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Africa Energy Survey Methodology

Submitted to:

Offices of Development Resources

Bureau of Africa

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PREFACE

Donovan, Hamester and Rattien, Inc. has prepared the Africa Energy Survey Methodology for the Office of Development Resources, Bureau for Africa, Agency for International Development. It is designed to assist planners in undertaking energy assessments in sub-Saharan African states. Work has been executed under Indefinite Quantities Contract AID/SOD/PDC-C-0147, Work Order Number 7, with contributions from work performed under Work Orders 1 and 3.

Overall project supervision has been shared among Messrs. Thomas Graham and Robert Gordon, with staff assistance from Mr. David Delasanta and Ms. Chantel Reliquet. Many issues were deliberated in a series of task force meetings in which the DHR staff was joined by a number of consultants and special invitees. A number of consulting anthropologists concentrated on project level surveys, including Drs. Asmarom Legesse, Peter B. Hammond and Theresa A. Ware. Dr. Ernest L. Murphy, consulting economist assisted in benefit-cost analysis. We are also grateful for participation from other members of the professional community, including Mr. Lawrence Ervin, of al Dir'Iyyah Institute, Mr. Paul Jankura of the Overseas Development Council and the Peace Corps; Dr. James Keyser of Brookhaven National Laboratory Mr. Michael Zewolde and Dr. Eric Melby of A.I.D. Dr. David French of the Bureau of Africa has been our technical and program officer.

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Section I - Introduction

The purpose of the Africa Energy Survey Methodology is to assist planners to assess energy resources, uses and suitable conversion technologies. The methodology is flexible to accomodate a number of different operational objectives based on the specific needs of the country. These can range from macro-economic forecasting of future energy demands and available supplies to selection of a particular energy consuming device for a specified development project.

The methodology is organized in such a way so as to provide guidance to the planner on shaping the assessment to fit national planning objectives. The critical issues that are addressed include:

- For what purposes is it necessary to collect and analyze energy-related data.

  A number of policy and research objectives are listed in Section II - Objectives. These cover three major energy planning considerations:

  - national energy accounts and environmental relationships
  - allocation and use of capital, manpower and energy resources
  - project analysis and choice of technique

- What specific data are required.

  Once particular objectives have been chosen, then the planner can determine what information needs to be collected. A wide range of possible data is outlined in Section III - Data Base Summary, grouped by category and aligned to an

appropriate "class", contributing to research objectives. Detailed questions are listed in Appendix II - Data Base.

- How to collect chosen data.

  The planner needs to consider what specific decisions have to be made on final survey research design to collect data. Locally available technical and social science research expertise can be used to assist in final selection of methods. However, it is recommended that the planner become familiar with crucial elements that constitute proper research design. For that purpose, the planner can consult Section IV - Ways to Collect Data.

- Ways to use data.

  There are several analytical processes that can be applied to the data gathered. Section V - Ways to Use Data illustrates four such methods without attempting to be fully comprehensive.

  For overall country future energy resource requirements, two methods will be explained.

  - Reference Energy System, which organizes in a matrix form aggregated data by energy source, process and end use.
  - Linear projection, which forecasts future demand.

  For the objective of choosing candidate energy conversion technologies for specific development program, two analytical methods are offered:

- Socio-cultural feasibility - a qualitative assessment of local conditions that have an impact on techniques under consideration.
- Benefit-cost analysis - a quantitative measurement of financial and economic feasibility of each technique.

In order to demonstrate how the latter two analyses can be applied to a specific situation, a case study is attached as Appendix I. An example is given of a maritime artisinal fishing village in Senegal. Out of four project opportunities identified, one--fish drying--is chosen. A number of suitable technologies are then subjected to both analyses. Conclusions are then made to determine what techniques should be field tested.

Section II - Objectives

The planner recognizes that energy availability is a major determinant for both economic growth and equitable distribution of benefits of that growth. A major problem is constantly posed how existing energy sources can be used most efficiently and how alternative new sources can be exploited. In Africa, increasing energy demands occur for domestic activities such as cooking, heating, drawing water and grinding grain. Income producing and subsistance agriculture require in some cases powered irrigation, plowing and threshing. Manufacturing and industrial activities consume energy as well as transport, processing and marketing functions that support these activities.

In order to resolve the problems of increasing scarcity of existing energy resources noted above, additional data may be required for purposes of policy formulation, planning and program design. The planner then needs to decide what final aggregated information is necessary; hence, may wish to consult the list below of "policy objectives."

Policy Objectives

1. Sources

   - Assess import requirements of fuels, including import restrictions, balance of payment problems and problems of energy dependency of the country.
   - Choose new energy sources for development on economic and social considerations.
   - Types of incentives to be offered for resource development.

2. Uses

- Forecast future demands for various forms of energy.
- Develop energy pricing policies.

3. Action

- Develop and plan growth in the energy sector within the context of requirements for overall social and economic development.
- Examine the feasibility and value of developing industries for the manufacture of energy and energy related equipment.
- Investigation of specific energy development schemes and estimation of costs involved and arrangement for financing the projects.

A sound energy policy and program plan reflecting any one or a number of the above policy objectives requires in many instances a coordinated series of data collection and analyses activities. These assessments will determine the energy implications of development needs as perceived by the people being surveyed. In addition, appropriate fuels and conversion devices needed to meet those needs should be evaluated in an objective manner.

The planner then needs to formulate a specific set of survey or research objectives. With reference to the list below, the planner then can subsequently design the data base, along with methods to collect and analyze data collected. Each survey or research objective implies a differing mix of methods.

Survey/Research Objectives

1. Needs Assessment

   - Identify present energy problems, areas and needs as perceived by rural and urban inhabitants and economic enterprises.

2. Resources

   - Identify present and future energy resources in terms of ownership, quantity and type, availability, location and distribution and trends.
   - Identify environmental deterioriation due to energy supply patterns by source, degree and costs.

3. Uses

   - Identify characteristics that affect energy end-use consumption patterns, by income and social groups, geographic location, rural and urban populations, weather patterns and by labor.
   - Identify trends in energy consumtion patterns, costs/benefits pricing, energy intensity for particular end-use functions and energy-economy relationships.

4. Processes

   - Catalogue and evaluate current in-country energy consuming technologies in terms of efficiencies, labor intensities and costs.
   - Identify possibilities of new combinations in the mechanical/human/animal labor energy mix.
   - Identify possibilities of substituting new energy technologies or resources for traditional ones.

- Identify possibilities for energy research and development funding.
- Determine feasibility of extension of existing energy systems to new geographic locations or to income groups.

Section III - Data Base Summary

In this section essential data requirements are listed according to category and class. One or a number of classes will serve in processed form to meet the research objectives listed in Section II - Objectives. In addition, additional data requirements are offered on an optional basis for specific country conditions, if applicable.

For detailed q ..tions applicable to each "Data Category" the reader is advised to consult Appendix II - Data Base.

CLASS	DATA CATEGORY	ESSENTIAL DATA REQUIRED	ADDITIONAL OPTIONAL DATA REQUIRED
1. To measure household and demographic, economic, climatic and political indicators.	1. Population	1. Number of people in household 2. Age distribution 3. Religious affiliation 4. Family form and relationships 5. Sex distribution 6. Ethnic group 7. Number of households in village 8. Age distribution 9. Ethnic groups	
	2. Income, wealth and economic activities	1. Income generating activities 2. Total income 3. Livestock owned 4. Land owned 5. Houses owned 6. Location and operation of village market place 7. Allocation of grazing land 8. Ownership and availability of resources (i.e., water, food, land) 9. Barter	a) past livestock trends b) community allocation and ownership of resources (i.e., food, water, land) c) constraints to economic and income growth of the community d) importance of the barter systems in energy resource trade. e) historical trends in village land size, wealth, economic and industrial growth and population.
	3. Employment and Education	1. Occupations 2. Length of employment 3. Education 4. Literacy	
	4. Geographic, climatic and political	1. Area owned/possessed by village 2. Type of cooperative organizations 3. Agricultural period (i.e., planting, harvesting, etc.) 4. Local climatic conditions	

Table 1 - Class, data categories, essential and optional data required

CLASS	DATA CATEGORY	ESSENTIAL DATA REQUIRED	ADDITIONAL OPTIONAL DATA REQUIRED
2. To identify and quantify household energy consumption patterns (rural and urban)	1. Cooking and heating water	1. Types of cooking utensils/vessels 2. Fuels used in cooking and heating water 3. Amount of fuel used in cooking and heating water 4. Type of cooking facilities 5. Time spent in cooking 6. Kind and amount of food cooked 7. Cooking methods 8. Fuel costs 9. Method of obtaining fuel 10. Amount of water heated.	For each data category in this class, past uses of energy in the household: a) type of technology used b) why technologies were discarded c) changes in the type of food consumed and in cooking methods
	2. Lighting	1. Type of lighting fixture 2. Kind and amount of fuel used 3. Method of obtaining fuel 4. Fuel costs 5. Time period in which lighting is used.	
	3. Heating and cooling	1. When and for how many hours is heating/cooling needed 2. Type of heating/cooling facility 3. Type of fuel used 4. Method of obtaining fuel 5. Fuel costs	
	4. Water Lifting and Transportation	1. Where is water obtained 2. Types of devices used in obtaining and transporting water 3. Fuel costs for water 4. Fuel used in water lifting and transportation 5. Time spent in water lifting and transportation 6. Where is fuel obtained 7. Amount of water needed	

Table 1 continued

CLASS	DATA CATEGORY	ESSENTIAL DATA REQUIRED	ADDITIONAL OPTIONAL DATA REQUIRED
	5. Food Grinding (non-commercial)	1. Types of foods that are ground 2. Devices used in grinding 3. Amounts and types of fuels used in grinding 4. Fuel costs 5. Method of obtaining fuel 6. Time spent in grinding	
	6. Miscellaneous Household Appliances	1. Types of appliances 2. Fuel used. 3. Fuel costs. 4. Method of obtaining fuel 5. Time appliances spent in use	
3. To identify and quantify village energy resources	1. Commercial Fuels (except electricity)	1. Types and amounts of energy resources 2. Availability of energy resources 3. Ownership of energy resources 4. Resource distribution and location 5. Relative energy prices 6. Village plans for resource for development and use 7. Resource trends	
	2. Non-Commercial Fuels (i.e., firewood, dung, bagasse charcoal)	1. Types and amounts of energy resource 2. Availability of energy resources 3. Ownership energy resources 4. Resource distribution and location 5. Relative energy prices 6. Village plans for resource development and use 7. Resource trends	a) constraints on fuel resources b) village plans for fuel development c) quantity, use, costs, and availability of agricultural waste products that can be used as fuels, i.e., rice, bran, coconut husks, etc

Table 1 continued

CLASS	DATA CATEGORY	ESSENTIAL DATA REQUIRED	ADDITIONAL OPTIONAL DATA REQUIRED
	3. Electricity	1. How is electricity produced 2. Number of electric generators in village 3. Fuel used in electricity generation 4. Fuel cost and availability 5. Availability of electricity 6. Distribution of electricity 7. Electricity prices 8. Allocation of electricity 9. Village plans for resource development and use 10. Resource trends 11. Ownership of generators	a) energy pricing effects on: - labor-capital ratio - type of processing technology used b) the relationship of animal and human labor in industrial processes: - how animal labor is used - constraints on the use of animal labor
4. To measure energy consumption in industry	1. Labor Inputs	1. Work tasks and labor required 2. Animal labor use	- Shifts in capital-labor-animal labor ratios
	2. Manufacturing Processes	1. Energy inputs (types of fuels and quantities) 2. Availability of fuels 3. Fuel costs 4. Ownership of fuels 5. Types of processing technology used	
	3. Output	1. Type of output 2. Quantity of output produced	

Table 1 continued

CLASS	DATA CATEGORY	ESSENTIAL DATA REQUIRED	ADDITIONAL OPTIONAL DATA REQUIRED
5. To measure energy consumption in agriculture	1. Crops and crop patterns	1. Type of crops planted 2. Size of cropped land 3. Work tasks 4. Time spent on work tasks 5. Devices used 6. Fuel required to power devices 7. Availability of fuel 8. Fuel costs	a) spread of energy-intensive agriculture, i.e., "green revolution" b) country specific questions on agricultural crops and crop processing technologies c) marginal farming practices, e.g., slash and burn - extent of these practices - energy resources consumed - environmental degradation
	2. Fertilizer	1. Type of fertilizer used 2. Quantity of fertilizer used 3. When and to what crops is fertilizer used	
	3. Irrigation	1. Quantity of water used 2. Source of water 3. Location of water supply 4. Device used to pump water 5. Fuel used (type and quantity) 6. Availability of fuel used	
	4. Crop Processing	1. Type of crops processed 2. Processing technology e.g., threshing, drying, storing, grinding, etc.) 3. Devices used in crop processing 4. Fuels used (type and quantity) 5. Availability of fuel used	

Table 1 continued

CLASS	DATA CATEGORY	ESSENTIAL DATA REQUIRED	ADDITIONAL OPTIONAL DATA REQUIRED
6. To measure energy consumption in transportation	1. Vehicles	1. Type of vehicles (including boats) 2. Number of vehicles 3. Travel locations and number of trips and distances 4. Travel reasons 5. To what purposes are vehicles used 6. What fuels are used 7. Where are fuels obtained	The use of non-motor vehicles, e.g., animal power, walking, etc. - distance travelled - animals used - tradeoffs between the different competing uses of animal power and transportation
	2. Infrastructure	1. Miles of road/canals, etc. 2. Road type 3. Future road/canal development	
7. To measure energy consumption in commercial and government uses	1. Buildings (commercial)	1. Type of commercial building (hotel, shop, etc.) 2. Energy inputs a) heating/cooling and type of device used, time needed b) fuel used c) where fuel is obtained d) type of lighting device used e) length of time lights are used f) other energy inputs e.g., cooking, food preparation, and food stroage, etc.) g) Fuel costs	
	2. Buildings (government)	1. Type of government buildings in village 2. Number of government buildings 3. Energy inputs a) lighting b) heating and cooling c) food preparation and cooking d) other functions 4. Type of fuels used	

Table 1 continued

CLASS	DATA CATEGORY	ESSENTIAL DATA REQUIRED	ADDITIONAL OPTIONAL DATA REQUIRED
		5. Fuel costs 6. Fuel availability 7. Time energy is used	
	3. Vehicles	1. Type of vehicle 2. Vehicle uses 3. Time used 4. Fuels used 5. Fuel availability 6. Fuel costs	
8. To identify social and cultural relationships associated with energy consumption/ supply patterns	1. Divisions of Labor	1. Type of energy related work tasks (e.g., cooking, fuel gathering, etc.) 2. Time spent on tasks 3. Who performs task 4. Substitution of labor	
	2. Consumer Preferences	1. Food types 2. Cooking preferences 3. Energy consuming entertainment preferences	Relationship of lifestyle to energy use
	3. Perceived Needs and Problems	1. Related to energy factors: resources, technologies and energy consumption 2. Other present needs and problems	

Table 1 continued

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Section IV - Ways to Collect Data

The purpose of this section is to acquaint the planner with a brief outline of the state of the art of social science survey research methodology. It is assumed that scientific, engineering and social science experts will be available to design the final research strategy. Nonetheless, the decision-making planner needs to be aware of important elements. Therefore, the planner will be exposed to the following:

- Ways to restrict data required.
- What research instruments are useful.
- How will they be used and by whom.
- Management of the survey.

