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SMALL SCALE ENERGY ACTIVITIES IN INDIA AND BANGLADESH - TRIP REPORTS - MARCH 17-31, 1977 AND APRIL 3-14, 1977

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Energy Laboratory Working Paper No. MIT-EL-77-025WP

August 31, 1977

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The material presented in the trip reports which follow is a direct outgrowth of work initiated by Douglas V. Smith for the Massachusetts Institute of Technology/Lincoln Laboratory Photovoltaic Project entitled Photovoltaic Power in Less Developed Countries*. The previous work analyzed the potential for the use of photovoltaics in rural settings in Africa and South Asia, comparing this technology with such other energy sources as diesel power and gridded electricity. The trip reports which follow are an effort to further explore in rural areas of India and Bangladesh the potential for the use of on-site electric generation facilities and to identify individuals and research centers involved in rural energy research and development.

The work reported here was carried out in conjunction with travel activities by Dr. Smith funded through the Asia Society. It was funded by the MIT Lincoln Laboratory under contract to the Photovoltaic Branch of ERDA and was coordinated by Dr. Richard Tabors of the Energy Laboratory, Massachusetts Institute of Technology.

The trip reports are self-explanatory and should be read in conjunction with Dr. Smith's earlier work. We have attached below a summary glossary of terms used.

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* Douglas V. Smith, Photovoltaic Power in Less Developed Countries, The MIT Lincoln Laboratory, Working Paper No. COO-4094-1, March 24, 1977.

GLOSSARY

Rs. (Rupee) - In India Rs. 8.8 equivalent to U.S. $1.00
Tk. (Taka) - In Bangladesh Tk.14-15 equivalent to U.S. $1.00

Paisa - one one-hundredth of a Rupee or a Taka

Thana - small unit of government in Bangladesh roughly equivalent to a county in the United States

Lakh - .1 million (100,000)
Crore - ten million (10,000,000)

Maund - 82.29 pounds, 37.3 kilograms

HA. - Hectare

kWht - Kilowatt Hour Thermal
kWhe - Kilowatt Hour Electric

NCAER - National Council of Applied Economic Research (India)

IIM - Indian Institute of Management

TRIP REPORT-MARCH 17-31, 1977
BANGLADESH

Douglas V. Smith

Extensive discussions have been held with Bangladesh officials, researchers, and foreign advisors to ascertain the following:

a) status of rural energy policy,

b) status of rural electrification,

c) ongoing research into appropriate rural energy technology, and

d) recent (last two years) data acquisition efforts.

In addition, visits were made to rural areas of Comilla and Chittagong Districts to see first hand rural energy use and an experimental biogas unit.

Discussions have been held with the following people:

1) Dr. Abdullah Farouk, member, Bangladesh Planning Commission;

2) Dr. Shahadatullah, Bangladesh Planning Commission;

3) Dr. Abdus Samad, director, Institute of Statistical Research and Planning, University of Dacca;

4) Dr. Mohiuddin Alamigir, research director, Bangladesh Institute of Development Studies;

5) Dr. Muhammad Yunus, director, Rural Studies Project, Department of Economics, University of Chittagong;

6) Mr. Mohibbur Rahman, Instructor in Agricultural Engineering, Bangladesh Academy for Rural Development;

7) Mr. A.T.M. Aminul Islam, Chief Engineer (Planning), Bangladesh Water Development Board;

8) Mr Merrick Lockwood, Appropriate Agricultural Technology Cell, Bangladesh Agricultural Research Council;

9) Dr Joseph Stepanek, economist, USAID/Dacca;

10) Mr J. Gardner, engineer, USAID/Dacca;

11) Mr Paul Stary, Commonwealth Associates Rural Electrification Study, Dacca;

12) Mr Edward Gaither, National Rural Electric Co-operative Association, Dacca;

13) Dr John Briscoe, Cholera Research Laboratory; and

14) Dr Stephen Biggs, Ford Foundation.

General impressions were the following:

1) There have been collected and analyzed few new data since the Bangladesh Energy Study work in 1975.

