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As presented

ENERGY AND POST-PRODUCTION SYSTEMS

THE IDRC PROGRAM

Presented at the Seminar on Energy
Conservation in Food Processing Industries
Ottawa 26 May 1982 by W. Edwardson

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I. Introduction

Post-Production Systems or PPS refers to the stages through which a food commodity passes from the time and place of harvest, or in the case of fish, from the landing site, to the consumer. This includes field activities such as threshing and drying, storage, processing such as milling and drying, marketing, cooking, and consumption. IDRC, from its beginning, has responded to the need of developing countries to increase the availability of foodstuffs, not only by supporting research and development in production agriculture and fisheries, but also in the post-production sector. Thus gains achieved by increasing productivity through, for example, improved plant varieties, farming systems, animal husbandry, and aquacultural practices, should not be diminished through inadequate post-production systems.

For many commodities in developing countries, post-harvest losses have been estimated to run as high as 30 per cent. This means that an increase of about 43 per cent in production/yield would be required just to make up this loss. This seems to be an unrealistic goal for most developing countries. However, improvement of post-production practices to reduce the losses due to spoilage and wastage, will ensure that some of the achievements in production research will result in more food for consumption. Even with the reduction of post-harvest losses to 15 per cent or 10 per cent, an increase in production yield of 18 per cent or 11 per cent respectively would be required before any real gains in food availability could be realized. These targets are however perhaps more achievable.

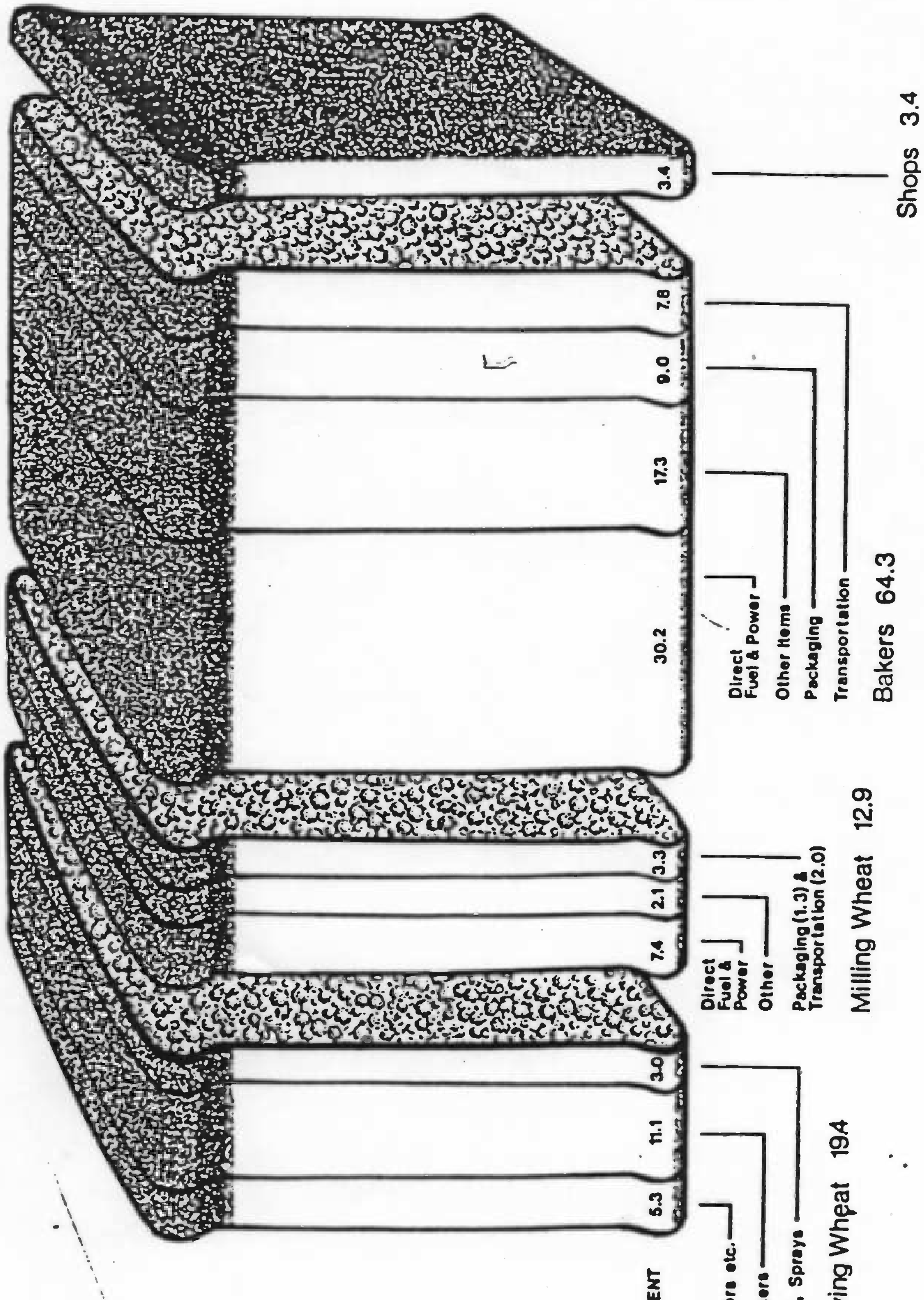
In both production and post-production, the development of new or improved technologies, necessarily implies inputs of energy, be they directly as fuels or indirectly as in the supply of fertilizer, machinery, transport, etc. The problem is to define wise investment of energy resources which are generally limited in supply and expensive in production and post-production technologies, to ensure real and affordable gains in food availability.

