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POLICIES OF CONVENTIONAL AND NON-CONVENTIONAL ENERGY FOR SUSTAINABILITY IN LIBYA

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ABSTRACT

Energy is defined as the primary and most universal measure of all kinds of work by nature and human beings. Today, every country draws its energy needs from a variety of sources. We can categorize these sources as primary and secondary, commercial and non commercial, renewable and non-renewable, conventional and non-conventional.

This work concentrates on the use of conventional and non-conventional type of energy and their impact on society in Libya. The policies used in investing energy in Libya were reviewed in order to illustrate the major problems (challenges) facing these polices, specifically in connection with water demands. This approach underlain the national policies of Libya in the field of energy and water interrelation.

The nexus of water with energy, demonstrated in this work through the suggested policies viewed to integrate the two analysis, energy types for the sake of keeping resources sustainable in Libya.

KEYWORDS: Conventional, Energy, Non-conventional, Policies, Sustainable

INTRODUCTION

Nations around the world are evaluating their energy options and developing policies, that apply appropriate financial carrots and sticks to various technologies to encourage sustainable energy production, including cost, carbon, and security considerations. Nowadays each country draws its energy needs from a range of sources. We can in general classify these sources as commercial and noncommercial, conventional and non-conventional. The commercial sources consist of fossil fuels (coal, oil and natural gas), hydro-electric power and nuclear power, whereas the noncommercial sources include wood, animal waste and agricultural wastes. The conventional sources include the fossil fuels (coal, oil and natural gas), while, hydro-electric power and nuclear power (similar to commercial sources), non-conventional sources include wind, tidal and solar energy which are being produced constantly in nature and are in exhaustible are called renewable sources of energy (or) non-conventional. Another classification grouping the sources as primary (includes nuclear energy, fossil fuels, falling water, geothermal and solar), and secondary (includes all sources derived from a primary source like; electricity, gasoline and alcohol fuels).

For the last four decades, Libya has been dependent mainly on fossil fuels (petroleum and natural gas) for its supply of energy; only a very small amount of energy has come from renewable sources.

The General Electricity Company of Libya (GECOL) is the only Libyan company that produces and distributes electricity in the country. According to GECOL, its installed electricity generating capacity was 6.28 GW in 2008, and this capacity depended entirely on the use of oil and natural gas. The national grid of Libya has an extensive high-voltage network of about 12,000 km extend across the country. In spite of this, Libya, like other North African

countries, has distant areas where people live yet, are not connected to the grid (Saleh, 2006). Figure 1 (a) shows the Libyan consumption of electrical energy by sector during 2008, with the services and residential sectors consuming around 70% of the total. Also, Figure 1 (b) shows that many power plants have been converted, to use natural gas instead of oil so that, the export of oil volume (and the associated revenue) could be maximized (IEA, 2011).

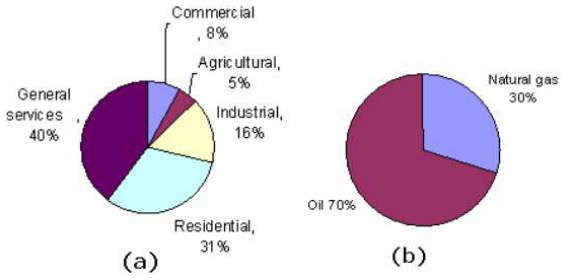


Figure 1: Electricity in Libya Consumption and Fuels Used in Power Plants
(A) Consumption by Sector and (B) Fuels Used in Power Plants (IEA, 2011)

Libya has a high per capita consumption of electrical energy, compared with other North African countries, (UK data included for comparison) (RCREEE, 2009) as seen in figure 2. According to data from GECOL, the per-capita energy utilization increased from 330 kWh in 1970 to 3920 kWh in 2008, and the peak load of electrical power in Libya has increased continually at a high rate of something like 10% per year, while the population growth rate has averaged just over 2% per year. This shows that, energy demand is largely controlled by the very rapid improvement of standards of living in the country.

Diana, et al. (2011) stated that, the policy questions over the energy already reflect a general understanding, that policy choices will impact cost and availability, national security, and carbon emissions. Since water is devoted in producing conventional and non-conventional energy (Figure 3), Diana, et al. (2011) mentioned that, it is time to add water to that list of considerations.