2) There is now more interest in alternative energy technology with speeches by General Zia on biogas, operating units in Comilla and at CSIR, Dacca, and an active program under the direction of Dr. Nurul Islam of the Engineering University, Dacca. Comilla's Academy for Rural Development plans 3 - 4 plants for co-operative societies next year and the Cholera Hospital, Matlab, also plans to build a plant in a village of the Thana. There is also interest, but no action, at the Agricultural Research Council in small steam engines utilizing rice husks for milling.

3) Handpump technology for irrigation water lifting continues to dominate foreign thinking on appropriate tubewell technologies (with continued interest in the Indian-type bamboo tubewells) but that bandwagon seems to be slowing down with the realizations that:

a) its damn hard work and inefficient to boot so that it is expensive at any reasonable wage rate and even at value of rice needed to power the worker;

b) lower price of rice prevailing now is making farmers more cautious about such investments;

c) a great deal of imported iron is needed for manufacture;

d) and even with such a "low" technology the benefits still flow primarily to landlords and owners of the larger farms.

4) The entire deep tubewell program is deep in trouble; expansion of low lift pumps has ceased. Local manufacture of diesel engines of low (600-800 rpm) or medium (1500 rpm) speeds is not occurring although the Agricultural Research Council is interested in introducing the latter from India.

5) Rural electrification continues to be a catch phrase of considerable emotional appeal among politicians, generals and power engineers. There is no evidence of the development inducing effects of rural electrification in Bangladesh although there have been monitored projects since 1963. In any event, rural electrification in practice means electrification of town centers, lights and fans for the influential, and volumes of talk about energizing tubewells. A few merchants and small industries are able to receive the subsidized electricity as well but there is no evidence that their expansion or location decisions are influenced by the presence of electricity.

6) Energy problems of the rural poor overshadow all other energy problems in my mind but receive almost no government or foreign aid attention.

The ongoing Rural Electrification Study has been required by USAID before U.S. financing of a rural electrification scheme proposed by the Power Development Board. Work is in progress so it was not possible to discuss actual findings or recommendations of the study.

Two data collection efforts were undertaken by Bangladesh institutions to provide information to the foreign study team. The Academy for Rural Development, Comilla, has published results of "A Survey on the use of Electricity in Comilla Rural Kotwali" which is an area where rural electrification began in 1963. The survey shows that: (a) less than 5 per cent of the rural population of this thana use electricity for any purpose, (b) 82 per cent of connections go to businessmen, civil servants and farmers with more than two acres of land owned (larger farmers in other words), (c) two-thirds of connections are to homes and 22 per cent to shops, (d) most (77 per cent) of connections are for lights but most of connected load (about 80 per cent) is for tubewells, (e) very little electricity is consumed for productive uses other than powering tubewells although the survey was conducted in such a way that it is impossible to be more precise about use of electricity in small agro-industries such as rice mills.

In February the Institute for Statistical Research and Training of Dacca University began a survey of socio-economic conditions with emphasis on energy use. This survey has been completed but results are not yet tabulated. Six thousand households and 1200 commercial/industrial establishments in 12 thana were surveyed by questionnaire. One hundred and four investigators did the job in seven weeks. The survey was not designed to ascertain current fuels used but rather ability of households and establishments to pay. Thus no attempt was made to determine total quantities of fuels consumed but only those fuels for which cash payment was made. For those thana bazaars surveyed and now electrified, data on current consumption patterns will be available.

BARD has also recently completed a study "Use of Diesel and Electrically Operated Pumps for Irrigation." Although the economics is hopeless (e.g., price of electricity to consumers is taken as cost of electricity) the report does contain useful information on costs (including "bribes and entertainment"), maintenance frequency and duration of outages, and acreages covered. The study is based on a random sample of 20 (out of 165) diesel tubewells and 20 (out of 75) electric tubewells. Salient points are (a) the weight of diesel pumpsets is an important factor in transport costs (the sets are removed from site every year) and in transport/handling damages, (b) electric supply failure was the major cause of inability to operate motors but diesel units broke down three times as often and took twice as long to repair each breakdown, (c) diesel engine repair costs, however, are only 30 per cent above electric system repair costs on a total-annual-bill basis, (d) electric pumpsets operate on the average 33 per cent more hours than diesel pumpsets. (e) electric units averaged 24 days a year idle (mostly due to power failure) while diesel units averaged 32 days a year idle (mostly due to repairs).

