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# Studies on installing solar water pumps in domestic urban sector

K. Padmavathi, S. Arul Daniel*

*Department of Electrical and Electronics Engineering, National Institute of Technology, Tiruchirappalli 620015, T.N., India*

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ABSTRACT

Per capita energy consumption is high in urban locations of any country. In this context, this article explores the deployment of standalone photovoltaic (PV) water pumping units in every household of a sustainable city. The various photovoltaic water pumping schemes and the domestic pumping requirements of a city in India are given in this paper. The peak shaving of load and reduction in line losses due to PV pump deployment on a secondary distribution transformer in a residential locality of the same city is investigated to bring out the advantages of the above policy initiative. The need for a legislation to install PV water pumps is thus brought out in this paper.



## 1. Introduction

### 1.1. Back ground

In certain countries like India, centralized water supply by a water supply company is only during certain hours of the day and pressure is generally insufficient. Residents store water from the central supply in a local sump and is pumped to an overhead tank (roof top storage tanks) for consumption. Apart from the central water supply, households or a colony like apartment have independent ground water wells from which water is to be lifted for consumption. Hence, in residential areas, when either ground water or central water supply along with ground water is consumed, there is a need for pumping water to overhead tanks. In India, the present scenario has water pumps in every household of a city; that are driven by electric motors connected to the utility network.

In many industrialised countries cold water supply is continuous and is directly fed from water mains. In case the water supply pressure is insufficient, then booster pumps are used to increase water pressure. A pressure booster system consists of a pressure tank and a one line jet pump. The pressure tank is generally placed in the ground floor and it feeds water at pump boosted pressure to the house faucets. The pump will draw more water from the water mains and feed it to the pressure tank as water is consumed in the houses. These pumps need not lift water deep in the ground to high level in the buildings. A second booster pump, when used to improve water pressure in the upper part of the building is then placed in the upper floors of the building. The booster pumps come with pressure switches, with cut in and cut off pressure settings. Multi story apartments and very tall buildings called “sky scrapers” are most likely to install a roof top water supply tank which is fed by a pump from street level.

Per capita energy consumption is high in urban locations of any country. Urban growth rate in a developing country like India is high and is projected to continue for another 30–40 years. Fossil fuels are getting depleted at a faster rate. Another challenge is to face the climatic changes the world is undergoing. Urban society should adapt itself to utilise alternate energy resources available in the surroundings. Solar photovoltaic energy is accepted as the most reliable and cleanest source of alternate energy. In ‘along the sun’ solar water pumps, energy is stored indirectly in a tank, in the form of water at high elevation. This form of storage is more economical than battery storage. In this context, this paper proposes a policy initiative on deployment of domestic solar water pumps in all the households of a city.

Israel today, is the world leader in the use of solar energy per capita with 85% of the households using solar thermal systems. This is the result of Israeli Knesset passing a law in 1980, requiring the installation of solar water heaters in all houses. In 2005 Spain became the first country in the world to require the installation of PV electricity in larger buildings and the second after Israel to require installation of solar heating systems in 2006. In Germany building regulations give credit for solar thermal systems but are silent about solar PV installations. In UK new building regulations

* Corresponding author. Fax: +91 0431 2500133.
*E-mail addresses:* kpeesame@yahoo.co.in (K. Padmavathi), daniel@nitt.edu (S.A. Daniel).

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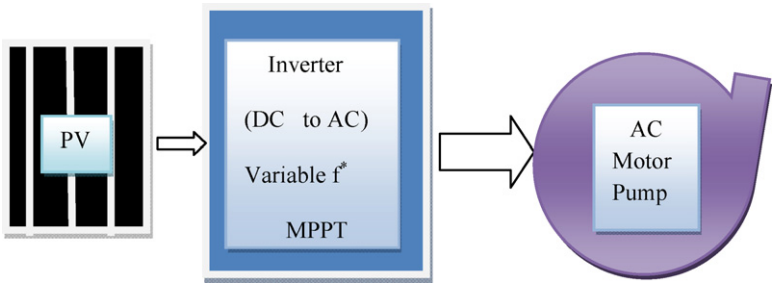


**Fig. 1.** PV pumping with AC motor (f* = frequency).

aim at reducing the carbon emission of new UK houses to zero by 2016. This includes "code for sustainable homes", which may require the use of solar thermal and PV installations.