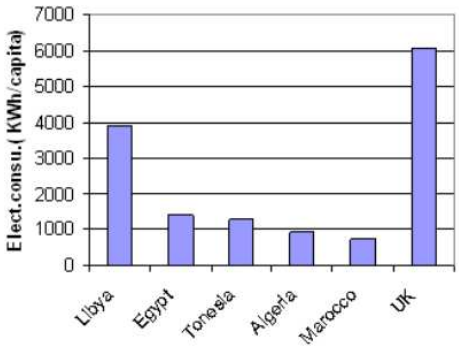
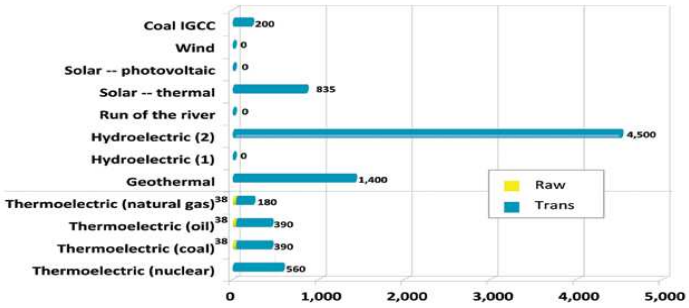


Figure 2: Electric Energy Consumption Per Capita for Libya and Other Countries (RCREEE, 2009)

She also added that the resist between water and energy needs represent a critical business, security, and environmental issue, but has not yet received the consideration that it's critical worth. Energy production consumes significant amounts of water; providing water, in turn, consumes energy. This interrelation indicates that in a country where water shortage is a major, a great challenge residential.



***Source**: World Policy Institute-EBG Capital analysis based on U.S. Department of Energy, 2006, and World Economic Forum and Cambridge Energy Research Associates, 2009. See Appendix V, Table 2 for additional*

Figure 3: Average Number of Gallons of Water Consumed to Produce 1 MWh

Every nation in the world is awake of the two main problems associated with the use of fossil fuels, this means; **1)** they are limited and will be depleted within the next century and **2)** using fossil fuels produces severe environmental problems from the effects of CO_2 and other emissions. To avoid a future crisis in both of these areas, it is important for Libya to begin the rapid development of renewable energy as a strategic energy policy. Both wind and solar sources can produce significant amounts of electrical energy, and both technologies should be developed as rapidly as possible.

We hope this paper serves as an objective, unbiased information source that motivates policy makers, business leaders, investors, NGOs, and the general public to ask further water-related questions – and to investigate seriously into the responses they receive. We also seek to increase visibility of water-energy nexus implications on business (opportunities, supply chain costs/inefficiencies, and risks), security (food, military, and energy), and the environment (agriculture, forest, and climate). These are made more complicated by issues of justice (ownership, pricing, and equity) and sustainable development (poverty, sanitation, health, and gender).

AIMS AND METHODOLOGY

This study is intended to provide a baseline of the most realistic current available data and to encourage additional work and cooperation to improve overall data quality regarding energy and water. Based on existing research on current energy technologies, it describes this information to help identify data holes and questions that deserve further evaluation. Numerous technology developments that are underway or anticipated may result in different data on water consumption. We have assembled and simplified extremely technical, fragmented, and frequently politically biased information. Omissions such as water quality, early stage technologies, the state of the grid, or land use, are made for the sake of transparency. We do not wish to suggest they are unimportant.

Process

- The existing research and reports from a wide range of sources were assembled. The data are often incomplete, fragmented, inconsistent and/or dated. Some data (consumption and production) thought to be biased by political influence.
- Personal communications with, authorized managers and engineers of Libyan energy organizations carried out concerning the various policies implemented by their organizations and their future plans. The discussions were set as a base. The existing conditions of the energy in Libya discussed in this work were analyzed for their policy challenges and opportunities. Comparison of energy production with the neighbor and some other countries were

used to examine the policies used to implement conventional and non-conventional type of energy. Energy demands on water resources were relatively independent in the Libyan energy policies, therefore the ideas of using water consumption is presented in this work to be considered in any future planning of energy in Libya under the title of water energy nexus for sustainable life. The authors pleased to see energy authorized managers' interests in this subject and hope to encourage collaboration for further research.