It has generally been found that greater amounts of energy are expended in post-production activities than in production. (See "Bread Diagram, Fig. 1 and Pimental data for developing countries, Table One, pp. 3 and 4) Efforts must be made to ensure maximum productivity per unit of energy expended in the PPS, or a reduction in energy input for PPS activities.

II. Energy in the PPS Program

While we must bear this in mind, the realities of the activities supported in the PPS program, are that researchers aim to reduce losses through the development of technology (hardware and software) which ultimately has to be technically feasible, economically viable, and socially acceptable for the particular situation being considered. Therefore, while the energy factor is important, + often options are available it is usually handled as one of a range of components in the research, and generally as an economic input.

Additionally, the scientists to whom we respond are rarely energy specialists, being generally agricultural and mechanical engineers, food scientists and technologists, nutritionists, and economists. While they may appreciate the energy component of the post-production activity, their interests are normally in their familiar discipline activities.



1 Kg. WHITE LOAF · ENERGY REQUIRED: 20.7 MJ = 0.48 Kg. Oil Equivalent

Fig. 1 "Bread Diagram"

TABLE ONE

ANNUAL ENERGY USE IN FOOD SYSTEMS

	Rural populations in developing countries*	UK (1968)+
Production	31.0%	22.3%
Processing/Storage/ Transport	5.5%	48.0%
Preparation	63.5%	29.7%
Total estimated per capita (GJ)	8.4	33.6
Per cent total energy in food system	60-80%	~16.0%

* Adapted from Pimental and Pimental (1979)

+ Adapted from Leach (1975)

III. PPS Projects with Energy Component

Some 25 projects (listed in the Appendix) have been supported in which energy has been a component of the study. The energy component has been handled in a variety of ways, some of which are described in this section. Most activity is being carried on in drying

Public

1. Fish Drying Projects

Fish drying projects aim to develop economically, socially, and technically appropriate dryers to enable fisherfolk to dry a portion of their catch in peak seasons, thereby preventing waste and allowing the fish to be transported to markets in areas away from the landing sites, thus stabilizing and enhancing their income.

For example, in Mali, researchers concluded from extensive talks with fisherfolk, co-operatives, and marketing people that three different dryers were needed. Some of the fisherfolk follow the flood waters of the Niger River and need a small (20 kg) portable dryer; the farmers/fisherfolk who live in permanent villages need a dryer of the same capacity but one that is permanent; while the co-operatives need a larger (500 kg) unit. While the small dryers must rely entirely on solar energy, in the large unit this could be supplemented by electrical energy, if economically appropriate. Research is continuing on the development and testing of these dryers.