Current cost of subtransmission line extension is U.S.$10,000 - 12,000 per mile. Commonwealth Associates estimate this cost can be halved by using single phase lines and wooden poles. They suggest locating these lines along roads at irrigation pumps with 1 - 2 sub-stations per thana. If this cost reduction can be effected cost per meter of connection will be $350 with a reduction in 15 years to $100 - 150 if 50 per cent of residences take service. (Average connection distance is 15 miles). They estimate irrigation load will quadruple in 15 years based on IECO projections of numbers of tubewells as part of IECO's

Farakka crash study. All assumptions in the Commonwealth Associates rural electrification study are very optimistic and frankly so.

The furthest distance at the moment from the grid to a village in Bangladesh is nearly 60 miles - from Bakerganj to a far south village in Patuakhali District. The islands, however, are effectively cut off from the grid for a long time and must depend on auto-generation by diesel generators for limited electric service. Hatia, Sandwip, Bhola, etc. should be prime areas for interest in solar (and wind) power.

Finally, rural energy use studies underway or planned include the Cholera Laboratory's intensive micro study of village energy use by John Briscoe, the women's time study (including fuel collection) by Bureau of Economic Research, University of Dacca, that is a followup to A. Farouk's "The Hardworking Poor"; and a rural energy use study proposed by the Energy Study and recently requested by the Planning Commission.

TRIP REPORT - April 3-14, 1977 - INDIA

Douglas V. Smith

My itinerary in India was as follows:

1. April 4-5, Indian Institute of Science, Bangalore
   a) Prof. Amulya K. N. Reddy, secretary, Karnataka Council of Science and Technology; convener, Cell for Application of Science and Technology to Rural Areas (ASTRA); UNEP consultant on appropriate technology;
   b) Dr. D. K. Subramanian, ASTRA; energy plantations;
   c) Mr. Rama Prasad, ASTRA, water lifting technology;
   d) Prof. D. P. Sengupta, electrical engineering department, Karnataka State Electrical Distribution Study;
   e) Prof. Somasekhera, economist, energy use study of 5-6 villages in Karnataka.

2. April 7, Ahmedabad
   a) Mr. Vimal Shah, Director, Gujarat Institute for Area Planning;
   b) Dr. Nitin Patel, Indian Institute of Management, rural energy use studies.

3. April 9, Baroda, Jyoti Industries:
   a) Mr. Nanubhai B. Amin, Chairman of Board, Jyoti Ltd.,
   b) Mr. J.S. Negi, General Manager, R&D
   c) Dr. B. C. Jain, R&D officer, energy systems

4. April 11-14, Delhi:
   a) Dr. Ramesh Bhatia, Assoc. Prof., Institute of Economic Growth;
   b) Dr. V. Ranganathan, Senior Planning Engineer, National Thermal Power Corporation;

c) Dr. K. Venugopal, Director; Mr. I. Natrajan, Senior Economist; Mr. P. P. Pangotra, Junior Economist; National Council of Applied Economic Research (rural energy use survey and rural electrification studies);

d) Dr. Lalit Sen, Chief, Research and Evaluation, Rural Electrification Corporation;

e) Mr. S. B. Saharya; joint director; Mr. S. N. Dar, joint director (statistics); Mr. V. V. Jutley, deputy director, Mr. P.N. Deb, assistant director; Programme Evaluation Office, Planning Commission (rural electrification and groundwater Development evaluation studies);

f) Dr. R. K. Sharma, Institute of Agricultural Economics Research, University of Delhi.

The following topics were made foci of discussions.