I. How to restrict data.

These are constraints on how much data, in what level of aggregation needs to be gathered, as well as appropriate strategies to be undertaken to collect data. The planner may wish to be guided by consideration of the following limits:

- Clear specification of a discrete number of policy, planning, program and research objectives.
- Personnel, budget, equipment and institutional capability.
- Added cost of obtaining additional data exceeds the added benefit of doing so. That is to say, data collected may be sufficiently precise, detailed and certain upon which to make planning decisions.
- Existing knowledge obtained through already collected primary and secondary data sources are reliable and up to date.

- The predetermined use of analytical methods may restrict what data needs to be collected. See Section V - Ways to Use Data.

Decisions to define well the boundaries of the data base and collection methods early in the design phase will avoid the danger of insufficient emphasis, or missing altogether, critical elements of the survey. This danger can arise if an attempt if made to cover everything.

II. Research Instruments

A) Unstructured

1. Compilation of Existing Data

Before inplementation of a new survey, the first task consists of reviewing all existing data relevant to research objectives.

- economic literature: energy balance sheets, including energy requirements, potential of renewable resources, etc.
- ethnographic literature: patterns of subsistence technology, economic systems, forms of social and political organization, religious beliefs and practices which sanction the existing institutional order. This information will be later needed to identify those aspects of traditional rural life which may either facilitate or impede technological innovations.

This task is partly "desk work" based upon information obtained from government departments and libraries, where one can find similar relevant studies. Data should also be obtained by experts and key informants.

All these sources are subject to biases. One should be cautious about the reliability of sources, which may be out of date or incomplete. Existing studies may refer to situational analyses which are irrelevant to research objectives under consideration. Data already existing may be presented at an impractical level of aggregation, or the data may be impossible to fit in a proposed system of measurement.

2. Reconnaissence

A reconnaissence phase must also take place before the construction of the research instrument. The purpose of this preliminary phase consists in finding out the features of the environment, as well as the rate and direction of change. The result is to find out the most important elements, on which the survey will have to be focused. This phase is necessary to determine the limits of the survey as well as to define data requirements more precisely. This phase consists of work in the field conducted by qualified specialists, economists, and energy engineers, and an information specialist.

Such exploratory phase would then be needed in the process of the survey itself.

3. Interviews

An interview can be defined as "a conversation with a purpose" initiated by the interviewer for the specific purpose of obtaining research, relevant information and focused by the researcher on content specified by research objectives.

Essentially, this kind of interview is very much unstructured. The interviewer's task consists of obtaining a wider and even unprecise range of information from the respondent, whose comments and behavior needs to be reported.

Such personal interviews are effective in sensitivity and are economical in methods of gathering first-hand data. Primarily, the information can be gathered relatively quickly. The cost of such interviews is not prohibitive because it does not require expensive material (e.g., precoded questionnaires). Interviews are applied to key informants who are expected to give the most relevant information.

Finally, the interviewer may obtain candid and in-depth information.

To conduct the survey well, it should be performed by well-trained interviewers, as well as by carefully chosen respondents.

- To be relevant, an unstructured interview would have to fulfill three conditions: accessibility, cognition, and motivation.

  - Data can be inaccessible for the following reasons: information may simply have been forgotten; the respondent may fear speaking freely because of possible repression; there may also be problems of language, vocabulary and differing degrees of sophistication between the respondent and the interviewer.
  - Cognition of the respondent, who should know what he is saying and communicate it in detail. The respondent

needs to know the concepts, or terms of references on which he is asked to provide data. He does not need to understand the nature of the measurement being attempted, but he should be fully aware of the requirements of his own role in the interview: the demands to be made on him, and the criteria for relevance and completeness.

- The third condition for a successful interview is motivation. The respondent is asked to provide information about himself, his experiences, his perceptions, or his attitudes, to an interviewer who has no direct power or intention to provide him with instruction, a job or any major tangible reward. However, he must be available to give relevant information. Obviously, this condition of motivation also applies to the interviewer who may be personally relatively detached from the research situation. The limit of this type of interview is that data obtained cannot be generalizable. Moreover, data is hard to process, hence needs to be complemented by pretesting a precoded questionairre.

4. <u>Community and Case Studies</u>

These studies consist mostly of participant observation and unstructured interviewing.

Community studies attempt to describe general socio-cultural patterns, while case studies are focused on observations of rate and direction of possible change within the socio-cultural context. Case studies may refer to the description of a specific

local project within individual villages or group of villages.

Community and case study approaches have similar advantages to those of unstructured interviews: in-depth information, quickly obtained and candor. However, both types of studies are relatively difficult to analyze. Case studies may be hard to compare because of the fact they are done separately.

Both studies can provide a high degree of validity. However, they are costly and require skilled interviewers as highly trained observers, and take up a considerable amount of time.

B) Structured

1. Questionnaire

The questionnaire approach is now widely used in developing countries, primarily because it provides large amounts of easily tabulated data. Preformulated questions are asked to a wide range of respondents who fit within a sampling frame (see below). Questions are simple and should not require complex responses. Then data can be quickly processed by compilation and can be relatively easily analyzed.

The structured questionnaire is considered appropriate to collect detailed but not in-depth socio-economic data useful to large and comprehensive assessments in a standardized manner. Questionnaires facilitate comparisons of data across wide areas and differing populations. Questionnaires are relatively convenient to administrate because they can be applied to respondents with low levels of literacy. It is less time-consuming and its cost is relatively reasonable. Enumerators do not need to be as highly qualified as those interviewers needed for unstructured approaches. The formal nature of the structured questionnaire

does not encourage spontaneous answers. This method relies almost exclusively on statements by respondents, whose answers may be biased.

2. Objective Measurements

Data on wind speed and direction as well as solar insolation characteristics exist for regions of the world. For wind, measuring equipment is generally used at weather stations and airports. However, these data do not provide an accurate indication of a countries' actual wind energy potential. Often, information is unreliable due to poor siting of equipment, uncalibrated instrumentation, and equipment breakdown. It is therefore recommended as part of a national energy assessment that both wind and solar measurements at various sited be made.

For wind it would be necessary to provide wind speed frequency distribution measurement and recording equipment. In addition, mobile mean wind speed recorders, towers, and turbulence measuring equipment should be provided. For solar, direct and diffuse radiation sensors should be installed at a number of sites. This equipment would enable the establishment of a reliable data base upon which sound future decisions may be based.

C) Experiments

To get better understanding of people's use of energy, it is also quite useful to implement field experiments in addition to structured and unstructured approaches. Field experiments are ways of testing the appropriateness of a program or technology intervention.

Experiments test hypothesis, deduced from information collected through unstructured and structured interviews.

To implement the experiment the researcher will have to select a representative sample of area or population, and design the "treatment" (what is to be experiment). One or several program or technology interventions (i.e., "treatment") will have to be administered to an experimental group of people selected at random from a specified population. Then follows interpretation of results caused by the introduction of the intervention. The method employed may very well consist of a comparison between the behavior of the treated unit of population with another unit which would not be submitted to such an intervention. Measurement of effects may also deal with changes in time before treatment and afterwards.

III. Methods of Gathering Data

In this part we will discuss means of implementing the instruments described above. Concentration here is on how and to whom the instrument should be administered.

A) Unstructured

1. How - Collection of Relevant Information

Unstructured interviews depend upon proper observation of the respondents, their attitudes and beliefs. Interviewers should take notes and keep diaries about any kind of observations they feel necessary to add.

An interview can be totally free, semi-directed or focused. The "free" interview does not include pre-written questionnaires. It should be directed toward key informants, who are very much

aware of the situation as well as the purpose of the survey. In the semi-directed interview, the interviewers will have to orient the conversation much more directly, using few general questions. The "focused" interview is even more structured. Questions are more numerous and precise. Such interviews are easier to administer. In the three types of interviews so mentioned, "open-ended" questions should be used, as they do not confine the respondent to a narrow range of pre-elaborated choices between possible answers.

Some questions generally do not bring out rational replies but may reflect the wishes of people. However, these questions will be quite difficult to formulate so as to allow the respondents to visualize a complex situation. These types of questions should be administered by experienced interviewers. In addition, the interviewer can make a statement and observe the respondents reaction. However, this approach is not as reliable as asking direct questions.

The interview should be administered, using vocabulary and syntax which would allow best communication between the two people. Wording of questions needs to be clear and straightforward. Finally, the interview should take between at least a half hour to a maximum of two hours.

2. Who - Sources

Relevant information can be obtained from key informants, community meetings and community organizations.

a. Key informants

Conversations with key informants should constitute the first stage of a village level interviewing process. Selection of these people can be indetified through informal

conversation with the population. These informants should have a deep knowledge of the historical and socio-cultural patterns of the village. These people are easy to identify. Key informants may have either formal or informal power; usually the latter are more informative.

However, some biases need to be avoided. Key respondents may not be representative of the whole population. They are often older and more conservative. Those who voluntarily participate with the research may be motivated by self-interest. They can also tend to be too subjective and perhaps are not representative of the entire population.

a. Community Meetings

These meetings are made up of organized and voluntary gatherings of local citizens. The timing of the meeting and agenda are usually controlled by the planner. The outcome of such meetings mostly depends upon the choice and clarity of objectives, good organization and deliberation. The meeting may constitute possibilities of eliciting an expression of local needs and even generating proposals. To be successful, these meetings should be established on a basis of equality in an open atmosphere. The planner shall also prevent formal and informal leaders from dominating the proceeding and carefully observe and assess any potential conflict between the people and their leadership, This approach is time consuming and requires specialist community organizers.

b. Community Organizations

This approach differs from the above in that communication is established with formally constituted representative organizations, public or private, in legal identity.

They can be characterized politically, by male or female membership sharing common interests. To be selected, such organizations should exemplify maximum participation in order to obtain as much accurate information as possible. Data on size, distribution, socio-economic characteristics of the membership should be compared to general data on the population.

Implementation is relatively easy, because of the structural nature of the organization. When community organizations are used as sources of data it is important to observe if deliberations are manipulated in an unrepresentative form by leadership.

B) Structured

1. How

a. Sampling Procedures

A sample can be defined as a segment regarded as representative of a whole. It is a short cut alternative to studying the entire universe of communities and areas.

The chosen sample must be typical of the situation, population, or area which is under study. The observation made out of the sample should enable valid inductive inferences about the whole population. The margin of error or uncertainty of these inferences should be as small as possible.

Practically, a good sample is one that, for the lowest cost, yields the desired information with a tolerable assumed error. However, the sample must be of sufficient size to give results that can attain the level of precision and confidence necessary for decision-making. The final criterion would be overall feasibility. Samples must be practical to carry out within the limitations of time, money, personnel and other material and

logistical constraints.

- Random Sampling

  In a random sample, each unit of the population has an equal chance to be included. However, random samples are not practical in large-scale surveys. Every unit of population must be enumerated in order to know in advance the equal probability of selecting any one unit. In most developing countries, there are no available lists of households. Moreover, the population is often spread out. In terms of efficiency, other sampling procedures may be more adequate.

- Purposive Sampling

  Purposive Sampling is used to select subgroups of the population, according to a perceived value of the subgroup in relation to the objectives of the survey. (e.g., wage - earning women) A practical and rapid method consists of the selection of representative villages, using subjective judgement, and then practicing random samples in these selected villages. However, this requires a good prior knowledge for choosing real representative villages.

- Stratified Sampling (applies to both random and purposive sampling)

  This term refers to ways of getting at unequal but important segments of population.

  To get more specific information, one may stratify the population by some key variables (e.g., age, sex, education, income, residence, religion, etc.)