Conventional Energy Used in Libya

The General Electricity Company of Libya (GECOL) is a national power company and it is the only supplier for the electricity in Libya. GECOL is producing and transforming electricity throughout the Libyan regions by using a vast electrical plants and stations and transforming tower network. It is completely responsible for the generation, transportation and distribution of electric power in the whole country. It operates more than 30 electricity generating plants, mainly steam and simple-cycle gas-turbine units and diesel generators in rural areas. The company provides energy services to residential, industrial, agricultural and commercial customers, besides it offers public and other consumer services related to electricity.

Libya in 2001 has electric power production capacity of about 4.6-4.7 Gigawatts (GW), with a peak load of around 3.3 GW. Most of Libya's existing power stations are oil-fired, though several have been converted to natural gas (Table, 1). Libya's power is growing rapidly as demand increases (around 6%-8% annually), and is planned to reach 5.8 GW in 2010 and 8 GW in 2020. (GECOL) has plans to spend $3.5 billion through 2010 building eight new combined cycle and steam cycle power plants (WELL project, 2014).

Electricity generation has more than doubled from 2000 to 2010, reflecting economic growth and greater investment in the oil and natural gas sectors (Figure 4). Since 2010, Libya has had a total electricity installed capacity of 6.8 GW, made up of power plants that are either fueled by oil or natural gas to lower the costs (Figure 5), but most of the country's power plants are still fueled by oil.

Table 1: Energy by Fuel Type (WELL Project, 2014)

Quantities of Fuel Consumption 2012 (m^3)	
Heavy Fuel	744,904
Light Fuel	2,166,918
Natural gas	5,423,496,703

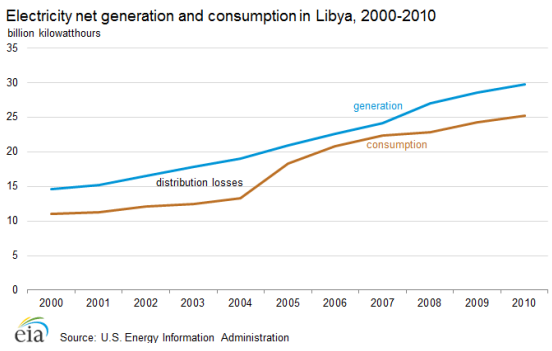


Figure 4: Electricity Generation and Consumption in Libya, 2000 - 2010

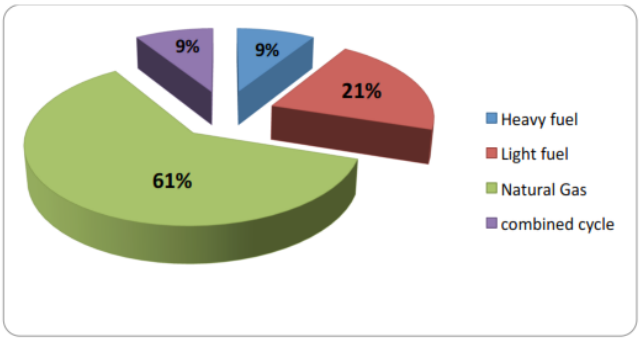


Figure 5: Libya Energy Consumption by Fuel Type, 2012 (WELL Project, 2014)

With a forecast growth rate of more 8% per year in electricity demand, a fair amount of additional capacity will be needed in the next decades. Considerations have to be given not only to the commissioning dates of future capacity additions, but also to the type of generating equipment that best fit the Libyan environment.

WELL project (2014) concluded that up to recent years, steam units were the preferred options for base generation because of their high efficiency and capability to burn heavy fuel. Because of the significant cost and efficiency of larger unit size, 300 MW and above units would normally be selected for future expansion.

Based on existing data, the most surprising finding is that both traditional and existing alternative energy technologies are growing toward higher water consumption per unit of energy produced. Data from one of Libya's gas dependent energy generation needs 278 m^3/hr of water, to produce 100MW and needs 2MW/hr to produce 340 m^3 of water for its energy generation per unit. If we count that for one year, the amount of 17000 MW is needed for the desalination unit to produce its capacity around 3,000,000 m^3 of water. While, the amount of water needed per year to produce (3,500,000 MW) reaches (2,500,000 m^3). The relations seen from this simple calculation indicate the importance of planning the energy, water nexus for sustaining both resources in Libya. Water scarcity in Libya is a major and growing challenge, meeting future energy needs. Maintaining sustainability depends on wise energy policy decisions. Further challenge of potential water quality impact is critical as well, but they are not the focus of this paper.

