DEVELOPMENT WORKSHOP

ON INDIGENOUS BUILDING METHODS IN THE THIRD WORLD
Mohammad-Reza Daraie · Allan Cain · Farroukh Afshar · John Norton

کارگاه توسعه
خیابان صبای شمالی ۲۲۴، تهران
224 Saba Shomali, Tehran Iran

RURAL ENERGY SETTLEMENT STUDY

Prepared by the
Development Workshop
Architects & Planners
for
Selseleh Integrated Development Project
Alashatr, Luristan, Iran
1977

Background papers for a proposed United Nations University "Rural Energy Study", in Iran.

Background Papers

DEVELOPMENT WORKSHOP
ON INDIGENOUS BUILDING METHODS IN THE THIRD WORLD
Mohammad-Reza Daraie · Allan Cain · Farroukh Afshar · John Norton

کارگاه توسعه
خیابان صبای شمالی ۲۲۴، تهران
224 Saba Shomali, Tehran Iran

RURAL DEVELOPMENT AND ENERGY

1977

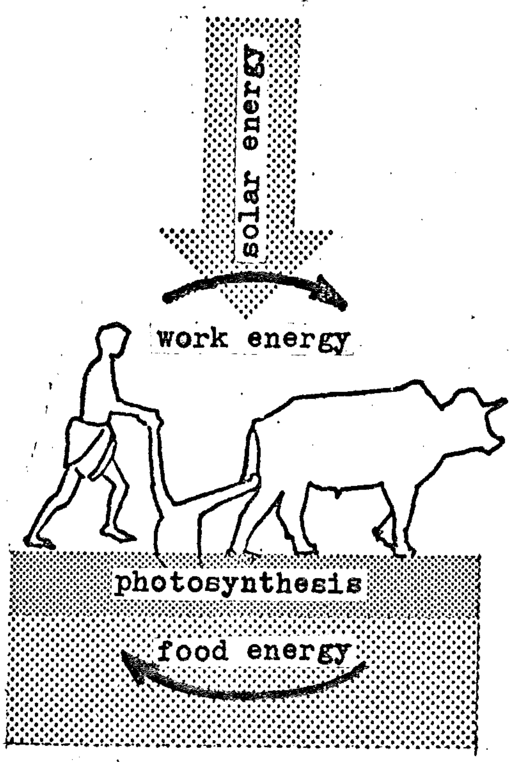
prepared by Allan Cain

Background paper for a proposed
United Nations University project.

Contents

Rural Development and Energy

An oversimplified view sees Third World rural economies as partially closed eco-systems: each self-reliant community relying on indigenous sources of energy to propel the cycle of human and animal labour used to grow and prepare human food, and depending on plant products from photosynthesis to provide energy for, in turn, growing more food. In fact as societies "developed", rural economies became much less cyclic and much more clearly linear with a uni-directional flow of resources - "outward". Energies were extracted from rural areas in the form of commodities and labour firstly to support its own local idle elites, later to fuel the cities and their swelling populations and often to be lost overseas to promote the industrialisation of other countries. It would be a mistake to see Third World rural areas today as self-contained eco-systems.



Rural Eco-System Model

As the technology of consumption rapidly advances in urban areas, the technology of rural production does not keep pace. While local, traditional sources of energy may have been able to propel the closed cycle of a one time village eco-system, they are progressively being drained off and lost to imbalanced exchange with the city. As irreplaceable rural energies are lost and rural re-investment lags far behind, recent history has seen the populations of these areas becoming poorer and weaker.

Iran's energy problem exists primarily in the rural areas where there are 50,000 villages, each with a population of less than 250 people. The access of rural populations to commercial fuels remains critical.

The consumption of gas in rural areas of Iran, which have 60% of the country's population, is approximately 1/176th of the total consumption of that in cities. The transportation expenses of gas to rural areas is more than 10 Rials per cubic metre, or more than 40 times as much as 0.25 Rials, the transportation charges of each cubic metre of gas sent to consumers in urban areas. Rural electrification in Iran's current budget receives only 12% of the total investment on electricity. The ratio of the amount of kerosene consumed in cities to rural areas has increased from 2.58 in 1967 to 3.4 in 1972 and is expected to rise to 4.75 in 1985.