Because these social strata are difficult to determine researchers use established geographic or political/administrative boundaries to define the clusters. However, the limit is that such boundaries can be artificial in terms of the economic and social characterizations of the sample under consideration. Such sampling may help to reduce enumerator travel time and save on travel costs.

b. Preformulated and Pre-Coded Questions

Before asking the questions themselves, interviewers need to establish preliminary contacts with the population, and establish rapport with respondents.

Direct questions should be limited to specific types of information involving objective and quantitative data . They need to be precoded and provided with fixed-alternative replies. Indirect questions should apply to more qualitative type information.

Respondents in some countries may have difficulties in answering negatively to questions or agreement in reply to statements, because of "courtesy bias". Alternative questions may have to be used.

2. Who - Sampling

The unit of sampling can be different from the unit of analysis. For example, one may use a village or a person as unit of analysis after having used a household as unit of sampling. Units of analysis include area, type of persons, population blocks, age groups (cohorts) or social units (households). Within each unit, a list of respondents would be elabor-

ated. This can be based on all the persons who reside in a household or all persons residing there at the time of the interview.

Units of analysis are defined refering to geological, demographical, socio-economical, political bases to the purpose of the survey itself.

C. Field Experiments

1. Selection of Most Appropriate Interventions

According to the objectives of the behavioral energy survey, it is necessary to test the most appropriate interventions or "treatments". They are likely to be tests of new technologies, such as solar pumps to collect water. A preliminary study of people's priority needs is necessary.

2. Selection of Sites for Experiment

The specific patterns of the selected group must be identical or quite similar to the general patterns of the whole community.

3. Observation

The tested community may be observed before, during, and after the treatment. Before and during implementation of the test, social researchers will be in the field to study people's general behavior and reactions towards the new technologies or other interventions.

After implementing the test, researchers will analyze the economic and socio-cultural impact of the intervention, by a simple analyses: comparison of the village situation before the after intervention, or comparison of the tested village with a similar non-treated community only after intervention, or

comparison of the tested village with similar non-tested community both before and after intervention. This last alternative is more satisfactory but more costly. The analysis of the experimental results reveals an observed difference that is statistically significant. This means that one can assume that the experimental treatment was attributable to observed changed behavior and not just attributable to chance.

The analysis of the results of a field experiment can help to reduce the uncertainty of the accuracy of the conclusions. However, it is best used as a complement to use of interviews and questionnaires in a survey.

IV. Management

A. Chronology of Operations (when)

These operations are defined in the above parts of Research Instruments and Methods of Gathering Data. The following order is suggested:

1. Exploratory phase

    a. unstructural interviews
    b. pretest of questionnaire
    c. feasibility: assessment of survey
    d. reformulation of questionnaire, sampling procedure and units.

2. Administration of survey

    a. sample
    b. scheduling of interviews
    c. logistics (e.g., transportation of enumerators, recording of response)
    d. processing
    e. field experiments
    f. analysis
    g. interpretation

B. Personnel

1. Selection

Enumerators will be responsible for questionnaires which are preformulated and precoded. Selection of enumerators should be based on the following:

- Fluency in the language or the dialect being used in the survey.
- A maximum knowledge of local conditions.
- Personal characteristics should be taken into account only if they represent a handicap to eliciting needed information. (problems of sex, age, ethnicity, religion, marital status).
- Apparent willingness to work and learn adaptability, social ability, respect for cultural values and respect for the respondents as individuals.
- There is a decision to be made whether it is better to choose local people, who have close rapport already, or using students - outsiders who can adapt and learn the procedure for interviewing possibly in a more efficient manner.

2. Training

Quality of data collection depends more on the quality of interviewers than on the degree of education and sophistication of respondents. Enumerators should receive

good written instructions. But they also need to be properly trained before being sent to the field: one should let enumerators interview each other and ask the others to critize the performance.

More qualified interviewers need more intensive training. They should be sent into the field to take trial interviews, which would then be reviewed carefully by their supervisors in pointing out errors, omissions, inconsistencies, and implausible answers.

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Section V - Ways to Use Data

Introduction

The purpose of this section is to describe four major analytical tools that can be used to analyze data collected from a series of energy related assessments. These four are grouped according to two parts:

- Part One: Macro Energy Analysis
- Part Two: Micro Project Assessment

For Part One, two methods have been identified: Reference Energy System and Projections. For Part One, Socio-Cultural Feasibility Analysis and Cost Benefit Analysis will be discussed.

Part One: Macro Energy Analysis

Note:

Macro energy analysis describes a nation's entire energy system, including the events that transform raw energy resources to something usable by the consumer. It provides an understanding of the dynamics included in the relationship between energy using technologies and the sources of energy. National energy planning often requires this comprehensive understanding as the basis for major energy policy decisions.

The kinds of decisions that are based on macro analysis include:

- size and type of subsidies to promote the production or use of a specific energy resource,
- structure of a national research and development agenda,
- fuel pricing or taxation policies,

- economic development objectives
- energy infrastructure investments (e.g., pipeline, roads).

Method One: Reference Energy System

A requirement of macro energy analysis is a framework to examine the elements of the national energy system. One such framework used by the United States Department of Energy is the Reference Energy System (RES) developed by Brookhaven National Laboratory. The RES is a useful analytical tool to predict changes throughout the energy system based on specific interventions such as new national energy policies, the introduction of energy using technologies, or changes in the relative prices of fuels. The interventions must first be translated into changes in end-use demand.

The RES illustrates (Figure 2) the flow of each fuel (energy resource) from extraction or import, through conversion to end-use. All the processes are linked by transportation or transmission. At each step of the way, total quantities in British Thermal Units or in Joules are shown along with the efficiency of conversion. Figure 3 illustrates results of a disaggregated RES. As illustrated in that figure, each path through the energy system network indicates a possible route for the flow of energy from an energy resource to a given demand category. Alternate paths and branches reflect the substitutability of various resources and technologies for one another. The energy flowing through each step or process is shown above the line representing the activity. The numbers in parentheses are the

efficiencies, or relative effectiveness, of the processes. The RES representation permits calculation of the amount of a particular energy resource for examples, oil used to satisfy a particular demand; or space heating either through a particular intermediate fuel form, such as electricity, or directly. Energy demands are assumed for each reference year from historical data and projections. Both commercial and non-commercial fuel forms can be dealt with and centralized energy systems (such as large scale electricity generation) are distinguished from decentralized systems (such as small scale solar electricity production).

The efficiency of conversion is determined by the nature of the conversion technology. The quantities of energy are determined by the initial input of fuel to the system. The information necessary for the RES can be acquired by reference to Section III - Data Base Summary and Appendix II - Data Base.

Method Two: Projections

Calculations are made back through the first method described--Reference Energy System. Results will show how the system must respond in order to accommodate these changes.

Growth in demand overtime can be projected by estimating growth for each end-use function. This is based on historical trends and growth in a basic unit of analysis such as residential water heat based on the growth in the number of households. Section III - Data Base Summary and Appendix II - Data

Base provide questions to make these projections. Figure 4 is a sample demand worksheet which illustrates demand growth for residential water heat for five-year intervals to 2020.

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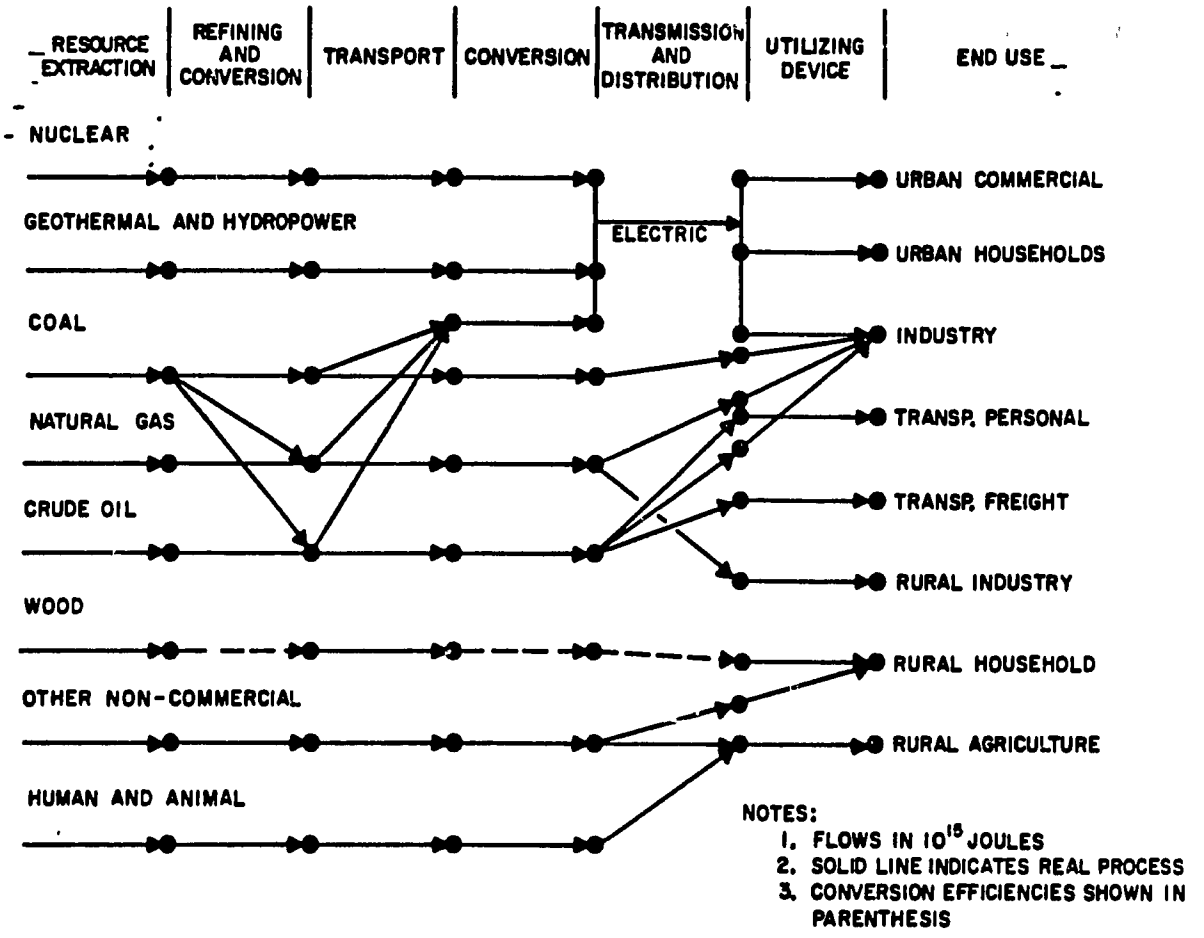

Figure 2 LDC Reference Energy System (Illustrative).

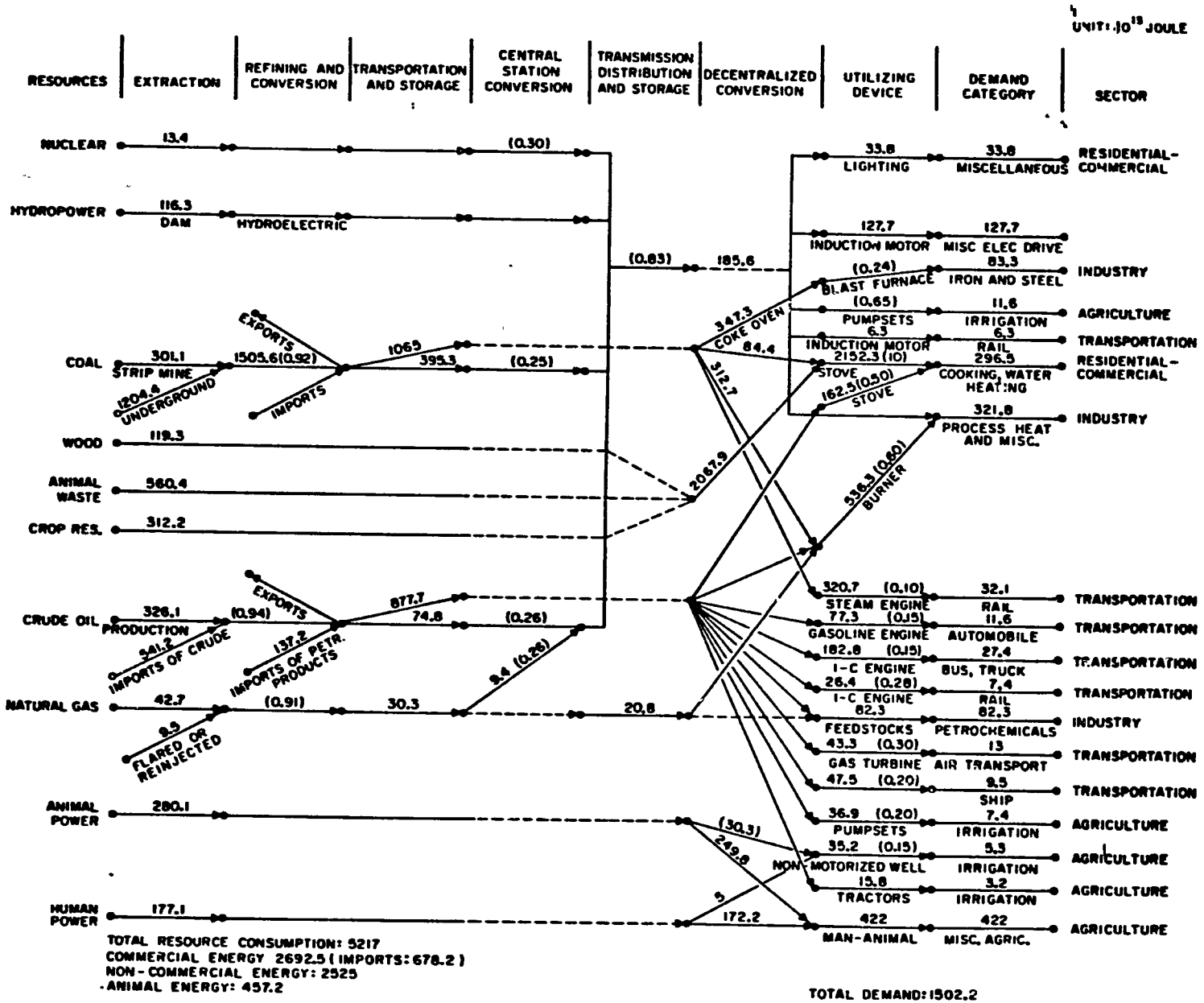

Figure 3 Reference Energy System - Commercial and Non-Commercial Energy - India 1972