An interesting example of the iterative approach often found in projects is the development of the Philippine fish dryer, where the energy component was a major factor studied. Firstly, the young engineers looked at small prototypes using electricity and then kerosene as fuels and found that the drying costs were unacceptably high, due to the cost of energy sources (over 60 per cent in both cases)--see Table Two, p. 6. They moved on to quite a different design, using a furnace burning an agricultural waste--rice husk obtained free from local rice mills--incurring only transportation charges. The hot flue gases passed through heat exchanger tubes, heating the

TABLE TWO

ALTERNATIVE DRYERS/FUELS FOR FISH DRYERS*

	Dryer Type: Horizontal airflow		Dryer Type: Vertical airflow	
	Electrically heated Nichrome wire (4.5 kw) Centrifugal fan	Kerosene burner 1.1 ℓ/h Axial fan run off diesel engine	Ricehull furnace (10-20 kg/h) Heat Exchanger: Free convection	Ricehull furnace (10-20 kg/h) Heat Exchanger: Axial fan run off diesel engine
Capacity				
Wet fish/batch	117 kg	140 kg	140 kg	1,000 kg
Dried fish yield	39 kg	47 kg	47 kg	330 kg
Costs/kg dried fish (pesos)				
Fixed--(depreciation, interest, taxes, insurance, repairs, maintenance)	0.1	0.07	0.05	0.13
Variable--fuels	0.86	0.42	0.02	rice hull 0.01 gasoline/oil 0.13
labour	0.26	0.21	0.21	0.36
Total drying costs/kg dried fish	1.22	0.70	0.28	0.63
Total drying costs/d (1 batch/d)	47.7	33.1	13.6	207.7
Drying time/batch	15 h	15 h	15 h	8 h

*Source: IDRC supported project (Philippines) 3P80-0137 air which by convection then flowed vertically up through the drying chamber. Drying costs fell markedly with the low fuel costs, but technically the design proved to be inadequate causing uneven and slower drying. A diesel-powered fan was added to increase the air-flow rate and enable control of air velocity and air temperature. This resulted in a technically and economically feasible dryer.

The dryer was scaled up to 1 t capacity to fit the needs of the local fish processors and was still found to be economically attractive. When the dryer was tested in a fish processor's yard attached to his home, the noise of the diesel motor used to run the fan was found to be objectionable during the night, and it was replaced by a small electric motor. Thus, the social acceptability factor has also affected the energy selection. Electricity is available in the fishing village and costs less to use than diesel.

The dryer is now being tested with processors during the fishing season, but although it appears to be ideally suited, the fish processors still do not accept the change very well and only see the dryer at this time as a security measure for rainy days and for when they have glut conditions and need to dry during the night to clear their batch. So energy is only one component and other factors appear more crucial.

2. <u>Rice Drying Projects</u>

A similar situation appears to be delaying the uptake or use of dryers by rice farmers for drying their second or wet-season harvest. In a project in Indonesia, existing flat-bed dryers which were economically unsuitable for use by farmer co-operatives, were modified to be more energy-efficient and economical to use (kerosene fired); in Thailand, a rice-hull fueled flat-bed dryer for rice has been designed and tested with satisfactory results; also in Thailand at the Asian Institute of Technology (AIT), a simple, cheap solar rice dryer, made of bamboo and plastic sheeting, using burnt rice husks as the collector, which can be easily constructed by a farmer for $175 (for 1 tonne capacity) has proven effective for rice drying. All of these are technically viable, but their use means capital operating costs in some cases, or drying fees, never before faced by the farmer. He is perhaps wary of investment too since his wet harvest may mean only needing the dryer for around two weeks per season. A mechanism has to be found, so that the faster drying and security of obtaining good quality rice is seen as worthwhile. Perhaps this awaits effective grading systems where millers and brokers will pay premium for good quality, well-dried grain. When this come about, the energy and other costs of drying should influence the acceptable price levels.

3. Solar Drying Projects

A high proportion of the projects is on the use of solar energy in the development of technologies to dry and hence preserve food crops such as cereals, grain legumes, vegetables, and fish. The criteria for an acceptable solar dryer are similar in most countries, namely: efficiency, low-cost and easy construction and maintenance, the dried product must be of acceptable quality. Generally, indirect heat has been found to be more effective, because it provides for greater control of drying conditions and product quality.

The AIT dryer mentioned in (2) is also being tested in Zambia for vegetables, and will soon be evaluated for drying fish in Mexico. Small direct solar cabinets have been used for vegetables in Kenya and Bangladesh. This represents a low-cost technology for preservation of small quantities of produce, but at larger, more commercial scale, the need for bigger surface area collectors and more sturdy structural support, increases capital costs, and economic viability becomes difficult. Projects in Niger on onions, and Egypt on vegetables are faced with this problem. The AIT concept shows promise in overcoming these problems with a modular design and cheap and disposable materials.

