OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Distr.
RESTRICTED

IO/R.9
24 October 1986

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ENGLISH

CONSTRUCTION OF A SOLAR WOOD DRYING KILN

UC/MOT/86/062/11-51

MONTSERRAT

Technical report: Design of a solar kiln*

Prepared for the Government of Montserrat
by the United Nations Industrial Development Organization

Based on the work of Eugene M. Wengert
Expert in solar lumber drying

Backstopping officer: Antoine V. Bassili, Agro-Based Industries Branch

* This document has been reproduced without formal editing.

V.86 61453

ABSTRACT

A survey of the needs of furniture and allied manufacturing industries in Montserrat indicate an annual usage of approximately 50 MBF of lumber. For best manufacturing conditions and performance of the final product, the lumber should be dried to approximately 10% MC. A solar-heated lumber dryer with 1500 BF capacity has been designed and a bill of materials included.

Explanatory Notes:

The local currency is East Caribbean dollar (EC$). The rate of exchange is EC$ 2.70 = US$ 1.00. This rate does not vary.

This report is written in the British units of measurement as its intended use will be by persons familiar with those units. Lumber is measured locally by the board foot (BF) which is approximately 1-1/8 inches x 1-foot x 1-foot (or 0.09375 cu. ft./BF or 0.00265 cu.m./BF). The abbreviation MBF is 1000 BF.

The Government counterpart was Mr. Joseph Daniel, Energy Officers, Ministry of Agriculture. Currently the Minister of Agriculture is Mr. Newell Tuitt and the Permanent Secretary is Mr. Magella Cassell.

The mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization.

CONTENTS

INTRODUCTION

The objectives of the first phase of this mission were to:

1. Survey the needs of the wood manufacturing industries in Montserrat in order to establish the volume of kiln dried lumber required annually and the most convenient kiln sizes.

2. Develop the technical specifications for a solar heated lumber dry kiln.

3. Provide a list of materials and equipment necessary, using local materials when possible.

4. Select a site for the kiln.

5. Select wood species to be tested in the kiln.

6. Prepare an interim report, indicating the steps necessary to accomplish the construction and evaluation of the above kiln. Expert's full job description is given in Annex I.

I. SURVEY

Four firms were contacted. Species and volumes presently used and/or future demands are indicated (Tables 1 and 2). The smaller firms indicated that under 500 BF was the maximum extent of their dry storage facilities. Lumber lengths vary from 8-20 feet. Almost all lumber is of 4/4 size and is air-dried, seldom being much above 30% MC (oven-dry basis). Final MC's desired are 10%. Overall usage of dried wood is under 4 MBF/month.

There is no functional or operational sawmill. One mill used in the

past could produce about 4 MBF per week but there isn't logging equipment to support that level. Obviously there aren't markets of that size either. One building supply dealer handles pine and mahogany, but for building construction uses (i.e. framing) drying isn't necessary. The wood is partially dried when it arrives and continues to dry during storage.

The temperature in Montserrat averages 82°F with the maximum rarely above 90°F and lows seldom below 65°F. Solar radiation (horizontal) is 1900 Btu/sq. ft./day[1] except near or downwind of the mountains. Breezes are common throughout the day in most of the island. Latitude is 17° North.

Electrical energy is typically over US$0.20/KWH. It is 220 v. at 60 cycles. It was stated that if a kiln is run on electricity, that cost may be so high, compared to the profit margin, as to discourage its use[2] and manufacturers would use air drying instead. Imported materials available in the island generally come from Puerto Rico or Miami, not Europe. Lumber for construction and fiberglass are not locally produced.

---

[1] March, 2000 Btu/ft^2/day; June, 2200; Sept, 2000; Dec, 1600.

[2] As a point of reference, the Virginia Tech solar kiln with electrically operated fans uses 0.5 KW/MBF or about 42 KWH per run, which would be EC$21/MBF.

