SOLAR HYDROGEN ENERGY PILOT PROJECT FOR LIBYA, SHEPL

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Abstract
This work presents the first stage of the SHEPL project which includes technical and economic analysis of the main project components. These are Photovoltaics power generation of one MW, electrolysis plant for hydrogen production, fuel cells power plant to generate electricity at night time, sea water desalination plant, and other required facilities.
The project is intended to supply a small community of twenty families with all its energy and water requirements, to be completely independent from local utilities.

Introduction
The search for reliable, long-lasting sources of energy has been an ever challenging task to mankind. This search is more urgent today than ever before. While conventional energy sources are quickly diminishing, and disrupting life on earth, renewable energies, particularly solar energy of North Africa, promise to be a reliable source of energy that could improve the quality of environment and ensure continued progress of our clean civilization [1].
The recent astronomical increases in oil prices in the international markets are happening simply because the world has been finding less oil than it has been consuming for the last twenty years. It consumes two barrels of oil for every barrel discovered [2].
It is expected that the energy consumption, worldwide, will increase at an annual rate of 1.5 per cent per year. As a result, atmospheric concentrations of CO2 are likely to increase at the same rate or more [3]. The world pumps CO2 to the atmosphere today at a rate that is three times as fast as the oceans and land can absorb it. No one knows the exact consequences of this upsurge in CO2 concentration in the atmosphere or the effects that lie ahead as more and more of the gas enters the air in the coming decades [4].
Increasing energy demand is well related to advancement of lifestyle. The wealth of the world, monitored for the past 1000 years, is increasing exponentially, and so does the energy demand which is expected to reach 50-80% above 1990 levels by 2020 [3].
It is clear that the world is not only running out of cheap oil and natural gas, but also out of environmental capacity to absorb the impacts of processing and burning fossil fuels [5].
Libya consumed about 86.5 million bbl of oil in 2004, and the demand grew at about 2.3% per year during 2000-2003, Figure 1. It is expected to grow at high growth rates due to the reforming of the economy.
Libya emitted more than 50 million tons of CO2 in 2002 that is about 0.2% of world carbon dioxide emissions. Libya is number 26 among the countries with high emission rates in the world [6]. Most of CO2 emissions come from burning oil, Figure 2 [7]. Libya can reduce this amount of CO2 emissions by starting to invest in the conversion to solar and solar hydrogen today.
Solar generated hydrogen will provide the ultimate, renewable, clean fuel for all of our energy needs. Hydrogen is the only energy option that can be integrated with virtually all other energy sources [8, 9].

Figure 1 Oil consumption of Libya for the period (1980-2003)

Figure 2 Carbon dioxide emissions from fossil fuel combustion by source

2- SHEPL Project
The initial idea of this project started, as a Ph.D. thesis, at the University of Miami about 20 years ago [10]. The work called for more detailed analysis and
demonstration projects, in cooperation with technologically advanced European countries for the benefit of all including our climate.
This project has been initiated as a result of the fruitful cooperation agreement between UNIDO-ICHET and the Secretariat of Industry and Electricity of Libya, SIÉL, (GPCEL), to develop and establish scientific and technological cooperation in solar and solar hydrogen energy fields. And it is one of many pilot projects around the world proposed and supported by the ICHET.
Demonstration projects remain the most effective way to present the technology, and the applicability of the solar hydrogen energy concept to wide audience of concerned people. The project will be visited by officials, university educators, students of all levels, the general public. It is expected to become an educational and training center for all kinds of solar energy applications and environmental awareness in Libya.

3- The Project concept
The project is intended to explore the merits and challenges of supplying a small community by all its energy requirements in the form of electricity, heat, and domestic water, through solar and hydrogen energy system. It will represent an important and logical step towards supplying a larger community, village or town, with their energy and water requirements in the future. It will convert solar radiation, using solar Photovoltaics, into electricity which is to be used for three interconnected applications:

a- To supply electricity, during day-time, for a community of twenty homes representing a small town.
b- To desalinate sea water required to meet the needs of the project and the proposed community, by the use of solar PV electricity.
c- To produce hydrogen through water electrolysis, during sunny hours, that is necessary to provide the community with the electricity, during night-time, using fuel cells.

4- Project objectives
It is important to increase the local technological capacities of scientists and engineers in applied research and development, AR&D, and technical training in the field of solar hydrogen energy. A real demonstration project is the first step towards building large scale plants in the future. The specific objectives of the project can be briefly mentioned as follows:

a- To present the concept of solar and solar hydrogen energy system to the local and regional communities.
b- To construct, operate and test the major technical systems of the project, at real environmental conditions of Libya, and to monitor the interactions of the systems of the project, under long-term operating conditions compared to other commercial projects.
c- To evaluate and compare different technologies included in the project; solar cells, Electrolyzers, fuel cells, hydrogen storage, sea water desalination, etc. and acquire practical experience and know-how to be able to plan, initiate, construct, and operate similar projects in the future.
d- To study and understand the individual behaviour of the systems of the project, and obtain a reliable operating data that can be used to assess the future challenges.
e- To educate people and develop awareness and draw attention to the importance of initiating solar and solar hydrogen demonstration projects for
the future of the country and for the world, and to estimate the real operating and maintenance costs of the whole project.

5- **Main project systems and components**
This project is intended to be a complete energy and water supply system for a small community. To satisfy these requirements, it is suggested that the project consists of the following systems as depicted in Figure 3.

**Photovoltaics**
The core of the project is one Mega Watt Solar Photovoltaic Cells installed capacity of mainly single-crystalline silicon cells. Part of the electricity generated by the PV cells, 246 kW, to be used for RO sea water desalination, 600 kW is connected to the Electrolyzer, for hydrogen production, and the remaining part, 154 kW, is used to supply the community with electricity during day time and to compress hydrogen and oxygen and for other services. Excess electricity is to be sold to the local grid.

**Electrolysis**
Alkaline Bipolar Electrolyzer of about 600 kW installed capacity and 80% efficiency is suggested to split water into hydrogen and oxygen at a pressure of about 25 bars.

**Sea water desalination**
Sea water desalination plant of 100 m$^3$ per day, 246 kW, will supply fresh water for the Electrolyzer, the community, and any other needs. The excess desalinated water will be sold to local utility.

**Hydrogen-oxygen purification and storage**
Hydrogen and oxygen produced during the day-time hours are purified and stored as pressurized gases. The major part is to be used for electricity generation in fuel cells.
at night time, and the rest will be used for direct consumption in automobiles, local industry and other appliances.

**Fuel cells and other applications**

PEMFC of 60 kW output is suggested for the project, to supply the end-users with the electric energy they need at night. A filling system is proposed to refill cars, bottles, containers, cylinders, etc.

**End-users**

The end-users of the project is estimated to consist of 20 families (100 persons) living in new houses, mostly engineers and technicians who are working in steel industry, near the project site. So they can be easily trained to deal with the new technology in their homes and around them.

**6- Call for international cooperation and contribution**

Establishing ICHET by UNIDO is a major step forward, to disseminate knowledge and illustrate concepts to help developing countries to be aware of the real progress being achieved in this field of energy. **There is a real need for technological support and contribution from international community, particularly, European Institutions**, to help establish this project which will lead to building large scale solar hydrogen projects in Libya to supply Europe with inexhaustible clean energy for ever. This could promote research and experimental work in the universities and research centers in the country. This project presents concept, technology, real applications, clear benefits, development. All these aspects can be realized in this pilot project SHEPL, so it should be a successful project.

**References**