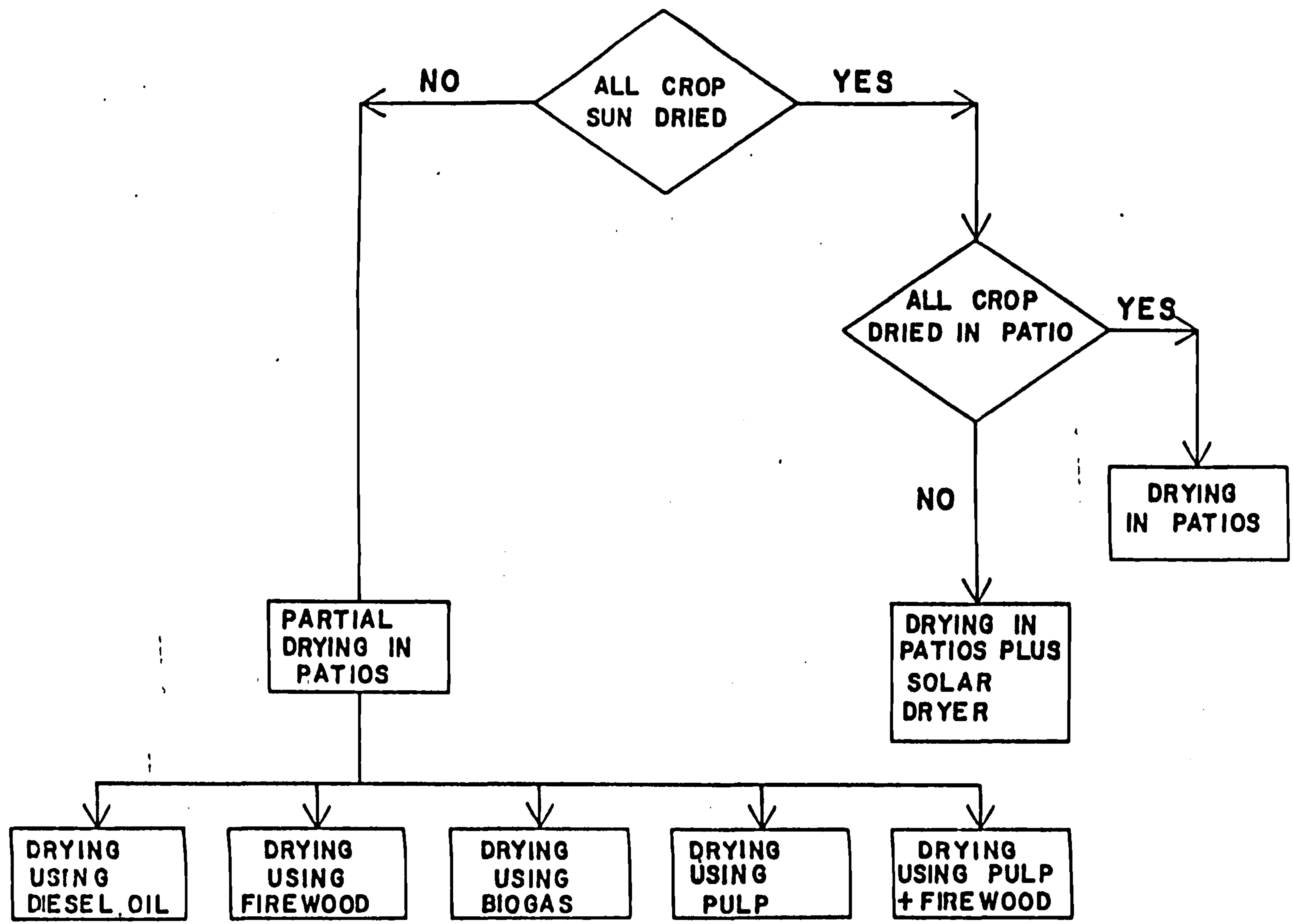
4. Coffee-drying projects

One project which has focused particularly on choosing the most economic fuel sources from a range of agricultural resources has been in Guatemala, where the improvement of the coffee-drying operation in a poor farmers' co-operative or beneficio in the highlands is being studied. There is little flat land to extend the concrete drying floor, or patio, and little operating cash available to run a conventional dryer. Thus, only partial drying of the bean after removal from the berry has been possible. Here complete drying is seen as beneficial to the co-operative since currently, the co-operative must sell the partially dried coffe beans at a low price to another agency which finishes the drying and receives a better price.