Sector: RESIDENTIAL
Category: WATER HEAT

	1972			1980			1985			1990			2000			2020		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE																		
Methane	.51	.57	1.178	.53	.57	1.357	.53	.57	1.448	.50	.57	1.467	.44	.57	1.486	.44	.57	1.847
Jet fuel																		
Gasoline																		
Distillate oil	.10	.63	.183	.10	.63	.232	.10	.63	.247	.10	.63	.266	.10	.63	.306	.10	.63	.380
LPG	.05	.57	.117															
Residual oil																		
Coal																		
Other																		
ELECTRICITY	.30	1.00	.393	.37	1.00	.540	.37	1.00	.576	.40	1.00	.669	.46	1.00	.886	.46	1.00	1.101
TOTAL FUEL DEMAND, D, 10^{15} Btu			1.871			2.129			2.271			2.402			2.678			3.328
BASIS 10^6 households			66.7			75.			80.			86.			99.			123.
SATURATION, S,	.96			1.00			1.00			1.00			1.00			1.00		
BASIC ENERGY DEMAND, E, $.10^{15}$ Btu			1.246			1.459			1.557			1.673			1.926			2.393
UNIT BASIC DEMAND, E_u, 10^6 Btu/household			19.459			19.459			19.459			19.459			19.459			19.459

REFERENCE TECHNOLOGIES: Gas and oil burners, electric resistance heat.

DATA SOURCES: (from BNL 50483)

D_i for 1972: Btu/household requirements, by housing type, from Ref. (10) for gas and electric; Btu/household consumption for oil water heated homes taken from Ref. (16), Region II Fuel Mix tables.

f_i for 1972: Ref. (7).

e_i : Ref. (4) for gas and electric, Ref. (16) for oil. The e_i are held constant over all reference years.

BASIS OF PROJECTIONS: The basic demand derived for 1972 is escalated in proportion to the saturation and to the number of households as projected in Ref. (14) for 1985 and 2000 and interpolated for the other reference years.

Figure 4 Sample Demand Worksheet

Part Two: Micro Project Assessment

Note

Before proceeding to the third and fourth methods of analyses, some preliminary comments need to be made.

The last two methods are useful to determine an appropriate project-level "intervention." Here we define this term as a response by either a government or private investor to solve a specific problem, based upon the findings of a survey or other means of assessment.

Evaluation of possible project interventions takes place in a three stage process:

- In stage one, an inventory of indigenous and non-energy technologies that meet a specific energy need are matched against the technical resources available at the project site. Those technologies that require scarce or unavailable resources are eliminated from further consideration by the planner.
- In stage two, each remaining technology is evaluated in terms of the social, legal and cultural profile of the intervention site. A technology that requires substantial changes in the social, legal and cultural institutions in a village or region is often found to be unacceptable to the end-user and therefore ends in disuse. The social, legal and cultural profile would allow the project planner to match

technologies with the lifestyles of the end-users in order to select those techniques that minimize social disruption.

- In stage three, the planner evaluates the remaining technologies in terms of their economic worth to the investor and to the nation. In order to establish the economic worth of technologies, the planner analyzes economic and technical information gathered from national survey data, technical experts and a site visit by a project analysis team. Costs and benefits of each technique are defined and quantified. These costs and benefits are then evaluated through a cost-benefit analysis and a selection of economically viable technologies is made. At this point, the initial range of technologies has been narrowed to those that address the specific problem identified in the survey; match the technical resources of the project site; fit into the social, legal and cultural institutions of the end-user; and are economically worthwhile to the investor and to the nation.

Method Three: Socio-Cultural Feasibility Analysis

Introduction

This part examines the method of socio-cultural feasibility analysis to a body of data collected at specific urban and rural localities.

There are six primary factors which are related to approximate data categories. Justification, or objective of each factor is provided along with an example of its importance to the hypothetical case of installing a solar energy pump. Specific points are listed then under each factor.

It should be noted that required data listed below can and should be incorporated into the initial survey/field experiment data base questionnaire.

Data Required

Factor 1. Technolgical and Environmental Adaption

Data Category: Patterns of technological adaption to environment. Interplay between available natural resources and indigenous patterns of subsistence.

Objective: Identification of those traditional tasks which may require utilization of an alternative or more efficient existing energy source. For example, substitution of a solar pump for manual drawing of water; the latter activity requiring a considerable amount of time.

A. Subsistence Technology

- Relevant importance of various productive activities; such as farming, herding, fishing.
- Types of activities:
  - livestock raising

- fishing, hunting, gathering, foraging
- farming techniques: land preparation, seeding, cultivation, harvest, food processing and storage
- Extractive industries

B. Shelter and Crafts

- Shelter: description of the house--internal and external architecture (walls, roof, number of rooms, windows, open space). System of cooling and heating, lighting.
- Clothing
- Manufacturing: pottering, metalworking, wood-working, basket-working, textile-working.

C. Traditional Energy Sources

- human
- animal
- wood, wind, sun

D. The Cycle of the Economic Year

- Kind of work and type of life

E. Transportation

- means (foot, animal, vehicle)
- frequency
- length of trip
- purposes

2. The Economic System

Data Category: Allocation of productive resources. Organization of work and system of distribution.

Objective: Appropriateness of indigenous work organization to performance of those task required by the introduction

of an intervention. For example, how to allocate responsibility for the maintenance of a solar pump.

A. Allocation of Productive Resources

- the system of land tenure and potential conflicts
- allocation of other productive resources, e.g. tools, capital, laborers.

B. Organization of Work

- role of kinship
- division of labor by sex, age and social status
- Wage-labor and labor-migration

C. Distribution and Patterns of Consumption

- Domestic consumption
- tribute and taxes
- gift-exchange and barter
- the role of money and organized marketing networks.

D. Distribution of Income

- Patterns of spending, saving and investment.

3. The Social System

Data Category: Social organization of the community as a productive and distributive unit.

Objective: Relevance of the providing social cultural factors that assure that all segments of the rural population share in the benefits resulting from introduction of a new project. For example, would farmers of slave descent be allowed to share in the benefits of a newly installed irrigation system reliant upon the use of a solar pump

A. Kinship Organization

- Marriage

- Systems of descent
- assignment of status
- role of the household
- system of inheritance

B. Associations

- Associations based on age, sex
- Common interests
- Secret societies

C. System of Stratification

- ethnic stratification
- castes: importance and organization
- social classes
  - sexual stratification
  - slavery

4. Political Organization

Data Category: The structure of authority: Processes of decision-making (by whom and how)--Levels of political authorities.

Objective: Assessment of decision-making processes to accept and manage the proposed technology. For example, in the instance of a solar pump intended to be used to irrigate commercial vegatable farms, is it certain that water will not be diverted to alternative non-project uses.

A. Authority

- who
- power
- characteristics of authority and legitimacy
- relationship between authority and the most important

households within the village

- popular participation in political activities
- relationship between authority and the formally constituted political system of the country

B. Legal

- ownership
- transfer of property
- state domains
- legislative system and its enforcement

5. The Belief System

Data Category: system of beliefs and observances

Magical religiosity.

Objective: Adequacy of the proposed technological innovation to religious behavior. For example, would the reliance upon a solar pump as a water source undercut the traditional authority of priests who derive their power from the control of the water supply.

A. Beliefs

- nature and variety of religions
- religious freedom
- role of magic
- nature of worship

B. Observances

- ritual calendar
- ritual prohibitions

C. Religious Hierarchy and Power

- social and political power of priests
- social and political power of sorcerers

6. Languages

Data Category: System of communication

Objective: the relevance of the traditional system of communication to needs entailed in the introduction of a new technology. For example the language in which the instructional materials should be prepared--in the vernacular or the official Government language.

- local dialect
- market language
- official language
- characteristics of use of above three.

Analysis

Based upon personal observations, professional familiarity with this specific culture and review of collected survey/field experiment data, social scientists can make certain inferences:

- Relevancy of each factor to traditional technologies
- Those aspects of the socio-cultural context which are most amenable to changes resulting from proposed innovation
- Similary, those aspects that may impede outside change brought in by an innovation
- Conversely, the impact new technologies make on daily life and practice

Final judgements are made on the basis of the relationship among one important factor with other aspects of the local culture. Accurate conclusions are based not merely upon the professional merit of the analyst; but, more importantly, on the degree of popular participation attained when final conclusions are made.

Method Four: Cost-Benefit Analysis

Introduction

This part examines the role of cost benefit analysis for the planner's evaluation of energy project interventions. Discussed will be general methodology, required data, methodological biases and general limitations of the approach.

Description of Cost-Benefit Analysis

Cost-benefit analysis is a convenient analytical tool with which a nation or private investor can evaluate investments. It can help determine net benefits of various projects and can help rank alternative projects which are competing for scarce resources.

Costs and benefits for a project reflect the technical characteristics of the technology and economic factors prevailing at the project site. Project costs often include such items as initial capital expenditures, raw materials, fuel, labor, maintenance and taxes; project benefits are expressed in terms of primary and secondary outputs of the investment under consideration.

There are two methods of cost-benefit analysis. One method, financial cost-benefit analysis, evaluates costs and benefits from the viewpoint of the private investor in a project investment. The other method, economic cost-benefit analysis measures the total return to society, on the economy of all resources consumed in a project. These two types may not value the costs and benefits for the same project equally. A project may create

secondary benefits or costs not captured by the investor.

Data Requirements

This analysis is intended to narrow the list of investment possibilities by eliminating those technologies that are not feasible. In this sense, cost-benefit analysis is intended to screen and short-list a wide variety of technologies. Since only a crude analysis is often necessary to eliminate clearly bad technologies, data gathering and subsequent analysis can be comparatively simple.

Economic and financial analyses differ in data requirements. For economic evaluation, certain valuations--duties on imports and subsidies--are considered as transfer payments to be spent on behalf of society to or from the government and the project. Thus, these valuations are not considered as costs or benefits in an economic analysis because income will be redistributed throughout the economy. A private investor, however, would consider subsidies, taxes and duties as project costs or benefits, and would include these in a financial analysis of a project.

It is also possible that secondary and intangible costs and benefits, such as social values, employment opportunities, and environmental considerations, can arise from a project.

These factors are of importance only in an economic evaluation because they reflect national economic costs and benefits of a project. As difficult as these factors are to quantify, the analyst needs to consider them and attempt to measure them. Such secondary and intangible factors are on the other hand not

required for the financial evaluation, because there is no direct monetary value to the private investor.

In order to perform a cost-benefit analysis, three categories of data would be needed to determine a technology's costs and benefits:

Technical information on the operation, efficiency, outputs and inputs of a technology. These data are required in both economic and financial analyses and can be obtained from experts familiar with the technology.

Prices charged for inputs, outputs consumed and manufactured by the technology, wage rates, and the initial capital cost of the technology. Data required in this category differ for economic and financial analyses, as will be shown below.

National aggregate economic data can be obtained from national surveys or existing data files. These data include information on interest and rates, and cost, insurance and freight, or charged-in-full along with free-on-board prices for internationally traded goods, which will be used in the economic evaluation (see Table 5).

Prices in an economic evaluation of costs and benefits must reflect the true national and economic values of all goods and services required for the investment. Such prices are called "shadow prices".

In theory, shadow prices can be given for each commodity and service in a nation's economy. However shadow prices eliminate the effects of all transfer payments, such as taxes, subsidies, export and import quotas on the price of a good.

In practice, shadow pricing goods and services may involve lengthy and complex calculations. For purposes of this methodology, simplified techniques for obtaining shadow prices are suggested to the planner. (See table 6 for a brief description of these techniques). However, these simplified shadow pricing techniques may introduce a bias into the analysis, and the planner should be aware that these techniques are only a useful first approximation.

Projection of Prices

In many projects prices will have to be projected over the entire lifetime of the project. Such projection for project inputs and outputs is generally very difficult. Changes over-time of the relative prices of inputs and outputs can alter an investment decision, although such changes are usually long term. As a simplification, the analyst can assume that prices adjusted for inflation will not change significantly in relative value over a short project period. In this case, all future prices can be valued at today's levels. However, if the analyst feels that the relative prices of some goods and services will change significantly then future prices will have to be accounted for in the analysis.

Data Evaluation

Once a project's costs and benefits have been identified and quantified, then the net economic worth of the project is calculated. For projects, in which benefits and costs are spread over several years, the concept of the time value of costs and benefits enters into the project analysis. Simply

defined, the time value of costs and benefits is how much are future benefits and costs worth to the investor or nation today. The present worth of future benefits and costs is influenced by the discount rate and the expected liftime of the project. The lifetime of the project depends on the technology involved, and is defined as the period before major capital equipment is expected to wear out.