GECOL Future Vision

In addition to progress in generating energy inside the country, GECOL also looking for exporting electricity, according to connection with Libya's' neighbors (Figure 6).

- Increase the exchange capacity between Libya and neighboring countries.
- **Libyan-Italian Interconnection:** The preliminary findings of the feasibility study of the Libyan Italian Interconnection over DC, through a submarine cable suggested that, exporting 1000MW to Italy is possible.
- **Libyan-Greek Interconnection**: Discussion between Libya and Greece are underway, with emphasis on the importance of such interconnection, aiming at exporting 3000 MW to Greece.

Figure 6: Interconnection with Neighboring Countries (WELL Project 2014)

Non-Conventional Energy

The main argument against the installation of renewable energy technologies was its high investment cost. Since, initial investments in renewable energy systems are still higher than for traditional heating systems, it is important to evaluate the investment in provisions of long-term operational costs and savings. As conventional systems become more and more expensive to run with the rising price of fossil fuels (oil and natural gas), the cost of operating a renewable energy system is constantly falling. The return period for investment in renewable technology is already down to around 15 years, and the systems are operational for up to 30 years.

As a result of Libya's growing domestic energy demand, the government plans to increase the amount of power generated from renewable sources, particularly wind and solar, and is fostering nuclear power development (WELL project, 2014). Renewable Energy Authority of Libya (REAoL) established in 2007, as corporation responsible for implementing and distributing renewable energy in the country.

Libya is one of North Africa countries, most of its area considered to be desert areas. Libya has good spreading of Renewable Energy Sources (RES). South Libya represented by the Sahara desert, showed high potential of solar energy which can be used to generate electricity as well as wind. Other renewable sources available in Libya like geothermal, biomass, and tides, not evaluated yet. Production from RES in Libya, mainly based on wind and solar sources in limited application.

Wind

In 2004 measurement of the wind speed for wind potential has been conducted. The measurements showed that there is a good potential for wind energy in Libya and the average wind speed at a height of 40 meters is between 6 - 7.5 m/s. The use of wind energy for electricity production has not started yet in Libya, but the first project to generate electricity by using wind energy currently under construction in the city of Dernah and Misallata.

REAoL has installed 26 meteorological stations over Libya, to measure the wind speed to select the most suitable places for wind farm. Based on measurement from meteorological station and satellite data, a wind atlas for Libya has been achieved (Figure 7). The Libyan wind atlas showed that there are several attractive sites along the Libyan coast are suitable for wind farms where the average wind speed can exceed 7 m/s.

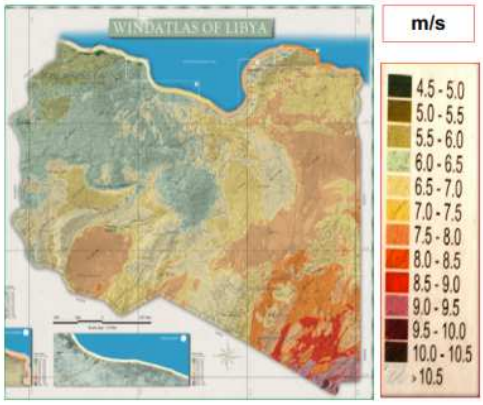


Figure 7: Libyan Wind Atlas (WELL Project, 2014)

Solar

Photovoltaic (PV) systems started in Libya 1976, and since then many projects have been erected for different sizes and applications. The first project put into work was a PV system to supply a cathodic protection, to protect the oil pipeline connecting Dahra oil field with Sedra port. Projects in the field of communication were started in 1980, where a PV system was used to supply energy to a microwave repeater station, near Zella (WELL project, 2012). A project in the field of water pumping was started in 1983, using PV pumping system to pump water for irrigation at El-Agailat. The use of PV systems for rural electrification and lighting was started in 2003. Water pumping projects were also erected, beginning in 1984. The role of PV application was growing in size and type of application.

Concentrated solar power (CSP) has no applications in Libya yet, for that, REAOL has planned CSP power plant (50 MW) in south of Libya. However, Some RE projects are in the planning phase by REAoL, to raise the contribution of renewable energies upto 7% of the energy mix of the year, 2020 (RCREEE, 2009).