The Guatemala researchers have designed, constructed and are testing a concrete bed dryer, heated by hot air from a furnace/heat exchanger unit which can burn a variety of agricultural waste materials. Figures 2 (pp. 10 and 11) indicate alternatives evaluated and/Figure 3 the comparative costs for drying a proportion of the coffee handled by the beneficio at peak times. All the fuels had been tested for technical feasibility. The burning of partially dried coffee pulp was found to be most attractive, having the added side benefit of reducing the serious pollution problem caused by its disposal. This is now being tested fully over a season, to determine actual economic viability. The social aspects are being examined in terms of designing acceptable management of the pulp, its drying and storage.

5. Process Improvement Projects

IDRC is also supporting research to develop methodologies to work in small food factories, to ensure their viability as suppliers of low-cost traditional foods and as a source of employment and income. The aim is to improve their processing operations by increasing yields, reducing wastage, and where

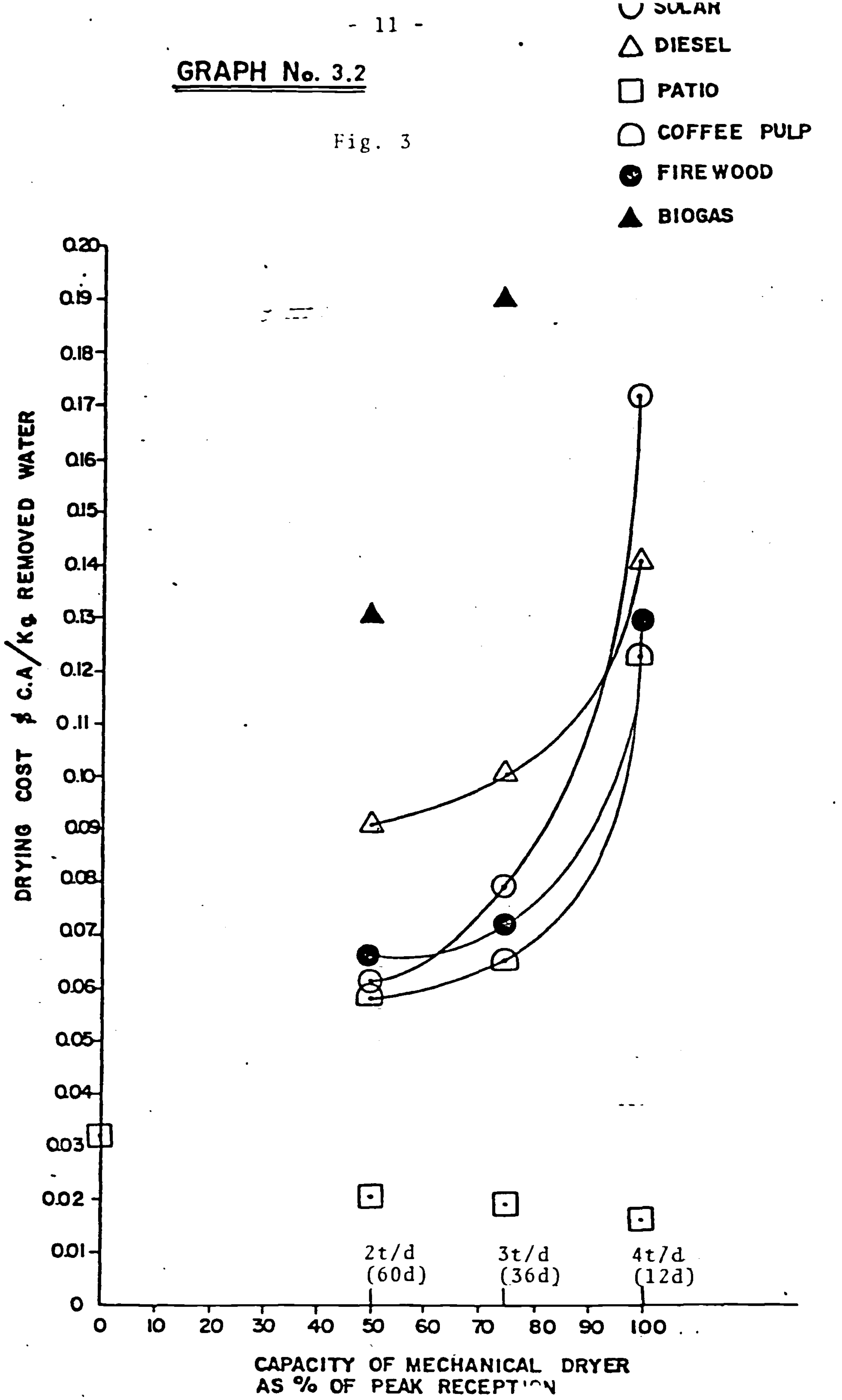


GRAPH No. 3.1

Fig.2 DIFFERENT ALTERNATIVES FOR DRYING COFFEE BEANS

GRAPH No. 3.2

Fig. 3



possible, energy and other operating costs, in a way that is socially and economically acceptable to the owners/managers.

The process improvement project in Singapore has designed and contructed a solar collector which is designed to provide hot air at $\sim 50^{o}$C, on the roof of a noodle plant, there [illegible] reducing the costs of running the plant's large electrically heated, drying chamber. Savings are estimated at approximately $8,000/year which is being borne out by comparing actual electricity bills being received since the solar collector has been installed with those received prior to its installation. Yet, in another noodle plant, electrically heated drying cabinets were designed and installed to meet the particular space and drying time restrictions of the factory which had previously relied on sun-drying and some poorly designed airing cabinets with very slow drying.

In a process improvement project in Thailand, initial research to increase the yield of starch in a mungbean noodle factory indicates that it may involve higher energy costs. The question then will be whether the higher returns would justify this improvement.

6. Rural energy utilization and needs