For the private investor, the discount rate is the local interest rate for loans. For the nation, the economic discount rate is the interest rate at which all capital in the economy would be invested under perfectly competitive conditions with no distortions. However, this "shadow" discount rate is difficult to estimate. For this methodology it is suggested as a simplification that several economic discount rates be used to calculate the economic worth of a project.

There are three methods of calculating the net worth of a project. They are: benefit-cost ratio, net present value and internal rate of return.

Benefit-cost ratio is defined as the ratio of the present worth of benefits to the present worth of costs. If the discounted benefits exceed discounted costs, the ratio is greater than one, and the project is acceptable for investment.

Net present value is defined as discounted benefits minus discounted costs. If the project has a positive net present value, that is, if the project's discounted benefits exceed discounted costs, then the project is viewed as worthy of investment.

Internal rate of return, is defined as the discount rate that makes the net present value zero, or when discounted benefits

equal discounted costs. This rate would be compared to the discount rate to determine the value of a project.

Net present value and internal rate of return are the most commonly used methods to determine the economic worth of a project. The reasons for this preference are that benefit-cost ratios discriminate against projects with relatively high gross returns and operating costs, even though these may be shown to have a greater wealth generating capacity, than projects with higher benefit-cost ratios. The internal rate of return method has an advantage over net present value in that it allows the planner to rank projects.

Ranking and Comparing Technologies

Alternative technologies can be ranked in order of the value of the internal rate of returns when more than one of the alternative technologies under reivew can be implemented. However, when this is not possible; i.e. the technologies are mutually exclusive; direct comparison of internal rates of return can lead to an incorrect investment choice. Mutually exclusive technologies can occur if one technology preempts a site or if resources can be used by another technology, such as a large scale project and a smaller version of the same project. To rank mutually exclusive technologies, the analyst must find the differences between discounted costs and benefits for the alternative technologies and calculate the internal rate of return for this stream of differences. For large and small-scale versions of the same project, this internal rate of return can be interpreted

as the value of investing additional resources necessary to do the larger alternative.

A special case of mutually exclusive projects is alternative technologies that produce identical benefits. Here it is necessary to only consider costs when comparing projects. The planner then selects the alternative with lowest discounted costs, provided that in the same project, benefits exceed costs.

Sensitivity Analysis

There is often a great deal of uncertainty in the reliability of some of the data used for a project analysis. To account for data uncertainties, the analyst can examine a range of values for important factors affecting the economic worth of a project. There are four common data uncertainties that can greatly influence the outcome of a project analysis.

- Inaccuracies in price data
- Delays in implementation of a project
- Incorrect discount rate
- Erroneous estimate of project lifetime.

To determine the effect that these uncertainties have on the worth of a project, the analyst can re-calculate the internal rate of returns (or other measures of economic worth) using estimates of the most probable fluctuation of an economic or financial factor. The sensitivity analysis will give the planner a range of the net worth of a project under a variety of possibilities.

Conclusion

Cost-benefit analysis is a unique economic tool with which project interventions can be systematically evaluated because

it can identify unrealistic or questionable economic and financial assumptions in a project. The technique is also useful in determining ways of increasing the economic or financial worth of a project.

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Table 8

Costs and Benefits for a Project Intervention

Category	Technical Data Required	Source of Data	Economic Data Required	Source of Data	Comments
1. Capital Costs					
a) Land costs	Total land area requirements for siting a technology.	Technical experts or survey data for indigenous technologies	Land prices per unit area for possible project sites.	Survey data, national economic data, or site visit by project analysis team.	In many cases, Land costs may be very small
b) Technology costs			Capital cost for technology	Technical experts or survey data for indigenous technologies	Would include construction costs transportation costs Etc. in siting a Technology
2. Operating Costs					
a) Labor costs	Labor skills and total workdays per year for each skill group.	Technical experts or survey data for indigenous technologies.	Wage rates for each skill level	Survey data, national economic data, or site visit by project analysis team.	Man-days required would be based on the optimal operation of the technology.
b) Input costs	Type and quantity of inputs consumed by a technology.	Same as 2(a) above.	Prices for each type of input.	Same as 2(a) above.	Data would include raw materials, fuels, lubricants, etc.
c) Taxes			All input and output taxes and capital taxes, import taxes on goods that are not accounted for in input price data.	National economic data.	
d) Depreciation			Straight line depreciation based on lifetime of major capital equipment.	Technical experting and project analyst.	
e) Repairs and Maintenance	Types of repairs and maintenance expected.	Same as 2(a) above.	Equipment replacement costs. Labor costs.	Same as 2(a) above.	Includes transportation costs, Raw materials, construction costs, Labor skills and hours spent each year.
3. Benefits (Outputs)	Type and quantity of outputs manufactured by a technology.	Same as 2(a) above.	Prices for each type of output	Same as 2(a) above	Waste by-products with economic value included. Marketing and translation costs should be subtracted from output benefit.
4. Interest rates			Local and National interest rates.	Sames as 2(a) above.	Local interest rates reflect what is charged for a loan to private investor at the project site. National interest rates reflect the cost of capital loaned by the government.
5. Technology Lifetime	Lifetime of major capital equipment.	Same as 2(a) above.			

Table 6

Shadow Pricing Techniques for Important Economic Resources

Resource	Technique	Data Required
1. Commodities		
a) (Internationally) Traded Goods	Price these goods at world market Price.	Imported goods are shadow priced at the c.i.f. price (cost, insurance, freight) Exported goods are shadow priced at the f.o.b. price (free on board).
b) Non-traded goods	Price these goods at local. market price.	Market price of inputs and outputs.
2. Exchange rate	Based on the ratio of the total world market value of all imports & exports to their total value at domestic prices.	Requires c.i.f. and f.o.b. prices for all traded goods.
3. Labor	As a first approximation, shadow price labor on an annual basis at a value which is determined by multiplying a villager's market wages or income for a task by number of workdays for those tasks.	Need data on tasks performed by villagers the number of workdays spent and wage rates.
4. Interest rate	Use several interest rates for estimation of economic worth of project.	

Africa Solar Energy Survey Methodology

Appendix I: CASE STUDY

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1. Introduction

The case study described below illustrates how collected data can be anlayzed to achieve a particular set of objectives. Selected are the following:

- Policy Objective

  Investigation of specific energy development schemes and estimation of costs involved and arrangement for financing the projects.

- Survey/Research Objective

  Identify possibilities of substituting new energy technologies or resources for traditional ones.

Hence, as will be seen, a particular project of fish drying was examined within the context of Kayar, a maritime artisinal fishing village on the coast of Senegal.

The main concern of this case study is to prove the thesis that one should evaluate initially the rough feasibility of a range of candidate techniques prior to field-testing or during project implementation. By employing certain analyses, the expense of field demonstrations can be made minimal and the beneficial effect of the technology on village life can be maximum.

Two analytical processes were employed:

- Socio-cultural feasibility
- Cost-benefit analysis, including both financial and economic assessments, with four sensitivity analyses performed.

The reader can become familiar with these methods by referring to Section V - Ways to Use Data contained in the methodology.

At this stage it is important to make certain qualifications on the applicability of this case study.

- It is assumed that data on Kayar have been collected from an earlier energy related assessment. The data are presented in such a way as to orient the analysts, and are not presented to reflect final organization of a survey.
- Specific questions and answers on socio-cultural feasibility and cost benefit analysis may conceivably have already been imbedded in the original energy assessment. For purposes of illustration, however, they have been extrapolated. It is expected that certain specific analyses may require return to the original sample site.
- Kayar has been chosen because of availability of data from secondary sources. The village is not expected to be considered representative of Senegal, the Sahel or of sub-Sharan Africa. Indeed, there may be some discrepancies in the data discussed, as there was no opportunity for field verification.
- The way answers have been obtained does not reflect necessarily a final methodology of gathering data. Therefore, no attempt was made to phrase questions in an appropriate cultural manner, nor do answers reflect just one segment of the population.

2. Background

A. Orientation to the Village

This paper profiles a fishing village considered typical in the Cap Vert region of Senegal. Kayar is located approximately 60 kilometers north of Dakar. It is an important center for artisinal fishing; ranking second in total catch and first in terms of the volume of fresh fish it supplies to the domestic market. It is also a center for commercial production of vegetables.

Population and Ethnicity

The original settlers of Kayar were members of the Lebou ethnic group. The Lebou are fishermen-farmers who settled all along the coast between Dakar and St. Louis. They are a relatively small group of 40,000 to 50,000 members overall. They are often characterized by their individualism, which makes it difficult to enlist them in cooperatives. Like other ethnic groups in Senegal, they tend to be organized by sex and age into work associations.

While Kayar was originally a Lebou village it is now predominately Wolof: Wolofs inhabit nearly two-thirds of its 126 households. There are also smaller numbers of Serers, Peuhls, Toucouleurs and Maures. Both Wolof and Lebous engage in fishing, whereas the remaining ethnic groups are primarily cultivators, herders or small shopkeepers (Maures). Nearly all the fishermen also engage in farming; however, cultivating fields of millet, groundnuts during the rainy season.

Social Organization and Productive Behavior

Kayar's year-round population of about 2,000 people swells to nearly 10,000 during the fishing season, which runs from December to June. Seasonal migrants come from many parts of Senegal and include fishermen as well as others attracted by the economic activity associated with the artisinal fishing industry.

Each household is a separate unit of production, dependent on both fishing and agriculture. Kayar became part of the market economy, about 25 years ago; improvements resulted in road transportation between the village and Dakar.

Now, at least among families with access to good agricultural land, there appears to be more interest in dry season vegetable production than in fishing. Even though there are opportunities for income generation through fishing during the rainy season, people generally prefer to devote their time to millet and groundnuts production at this time of year.

Starting in the early 1970's, the government began to promote the organization of artisinal fishermen into village-level cooperatives. By 1976, about 15 percent of the small-scale fishing population were members of cooperative associations, through which they could obtain equipment and commercial inputs such as gasoline and oil for their boats. In the long run, it is intended that these cooperatives will also perform a marketing function on behalf of their members.

Fishing Infrastructure

Fishing infrastructure at Kayar consists of 1) a lighthouse which is not really necessarily used, as fishing rarely takes place after dark; 2) a motor repair shop with 12 individually-operated units, of which eight are run by migrants; 3) four gas pumps of 8,100 liters capacity each; 4) a fresh fish market (halle de maree) and 5) the local Service de Peche officer whose duties include distribution of discount coupons for gas and reporting the record-keeping.

Fishing Production

More than half of the 75 pirogues had been motorized. It was felt that motorization had made little change in methods of production in Kayar.

On the average, motorized boats had a 6-man crew, non-motorized (sail) boats used four men. At one time, most of the crew was made up of family members, but this has changed with the influx of seasonal workers to the community and the advent of other income-generating opportunities such as vegetable gardening. In a typical concession, 3 to 4 members are involved in fishing, and 12 or more in other occupations. Women raise vegetables (aided occasionally by men) and process fish. Most men stop fishing around age 40-45 to devote their time to farming.

Pirogues can last up to 12 years, and are usually repaired annually. New boats are built right on the beach by skilled carpenters out of tree trunks brought by truck from lower Casamance.

Most fishing is done with nylon nets, especially between January and June.

Proceeds from the sale of the Kayarois fishing catch are shared equally by the fishing crew at the end of the 5-month season.

Processing

Processing is strictly a woman's activity, and the months of February, March, and April are the busiest for processors, as

these are the months when the largest volume of fish are brought to shore.

In addition to regional specialties, nearly all fishing villages produce guedj, using one of two methods. With the first method, the fish (a number of different varieties are suitable) are cleaned, their heads and entrails removed, and washed in salt water. Then they are sliced in half longitudinally, salted with sel de Kaolack or DDT powder, and stacked in the shade for two days. Weights are used to flatten the fish. On the third day, they are washed and placed to dry in the sun, either on mats or on the sand. While they are drying, they are sprayed with red oil (which gives them a distinctive brown color), given another dose of salt, and turned once every four hours. On the next day, they are ready for packaging, generally in 40 kg. sacks made from vegetable fibers.

The maximum shelf life of processed fish is six months, due to the fact that decay is allowed to set in even before processing. Ten kgs. of fresh fish produces about 3 kgs. of guedj. On a per kg. basis, guedj sells for about three or four times the selling price of fresh fish. It is usually cut up into pieces, of about six pieces per fish. Distributors and retailers (bana-bana) take most of the markup. In Kayar, the women generally resell all they produce, and may end up buying some of it back at much higher prices if they need it during the dry season.

Marketing and Distribution

The marketing system for both fresh and processed artisanally-caught fish in Senegal is very disorganized. It is entirely in the hands of small private male entrepreneurs. There are usually three, and sometimes four middlemen involved, each of whom handles a relatively small portion of the total catch.

After the fisherman has landed his catch, he typically hands it over to his wife, whose responsibility it is to resell it to a bana-bana, or distributor. The wife takes a small (15 to 20 percent) profit for her efforts, and turns the balance over to her husband. Fish are sold by the piece, rather than by weight. The bana-bana tries to delay purchase as long as possible in the hope that the price will come down. There is no organization among the producers, who compete with one another for sales which helps to lower the prices received for all concerned.

Once he has purchased his daily supply, the bana-bana transports the fish to major urban markets. The catch is generally landed in the evening, and the objective is to have it delivered to urban fish markets before they open the following morning.