Three meteorological stations were installed in different sites of Libya to measure solar radiation and the direct normal irradiation to select the most suitable places for solar plant. Based on measurement from meteorological station and satellite data a solar atlas of Libya has been achieved. The Libyan solar maps showed that there is a high potential of solar energy which can be used to generate electricity (Figure 8). The daily solar radiation on the horizontal plane reaches 7.5 KWh/m2 with 3000 to 3500 hours of sunshine a year. Although, REAOL set a target for its contribution of energy to the total energy grid in Libya, still this contribution very moderate comparing with that achieved in North African countries (Table, 2).

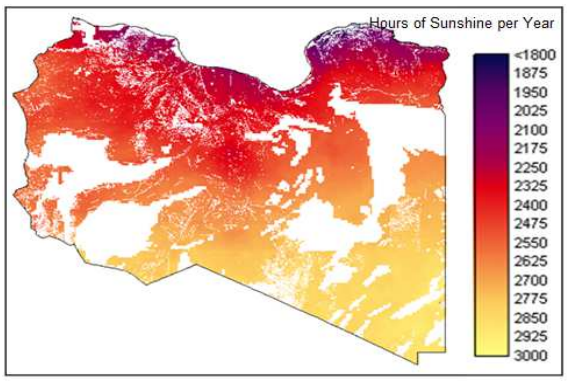


Figure 8: Libyan Solar Intensity Map (WELL Project, 2014)

Table 2: Renewable Contribution in the North African Countries (REAoL, 2012)

Country	RE Contribution by the End of 2009	RE Target contribution to Produce Electricity
Egypt	10%	20% (2020)
Tunisia	1.1%	11% (2016)
Algeria	0.8%	5% (2017)
Morroco	14%	42% (2020)
Libya	**0%**	**No definite target set**

REAoL Future Vision (REAoL, 2012)

- Increase participation of producing renewable energy in a national transmission system to reach 10% in 2025.
- Supporting national economy
- Transferring knowledge and technology to build national capacity
- Working hard to make Libya, renewable energy exporter.
- Evaluate renewable energy resources in Libya.
- Implement projects based on the use of renewable energy in various forms.
- Encourage and support the industries related to renewable energies.
- Propose the legislation and the regulations necessary to support and facilitate the use of renewable energy.

Analysis of National Program

There are several aspects of the Libyan energy sector, that can be considered to be quite problematic. Due to the quantity of fossil energy sources, renewable energy sources have ever since, been considered to be of secondary importance. Instead of energy sector being forceful on developing alternative energy sources, the regime has strongly subsidised energy coming from domestic fossil sources.

The Picture on Electricity Generation by Conventional

Bliss, et al. (2007) indicated that, conventional power plants and gas-fired plants consume the least amount of water per unit of energy produced, while Oil-fired plants consume roughly, twice as much as water, as gas-fired plants. This formula was not considered in the planning of using power plants in Libya, therefore the concentration on water use must be measured as water consumption, withdrawal and quality.

The Picture on Electricity Generation by Non-Conventional

Considering Bliss, et al. (2007) ratios as a base for decision, wind and solar photovoltaic electricity consume minimal water and are the most water efficient forms of nonconventional or alternative electricity production. In addition, the installed base of the solar thermal form of electricity generation (as opposed to photovoltaic) consumes twice as much as water than coal and five times as much as gas-fired power plants. Since, RAEOL has not carried research evaluating renewable energy resources, the measurement of water needed or produced was not considered as well.

Nuclear energy is not used in Libya, but as energy source consumes around three times as much as oil fuel plant (Bliss, et al., 2007). Energy demands in Libya needs more research on contemplated future projects, including modular nuclear energy; especially the new advanced technology used in nuclear power plant is safe, reliable and economic.

The reports used in this work are relatively comprehensive, widely cited, and appears to be objective and the most credible data that currently exist.

CHALLENGES

From the previous analysis and the discussions carried out by the Libyan energy experts, it seems that, the following challenges were met which in our view need to be faced seriously, to sustain energy for life in Libya.

Technical: Regarding the energy sector, lack of suitable plans and the right future visions, have restricted sector development, where the actions are limited to the generation, transmission, and distribution. Lack of record and data about energy for simulation and evaluation. Regarding the renewable energy sources (solar, and wind) and their technologies, a few and small projects have been carried out, apart from the lack of research programs in Libya. Many international water and energy projects accomplished in Libya have no significant effects at the Libyan national level.

Institutional: Lack of integrated governmental co-ordination in the fields of action plan for implementing organization visions – Lack of governmental support to energy efficiency programs. – Lack of sufficient technical capacity in public sector.

