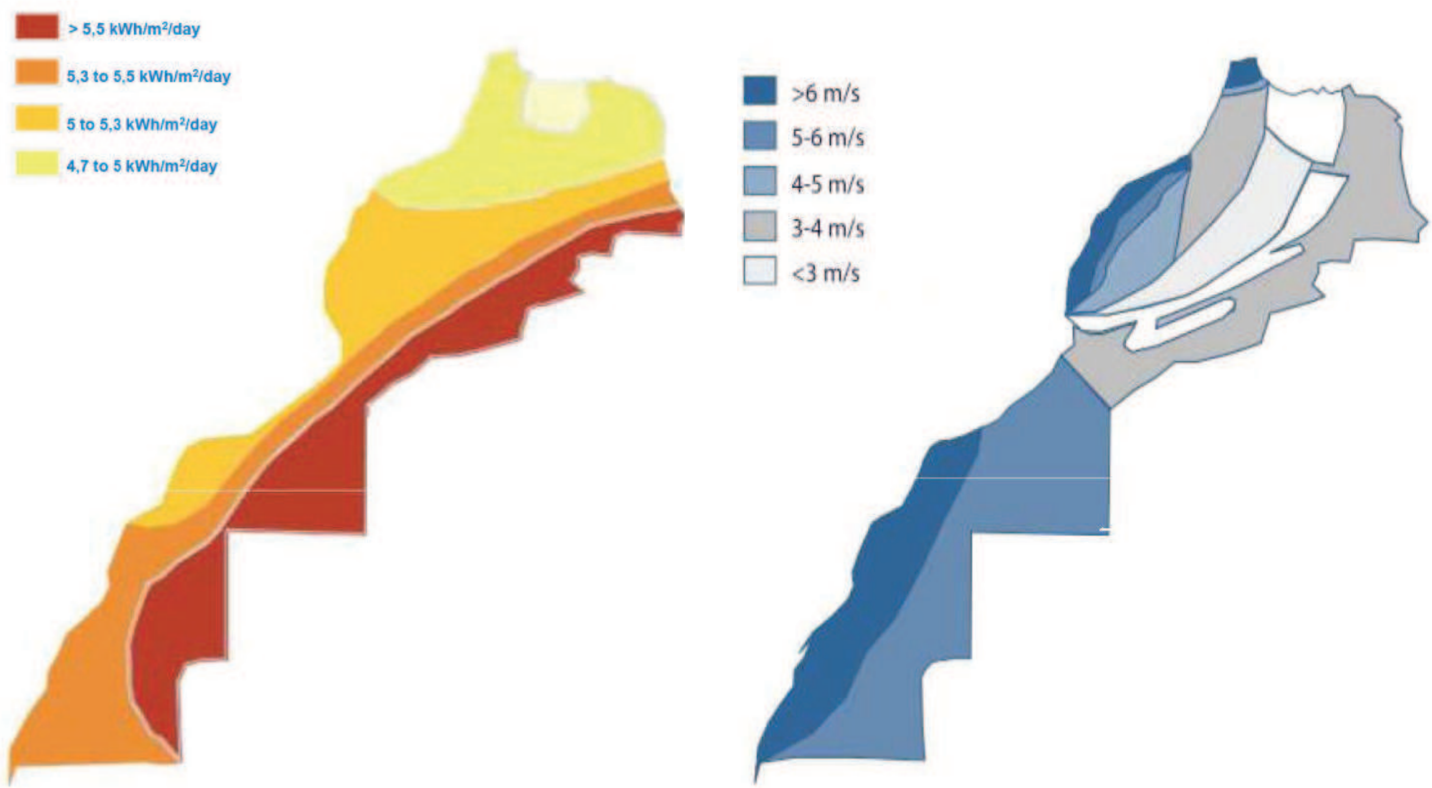

Figure 1 - Wind and Soalr Potential of Morocco. (MEM, 2011)

pendent on foreign sources of energy with continual growth in imports of crude oil, petroleum products, coal, and electricity. Forecasts by the Moroccan government predict that primary energy demands could increase three to four times over the next 20 years. This presents a challenge to the government because current power production is insufficient to meet the demand, and Morocco relies on electricity importation through interconnections with Spain and Algeria.