The average bana-bana handles 300-500 fish/day. However, some "specialists" may handle as many as 3,000 fish/day, netting 25,000 fr. CFA or more. Some of these big-time distributors own their own delivery trucks. They distribute only fresh fish, leaving the distribution of preserved fish to smaller, part-time dealers. Some women also engage in the resale of fish on a small-time basis, on the order of 2/3 baskets of fish per trip. They usually travel by car rapide or taxi rather than truck.

For Kayar, on the average, about six percent of the catch is preserved and another thirty-one percent is sold locally. The balance (63 percent) is transported to urban centers. There are no regular delivery circuits. During the dry season when most of the fishing is done, the trucks may travel to cities 200 km. away or more. During the rainy season, when supply is down, they travel shorter distances in order to maximize profits by cutting transport expenses. Processed fish is also taken to the major cities for redistribution by truck or rail into the hinterland.

The final selling price is generally three to four times the price received by the producer, more in the case of preserved fish that are sold in small slices. Prices depend on the size and species of the fish, the time of year, day of week, and hour of the day.

B. Identified Problem

There are several options to use fuels more efficiently and to apply new uses of energy, including the following:

1. Motorized fishing boats
2. Smoke-Dried Processing
3. Cooling and refrigeration
4. Fish Drying---Fish preservation in Senegal involves not only processing through smoking, braising, salting, or fermentation, but also sun-drying in the open air. While traditional drying methods require minimal investment in equipment and materials, they do not expose the fish to high enough temperatures to forestall deterioration. They also pose certain

health hazards resulting from contamination of the fish by flies and other insects which may reduce the export potential of artisanally-processed products. An estimated 39 million MJ in nutritional energy is lost each year due to insufficient drying of processed fish and an additional 11 million MJ loss can be attributed to the abbreviated shelf life of products which continue to deteriorate even after they have entered the distribution system.

For the purpose of this illustrative case study, the last option has been chosen for analysis.

Bibliography

Data has been supplied by the courtesy of Checchi and Company, Washington, D.C., with research notes and drafting from two sources:

Aubren, Roger, 1977. The Fisheries of Senegal: A Comprehensive Study. FAO. Rome.

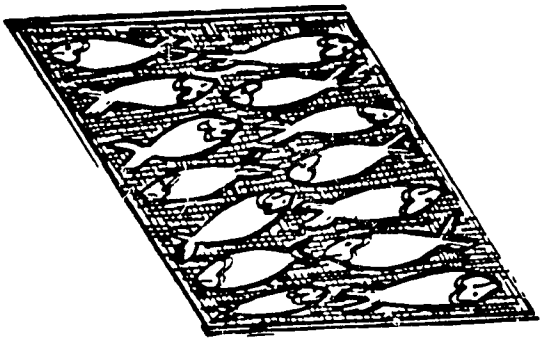
Van Chi, Regine Nguyen, 1967. L'Economie Maritime et Rurale de Kayar, Village Senegalaise - problemes de developpement. IFAN. Dakar.

E. Recommended Techniques to Solve the Problem

The six attached figures portray characteristics of, first, the existing traditional method, with five alternatives:

- Traditional Fish Dryer
- Screen/Rack Fish Dryer
- Solar Fish Cabinet Dryer
- Flow-Through Cabinet with Attached Collector
- Flow-Through Cabinet with Burner
- Commercial Fish Cabinet Dryer.

Figure I. TRADITIONAL FISH DRYER



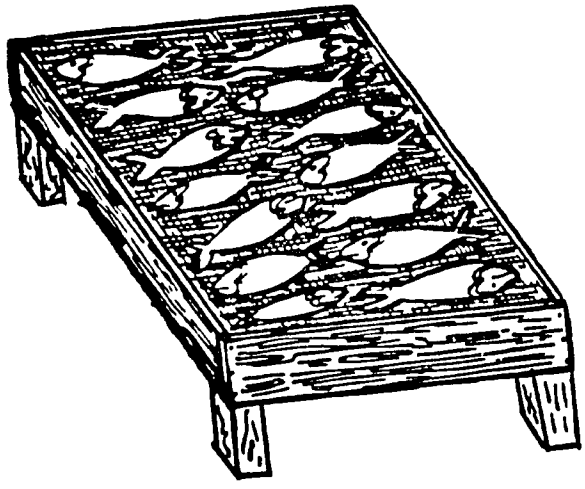
Description

The traditional method for drying fish is to simply lay them on the sand for several days or to place them on woven or twig mats to dry.

Technical Characteristics

Scale of Operation:	100 lbs/day
Capital Costs:	1,150 CFA
Labor Requirements:	unskilled - 115 skilled - 1
Lifetime:	1 year

Figure II. RACK/SCREEN FISH DRYER



Description

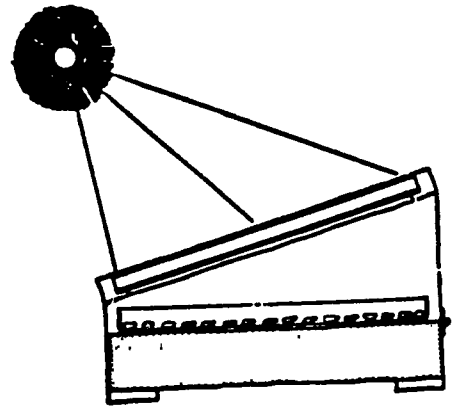
The dryer is composed of a wood frame and a wire or thatched screen set on legs.

Technical Characteristics

Scale:	100 lbs of fresh fish/day
Capital Cost:	3,450 CFA
Unskilled Labor:	115 hrs
Skilled Labor:	1 hr.
Salvage Value:	345 CFA
Lifetime:	1 year

Materials - wood, screening material, nails.

Figure III. SOLAR CABINET DRYER



Description

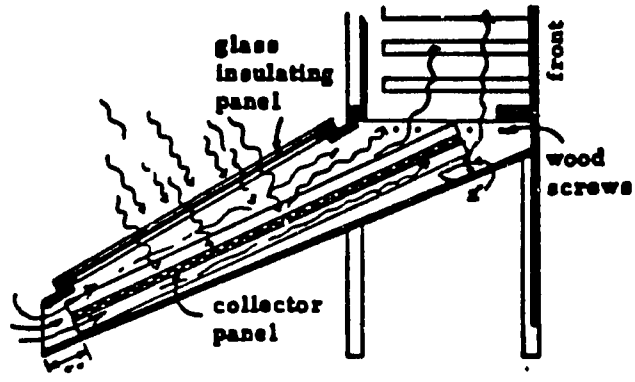
The dryer is essentially a solar hot box in which fruit, vegetables, fish or other matter can be dehydrated. The dryer is a rectangular container, insulated at the base and sides, with a transparent roof and circular air flow. The framework can be made of virtually any material--woven bamboo, metal, plywood, adobe or brick. Insulation could consist of locally available materials such as wood shavings, sawdust, bagasse, coconut fibers, reject wool or animal hair.

Technical Characteristics

Scale:	100 lbs of fresh fish/day
Capital Cost:	34,500 CFA
Unskilled Labor:	225 hrs.
Semi-Skilled Labor:	6 hrs.
Salvage Value:	10,350 CFA
Lifetime:	4 years

Materials - wood, masonite, hose, aluminum foil, steel plate, galvanized wire, glass, sealant.

Figure IV. FLOW-THROUGH CABINET WITH ATTACHED COLLECTOR



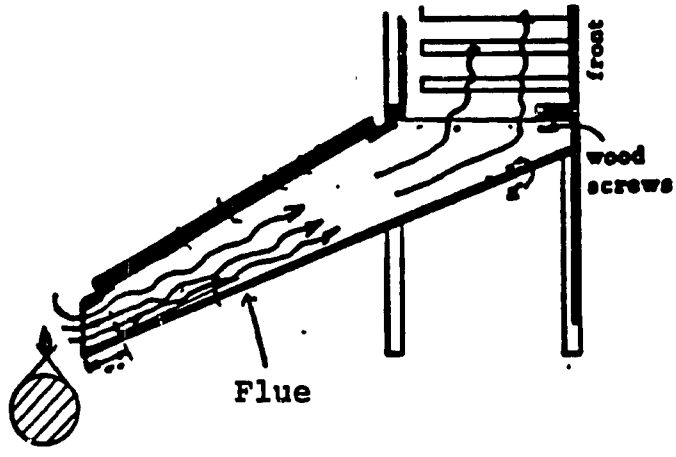
Description

The dryer is composed of a multilayered set of fish-drying racks coupled with a simple flat-plate solar collector as the heat source. Hot air (60-80°C) rises from the collector and circulates up through the fish. The fish are first dryed to 50% moisture content on the traditional rack fish dryer. They are then transferred to the cabinet where they are further dried to 20-25% moisture content. During this stage, parasites are killed.

Technical Characteristics

Scale:	100 lbs fresh fish/day
Capital Costs:	110,000 CFA
Unskilled Labor:	180 hours
Semi-Skilled Labor:	7 hours
Salvage Value:	33,000 CFA
Lifetime:	4 years

Figure V. FLOW-THROUGH CABINET WITH BURNER



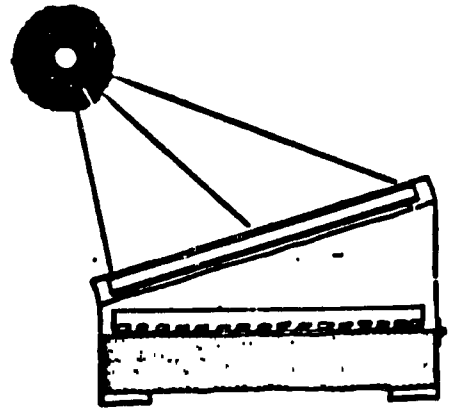
Description

The same as the preceding except that the solar collector is replaced with a propane or butane burner.

Technical Characteristics

Seale:	100 lbs fresh fish/day
Capital Cost:	46,000 CFA
Annual Fuel Cost:	
Unskilled Labor:	180 hours
Semi-Skilled Labor:	6 hours
Salvage Value:	13,800 CFA
Lifetime:	6 years

Figure VI. COMMERCIAL SOLAR CABINET DRYER



Description

The dryer is similar in design and construction to the small scale dryer, however, it is made to process 1 ton of fish per day.

Technical Characteristics

Scale:	2,000 lbs/day
Capital Cost:	621,000 CFA
Unskilled Labor:	4,050 hours
Semi-Skilled Labor:	132 hours
Salvage Value:	186,300 CFA
Lifetime:	4 years

3. Social and Cultural feasibility

Introduction

This feasibility was applied to data gathered specific to the village of Kayar. For the purposes of the case study a six-fold process took place.

Step 1. The analysts made themselves fully familiar with the technical and economic characteristics of the existing traditional and proposed five alternative technologies (see pages 7-13).

Step 2. They then reviewed the overall background of the village resulting from a previous energy related survey having taken place earlier (see pages 2-6).

Step 3. Upon return to the village the analysts queried village inhabitants on key questions contained in the Socio-Cultural Feasibility. (See Section V-Ways to use data).

Step 4. The analysts then summarized information obtained relevant to each heading.

Step 5. They offered specific conclusions germane to factors which would facilitate or impede adaption of the five proposed improved fish drying technologies.

Step 6. The team then examined the feasibility of each technique, taking into account the analytical conclusion reached beforehand.

Results from the last three steps are reported below.

Step 4: Summary of information by Heading

1. Technological and environmental adaptation

   A. Subsistance technology

   - Fishing. This activity represents about two thirds of the productive time during the six month peak fishing season. Labor is fully employed during that season.
   - Agriculture. Groundnuts and millet are cultivated. Vegetable gardening for subsistence purposes is performed by women, except for commercial vegetable cultivation, which is looked after by men.
   - Herding. Chickens and goats are kept and foodgrains are cultivated to feed animals.
   - Gathering. About 10% of food is gathered from the wild.

   B. Crafts

Crafts include brick making, textiles, and woodwork. However most of personal clothing is purchased. Most crafts are undertaken during the dry season.

   C. Traditional energy sources.

In terms of energy, most sources comprise human muscle and animal power (mostly donkeys). A certain amount of time is spent in case of donkeys.

   D. The cycle of the economic year.

The crop season takes place during the rainy period. During the dry non crop season, fishing is intensified. (July-December).

E. Transportation

Most transport is done by foot, with use of carts and boats. The frequency of trips depends on the time of the year. During the dry season, people travel more frequently and do so for economic and social reasons. People seldom travel further than Dakar, 60 kilometers away.

2. The Economic System

A. Allocation of productive resources.

- Land is held in hands of patrilocal extended family with residual land rights invested in the lineage.
- Tools, equipment, fishing boats (piroques) and fishnets are owned by men.
- Capital is held by individuals and is diffused among members of the kinship. There is a great tendency to redistribute what has been accumulated. Money is invested by giving it away to other family members. Money is then returned in case of emergencies or where the opportunity arises for some immediate benefit. Village male respondents are reluctant to state how much capital they own and what specific purposes they would allocate. However women villagers are more likely to talk about uses of money spent. Of the money that women earn, only 15-20% is retained for their own disposal. Some of these funds go for purchase of fabrics. Remaining earning are handed over to their husbands who allocate some portion for household expenses.