1. What is the appropriate conceptual approach to compare alternative energy technologies? How can rural electrification be compared with decentralized alternatives?
2. What new data are available or are being collected regarding energy use in rural India?
3. What are comparative costs of water lifting by diesel, electricity, human/animal power, and alternatives such as biogas?
4. What are rural electrification costs, reliability, and power losses?
5. What has been the impact of rural electrification on villages/regions so electrified?
6. What are the economics and recent technological developments of "new" energy alternatives; such as, soft coke for village fuel, energy plantations, biogas, and micro-hydropower?

7. What institutions in India might be interested in collaborating with Lincoln Labs on a field test?

The ASTRA group in Bangalore is perhaps the most interesting group in India of scientists and engineers devoting a considerable effort to technological developments of use to rural people. Not only are they inventors but they appreciate the value of basing decisions on correct information and sound analysis. As a consequence, the group is now in the forefront of micro-level rural energy studies based on measurement and observations of quantities, times and sources. ASTRA has adopted a village over 100 km from Bangalore and is conducting ecosystems studies of 5-6 villages in the vicinity. Prof. A.K.N. Reddy is about to take up residence in the village.

A preliminary energy survey of several villages based on questionnaires has been completed and the results analyzed. As a result of that survey, a number of difficulties with the questionnaire and with the approach have been identified and a series of re-surveys is under design. The work will include experiments on chula efficiencies. In the one village (electrified) for which data tabulation is complete, over 90 percent of total energy use (including human and animal power) is firewood for cooking. No dung is burnt in this village.

ASTRA is undertaking a study of the dynamics of the LT electrical system in Karnataka: who benefits from electrification and where, and how an area's growth is affected by the availability of electricity. The study will be completed in about two month's time but already it is obvious that rural electricity is for the relatively rich households in better-off areas and that its impact on development in the absence of a considerable development infrastructure is negligible.

Amulya Reddy and his colleague Krishna Prasad, currently on sabbatical, point out that rural electricifcation authorities plan for about 105 kwh per day for a village of about 100 houses and 500 persons. This is assumed used as: 75 kwh for 10 pumpsets, 20 kwh for 2 industries, and 10 kwh for lighting (15 domestic light, 3 commercial, 1 street light and 85 houses without electricity). Such an estimate of electricity demand is based on ability to purchase power and is independent of needs which are many times higher.

Reddy and Prasad estimate that the current per capita consumption of commercial plus non commercial energy in such a village is 6.5 kwht per day or 3200 kwht per day for 500 persons. 2400 kwht per day for cooking (.5 kwe/house for 4 hours per day at 25 percent efficiency), 200 kwht for 10-5 horsepower pumpsets (from 1974-75 all-India averages), and 375 kwht for lighting and other activities (25 watts per house for 3 hours at 2 percent efficiency).

It is encouraging that a major concern of Reddy and his colleagues is the labor requirement not only for agricultural operations but also for such activities as gathering fuels. Such time requirements have implications not only for labor availability for agriculture and household operations, but also for family planning attitudes and education because fuels collection is often done by children.

ASTRA has raised useful questions regarding operation of the rural electrification program-particularly in Karnataka State. D.P.Sengupta and D.K.Subramanian reviewed with me the ongoing study of the Karnataka electrical distribution system (low tension only). From this study, to be available in a month or so, and from other studies of rural electrification in India, it was observed that:

a) electricity transmission losses average 20 percent but are 35 percent (or more if only rural electrification is considered) in some states;

b) rural electrification load factors range from 1 to 14 percent;

c) rural electrification is considered by all to be financially uneconomic;

d) rural electrification goes to wealthier districts, villages and families/ merchants and has little or no effect on the standard of living of the masses;

e) Maximum demand growth over time is very slow in rural areas and is much below growth in connected load;

f) connected load statistics are inflated because of electricity board requirements for connection; 3 kw for 2 lightbulbs for example;

g) many farmers with electric pumpsets also have stand by diesel pumpsets because of power cuts and the unreliability of electricity supply;

h) irrigation loads with their notoriously low load factors account for 70 percent of consumption in rural areas:

i) installation and connection charges for domestic lighting exceed Rs 500 with a minimum charge of Rs 3 per month.

