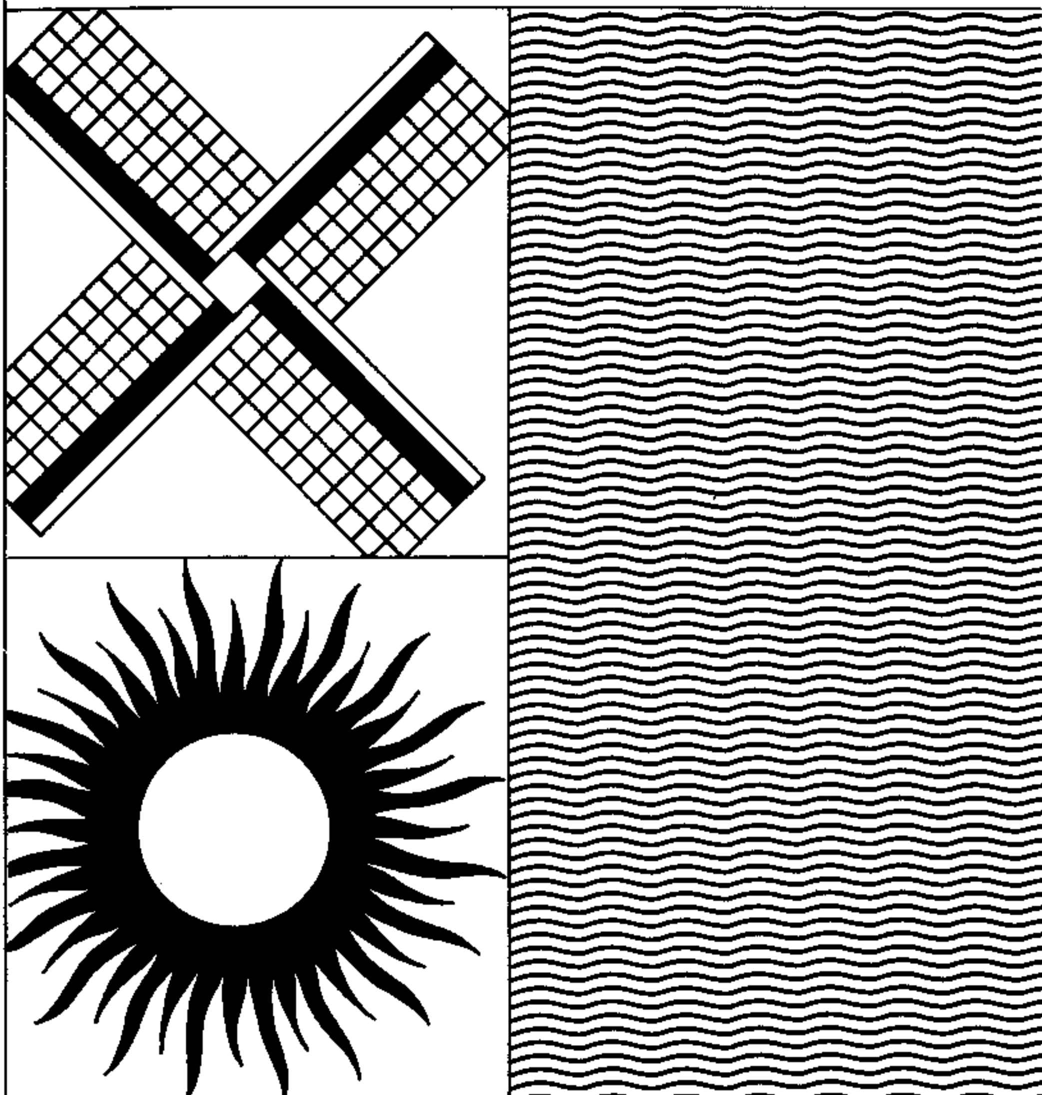
# Appropriate Technologies for Semiarid Areas: Wind and Solar Energy for Water Supply



**German Foundation for International Development**
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# INTERNATIONAL CONFERENCE

# APPROPRIATE TECHNOLOGIES FOR SEMIARID AREAS: WIND AND SOLAR ENERGY FOR WATER SUPPLY

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## CONFERENCE REPORT

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# 6,000 HAND-CRAFTED SAILWING WINDMILLS OF LASSITHIOU, GREECE, AND THEIR RELEVANCE TO WINDMILL DEVELOPMENT IN RURAL INDIA

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## 1. Abstract

The author visited Lassithiou, Crete, Greece, to ascertain the reasons for the widespread use of windmills there and to determine if any of the details of their design could be incorporated in the design of water-pumping windmills currently being developed for widespread use in rural India. The success of the Greek windmills may be attributed to their use of inexpensive and lightweight cloth sails, maximum use of local hand-craftsmanship in construction and simplicity in design of the steel turntable, the wooden main bearings, and the crankshaft.


## 2. Introduction

Lassithiou is a broad fertile plain isolated in the mountains of Crete, the largest of the Greek islands. Zeus, the kind of Greek Gods, is said to have been born in a cave overlooking the area. Farmers from several villages surrounding this plain produce export quantities of beans, cabbage, corn, potatoes and other vegetables through intensive cultivation of 1-2-acre plots during the warm season of May through September. Winds during this season are light to moderate. The general prosperity of this area may be partially attributed to the widespread use of Aeolian energy for the pumping of irrigation water.