B. Organization of work

- Role of kinship: labor is organized largely through family relationships.
- Division of labor by sex: male tasks include fishing, clearing the land and planting. Female tasks include fish processing, weeding, gathering water, firewood, child care and livestock breeding. Both men and women harvest millet and groundnuts. Children help in weeding.
- Female children help the mother, while relatively more male children go to school.
- Wage labor. During the fishing season there is a shortage of labor. Therefore, male head of household employs outsiders from his own kin; often persons from other villages. However, extra laborers are attached only to that particular household. The wage rate for males is approximately 300 CFA per day, for paid labor, which does not usually exceed 20% of the labor force. Payment in food and lodging is also extended to outside laborers attached to the household.
- Labor migration is mostly directed toward Dakar. More than 25% of village young men are enticed to leave the village. Kayar is probably a transitional point of migration.

C. Distribution-Patterns of Consumption

- Millet is grown and rice is bought for self-consumption, whereas, fish is usually sold. In this particular village there is more reliance upon the organized market for food than would be the case in more isolated areas. Usually milk is bartered for fish.

D. Disposition of income

- Generally speaking the villagers are not very likely to reinvest what they earn in economic activities. Only outside entrepreneurs would be likely to invest in machinery.

3. The Social System

A. Kinship Organization

- Men are dominant decision makers and have total responsibility for the household. That is why 80-85% of women's earnings are handed over to men.
- Patrilocal, extended family.

B. Associations.

- "Groupments" have been established in the village to handle decisions on local household - oriented projects.
- Cooperatives have been formed to deal with specialized activities.

C. Stratification

Normally Wolof are the dominate ethnic group in numbers and status compared to Lebon. Both groups are fishing people.

4. The Political Organization.

A. Political Authority

- Maribouts, informal village influentials, constitute the most important and visible element of power. These persons dominate the Muslim Brotherhood.

- The Chief, head of the offical village council relies upon the Maribout for appointment in some instances. Retention of the Chief's power must be acceptable to the Maribout, who can validate what appears to be an unpopular decision made by the Chief.
- The dominant political party has a representative in Kayar. This individual has great access to outside information.
- Local fishing cooperative is dominated by powerful local males.
- The local "groupments" have an unclear effect on power and influence.

B. Legislation

- The Government has ultimate ownership of land, and has final rights of arbitration. However, because of increasing litigation resulting from ownership disputes, the Government tends to allow local interests settle cases.

5. The Belief System (all categories)

The religion of the village is Islam.

6. Languages

Wolof is the language in the village and should be used for all communication related to the project.

Step 5: Analytical conclusions

1. It is likely that unskilled male labor could substitute for unskilled female labor in the use of improved fish drying techniques, if males perceive higher labor status and income.

2. It is likely that there may be a greater use of semi-skilled male labor to construct and maintain the improved devices. In this case, male labor costs may go from 300 CFA per day to 450 CFA per day. Consequently, a sensitivity analysis was made on revaluing net benefits with increased labor cost (See pages 27-28 and 30).
3. It is likely that males will take a much stronger role in marketing the anticipated increasing amount of dried fish because of use of improved techniques. Consequently the relative influence of women may decrease. In any case male influentials, especially the Maribouts need to pass acceptance in adoption of new devices.
4. Increased labor requirements for the proposed improved techniques may tend to depress labor prices during the intensified season of fishing (dry, non-crop period), because of temporary in-migration of laborers from outside Kayar. However during the crop season while fishing continues, labor costs may rise to meet additional labor demands for fish drying.
5. Increased labor demands may change the existing proportion of outside laborers to Kayar village household members. This may have effects on the behavior of the existing local kinship system.
6. Increased female labor for the improved techniques may not be affordable because of competing heavy demands in female labor. But it is likely they will respond positively to greater income earning possibilities of more efficient fish drying.

7. As fish drying techniques become more sophisticated design, cost and operation, existing family ownership may pass into hands of outside merchants and entrepreneurs. This factor may impede progress on social equity, if that is considered a priority project objective. Similarly, when the scale of the devices increases, operation responsibilities may pass to associations dominated by interests not fully representative of the village.

8. There does not appear to be a great possibility that increased earnings derived from the improved devices will be reinvested for replacement. Neither is it expected that there will be any significant salvage value once the devices have been used up. Consequently a sensitivity analysis was made on revaluing net benefits, with a zero salvage value. (See pages 27-28 and 30).

9. Prices for dried fish may change not only necessarily because of economics of scale; but also, taste of final product may differ either adversely or better.

10. There will be generally a risk-averse cautious approach on use of unfamiliar techniques, where immediate benefits are not directly perceived, especially by the village women.

Step 6: <u>Socio-cultural feasibility for each fish drying technique</u>

Based on conclusions reached above, the following techniques were assessed.

1. Rack/Screen Fish Dryer

   Acceptable, but characteristics are so close to that of the traditional fish dryer, that a discrete socio-cultural analysis is not necessary.

2. Solar Cabinet Dryer (100 lbs)

   Acceptable, on the condition that women who use it have a financial interest.

3. Flow through cabinet with attached collector; and

4. Flow through cabinet with burner

   Acceptable, but there is danger that women will be excluded. As system becomes more complex, males in household may take over operation and decision making. This may create social tension.

5. Commercial Solar Cabinet Dryer

   Unacceptable because of the large capital outlay, which few families could afford. Therefore outside entepreneurs would tend to own dryers. As there are outside persons, there may be a social issue as a result.

4. Cost Benefit Analysis

A. Cost Benefit Assumptions

Two sets of assumptions, methodological and technical, are defined for this cost-benefit analysis. The methodological assumptions used in simplifying the evaluation of costs and benefits have been explained in Section V. It should be mentioned that all the fish drying technologies considered in this case study are assumed to be mutually exclusive, with the choice of one technology eliminating the use of all other technologies.

The technical assumptions defined for this case study are:

- Dried fish produced in the Solar Cabinet Dryer (100 lbs.), Commercial Solar Cabinet Dryer and Flow-Through Cabinets (solar and burner) is of higher quality than the traditional fish dryer and Screen/Rack Fish Dryer.
- Dried fish produced in the Screen/Rack Fish Dryer is of equal quality as the dried fish produced with the Traditional Fish Dryer.
- Higher dried fish quality will result in higher market prices for the product.
- Spoilage rates for fish dried in Solar Cabinet Dryer (100 lb.), Commercial Solar Cabinet Dryer and Flow-Through Cabinets (sol [illegible] d burner) were five percent by weight of the [illegible] raw fish input.
- The spoilage rate for the fish dryer and the [illegible]creen/ [illegible]ack [illegible]ish [illegible]ryer is fifteen percent by weight of the raw fish input.

- The quantity of dried fish produced in all technologies, except for the Traditional Fish Dryer and the Screen/Rack Fish Dryer is twenty-one percent by weight of the raw fish input (based on calculations for a twenty-five percent moisture content after drying).
- The quantity of dried fish produced in the Traditional Fish Dryer and the Screen/Rack Dryer is thirty percent by weight of raw fish input (based on a fifty percent moisture content after drying).

These assumptions are made to simplify the technical data base and are not expected to have an appreciable effect on the relative value of costs and benefits for these technologies.

B. Identification of Costs and Benefits

(1) Technical Data Base

Based on information provided by experts familiar with the fish drying technologies being considered in this case study, a description of the important technical characteristics for each technology was developed (see Tables A-1 through A-6). These technical characteristics can be categorized as follows:

- Land requirements
- Capital costs
- Scale
- Length of fish drying season

- Raw fish inputs
- Fuel requirements
- Salt consumption
- Storage sacks requirements
- Labor skills
- Dried fish output
- Salvage value
- Technology lifetime

Land requirements, the length of the fish drying season, salt consumption and the quantity of storage sacks consumed were considered to be equal for all technologies. Materials used in maintenance of the technologies were too few to be included in the technical data base. Labor for all technologies was categorized at two levels of skills. Unskilled labor (i.e., cleaning fishing, turning the fish while drying, packaging, washing, the fish racks, etc.) is assumed to be the traditional domain of the village's female population. Semi-skilled labor (i.e., routine maintenance, carpentry, etc.) is the traditional role of the men in the village. The remaining data categories differed by each technology device.

(2) Economic Data Base

From data provided by experts familiar with the national economy of Senegal and with the economy of Senegal's coastal villages, prices were obtained for all inputs and outputs consumed in these fish drying technologies (see Table A-7). Prices are given in CFA Francs.

The shadow price for labor was measured from the yearly paid wages of coastal villagers, and was calculated to be one-half the market wage rate. As an approximation, shadow prices for capital, raw fish, dried fish and storage sacks were considered to be equal to their market price. Because the devices will be manufactured locally and there will be no imported materials used in their construction. All inputs will be bought locally, and outputs will be consumed locally; hence, domestic market prices prevail.

Costs and benefits can now be quantified for each device based on technical and economic data provided in Tables A-1 through A-7. These costs and benefits are categorized below:

<u>Costs</u>

- Capital
- Land
- Operating
  - Raw fish
  - Fuel
  - Storage sacks
  - Labor
  - Salt

<u>Benefits</u>

- Value of dried fish produced.
- Salvage value of technology.

C. Evaluating the Technologies

An economic and financial cost-benefit analysis was calculated for each technology using net present value (NPV) and the internal rate of return (IRR) as measures of investment worth. Since the fish drying technologies are considered to be mutually exclusive, cash flows for each alternative device were subtracted from the cash flow of the traditional fish dryer. Differences in cash flows were then evaluated in terms of net present value and internal rate of return (see Tables A-8 and A-17). Evaluating these differences provides a measure of the value of investing additional resources into a new device. Note that with this procedure, costs for land, salt, raw fish and storage sacks would be cancelled out among technologies and would not be included in the cash flow tables.

D. Sensitivity Analysis

Based on the conclusions of the socio-cultural feasibility of the village, several events could occur that would change the costs and benefits associated with these fish drying technologies.

- Men would perform the unskilled labor role in these technologies in place of women if they perceive that the technologies offer high labor status or higher income. Thus, men might expect to earn a higher wage rate than that of women.
- Devices could wear out within the lifetime of the project. This would imply that these techniques would have a zero salvage value.

- Capital costs could increase if these alternative technologies became in great demand. Increased capital costs would result in a lower investment worth for all of the alternative technologies.
- Prices for dried fish are established on the basis of local tastes and product quality. If villagers perceive a difference in the taste of the dried fish produced by alternative technologies, prices for this product would change.

To test the effects of these events on costs and benefits, sensitivity analyses were performed on labor, capital costs, salvage value and the price of dried fish. Unskilled labor components for the alternative devices was valued at 500 CFA/day instead of the 200 CFA/day originally used. Salvage values were considered to be zero. Investment costs were increased by twenty percent, and the price for dried fish was assumed to decrease by four percent.

E. Summary of Results and Conclusions

Both the 100-pound and the one ton capacity commercial solar cabinets were judged to be acceptable investments under both economic and financial analyses. The Flow-Through Cabinet with attached solar collector is a marginally acceptable investment under the economic analysis and a bad investment under a financial analysis. The Flow-Through Cabinet Dryer with attached burner and the Screen/Rack Fish Dryer are clearly bad investments for both the economic and financial analyses.

TABLE 1

Results of Cost-Benefit Analysis of Fish Drying Technologies for Kayar

	Cost-Benefit Analysis					
	Economic			Financial		
Technology	NPV (CFA)	IRR	Decision	NPV (CFA)	IRR	Decision
1. Rack/Screen Fish Dryer	-1,882	No	No	-1,656	No	No
2. Solar Cabinet Dryer (100 lb)	55,317	>50%	Yes	32,150	>50%	Yes
3. Flow-Through Cabinet with Attached Collector	3,241	12%	Yes	-15,801	10%	No
4. Flow-Through Cabinet with Burner	-110,083	No	No	-58,443	No	No
5. Commercial Solar Cabinet	1,145,986	>50%	Yes	699,643	>50%	Yes

The results of the sensitivity analysis for labor, capital costs and salvage value indicated that the 100-pound capacity Solar Cabinet and the one-ton Commercial Solar Cabinet would remain good investment choices, while the Flow-Through Cabinet with attached collector and the Screen/Rack Fish Dryer would be considered as bad investments under both the economic and financial analyses (see Tables 2-4).

TABLE 2

Sensitivity Analysis of Labor

Assume men will perform unskilled labor at 500 CFA/day

Technology	% Increase in Labor Costs	Economic NPV(CFA)	% Decrease in Economic NPV	Financial NPV(CFA)	% Decrease in Financial NPV
1. Screen/Rack Dryer	149%	-5805	208%	-5105	208%
2. Solar Cabinet Dryer (100lb)	283%	42,649	23%	12,073	62%
3. Flow-Through Cabinet with Collector	337%	-7,526	332%	-36,468	130%
4. Flow-Through Cabinet with Burner	330%	-138,300	125%	-84,271	44%
5. Commercial Solar Cabinet	298%	905,216	21%	341,032	51%

TABLE 3

Sensitivity Analysis for Salvage Value

Assume salvage value for all technologies is zero

Technology	Economic NPV(CFA)	% Decrease in Economic NPV	Financial NPV(CFA)	% Decrease in Financial NPV
1. Screen/Rack Dryer	-20%	11%	-1840	11%
2. Solar Cabinet Dryer (100lb.)	48,269	13%	27,907	13%
3. Flow-Through Cabinet with collector	-19,231	693%	-29,331	85%
4. Flow-Through Cabinet with Burner	-117,866	7%	-60,685	4%
5. Commercial Solar Cabinet	1,018,744	11%	623,260	11%

TABLE 4

Sensitivity Analysis of Capital Investment

Assume 20% increase in capital cost for technology

Technology	Economic NAV(CFA)	% Decrease in Economic NPV	Financial NPV (CFA)	% Decrease in Financial NPV
• Screen/Rack Dryer	-2390	27%	-2104	27%
• Solar Cabinet Dryer (100 lb.)	49,135	11%	26,630	17%
• Flow-Through Cabinet with Collector	-16,757	617%	-33,401	111%
• Flow-Through Cabinet with Burner	-118,445	8%	-65,803	12%
• Commercial Solar Cabinet	1,033,271	10%	600,443	14%

All alternative technologies would be considered as bad investments if the price of dried fish would decline by four percent (see Table 5). This information indicates that the alternative technologies are very sensitive to small changes in the price of dried fish. It is important that those factors that influence the price of dried fish be examined thoroughly prior to final selection of technology.