As a further reference, an electrically operated dehumidifier kiln would require 250-300 KWH/MBF or EC$125-150/MBF.

Table 1. Wood Used in Montserrat, as Indicated in Survey

Common name	Genus/species	SG	Drying Characteristics/Comments
		Major	
Mahogany	Swietania macrophylla	0.6	Easy to dry; rapid, few defects. Imported. Initial MC under 40%.
Red cedar	Cedrela spp.	0.4	Very easy to dry; rapid, few defects. Local. Initial MC under 60%.
Pine southern or	Pinus taeda (?)	0.5	Easy to dry; rapid, some warp. Imported. Initial MC under 30%.
		Minor	
Locust	Hymenaea courbaril (?)	0.8	Easy to dry; moderately fast, some warp or checks. Local. Initial MC under 50% (?).
White cedar	Tabebuia spp.	0.6	Very easy to dry. Imported.

Table 2. Wood used in individual furniture companies in Montserrat.

Furniture Co.	Visit	
Allen Furniture Company	Mr. Allen	<2000 BF/month - expansion possible
Forest Products	Mr. Payne	= 2000 BF/month
Quality Furniture	Mr. Felix	100 BF/month
Sweeney's Furniture	Mr. Sweeney	<500/month
Several small producers		unknown, but minimal
		4000 BF/month

II. DESIGN PARAMETERS AND SPECIFICATIONS

The major furniture species are mahogany (Swietenia macrophylla), pine (Pinus caribaea or P. taeda?), and red cedar (Cedrela spp.), which are used as the design basis for the kiln.

Species	Water content	Total MC change*	Water Evaporated
Mahogany	35 lbs/%MC/MBF	25%	875 lb/MBF
Red cedar	24 lbs/%MC/MBF	45%	1080 lb/MBF
Pine	30 lbs/%MC/MBF	20%	600 lb/MBF

---

*High estimates

In a semi-greenhouse kiln with dark walls, the evaporation rate at lower MC's is approximately 60% x horizontal solar input divided by 1000. For Montserrat, this would be approximately (0.6 x 1900 divided by 1000 =) 1.14 pounds of water per day per square foot of roof.

If a 7 day drying period is desired, the mahogany will require 110 square feet/MBF of collector area; cedar, 135 square feet; and pine 75 square feet. For design purposes, 110 square feet per MBF will be used.

Actually, with dark walls, higher efficiencies may be achieved.

Due to restricted storage areas for dry wood, due to stacking and loading ease, and due to flexibility requirements, a maximum kiln capacity is 1500 BF is suggested. The lumber stack, using 3/4-inch thick stickers, will be 4-feet wide, 20-feet long, and 3.5 feet high. The collector will be 191 sq. ft. or 21-feet long and 9.1 feet wide. Each kiln will dry 75,000 BF per year, using an average of 7-days drying time.

The furniture manufacturers in Montserrat presently require about 50 MBF/year of dried wood with an anticipated expansion to 100 MBF/year. Therefore, two small chambers of 1500 BF each are suggested for the kiln requirements.

Due to the high cost of electricity, it was suggested that the kiln be designed to run on wind power for the air circulating fans. The kilns designed here use electricity for the fans, but modification to wind power should be considered. Further, it was suggested that the two kilns be made with all imported materials, being assembled at Virginia Tech and then knocked down, shipped to Montserrat and reassembled.

The kiln design (Annex II) that has been developed consists of four insulated walls, an insulated floor, and a sloped (17°) roof covered with two layers of plastic or fiberglass. (Plastic life is over 5 years; fiberglass, over 20 years.) The interior walls are painted with aluminum paint to avoid moisture regain. Fans circulate hot air through the lumber pile. The expected dryer life is at least 10-years, the weak point being the fan motors which have limited life due to temperatures and humidities in the kiln.

Air-dried lumber doesn't require stress relief or exceptional fan speeds; these facts were used in developing the design.