In India, use of solar water heaters in residential buildings is made mandatory in many states through an amendment of building bye-laws (CTRAN report). As a result, there is a steep rise in the installation of solar water heaters. Solar lights with rechargeable batteries are also in widespread use. Wijaya, Fathoni, Pranayudha, Prakoso, and Suryani (2009) have worked on electricity saving through application of solar water pumps in domestic and commercial sector and have shown reduced dependency of these sectors on national grid of Java–Madura–Bali (Jamali) in Indonesia.

However, there is no detailed study available in the existing literature on the impact of employing photovoltaic water pumps in every household of a city. In this context, the paper presents a model of analysis, taking distribution transformer data, load curve, distribution network parameters and such a study has been attempted for the first time in this article.

### 1.2. Proposed policy initiative

There is an ever increasing demand for harnessing every possible resource to meet the per capita energy consumption requirements of a country. In addition to augmenting renewable resources to meet energy needs, there is a continuous emphasis on demand side management. All these initiatives are carried out to postpone capital investment in the electric distribution network, due to a continuous increase in power consumption. Government of India has announced a huge program on solar energy, JNNSM-2009 (Mission Document, www.mnre.gov.in). This program is aimed at wide scale deployment of solar farms, roof top generation and rural electrification. There is a need for well developed Transmission and Distribution (T&D) Network to evacuate power generated by solar farms located in remote areas. On the other hand, roof top photovoltaic generation can be a feasible substitute for utilising solar energy for meeting growing urban power demand and attain sustainability in the future.

Urbanization has significant implications on urban energy demand. Today, developing countries like India show an average degree of urbanization that developed countries were experiencing in the early part of 20th century. City planners in developed countries face challenges with regard to increasing urban energy consumption. The major share of energy consumed in urban areas is the energy consumed in residential and commercial buildings (Madlener & Sunak, 2011). As a matter of fact, the most sought after form of energy is electrical energy since it is pollution free at the utilization stage and has excellent transportability. Thus, policies regarding energy efficient measures and deployment of renewable energy sources are the need of the day.

In this background, the paper attempts to employ photovoltaic panels for pumping water in every household of a city. A policy initiative proposed in this paper is to install small solar water pumps in the premises of the private households of cities in place of water pumps driven by electricity drawn from the utility network. The size of the PV panel is designed for pumping the water through out the day to fill the overhead tank. An optimization algorithm is sufficient to find the optimum size of the PV panel for such an application and is not dealt in this paper. In order to bring out the positive features of installing PV water pumps in city households, power flow analysis after the removal of water pumps driven by electricity drawn from utility network is carried out and the results presented.

## 2. PV water pumps

### 2.1. PV pump schemes

In PV water pumping, the pumping set-up consists of a centrifugal pump or volumetric pump driven by an AC motor or a DC motor. The electrical output of the PV array is converted into AC using an inverter whose frequency is variable to drive an AC motor as shown in Fig. 1.

In case of a DC motor driven pump, the PV electrical output is either directly coupled or fed through a DC–DC converter as shown in Figs. 2 and 3 respectively. Utilization of available PV power is least in direct coupling.

In solar water pumping, efficiency of a DC motor coupled to a positive displacement pump with maximum power point tracking (MPPT) is shown to be higher than an induction motor driving the same pump with MPPT (Lujara, VanWyk, & Materu, 1999). Centrifugal pumps are suitable for high flow rates. They lose their efficiency in PV water pumping at low sun conditions. Positive displacement pumps have higher efficiency. They are used in solar applications in the power range of 500 W or less.

### 2.2. PV pump components

#### 2.2.1. PV module

India has a well organised PV module manufacture industry which has come of age in the last two to three years. India, with its advantages of lower labour costs, offers domestic opportunities

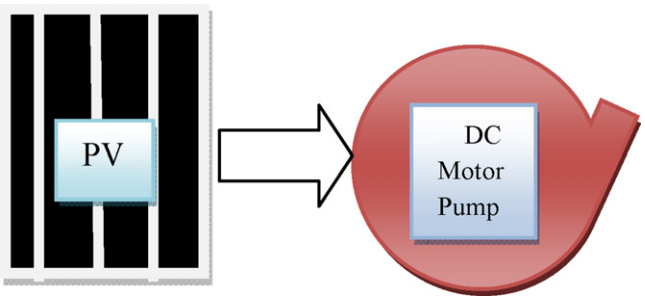


**Fig. 2.** PV pumping with direct coupling.