These factors point to the expensive, inefficient and inegalitarian nature of the current rural electrification program. As a conceptual approach to regarding rural energy alternatives, Reddy suggests a maximum per capita energy consumption for India of the future of 28000 kcal/day as:

shelter	3200	
food	6200	
clothing	2100	
transport	4100	(27.2 km/day by train; 22.4 km by bus)
education.etc.	12400	

These figures are based on a U.S. minimum energy budget suggested by Hafner. India today averages 6700 kcal/capita/day; rural India 5600 and affluent India, 11,200. Thus energy use in rural/poor India would need to be 5 times current levels.

Rural electrification is the energy-providing means bv which the Government of India attempts to foster rural development. The limitations of such an approach defined in such a technologically narrow fashion were emphasized to me by many thoughtful persons. Their interest therefore has focused on alternative technologies to compl ment rural electrification for accomplishment of rural energization: (1) decentralized technologies based mainly on local skills and materials (some types of biogas plants, the simplest solar devices including Minto wheels for water lifting, and gunny sack sail windmills); (2) decentralized technologies based on centralized production (photovoltaic devices for example); (3) centralized energy distribution systems as alternatives to electricity generation (mainly based on soft coke distribution); and (4) more versatile and local resource-oriented methods of electricity generation (such as small scale hydropower and thermal plants based on energy plantations).

Field testing of photovoltaic devices in India will require the active collaboration of an Indian organization. Two possibilities that I have not pursued are Aurobindo Ashram, Pondicherry, which has a strong interest in energy technologies based on renewable resources but which I understand is having a bad experience with a German water pump (solar), and Institute for Planning and Analysis, Lucknow (Prabhu Ghate, director of planning, research and action division) whose primary interest however is community biogas plants. ASTRA/IIS Bangalore is not, I believe, interested in foreign collaboration.

Some industrial organizations in India are making a commitment to solar/wind/biogas energy R&D. One such is Jyoti Ltd., Baroda, Gujarat, which has an energy systems group, has commissioned the Center for Social Studies, Surat, to do a rural energy survey*, is doing development of two types of solar waterpumps and of cold storage units, and does manufacture motors and pumps. Nanubhai Amin, chairman of the board, expressed interest in Jyoti's field testing M.I.T. photovoltaics with Jyoti motorpumps

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* The survey will have at least two phases. Phase one is to estimate energy requirements of farmers owning more than 20 acres who are presumed to be able to pay for a new energy source. Phase two will estimate energy requirements of villages remote from the grid, especially in NW Gujarat and Rajasthan. This study will tell what machinery now exists in surveyed villages.

in one or more of the 4-5 "total energy system" villages (of the UNEP type) Jyoti proposes for Gujarat.

Cost data sufficiently disaggregated to estimate rural electrification system extension costs are not easy to find. V. Ranganathan of the National Thermal Power Corporation recently completed a dissertation however for the IIM, Ahmedabad, which includes detailed cost figures for system components in Gujarat State. He kindly made available to me a copy of his thesis and time for extensive discussion. I then checked Ranganathan's costs with project proposed costs as submitted to the Rural Electrification Corporation by each of the state electricity boards.

Major points (details I will bring to Cambridge) are: (1) 80-85 percent of total rural electrification investment cost (i.e., excluding generation and transmission costs) is material; remainder is labor and overhead; (2) HT (11 or 22 KV) line costs range from 8500 to 14500 Rs/km but decrease with kilometers; (3) LT line costs are in the same range but are more appropriately thought of as functions of number/type of connections (e.g., 4537 + 1088 (no. pumpsets) + 2750 (no. industrial connections) + 70 (no. domestic connections) + 316 (no. street lights); (4) transformer costs (11 KV/0.433 KV) are about Rs 9600 for 25 KVA, Rs 14100 for 63 KVA, and 17100 R s for 100 KVA;(5) average service connection rates are Rs 360 pumpsets and industry and Rs 120 domestic and commercial.

Gujarat Electricity Board costs appear to be near the average for India but some regional variations that I noted from project proposals are as follows:

(1) costs for line installation are 25-30 percent higher on the average (for same conductor sizes and KVA ratings) in hilly, less-developed states such as H.P. and Tripura while transformer costs are 10-20 percent higher.