III. CONSTRUCTION/OPERATION DETAILS

The Government of Montserrat will prepare a flat site for the kilns with appropriate security at the site to prevent any damage during construction. A site near the old hot mix plant has been tentatively chosen, being satisfactory in all respects. The Government will provide electricity (220 v. @ 15 amp) to the edge of the kiln where the time clocks are. Thirty-two blocks (concrete) about 8" x 8" x 16" will also be provided. The Government will expedite the movement of the equipment through customs and will move the material to the solar site promptly. They will notify me when all is ready. They will provide daily transportation for the expert. They will assist in locating local materials, as needed. They will arrange for a furniture manufacturer to bring a test load of wood (mahogany) to the kiln.

The Government will arrange for interested manufacturers to attend a meeting (given by the UNIDO expert) after construction is completed to learn how to operate the kiln.

For security and ease of handling, it is suggested that all the materials (Annex III) be assembled at Virginia Tech and shipped in a dedicated container which would serve as the site storage building for two weeks. Further, when the container arrived, all materials would be there. Local transport would be easy.

Construction time preferred due to weather (rainy season) would be after January 30.

ANNEX I

UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

11 April 1986

Project of the Government of Montserrat

Construction of a Solar Wood Drying Kiln

JOB DESCRIPTION

UC/MOT/86/062/11-51

Post title Consultant in Solar Drying of Timber and Construction of Solar Drying Kilns

Duration 2.5 m/m

Date required As soon as possible

Duty station Plymouth

Purpose of project To determine the economic and technical parameters of timber drying in Montserrat, using the greenhouse type solar kiln.

Duties During the two phases of his split mission the consultant will be attached to the counterpart in Plymouth and work in close cooperation with the counterpart staff. During each phase the consultant will be expected to:

A. Phase I - Exploratory Mission

1. Survey of the needs of wood using industries for kiln dried woods and local conditions (weather, etc.).

2. Finalize, based on the above, the technical specifications of the solar wood drying kiln to be developed and designed. (e.g. type, size, design details, etc.).

3. Draw-up the list of equipment and materials to be provided by the project, clearly showing items which could be purchased locallyand those which need to be imported. Price estimates and potential suppliers should also be indicated.

4. Select the wood species that will be test-dried in the solar kiln. Drying schedules will also be prepared for each group of wood species.

5. Select a suitable site for the solar kiln to be installed.

6. Prepare an interim technical report setting out the findings of his preparatory mission and his recommendations to the Government on the tasks to be completed by the counterpart agency and to the UNIDO on what equipment must be purchased prior to his return mission.

..../..

B. Phase II - Return Mission

1. Assist in and supervise the erection and glazing of the kiln structure according to the supplier's drawings, specifications and building instructions using the equipment, components and materials supplied.

2. Supervise the assembly and mounting of fans, motors and switch gear supplied.

3. Supervise the connection of all electricial wiring to mains with the cables and electricity supplied.

4. Provide one copy of "as-built" drawings (for reproduction) showing actual location of all equipment as well as exact routing of electrical wiring and any modifications made to the manufacturer's proposal to insure better performance.

5. Test the erected kiln according to the manufacturers recommended procedures.

6. Train counterpart personnel in the above duties and in the operation and maintenance of the kiln.

7. Prepare a terminal technical report setting out the findings of his return mission, including detailed information on the actual design of the kiln, its operation procedures, cost, etc. and his recommendations to the Government.

Qualifications: University or equivalent education in wood technology with specialization in wood drying. Extensive experience in solar wood drying and design, construction and operation of solar kilns preferably in developing countries essential.

Language: English

Background information:

The Government of Montserrat intends to set up an appropriate and efficient wood drying kiln to meet the needs of furniture makers and other users of wood in the building and related industries.