In Iran the gap between cities and villages, in energy utilisation, is widening.

ENERGY USE IN A FEW AREAS OF THE THIRD WORLD

	Non Commercial Energy: wood, food, crop residues, grazing land (principal sources except North Mexico)										Commercial Energy		Total Energy	
	Rural domestic energy use per capita Billion Joules/yr		Agricultural energy use farm work, irrigation, chemical fertilizers Billion Joules/yr Per Capita		Per Hectare		Energy use in transportation, crop processing and other activities per capita Billion Joules/yr		Sub-total energy use per capita Billion Joules/yr		Oil, coal, hydro, etc., per capita Billion Joules/yr		Total energy use per capita Billion Joules/yr	
	Useful Energy	Energy Input	Useful Energy	Energy Input	Useful Energy	Energy Input	Useful Energy	Energy Input	Useful Energy	Energy Input	Useful Energy	Energy Input	Useful Energy	Energy Input
India (East Gangetic Plain)	0.2	4	0.5	7.7	1.6	25.6	0.1	3.4	0.8	15.1	0.5	2.5	1.3	17.2
China (Hunan)	1	20	1.4	8.3	6.5	41.5	0.1	3.2	2.5	31.5	1.6	8	4.1	39.5
Tanzania	1.1	22	0.06	2.3	0.1	3.8	0.02	0.7	1.2	25.0	0.2	1	1.4	26
Nigeria	0.75	15	0.16	2.4	0.4	7.3	0.03	0.9	0.9	18.3	0.14	0.7	1.14	19.2
Mexico (North)	1.6	17	13.5	41	14.9	45.5	0.1	3.6	15.2	61.6	3.0	15	18.2	75.6

If equitable development is a national goal, and it is true that Third World populations are largely rural, then rural development programmes must today receive priority. If in turn rural development is to be effective, the relationship of exploitation between the urban and the rural must be changed.

Rural populations should have equal access to national energies when these are needed to spur development and promote industry. More efficient use of traditional rural energies must be found so that they can do more than just propel a closed subsistence cycle. They should be rationalised and geared toward productive income generating forms of development. The utilisation of other local, latent forms of energy such as from the sun, wind and other natural elements can also be channelled toward production and the satisfaction of the population's basic needs.

Energies can be employed for the provision of basic human services and for productive economic activities which can in turn allow the population to aquire progressively higher degrees of service.

<u>Traditional vs. Commercial Energies</u>

The population of Third World Countries, particularly those living in rural areas, rely largely on traditional sources of energy. These energies - human and animal labour, firewood, crop residues, and animal wastes - were the sole sources throughout history until about 200 years ago when the now rich countries began to exploit external sources. Today in Third World Countries the consumption of traditional energies is approximately equal to their consumption of fossil fuels. Exact figures are difficult to gather because statisticians base their energy consumption data on "commercial" sources, ignoring indigenous ones; just as they gage a country's wellbeing by its G.N.P., which is only a monitor of capital flow in the modern sector, ignoring traditional economic activities which often employ the majority of people.

In rural areas of developing countries, energy provided by people themselves is five to ten times that obtained from commercial sources. In India with a population which is 80% rural, 85% of the available commercial fuels are used in the urban areas, while only 15% remains to supplement traditional rural energies.

Energy uses in rural India.