TABLE 5

Sensitivity Analysis of the Price of High Quality of Dried Fish

Assume that the price for high quality dried fish decreases by 4%

Technology	Economic NPV(CFA)	% Decrease in Economic NPV	Financial NPV (CFA)	% Decrease in Financial NPV
• Screen/Rack Dryer	N/A	N/A	N/A	N/A
• Solar Cabinet Dryer(100lb.)	-17,254	131%	-20,382	163%
• Flow-Through Cabinet with Collector	-67,278	2175%	-68,297	332%
• Flow-Through Cabinet with Burner	-206,854	88%	-124,052	112%
• Commercial Solar Cabinet	-249,413	121%	-340,410	148%

In conclusion, the cost-benefit analysis of fish drying technologies demonstrates that two technologies should be selected for field testing; the 100-pound capacity solar cabinet dryer and the one-ton capacity solar cabinet dryer. These technologies have high net present values and internal rates of return and are insensitive to reasonable fluctuations in labor, capital costs and salvage value. The Screen/Rack Dryer, the Flow-Through Cabinet with attached collector and the Flow-Through Cabinet with attached burner are sensitive to changes in labor, capital costs and salvage value and would be clearly bad investments. These technologies should not be selected for field testing.

Appended Tables to Cost Benefit Analysis

Table A1. Technical Data for Traditional Technology

Data Category	Quantity
1. Scale	100 lbs of fresh fish/day
2. Length of Season	180 days
3. Capital Costs	1,150 CFA
4. Land Required for Siting	$5m^2$
5. Raw Material Inputs (per year)	
a) Raw Fish	18,000 lbs
b) Fuel	0
c) Caulking Gums (locally made)	0
d) Storage Sacks (1 sack/100 lbs of raw fish/day)	180 sacks
e) Salt (½ lb/100 lbs of raw fish/day)	90 lbs
6. Labor	
a) Unskilled	115
b) Semi-skilled	1
7. Output (Dried fish)	5,400 lbs
8. Salvage value (10% of capital cost)	115 CFA
9. Technology Lifetime	1 year

Table A2. Technical Data for Screen/Rack Dryer

Data Category	Quantity
1. Scale	100 lbs of fresh fish/day
2. Length of Season	180 days
3. Capital Costs	3,450 CFA
4. Land Required for Siting	$5m^2$
5. Raw Material Inputs (per year)	
a) Raw Fish	18,000 lbs
b) Fuel	0
c) Caulking Gums (locally made)	0
d) Storage Sacks (1 sack/100 lbs of raw fish/day)	180 sacks
e) Salt (½ lb/100 lbs of raw fish/ day)	90 lbs
6. Labor	
a) Unskilled	115
b) Semi-skilled	1
7. Output (Dry Fish)	5,400 lbs
8. Salvage Value (10% of capital cost)	345 CFA
9. Technology Lifetime	1 year

Table A3. Technical Data for Solar Cabinet Dryer (100 lb.)

Data Category	Quantity
1. Scale	100 lbs of fresh fish/day
2. Length of Season	180 days
3. Capital Costs	34,500 CFA
4. Land Required for Siting	$5m^2$
5. Raw Material Inputs (per year)	
a) Raw Fish	18,000 lbs
b) Fuel	0
c) Caulking Gums (locally made)	1 lb
d) Storage Sacks (1 sack/100 lbs of raw fish/day)	180 sacks
e) Salt (½ lbs/100 lbs of raw fish/day	90 lbs
6. Labor	
a) Unskilled	225 hrs.
b) Semi-skilled	6 hrs
7. Output (Dry Fish)	3,780 lbs.
8. Salvage Value (30% of capital cost)	10,350 CFA
9. Technology Lifetime	4 yrs

Table A4. Technical Data for Flow-through Cabinet with Attached Solar Collector

Data Category	Quantity
1. Scale	100 lbs. of fresh fish/ day
2. Length of Season	180 days
3. Capital Costs	110,000 CFA
4. Land Required for Siting	$5m^2$
5. Raw Material Inputs (per year)	
a) Raw Fish	18,000 lbs
b) Fuel	0
c) Caulking Gums (locally made)	1 lb
d) Storage Sacks (1 sack/100 lbs of raw fish/day)	180 sacks
f) Salt (½ lbs/100 lbs of raw fish/day)	90 lbs
6. Labor	
a) Unskilled (1 hr/day)	180 hrs
b) Semi-skilled	7 hrs
7. Output (Dry Fish)	3,780 lbs
8. Salvage Value (30% of capital cost)	33,000 CFA
9. Technology Lifetime	4 yrs

Table A5. Technical Data for Flow-through Cabinet with Burner

Data Category	Quantity
1. Scale	100 lbs of fresh fish/day
2. Length of Season	180 days
3. Capital Costs	46,000 CFA
4. Land Required for Siting	$5m^2$
5. Raw Material Inputs (per year)	
a) Raw Fish	18,000 lbs
b) Fuel (Butane)	144 lbs
c) Caulking Gums (locally made)	1 lb
d) Storage Sacks (1 sack/100 lbs of raw fish/day	180 sacks
e) Salt (½ lbs/100 lbs of raw fish/day	90 lbs
6. Labor	
a) Unskilled	180 hrs
b) Semi-skilled	6 hrs
7. Output (Dried Fish)	3,780 lbs
8. Salvage Value (30% of capital costs)	13,800
9. Technology Lifetime	6 years

Table A6. Technical Data for Commercial Solar Cabinet

Data Category	Quantity
1. Scale	2000 lbs of fresh fish/day
2. Length of Season	180 days
3. Capital Costs	621,000 CFA
4. Land Required for Siting	$100m^2$
5. Raw Material Inputs (per year)	
a) Raw Fish	360,000 lbs
b) Fuel	0
c) Caulking Gums (locally made)	20 lbs
d) Storage Sacks (1 sack/100 lbs of raw fish/day)	3600 sacks
e) Salt (½ lb/100 lbs of raw fish/day)	1800 lbs
6. Labor	
a) Unskilled	4040 hrs
b) Semi-skilled	132 hrs
7. Output (Dried Fish)	75,600 lbs
8. Salvage Value (30% of capital costs)	186,300 CFA
9. Technology Lifetime	4 years

Table A7. Economic Data for All Fish Drying Technologies

1.	Raw Fish Prices	24.5 CFA/lb
2.	Butane Prices	230 CFA/lb
3.	Caulking Gums Prices	100 CFA/lb
4.	Storage Sacks	115 CFA/Sack
5.	Salt	16 CFA/lb
6.	Unskilled Labor (women)	200 CFA/day (25 CFA/hr)
7.	Semi-Skilled Labor (men)	500 CFA/day (62.5 CFA/hr)
8.	Dried Fish	
	a) High quality	147 CFA/lb
	b) Average quality	98 CFA/lb
9.	Shadow Price for Labor	½ market wage rate
10.	Shadow Price for Butane	300 CFA/lb

Table A8. Financial Analysis of Screen/Rack Dryer (in CFA)

	Year 1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	0					
Salvage Value	230					
-Costs						
Capital	2,300					
Labor	0					
=Net Benefits	-2,300					
xDiscount Factor (25%)	.800					
=Present Value	-1,656					

NPV = -1,656 CFA

IRR = Negative

Table A9. Economic Analysis of Screen/Rack Dryer (in CFA)

	Year 1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	0					
Salvage Value	230					
-Costs						
Capital	2,300					
Labor	0					
=Net Benefits	-2,070					
xDiscount Factor (10%)	.909					
=Present Value	-1,882					

NPV = -1,882 CFA

IRR = Negative

Table A10. Financial Analysis of Solar Cabinet Dryer (100 lb.) (in CFA)

	Year 1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	26,500	26,500	26,500	26,500		
Salvage Value	--	--	--	10,350		
-Costs						
Capital	34,500	--	--	--		
Labor	3,000	3,000	3,000	3,000		
=Net Benefits	-11,000	23,500	23,500	33,850		
xDiscount Factor (25%)	.800	.640	.512	.410		
=Present Value	-8,800	15,040	12,032	13,878		

NPV = 32,150 CFA

IRR = 750%

Table A11. Economic Analysis of Solar Cabinet Dryer (in CFA)

	1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	26,500	26,500	26,500	26,500		
Salvage Value	--	--	--	10,350		
-Costs						
Capital	34,000	--	--	--		
Labor	1,500	1,500	1,500	1,500		
=Net Benefits	-9,000	25,000	25,000	35,350		
xDiscount Factor (10%)	.909	.826	.751	.681		
=Present Value	-8,181	20,650	18,775	24,073		

NPV = 55,317 CFA

IRR = 750%

Table A12. Financial Analysis for Flow-through Cabinet with Attached Solar Collector (in CFA)

	Year 1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	26,500	26,500	26,500	26,500		
Salvage Value	--	--	--	33,000		
-Costs						
Capital	110,000	--	--	--		
Labor	2,000	2,000	2,000	2,000		
=Net Benefits	-85,500	24,500	24,500	57,500		
xDiscount Factor (25%)	.800	.640	.512	.410		
=Present Value	-67,600	15,680	12,544	23,575		

NPV = -15,801 CFA

IRR = 10%

Table A13. Economic Analysis for Flow-through Cabinet with Attached Solar Collector (in CFA)

	1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	26,500	26,500	26,500	26,500		
Salvage Value	--	--	--	33,000		
-Costs						
Capital	110,000	--	--			
Labor	1,000	1,000	1,000	1,000		
=Net Benefits	-84,500	25,500	25,500	58,500		
xDiscount Factor (10%)	.909	.826	.751	.681		
=Present Value	-76,810	21,063	19,150	39,838		

NPV = 3,241 CFA

IRR = 12%

Table A14. Financial Analysis of Flow-through Cabinet with Burner (in CFA)

	Year 1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	26,500	26,500	26,500	26,500	26,500	26,500
Salvage Value	--	--	--	--	--	13,800
-Costs						
Capital	46,000	--	--	--	--	--
Labor	1937	1937	1937	1937	1937	1937
Butane	33,120	33,120	33,120	33,120	33,120	33,120
=Net Benefits						
xDiscount Factor (25%)	.800	.640	.512	.410	.328	.262
=Present Value	-43,645	-5,476	-4,381	-3,508	-2,806	1,373

NPV = -58,443 CFA

IRR = NEGATIVE

Table A15. Economic Analysis of Flow-through Cabinet with Burner (in CFA)

	Year 1	2	3	4	5	6
Benefits						
Additional Value of Fish Sold	26,500	26,500	26,500	26,500	26,500	26,500
Salvage Value	--	--	--	--	--	13,800
-Costs						
Capital	46,000	--	--	--	--	
Labor	968	968	968	968	968	968
Butane	43,000	43,000	43,000	43,000	43,000	43,000
=Net Benefits						
xDiscount Factor (10%)	.909	.826	.751	.683	.621	.564
=Present Value	-57,692	-14,428	-13,118	-11,930	-10,847	-2,068

NPV = -110,083

IRR = NEGATIVE.

Table A16. Financial Analysis of Commercial Solar Cabinet (in CFA)

	1	2	3	4
Benefits				
Additional Value of Fish Sold	525,000	525,000	525,000	525,000
Salvage Value	-	-	-	186,300
-Costs				
Capital	621,000	-	-	-
Labor	50,800	50,800	50,800	50,800
=Net Benefits	-146,800	474,200	474,200	660,500
xDiscount Factor (25%)	.800	.640	.512	.410
=Present Value	-117,440	303,488	242,790	270,805

NPV = 699,643

IRR = 750%

Table A17. Economic Analysis of Commercial Solar Cabinet (in CFA)

	1	2	3	4
Benefits				
Additional Value of Fish Sold	525,000	525,000	525,000	525,000
Salvage Value	-	-	-	186,300
-Costs				
Capital	621,000	-	-	-
.Labor	25,400	25,400	25,400	25,400
=Net Benefits	-121,400	499,600	499,600	685,900
xDiscount Factor (10%)	.909	.826	.751	.683
=Present Value	-110,352	412,670	375,200	468,470

NPV = 1,145,986

IRR = 750%

5. Final selection of techniques for field testing

It was concluded that the solar cabinet dryer should be field tested, with note taken that this device is negatively sensitive to even small changes in price. Table 6 below summarizes all analyitical techniques applied to each device under consideration.

Table 6. Summary of both analyses by technology

	Rack/Screen Fish Dryer	Solar Cabinet Dryer	Flow through cabinet with attached collector	Flow through cabinet with burner	Commercial Solar Cabinet Dryer
1. Socio-cultural	+	+	+	+	-
2. Cost-benefit					
a. Financial	-	+	-	-	+
b. Economic	-	+	+	-	+
c. (Sensiti					
(1) Labor	-	+	-	-	+
(2) Salvage	-	+	-	-	+
(3) Capital	-	+	-	-	+
(4) Price	-	-	-	-	-