Currently, the consumption of wood by the major furniture makers is estimated at about 17.5 m^3 per week, but this will tend to increase as builders and homeowners demand that doors, mouldings, strips and other finished items of wood material be kiln dried. In fact the initial demand for a kiln has arisen from:

(i) the increasing requests being made for furniture and other wooden items to be constructed of adequately seasoned wood, and

(ii) the growing awareness among furniture makers that there are relatively significant quantities of local timber that can be utilized more quickly and efficiently if a proper kiln was available for seasong it. These local timbers include mahogany, red cedar, white cedar, the several varities of sweet wood and locust.

Annual timber imports presently total some 7,000 cubic metres (value $ 1,200,000).

The Government is encountering the development of further wood processing for which an improvement of product design, productivity, management and production technology is required.

Furniture, joinery products and components for prefabricated houses required wood to be dried to various moisture contents to ensure dimensional stability of the finished product and for glueing and finishing. Small woodworking enterprises however, cannot afford conventional wood dryers, neither the long immobilization of working capital under the form of wood stocks during the slow process of air drying.

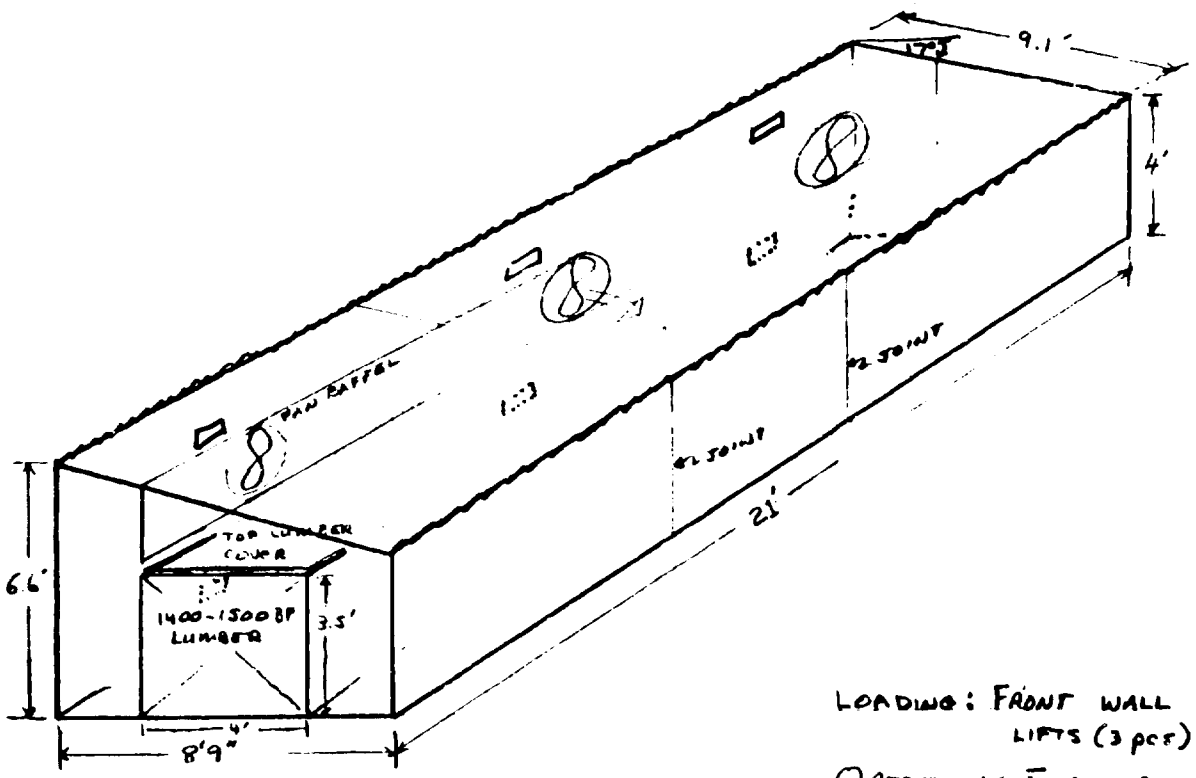
The building of a prototype solar kiln for timber will enable cost/benefit estimates to be made to help meet the wood drying problems in small workshops. The object of the project is, starting from this design and the results achieved in its operation, to popularize the solar timber drying using a low cost kiln that could, to a certain extent, be produced locally.