In the Mediterranean region large stone tower windmills rigged with triangular cloth sails were traditionally used for grain grinding and oil pressing. In 1918 this traditional windmill design was adopted to smaller lightweight structures for pumping water. At the present time at least 6,000 of these simple devices are in seasonal use. Not including pump and storage tank, a Lassithiou windmill costs 10,000 drachmas to instal (Rs 2,500).

## 3. Lassithiou Windmill Design

The Lassithiou windmill design consists of eleven basic elements: base well, pump-storage tank, tower, turntable, carriage, tail, main bearings, crankshaft, hub, spars, and sails.

### 3.1 Base well

A 15-cm thick concrete slab covering a 2-m diameter, 10-m deep well forms the base of the windmill.

### 3.2 Pump-storage tank

Mounted on the base in the centre of the tower is a 13-cm diameter, 15-cm stroke piston pump made of a discarded W.W.II German cannon shell, fitted with a leather foot valve and a leather-sealed piston. Pumping 2 litres per stroke, 40 strokes per minute, this pump fills a 3 metre x 4 metre x 80 cm deep concrete storage tank in two hours. The pump costs 1,200 drachmas (Rs 300) and the storage tank 4,000 drachmas (Rs 1,000).

### 3.3 Tower

The four-legged 5-metre high, 1.5-metre square base tower is made from 5-cm mild steel angle iron riveted with flat steel cross bracing. The tower is bolted and wired to the base.

### 3.4 Turntable

The turntable riveted to the top of the four tower legs is made of a 160-cm long piece of 5 cm MS angle iron bent into a 50-cm diameter ring to form a flat horizontal bearing surface for the carriage to rotate upon.

### 3.5 The carriage

The carriage is simply a rectangular-angle iron frame 35 cm wide and 140 cm long. The carriage is bolted down with four bolts to two 35-cm pieces of angle iron riveted to a 48-cm diameter flat steel ring which rotates on the bottom inside surface of the turntable ring. This arrangement keeps the carriage firmly attached to the top of the tower while at the same time allowing it and the attached shaft, sails, etc., to rotate vertically when the wind direction changes.

3.6 Tail

A triangular tail of corrugated sheet steel 1.5 m x 1.5 m x 1 m is supported by two 2-metre long pieces of angle iron from the rear of the carriage.

3.7 Main bearings

Two 34-cm wide, 15-cm high, 8-cm thick blocks of hardwood, each with 1 5 cm diameter hole bored in the centre of the large surface are bolted to the front and rear of the carriage to support the crankshaft.

3.8 Crankshaft

The crankshaft is made of a 5-cm diameter, 160-cm long MS steel rod which has a 'U' shape bent into the centre. The 'U' section has an inside width of 7 cm and a height of 7.5 cm, thus giving a stroke of 15 cm. A 2-cm-diameter steel connecting rod attached with two bolts to a wood crank bearing transfers the rotatory motion of the crankshaft into vertically reciprocating motion of the pump piston.

3.9 Hub

The front end of the crankshaft is inserted through a 30-cm diameter, 15-cm thick wooden hub into which eight 5-cm square holes are chiseled in the perimeter to receive the squared ends of the spars. The hub is fixed to the end of the shaft by a bolt passing through both. An improved hub made of two 30-cm diameter, .5-cm thick steel discs separated 5 cm apart by 16 small rectangles of 10 cm x .5 cm steel to form eight square holes has recently been adopted. A 60-cm diameter flat steel ring around the hub is bolted to each spar to keep them secured within the hub.

3.10 Spars

The eight 2.8-m long spars made of wood radiate out from the hub to form a total windmill diameter of 5.4 m. Small stones are attached to the tips of some spars when balancing is necessary. A central supporting spar of angle iron extends 2 m out in front of the hub along the main axis of the crankshaft. Steel wires radiating back and out from the tip of the central spar to the tips of the radial spars provide bracing against strong winds. Steel wires between the tips of all the radial spars provide additional bracing. A 60-cm diameter flat steel ring around the hub is bolted to each spar to keep them secured tightly within the hub.

### 3.11 Sails

A triangular cloth sail 2.6 m x 1.2 m x 2.4 m is attached along the long edge to each of the eight radial spars. The loose corner of each sail is secured with rope to the tip of the adjacent spar, thus forming a strong uniform surface for catching the wind. The sails can be wrapped around the spars to control the amount of sail area exposed to the wind.

Note: All measurements are accurate ± 10%.
Photographs are available with the author.

## 4. Conclusions

The lessons to be learnt in India from the windmills of Lassithiou are:

4.1 Cloth sail windmills can be successfully used for irrigation in some isolated areas.

4.2 Wood is superior to metal for low-speed windmill spars because of its flexibility and light weight.

4.3 The wooden hub used in Crete is similar in construction to a typical Indian bullock-cart hub.

4.4 The steel shaft normally used for making bullock cart axles can readily be fashioned into an excellent windmill crankshaft.

4.5 Wood may be used for the main shaft bearings and connecting rod bearing.

4.6 Ball bearings are not required for the turntable.

4.7 MS steel angle iron can be used to construct durable towers where long strong wood poles are not available.

4.8 A storage tank is important for controlled irrigation.

Note: As a result of these investigations an improved design for a windmill to be manufactured and used in rural India was developed in 1975 by the author and others with technical and financial assistance from Indian Agricultural Research Institute, New Alchemy Institute, East, and Oxford Committee for Famine Relief (OXFAM).