frequency is once in 15 years, assuming a mean HEPA filter failure rate once every four years. However, if this is decreased to once in eight years, the mean escape frequency decreases to once in 22 years. On the other hand, if the filter failure rate increases to once in two years, the mean escape frequency increases to once in seven years. If the filter mean time to failure detection is reduced from six months to 1.5 months, then the mean escape frequency again declines to once in 22 years. The impacts of other system modifications can be assessed in a similar manner.

We recognise that our fault tree — part of which appears in figures 3 and 4 — does not describe all the system parameters and modifications which may be of interest in a more complete description of escape likelihood from the P4 system. In particular, there remain considerations of:

- a more explicit description of the dependency of the likelihood of escape on the amount of released material, possible concerns that the organism survivability, and therefore potential for harmful impact, may depend on the mode of escape,
- the effect of alternative experimental protocols on the escape risk, and
- inclusion of experimental data on λ, τ, and q for system components. In addition, further examination of the fault tree for common mode failures would be useful. It is intended that future studies will reduce some of these presently perceived deficiencies.

This study does not describe whether our calculated escape frequencies pose a significant risk. The probability of a harmful consequence is the product of several probabilities involving biological details of the recombinant organisms and their escape probability. Further studies would be needed in order to determine whether or not a P4 laboratory provides an "acceptable" risk. □

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Full steam ahead to save Kenya's fuel

HARD-pressed by the rising price of oil and a growing shortage of fuelwood, Kenya, like many developing countries, badly needs alternative sources of energy. Fortunately, it has at least one: a huge natural reservoir of boiling hot water some 1,000 metres beneath the Rift Valley about 80 kilometres from Nairobi.

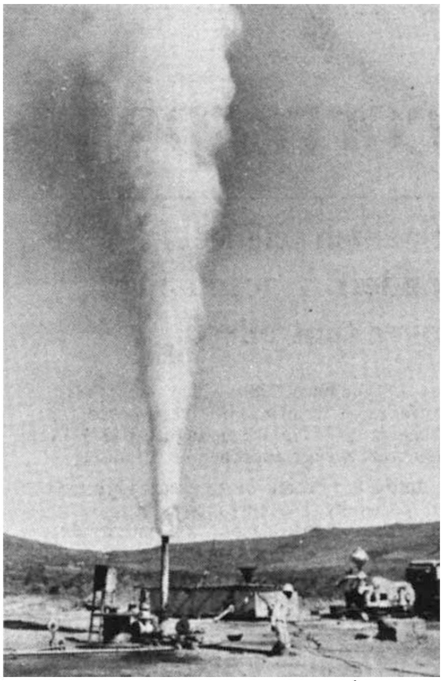
Interest in the area as a possible site for a geothermal power station began in the 1950s, but detailed exploration (financed by the United Nations Development Programme) did not begin until 1970 when four wells were drilled in a wild, semi-arid area known as Olkaria, about five kilometres south of Lake Naivasha. Eleven wells have now been drilled there, and a contract was recently placed for construction of the first 15 MW power station which will feed into the national grid by mid-1981.

The Olkaria Power Station will be the first full-scale geothermal power station in Africa (a 220-KW plant was installed in Zaire at a metal mine in the 1950s, but was costly and inefficient and was closed down with the mine). When Olkaria goes into operation, it is expected to supply about 5% of Kenya's electrical power. Another 15MW generator is planned for operation in late 1982, and the station's capacity will be expanded to reach 90 MW in the next 10 years. Total energy available from the reservoir has been estimated at 170 MW for 25 years.

Kenya has no known fossil fuel resources, and the rising cost of imported oil recently prompted the President, Daniel Arap Moi, to call for reduced consumption. But as T.S. Tuschak, a Canadian energy consultant currently on loan to the Kenya government through the UNDP, pointed out recently (July 5, page 2) savings in the essential sectors can at best be 7%, and consumption by private transport can only be reduced by about 10%.

Kenya's economy is divided into two sectors: the industrialised and the rural. The industrialised sector gets about 85% of its total energy supply from oil, the rest from hydroelectricity. The rural economy's energy source is almost 100% wood or charcoal. And while Kenya has not suffered as much as some countries from deforestation, a fuelwood shortage is likely and has already occurred in some areas. Population is increasing at 3.9% a year, causing not only increased wood consumption but declining land availability. Fuelwood consumption is currently 20 million tons annually.

The government's forestry department has introduced conservation and reafforestation programmes and has shown some interest in agroforestry, and



Rift Valley gushers, courtesy of the Kenya Power Company

public attention has been drawn by various groups to the advantages of tree-planting. But it is not possible to wean the mass of the population away from its reliance on wood as its principal source of energy.

Kenya's unused hydro-electric power potential is 600-700 MW. Total electricity demand, which has grown at 8-9% per annum and is expected to continue at that rate for the balance of the century, should reach 1200 MW by AD 2000. This would call for 1500-1600 MW installed capacity. Development of all the HEP potential together with the present installed capacity of about 400 MW would leave a gap of 400-500 MW. The total geothermal resource is believed to be between 170-500 MW which could fill that gap.

Kenya has so far evolved no rural energy policy. While there are arguments for and against rural electrification schemes in developing countries, Mr Tuschak believes that an increase in electrical consumption in certain areas of Kenya could reduce its growing consumption of wood.

"In my estimation there are about 1-1.5 million people in the rural sector who are better off in financial terms and can afford to pay for commercial energy, or at least part of the cost," he told *Nature*. "Many of these people have already requested electricity and others would be happy to have it. If they are supplied with electricity they will stop consuming wood, and Kenya could perhaps cut down wood consumption by 10% or more".

Although hydro stations provide most of Kenya's electrical energy at present, hydro generation is expensive to run because the country's rivers have highly variable seasonal flow. Capital costs are also high. Under such conditions, geothermal plants offer an economic supplement.

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