Source of energy	Energy used (kcal)					
	Agriculture	Domestic activities	Lighting	Pottery, brickmaking, metalwork	Transportation and other uses	Total
Human labor*	0.59×10^{14}	0.39×10^{14}		0.01×10^{14}	0.09×10^{14}	1.08×10^{14}
Bullock work	1.35×10^{14}				0.26×10^{14}	1.61×10^{14}
Firewood and charcoal		6.78×10^{14} (firewood and charcoal, cattle dung, crop residues)		0.75×10^{14} (firewood and charcoal, cattle dung, crop residues)		4.60×10^{14}
Cattle dung						1.86×10^{14}
Crop residues						1.07×10^{14}
Total from local sources	1.94×10^{14}	7.17×10^{14}		0.76×10^{14}	0.35×10^{14}	10.22×10^{14}
Petroleum and natural gas						
Fertilizer	0.35×10^{14}					0.35×10^{14}
Fuel	0.08×10^{14}		0.42×10^{14}			0.50×10^{14}
Soft coke		0.14×10^{14}				0.14×10^{14}
Electricity						
Hydro†	0.03×10^{14}		0.01×10^{14}			0.04×10^{14}
Thermal‡	0.12×10^{14}		0.05×10^{14}			0.17×10^{14}
Total from commercial sources	0.58×10^{14}	0.14×10^{14}	0.48×10^{14}			1.20×10^{14}
Total, local and commercial	2.52×10^{14}	7.31×10^{14}	0.48×10^{14}	0.76×10^{14}	0.35×10^{14}	11.42×10^{14}
Daily per capita	1.57×10^{3}	4.55×10^{3}	0.30×10^{3}	0.47×10^{3}	0.22×10^{3}	7.11×10^{3}

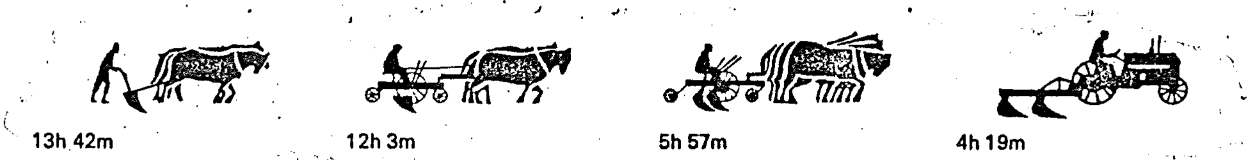
†Potential energy in water used to generate hydroelectric power. ‡Energy in coal used to generate thermoelectric power.

Human Energy

Human labour is a major source of energy in an unmechanised economy. All human activities employ energy in the form of food. A proportion of this is consumed through work activities. In Third World rural areas up to half of food energy is used in work. Women on an average use 44% of energy in work while men use 38%. In cumulative terms 51% of this total energy is consumed directly in agriculture, 40% in domestic activities such as cooking, fetching water and collecting fuel, and the remaining 9% in all other activities, including crafts and industries. In India for instance, 55% of all labour energy is engaged in agriculture. A man involved in unmechanised agriculture expends 6 kcal/min. of energy.

On the domestic level a great deal of energy is spent each day, particularly by women in obtaining water for household use. A person walking to a well or water hole and carrying water home in a jar on her head expends on an average 240 kcal/each day and takes about 3/4 of an hour for the task. This represents 10% to 15% of the daily energy food intake of a villager in many developing countries.

An increased supply and more efficient use of energy in rural areas would mean that people can divert their labour, time, and more importantly their creativity, from labour on the land to activities which more effectively employ their productive potential.



Animal Energy

Part of the bullock work in rural areas is used in plowing, cultivating and harvesting farm fields and part in lifting water for irrigation. Whereas a hectare of wheat requires the energy of 125 man days of labour per year the same land only requires 30 days of bullock work. The efficiency of animal labour for this kind of work is apparent. Overall energy efficiency for bullock work can be calculated: for a 2.3×10^3 kcal/hr. energy input in food, the output in work is $.43 \times 10^3$ kcal/hr., indicating a 19% efficiency.

In raising water for irrigation, an activity increasingly important as farming expands into drier areas, one pair of bullocks can lift one hectare metre of water in 600 hours or almost 17 cubic metres per hour.

Local Fuels

The terms local or traditional apply to fuels used in rural areas, like wood, dried dung, or vegetable residues as compared to commercial fuels, such as hydro-carbons, hydro-electricity and nuclear power. In rural Indiafor example, while per capita consumption of commercial fuels amounts to about the equivalent of 37 kg. of coal,* the coal-energy equivalent of local or traditional fuels is 227 kg./capita. On the national level this amounts to 100 million tons (coal equivalent) per year, having a total energy content of 7.53×10^{14} kcal. Local fuels break down as follows: 142 million metric tons of wood, 56 million tons of dried animal dung, and 39 million tons of vegetable waste.