(2) costs in M.P. and Karnataka are close to those reported for Gujarat;

(3) Tamil Nadu line costs are high (comparable to H.P.) but transformer costs are much lower than in Gujarat or elsewhere;

(4) Gujarat connection charges are about average for pumpsets but low for domestic and commercial where typical charges are Rs 170-230.

Ranganathan also computed comparative costs of diesel and electric pumpsets. Pump characteristics varied with particular installation but he assumed that for the same installation a diesel engine would have one third more horsepower than an electric motor to do the same job. Costs of electric pumpsets were:

15 HP	Rs 6850
17 HP	7763
5 HP	2740
Working Capital	1250

Costs of diesel pumpsets were:

20 HP	Rs 12185 (equivalent to 15 HP electric)
22.5 HP	13141
7 HP	4215
Structure/Installation	1600
Inventory	300
Repairs/Maintenance	800/year (zero for electric)
Oil Consumption	0.35 liter/HP hour or 0.47 liter/kwh

Oil cost (excl. duties, incl. transport at Rs 10/barrel)

	Rs 0.795/liter or
(0.47 x 0.795) =	Rs 0.37365/kwh

Note that all of the diesel cost assumptions are on the high side* while the opposite is true for electricity. Ranganathan concludes that electricity is less

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*Excepting perhaps the cost of diesel fuel which R. Bhatia now takes as Rs 1.2/liter with a 30% premium on foreign exchange. Ranganathan shadow prices neither alternative.

costly (to society as well as to an individual) than diesel.

Ranganathan's dissertation developed a prescriptive procedure for selecting rural electrification schemes. The Rural Electrification Corporation currently has underway a series of cost benefit studies of already existing schemes*. The only one of these studies to be completed is that by NCAER for four schemes in U.P. and M.P.

The study, a copy of which I have, has a number of faults of data collection and analysis. To properly point these out would require writing a paper. Here I will content myself with noting features and findings salient to our specific interests.

(1) Average capital expenditure per village on rural electrification was about one lakh rupees

(2) Generally speaking, average capital cost of electric pumpsets was higher than that of diesel pumpsets because of practice of constructing a pumphouse for electric alone.

(3) Operator and maintenance costs were generally higher for electricity by about 10 percent.

(4) In one scheme NCAER found that the per hectare cost of diesel pumped water was less than the cost of electrically pumped water. Electric pumping was cheaper in the other schemes because the subsidized tariff was used as cost of power.

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*These are being done under Dr. Lalit Sen, REC, New Delhi; Prof. V.M. Dandekar, Gokhale Institute of Politics and Economics, Poona (Maharashtra study); Prof. J. Roy, Indian Statistical Institute, Calcutta (W. Bengal); Prof. Balwanth Reddy, Administration Staff College of India, Hyderabod (A.P.); and Dr. M.T.R. Sarma. NCAER, New Delhi (M.P. and U.P.).

(5) Average capital expenditure per village on rural electrification including deposits/investments of users was about two lakh rupees.

(6) For the four schemes, B/C ratios were found to vary from 1.2 to 2.2 by attributing all increased production benefits to electrification. For example, benefits of electrification to increased crop production through irrigation are taken as the total value added by irrigation irrespective of whether or not that irrigation might have occurred even without electrification.

(7) All of the schemes failed badly to achieve targets in terms of villages electrified and/or number of connections. This is often due to lack of credit for connections.

(8) It is likely that in the already relatively advanced areas the provision of electricity has led to a growth in agricultural processing machinery of the flour/rice/oil mill type. No change in the nature of rural industries was found. Industrial value added due to electricity was based on a few respondents' recollections of before and after costs and incomes. No fuel/power costs of rural industries were reported.