Solar Heated Wood Drying Kiln for Montserrat

ROOF : CLEAR (1 layer corrugated fiberglass; 1 inner layer plastic)

WALLS : OPAQUE (2x4 wood frame; insulated; plywood both sides, outside stained dark; inside painted aluminum and then black)

FLOOR : OPAQUE (As with walls, except 2x6)



LOADING : FRONT WALL LOWERS (3 pcs.) AND ROOF LIFTS (3 pcs) AND IS PROPPED UP.

OPERATION : FANS OPERATE IN DAYTIME (CLOCK CONTROLLED)

1500 cf/min

LIST OF EQUIPMENT AND SUPPLIES

Bill of Materials and Supplies/

2" x 4" x 8' treated studs[1]*	206 pcs	US$ 410
2" x 4" x 10' treated studs[1]	40 pcs	107
2" x 6" x 8'treated studs[1]	62 pcs	185
1/2" x 4' x 8' treated plywood[1]	82 pcs	980
3" x 16" insulation (680')[1]	15 rolls	144
2' x 10' fiberglass, corrugated[3]	22 pcs	242
4' film (100')[4]	1 roll	416
20" fans[3]	7	791
clock[2]	2	81
lath, 10'[3]	8	12
flashing, 2"[3]	104'	50
paint[3]	6 gal	150
stain[3]	4 gal	80
hardware, misc (locks, bolts, screws, nails, wire)[3]		260
tie-down cables[3]		30
local stickers[5], (3/4" x 1 3/8" x 4') -	1760 lineal feet	220
	440 pcs	($2100@)
auxiliary equipment (328 + 786 + misc)[6,7]	(see note)	1200
caulk[3]		60
tools[3,8] (see note)		1000

corrugated mounting brackets[3]	24 pcs	72
literature[9]		60
shipping (B'bg, VA - Montserrat)		1500 (?)
		$8000

Suppliers

1. McClung's Building (Blacksburg)
2. W. W. Granger, Inc. (Chicago)
3. Reed Lumber (Christiansburg)
4. Norton Chemplast (New Jersey)
5. Allen Furniture (Montserrat)
6. VWR Scientific (Baltimore)
7. Delmhorst Instrument Co. (New Jersey)
8. Sears (Roanoke, VA)
9. Virginia Tech (Blacksburg, VA)

Auxiliary equipment:

Moisture meter (2), Delmhorst Model J @ $160.

Thermometer, stem (5)	@ 4.58	VWR Scientific	#61016-150
Sheath (4)	@ 8.81	VWR Scientific	#61017-561
Disk thermometer (5)	@ 18.33	VWR Scientific	#61159-227
Digital thermometer (1)	@119.99	VWR Scientific	#61220-157
Psychrometer (2)	@ 31.37	VWR Scientific	#35545-008
Velometer (1)	@ 93.06	VWR Scientific	#10656-257
Recorder (1)	@366.60	VWR Scientific	#35580-031

Tools include:

Hammer, skil saw, blades, paint brushes, paint solvent, hand saw, 100' extension cord, electric drill, drill bits, stapler, staples, measuring tape, pencils, square, wrenches, socket set, screw drivers, vice grip, wire stripper.

Local Building Materials

Pine lumber EC$2.03/BF (compared to U. S. treated 2 x4 at EC$1/BF)

Mahogany lumber EC$5.80/BF

Galv. sheets EC$1.50/BF (compared to U. S. plywood at EC$1.00/BF)