Economics: Libya maintained a one-sided economy, that greatly relied (and still relies) on the occurrence of fossil fuel (Oil and Gas). This does not only worsen future efforts to reform the Libya's energy sector, but also cancels out the expected effects of renewable energies, to bring along economic advantages. From a more general point of view, there has been no economic reasons to shift to a more sustainable energy for life.

Social and Cultural: Social resistance and acceptance for implementing new sources of generating energy, as well as no designated organization responsible for formulating, promoting, and implementing energy efficiency measures and policies.

POLICIES, ORGANISATIONS, LEGISLATIONS

Policies

Energy Demand Studies

In addition to its direct effects on water availability and hydroelectric generation, climate change may have secondary impacts, on both water and energy demand in Libya. Average daily temperatures show a direct relationship to energy use; on exceptionally cold days, customers use more electricity for indoor appliances and heating, and of higher temperature days, customers use more electricity for cooling indoor areas. In addition, an increase in summertime temperatures, when demand is on peak, has important implications for supply management.

Predictions of future average and peak energy demands are based on an empirical relationship, between annual energy demanded and average daily temperatures, and the relationship between peak energy demanded and maximum daily temperatures. Different models were presented, dealing with the impact of climate warming. Franco and Sanstad (2006), present a comparison of the impact under what is called Parallel climate Model, whereas Hadely Center, model climate warming for future periods, 2005 – 2035 – 2064 and 2065 – 2099, using variable emission scenarios.

Implementing Conventional with Non-Conventional Sources

In Libya, although non-conventional energy was used to a certain limit, but its contribution is still considered nill. To achieve sustainability of energy, hybrid system must be implemented through rising the use of non-conventional type with conventional. In case of Libya, this means putting more efforts, supporting the use of non-conventional type of energy in daily life.

Smarting the Grid

A smarter grid applies technologies, tools and techniques available now, to bring knowledge to power – knowledge capable of making the grid work far more efficiently

- Ensuring its reliability to degrees never before possible.
- Fully accommodating renewable and traditional energy sources. Potentially reducing our carbon footprint.
- Introducing advancements and efficiencies yet to be envisioned.

Energy Efficiency

By reviewing energy efficiency trends and policies at world level, it is needed to smooth the progress of exchange of information and share experiences on energy efficiency measures, among different countries around the world. It can help government decision-makers and analysts, select appropriate and cost-effective measures for each sector, taking into account their national conditions. Through policies implemented regarding energy efficiency, the decision tools such as energy efficiency/CO_2 indicators are suggested, for monitoring trends in energy use and CO_2 emissions and contribute to a better understanding of the impact of the measures, implemented in each sector.

Sustainability of Energy and Water

To follow up sustainability, policies implemented must provide the important facts, generate and adapt modeling tools for decision analysis, create and test new technologies and strategies, to increase water and energy use efficiency, conduct economic and policy studies, and communicate with stakeholders to provide timely answers to critical questions.

Organisations

Establishing a national council for managing the energy issue under the name (National Energy Council of Libya, NECL). This council shall hold all policy responsibilities, concerning with energy and water nexus. NECL should adopt n-tuple model, to construct its strategy depending on the Libyan institutes, working in/or related to the energy sector. The Libyan institutes, who must participate under NECL are GECOL, REAoL, Libya Atomic Energy Corporation (LAEC), National Oil Committee (NOC), and Ground Water Authority (GWA).

Legislations

All issued legislations should be reviewed in the sense of building the energy policies, taking in consideration water-energy nexus producing sustainable energy for life, in Libya. NECL shall be the authorized body, responsible for reviewing, following and issuing rules and laws, to maintain sustainability of water and energy.

RECOMMENDATIONS AND CONCLUSIONS

Meeting future energy needs depends on water availability –and meeting water needs depends on wise energy policy decisions.

- Execute focused research on energy and water intensity of main agricultural, industrial, commercial, and residential activities in Libya.
- Study limitations and opportunities affecting Libya's future energy supply.
- Analyze all factors that might increase Libya energy requirements, affecting water demands.
- Evaluate the implications of climate change on Libya's energy and water supply and demands.
- Examine the implications of increases in energy demand, including the ramifications on water supply and quality of habitat and recreational uses of water.
- Follow the development and test of technologies and water management approaches that result in a decrease in the water use of generating electricity.

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