Recently researchers in Egypt were supported to carry out an extensive survey in two villages to determine the present rural energy utilization and needs, including potential alternative energy sources, e.g.,biomass fermentation, solar, water, and wind. The survey has been completed and the data is currently being analysed and will be published in the near future. In the survey, it became apparent that the small farmer has choices to make in the use of agricultural wastes, a widely used fuel source. For example, whether to use his sorghum straw as fuel to dry his crops, with attendant financial gain due to crop quality and reduced loss, although part of this gain would be offset by having to purchase cattlefeed; or, to take his chances with traditional sun-drying of his crop, and use the sorghum straw for cattlefeed; or, to use his sorghum straw in the production of biogas which will provide him with light and oooking fuel, while the residue can be used as fertilizer? This type of survey provides an excellent base for research planning, indicating opportunities for making more efficient use of available resources, or identifying energy resource constraints to improved PPS activities.

IV. Energy Issues in PPS Program Development

1. Researchers in IDRC-supported projects are not always looking at the least energy-intensive solution to a problem, but consider what resources are available for the technology to operate at an economic cost and with which the farmer/processor/fisherman is happy to work.

2. It has been suggested that development and introduction of farm equipment with its inherent energy requirements might prove a more productive use of limited energy resources in rural areas. To date, PPS program has had limited involvement on farm equipment. Should this be expanded?

3. In food drying, indirect heating, with its lower energy efficiency is generally considered in dryer design for control of product quality. Currently, there appears to be a plethora of dryer prototypes with a variety of energy sources around the research world. Would it be useful to attempt to make an inventory of these, critically examine the principles being applied, and classify the dryers according to energy source, energy efficiency, cost, and use for particular products, for example? Currently in PPS we are encouraging researchers to start their drying studies with either the AIT simple solar dryer, or with the Philippine agricultural waste-fueled cabinet or concrete bed dryer, depending on their problem area. Is this a useful or restrictive approach?

4. The problem of social acceptance of any change or development over traditional practice remains. Despite the considerable efforts in food drying research, neither mechanical nor solar dryers have

made any great inroads into the rural areas of the developing countries. Are there any ideas from developed country studies - is the chance to reduce costs always able to promote change? The PPS group plans to encourage support for extension and implementation activities to attempt to overcome this apparent bottleneck.