In Morocco, there is a large difference between the growth of energy demand and rising energy costs. Over a period from 2009 to 2010 the annul energy consumption increased 5.6 percent, while the annual cost of energy increased 38.2 percent (Qxford Business Group, 2011). In order to maintain reasonable energy prices for consumers, the government subsidizes commodity costs like crude oil, which levels out the prices for the end consumer. This policy results in the government absorbing the rising costs of energy putting strains on the developing country's budget.

Energy constraints and challenges that Morocco faces have pushed the government to evaluate how the country produces and uses energy. Energy policy was restructured with a series of energy laws passed between 2007 and 2009. These laws made the mission of the Ministry of Energy, Mines, Water, and Environment to diversify energy sources, improve energy security, and lead in energy integration with European and Mediterranean markets.

Renewable Energies

Wind, hydro, and solar energy potentials are high in Morocco. Morocco can significantly increase the electricity generation capacity with the appropriate policy framework, financing mechanisms, knowledge transfer, and infrastructure development. For example, a major change in Morocco's energy policy leading to more power generation is the liberalization of the electricity market. The state-owned power company, Office National de

Figure 2 - Possible infrastructure for a sustainable supply of power to Europe, the Middle East and North Africa (DESRTEC Foundation)

l'Electricité (ONE), traditionally controlled the electrical sector. While ONE continues to have sole responsibility for distribution and transmission of electricity, the generation is open for the private sector. Liberalization of the energy economy is leading to more private sector investment and a growth in renewable energies.

Project under development will increase the share of renewable electricity from 10 percent in 2007 to 42 percent installed capacity by 2020. This increase will come from developing solar, wind, and hydroelectricity (East, 2009). In 2009, Morocco announced multiple concentrated solar energy projects which when completed in 2020 will account for 38 percent of North African installed renewable power generation capacities and produce 2,000 Megawatts across five sites throughout Morocco. The expansion of wind farms throughout the country will also result in an additional 2,000 megawatts by 2020. Most of Morocco has good wind potential, with many places having 10 meter per second or higher prevailing winds, making it attractive for development (Nfaoui et al., 1998).

Energy Integration

Energy integration is a high priority for Morocco who is working on integrating the Moroccan grid with European and Mediterranean markets (Brand and Zingerle, 2010). Currently Morocco is the only country in Africa with an electrical grid connected to Europe (Clearly, 2010). The ambitious plan to develop green power will result in a surplus of renewable energies, which Morocco can sell in other markets that have less potential for the development of clean energy (Mason, 2009). Given land constraints of Europe, importing renewable energy from North Africa is necessary if Europe

Figure 3 - Photovoltaic kits were provided to remote villages to electrify region that were to far away from the grid. (ONE)

is to reach the goal of having 100% of its electricity generated by renewable sources by 2050 (Desertec, 2010). Morocco is capitalizing off this and attracting foreign investment through expansion of energy integration between Morocco and Europe.

Adoption of Solar Energy

Recently the urban market for distributed energy generation is rising in Morocco with the growing adoption of solar thermal and solar photovoltaic. Currently most thermal energy demands are met through liquefied petroleum gas (LPG), which is distributed through portable canisters due to the lack of gas service lines infrastructure. Morocco is poised to leapfrog gas technologies with an increasing demand in solar thermal installations on rooftops. Popularity is spreading with a public perception that solar water heating is safer and more economical.

Electricity for Everyone

Morocco is beginning to be seen as an energy leader across the Maghreb region because its successful rural electrification program. In 1996, the Moroccan government implemented a social program named Le Programme d'Electrification Rurale Global (Global Rural Electrification Program - PERG), which aim was to provide electricity to all Moroccans. In about a decade, Morocco went from having 18 percent of rural population having electricity in 1995 to 98 percent in 2007 (MEM, 2011). This has had numerous social and economic benefits including the reduction in rural to urban migration, improved indoor air quality, higher productivity of rural populations, and introduction of communication devices like phones and radios. In some cases the low population densities and remoteness of villages in rural Morocco made conventional distribution network uneconomical to provide electricity. PERG utilized distributed power generation to bring electricity to approximately 10 percent of rural Moroccans by equipping them with individual solar photovoltaic (PV) kits.

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Images

"Concentrated Solar Thermal Power Station, Ain Beni Mathar, Morocco" by the World Bank Photo Collection

"Sketch of possible infrastructure for a sustainable supply of power to Europe, the Middle East and North Africa (EU-MENA)" DESERTEC Foundation, www.desertec.org

"Kit Photo Voltaique : Province de Khouribga" by O.N.E Maroc