	Wood	Dung	Crop Residues
Energy Content kcal/ton	4.4×10^6	3.3×10^6	3.3×10^6
Quantity million metric tons/year	142	56 to 97	39
Total Energy kcal/year	4.60×10^{14}	1.86×10^{14}	1.07×10^{14}
Coal Equivalent million tons	61.3	24.8	14.3
Per Capita Coal Equivalent kg.	139	56	32

* Coal is used as a basis of comparison for all fuels as they have each different weight to energy ratios. In U.N. statistics 1 ton of coal is equivalent to 7.5×10^6 kcal. of energy.

Wood Energy

Wood is the most common fuel in most areas of rural India, as it is in many rural areas. It is estimated that an average of 300 kg. of wood is used per capita every year. Cool regions would use much more than this average. One to one and a half tons of timber are burned per capita every year even in warm countries like Tanzania and Nigeria.

Forests normally contain about 50 tons of wood per hectare. Supplies could be rapidly depleted if wood was cut indiscriminately for fuel. Foests or wood-lots can be "cropped" annually for timber for both building and fuel without depleting the supply. Annual production of a forest is about 12.5 tons/hectare, and if properly managed and selectively replanted can be seen as a constant, renewable resource.

Animal Dung

Animal dung is an important by-product of animal husbandry and the keeping of draft animals.

Animal dung has a variety of uses, the most important being as an agricultural fertiliser and as a fuel. Cattle produce 1.4 to 3.5 kg. of dry dung per day. Most often dung is used for fertiliser, but between 22% and 75% is burned as fuel. In dry areas where wood is unavailable dried dung is the principal source of domestic fuel. In such areas fuel needs often take priority over fertiliser needs to the detriment of agricultural production.

Crop Residue

Chaf and straw are important by-products of grain production. Wheat fields for instance produce 1570 kilograms of usable residue per hectare annually. The ratio of straw and chaf to grain output is 1.75 to 1. Most crop residue is eaten by livestock, accounting for about one half of their food energy. In all only about 20% of total crop residues are used as fuels, but these account for between 10 and 15% of fuel energy used in rural India.

Energy for Development

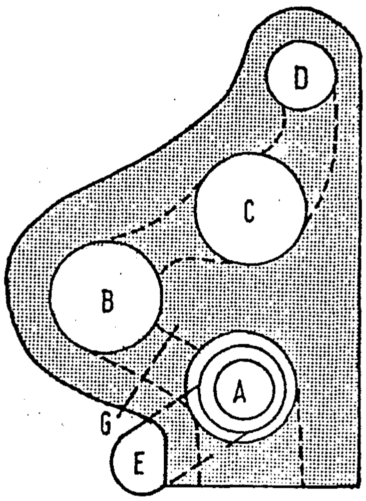
Third World rural areas need greater access to energy on which to base their development. Irrigation schemes to water dry farmed land can increase production by allowing double or even triple cropping, but require energy in the form of fuels or animal labour to power pumps, or to cultivate the extra crops. Energy is needed in the development of rural based industrialisation. Energies to run mills and agro based processes as well as kilns and small manufacturing operations are all necessary in an integrated approach to development. Better services, roads, housing, water supplies, even access to medical and educational facilitites all depend in various ways on better control of and greater access to energy.

The more efficient use of indigenous energies both within the household and in agricultural production can create surpluses which can be diverted into productive needs.

As well, latent local energies in the sun and wind can be harnessed to provide energy surpluses. This new energy can be either channelled towards tasks previously carried out by traditional fuels, thus freeing those energies for other more efficient uses, or new energies can be used directly in increasing production or the level of services.

Rationalising Traditional Energies

Cooking is the greatest consumer of fuels in the rural areas. Inefficient cooking and heating fires waste large quantities of energy in rural households. These open hearths usually burn traditional fuels like dung, wood or chaff. Such cooking fires usually consume more energy per calorie of food cooked than the estimate of energy used per food calorie for cooking and home refrigeration combined in the United States. For example, the energy used in rice cooking by this traditional method is 600 kcal/kg. or 17.5% of the food energy content of the rice. The traditional cooking method is estimated to be only 9% efficient in energy compared to the 30% to 60% energy efficiency of the modern gas stove.