5. Rather than adapting energy resources to a particular end-use, e.g., drying or milling, as in the present program approach, should the PPS program consider supporting some basic research on energy production per se, which could have potential use for PPS activities in rural areas? For example, the utility of small-scale hydro or waterpower systems; biogas production and distribution; vegetable oils as fuels or additives; or, should some other agencies be asked to support work in this area.

6. Would energy-auditing methodology, currently used in processing industries in developed countries, be applicable and useful in small industries in developing countries - such as mills, oil extraction plants and bakeries? Should the more macro-level village energy survey, as was done in Egypt, be encouraged elsewhere, to pin-point resource problems and constraints?

7. The major energy consuming activity in PPS - cooking - has not been part of the program, to date, being addressed as wood fuel utilization activities in our Forestry program. There is a need to work more on consumer needs and acceptability in this field.

8. Many of the developing country researchers in PPS activities are often remote in location, in thinking, or experience from the real problem situations which need to be resolved. Even if a group with a range of disciplines is involved, which we continue to encourage, this human resource is perhaps the major factor in the development of appropriate improved post-production systems, regardless of the degree to which energy components are being considered.

Need for ~~policy~~ activities to guide researchers + policy makers — not necessarily following dev'd country [illegible] patterns.

LIST OF PPS PROJECTS WITH ENERGY COMPONENT

ASIA

BANGLADESH	
- Legume Processing 80-0062	Improve cooking quality (reduce cooking time - save energy) of legumes with dehulling operation also using minimum amount of fuel)
- Legume PHT 80-0127	Development of a solar dryer for on-farm use
- Solar Crop Dryers 81-0128	Testing and modifying two existing solar dryers for paddy, fruits and vegetables, at village scale
INDIA	
- PHT 73-0148	Includes research on energy-efficient drying of cereals and legumes at five different regional centres in India
INDONESIA	
- PH Rice Technology 78-0115	Rice dryers being optimised for maximum fuel efficiency (kerosene)
- Fish Processing 79-0111	Fish drying by burning agro-waste such as rice husks as heat source in mechanical dryer
MALAYSIA	
- Fish Processing 80-0055	Fish drying in 24 hr combination dryer using solar radiation during daytime and burning agro-wastes at night
- Wet Padi Handling 74-0121	Includes a component on the flash-drying of padi by solar heat and/or by burning straw or other agricultural wastes
PHILIPPINES	
- NFA II 78-0114	Using fans to recycle heated air to reduce energy demand in drying of rice in bulk storage
- Fish Processing III 80-0137	Development of a medium-scale tray dryer using rice husks as fuel source
SINGAPORE	
- Process Improvement	Development of operations research methodology for small food industries including optimisation of energy use

ASIA - cont.

THAILAND

- Solar Rice Drying 80-0060	Development of a medium-scale tray dryer for on-farm use, using no supplementary heat, effective for rice and other crops
- PH Rice Technology 74-0120	Developed a dryer using waste rice husks as fuel source for drying of paddy
- Groundnut Dryers 81-0129	Drying of groundnuts using solar heat supplemented as required by other fuel sources
- Passive Cooling 81-0060	Cold storage of fruits and vegetables without mechanical refrigeration
- Process Improvement 81-0061	Development of methodology for process improvement research in small food industries in the Bangkok area

EAST AFRICA

ZAMBIA

- Vegetable Dehydration 80-0064	Use of solar dryers to dry vegetables

LATIN AMERICA

GUATEMALA

- Crop Drying 81-0059 II	Drying of coffee and other crops using existing dryers modified to use formerly waste materials such as coffee pulp instead of wood or fossil fuels

PERU

- Potato Dehydration 79-0124	Use of solar radiation and agro-waste fuels to produce dehydrated potatoes (Papa seca)
- Fish Processing 80-0066	Testing of solar and agro-waste heat sources for fish drying

MIDDLE EAST

Egypt

- Solar Dehydration II 80-0126	Solar drying of vegetables and grains
- Rural Energy Survey	Survey of energy use and resources of two villages in Upper Egypt

WEST AFRICA

MALI	
- Fish Processing 79-0110	Fish drying in solar dryers
NIGER	
- Onion Drying 78-0051	Development of solar dryer for onions and tomatoes
SIERRA LEONE	
- Solar Crop Drying 78-0113	Development of solar dryer for rice and other crops

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Edmonton
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