None of these observations run counter to those of other studies; these are cast perhaps in an optimistic light given the interests of the sponsor. At other moments, however, NCAER is less positive regarding the virtues of rural electrification. For example, in an unreleased study for the Indian Diesel Engine Manufacturers Association, Poona, an organization with their own interests of course, NCAER concluded rural electrification led to little if any stimulation of load growth, that diesel pumpsets were generally cheaper (on a total cost basis) than electric pumpsets, and that the two estimates of number of electric pumpsets in India (from the state electricity boards and from the 1972 livestock census) were off by one million sets, with the census quantity the lower. In a more recent study for Rajasthan, NCAER found (1) 45 percent line losses on account of rural electrification, (2) 42 paisa total cost of delivered electricity to wells in the state versus a current charge of less than half that (3) and 9 paisa cost of electricity to the rural electrification system (i.e., 9 paisa generation and transmission cost).

Ramesh Bhatia's tubewell paper referred to in my earlier report is supported by those conclusions. In Ludhiana District of the Punjab, which is a district with all villages electrified, the number of electric motors for water lifting increased from 11051 in 1969-70 to 15322 in 1974-75 and 19497 in 1975-76 while the number of diesel engines (for stationary and mobile use) increased from 24206 to 42070 to 43769 over the same period.(17) Many farmers have both because of the unrealiability of electric supply. In Nainital District of Uttar Pradesh, Moorti and Verma found from a comparison of actual data on 26 diesel and 16 electric pumps that costs of pumped water were not significantly higher with diesel sets but that electric sets were run twice as many hours in a year (electric tariffs there have a relatively high fixed minimum rate so there is no incentive to economize) and that the civil works component for diesel wells (pumphouse, etc.) was one-quarter that for electric. (10) In Mehsana District of Gujarat, Patel and Singh also found only about a 10 percent higher cost (Rs/ha) for diesel dug- cum -bore wells as compared with similar wells with electric pumpsets. Electricity cost was based on tariff (heavily subsidized). Repair costs were (for nearly 100 pumpsets) higher for electric than for diesel wells; Rs 562/year/pump versus 469. (10)

I conclude that for a solar energy comparison with conventional energy sources, it is legitimate for India to take the cost of diesel power assuming it is not significantly different from the cost of rural electrification. This yields a lower bound on costs applicable to areas near the grid.

NCAER are undertaking a rural energy survey of North India (Rajasthan, Haryana, Punjab, J & K, H.P., and U.P.) that is viewed as an update of the 1963 survey with a focus on non-commercial fuels. This is being done for the Environment Committee of the Department of Science and Technology who are concerned about tree cover. A summer and winter survey have been made; the report is due at DST by end of May. (An urban fuels study is also being done for Coal India). The survey, unlike that in 1963 which was domestic only, covers all fuel use sectors. There are fifty strata by environment (desert, hill and plain); state, and general wage level. Two villages were selected from each stratum and within villages households were stratified into high, middle and low income. 16 hill villages and about 20 desert villages were surveyed. About one-half the households were in high and middle income levels because it was felt variations in fuels use would be greater in these households than in low income households.

Randomly selected households will be asked an extensive series of questions from a long energy consumption questionnaire and, if farmers,also from an agriculture questionnaire. Analysis focuses on households that purchase fuel and are therefore assumed to most accurately recollect actual fuel consumption. End uses of the fuel are identified. Foodgrain consumption is also determined by questionnaire so that a coefficient: kg fuel per kg foodgrain can be computed. Fuel consumption of non-purchasing households is then calculated based on foodgrain consumed and fuels coefficient for a "similar" household. Because dung is rarely purchased, conversion to coal replacements is made using the old Fuel Policy Committee conversion factors.

Preliminary indications are that coefficients range from about 0.7 kg coal replacement per kg. Foodgrain for low income families to about 1.3 kg per kg in high income families. This is presumably because of the greater number of side dishes cooked in high income households.

Two other surveys about to be undertaken that are of interest to us will be done by the Planning Commission-Programme Evaluation Organization. One will be an update of their 1965 rural electrification evaluation and will survey 49 districts throughout India. RE impacts and socio-economic benefits will be assessed. The second will be an intensive analysis of minor irrigation schemes in 2-3 districts.

Finally, and somewhat irrelevantly, the recent REC workshop suggested use of 15-20 percent discount rates for analysis of RE schemes based on commercial bank interest rates.

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