A.B.C. Pot Seats

D. Chimney Base

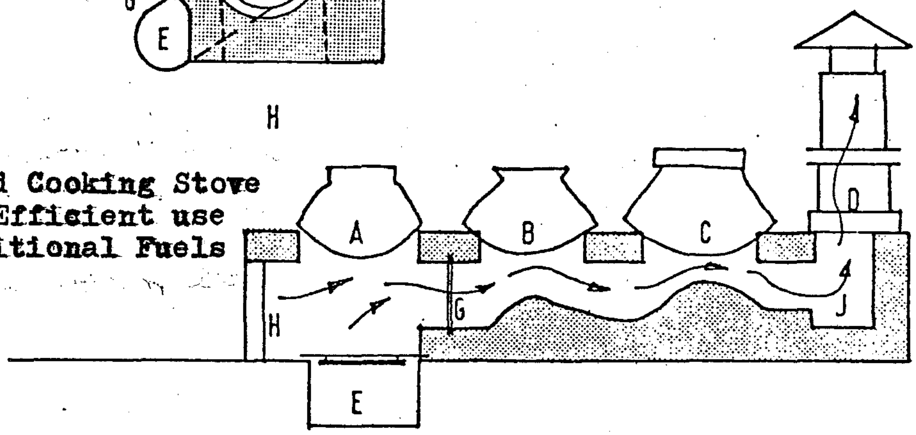
E. Ash Removal Pit + Air Vent

G. Dampers through Wall

H. Fuel Feed

J. Chimney Pit for Soot Accumulation

Improved Cooking Stove
Energy Efficient use
of Traditional Fuels



Cooker burning dry fuels

Constructed of mud clay or similar material.

By redesigning the traditional solid fuel cooking stoves a great deal of energy can be saved. Such a redesign need not alter local cooking or eating habits. Fuel efficiencies can be improved to the standards of modern stoves, and traditional fuels can still be employed but in much smaller quantities. It has been estimated that approximately 75% of the domestically used energy from traditional fuels is used in cooking. If stoves can be improved from their present 9% efficiency to an acceptable modern standard of 40%, fuel consumption can be reduced to less than 25%. An average household could save more than $6.5 x 10^6$ kcal. of energy per year, equivalent to almost one ton of coal.

Energies thus saved will be in the form of traditional fuels and can be diverted to village scale industrial use such as the operation of various types of kilns, forges, boilers or ovens.

Community Energy Resources

The rationalised use of animal dung as a fuel source is the focus of much recent research and development. It has been shown that animal dung is one of the major traditional sources of fuel in rural areas, accounting for over 25% of the usable energy. This proportion is much higher in areas that do not have direct access to wood or other combustible fuels.

In India, of the 310 million tons of dung produced per year, 97 million tons are used for fuel. Much of the remainder is collected and used for agricultural fertiliser. Again in areas lacking other fuels a greater proportion of dung is burned as fuel and less returned to the land.

The development of "bio-gas" plants which extract energy in the form of methane gas from animal dung offers a much more efficient use of a traditional fuel source. Dung, after being processed through a bio-gas plant, makes a superior agricultural fertiliser which does not run the risk of harbouring dangerous pathogens. The methane gas produced by such a plant has a higher calorific value than the original dung had it been burned in the traditional manner.

Bio-gas plants require a moderate initial capital investment. Most plants are now used by individual families or by farms. Costs could be greatly reduced and dung supply and maintenance handled more efficiently if larger plants were built on a community scale. A village energy co-operative could be established where the village wastes and domestic animal dung were processed and energy in the form of gas was distributed to each household. Methane gas for cooking does not imply any major changes in food preparation or cooking habits. It does mean though that kitchen areas can become much more hygenic and smoke free.

In many ways, methane gas is a much more versatile form of fuel than the solid traditional ones. The gas can be used for powering engines and pumps as well as for various heating tasks. It therefore has a wide range of uses in domestic servicing and village industrialisation.