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area to the port of Maputo. Up to one-third of Mozambique's foreign exchange earnings derive from the shipping of Witwatersrand freight overseas via Maputo.

Power and water

The use of the financial surplus from South Africa's mines, the result of the region's labor and South Africa's mining skill and technology, is the legitimate object of negotiations for the region. The "Great Projects" for southern Africa that ought to be financed, center on power and water. South Africa has plenty of the former—primarily coal-generated—and a scarcity of the latter. South Africa's neighbors need energy, but have plenty of undeveloped water resources. South Africa's need for water is a vital strategic matter. If it cannot negotiate access to its neighbors' water, it will have a large shortage in 20 years and will have to begin implementing zero economic and population growth policies.

In the accompanying article by South African water engineer Desmond Midgley, we present one plan for aggressive regional development of water and hydropower resources. The buoyant optimism of his opening paragraphs should be contrasted with the malthusian pessismism of the IMF and World Bank on such matters.

There are currently two hydro-electric facilties in the region, aided by South Africa, that are largely unused due to political instability. Cahora Bassa, on the Zambezi River in northern Mozambique, is a 1,425 MW dam that is only intermittently in use because of Renamo guerrilla sabotage activities against the two transmission lines. Mozambique is committed by treaty to the delivery of 1,350 MW to South Africa.

In southern Angola, the Ruacana Falls project on the Cunene River, on the border with Namibia, is a 240 MW unit which is not producing much power, because the Angolans will not permit the regulating dam at Calueque to be completed, Both problems derive from the Soviet entry into the region with the collapse of the Portuguese colonies in 1974-75.

Internal regional trade

Due to the fact that South Africa is surrounded by nations that for the most part are still dominated by typical colonial economy structures—raw material exports and subsistance agriculture—the volume of trade within the region is correspondingly constrained.

The only significant exception is the nation of Zimbabwe. During the Rhodesia crisis and after the country's Unilateral Declaration of Independence from the British, the industrial sector was built up in a dirigist manner, because of international sanctions. In 1964, a preferential trade agreement was signed with South Africa, such that 18.1% (in 1983) of total exports and 40% of its manufactured exports go to South Africa.

Water and electric power to develop southern Africa

by D.C. Midgley

The article excerpted here, by South African water engineer Desmond Midgley, which first appeared in Africa Insight *(Vol. 14, No. 4, 1984), presents one possible plan for rapidly expanding the economic potential of southern Africa as a whole, through regional cooperation in the development of water and electric power resources. Professor Midgley was formerly a professor in the Faculty of Engineering at the University of the Witwatersrand.*

. . . It is by no means in South Africa's interests to be surrounded by less-developed impoverished neighbors, many of whom naturally resent their dependence on South Africa. Some make no secret of their steps to sever links and form an independent bloc. There are elements, too, who would aid and abet the undisguised Russian efforts to gain control of the South African economy. . . .

The southern subcontinent has enormous natural resources and South Africa has the technical know-how with which, provided there is cooperation, to bring southern Africa to a level of development comparable with that of the United States within a couple of decades. . . .

Secondary industry, both agricultural and manufacturing, must be expanded along with the necessary training facilities. Plants must be erected to beneficiate locally the raw materials in which these countries are so rich—rather than that they should continue merely to export and thus remain for too long reliant on primary industry, in some cases based on mining of a single ore—for example Zambia's copper.

Few countries are as well placed as South Africa to help expand the infrastructure and with it the prosperity of the southern subcontinent. The incentive to do so lies chiefly in the advantages to be gained from cooperation in the development of water and electric power resources.

Resources and demands

South Africa's Electricity and Supply Commission (ESCOM) provides 80% of the country's electricity needs and much of the demand of several neighbor states. ESCOM's present installed capacity (1984) is about 20,000 MW and, if past growth rates persist, will by the year 2020 have to exceed 200,000 MW to meet an energy demand exceeding

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TABLE 1
Demand/resource scenarios 1980 to 2020

Year	1980	1990	2000	2010	2020
Water demands:		(values in millions m^3)			
Domestic and industrial	2,706	4,349	6,719	10,657	17,376
Afforestation	1,352	1,726	2,097	3,232	4,364
Irrigation	9,640	10,275	12,445	15,075	18,295
Totals	13,698	16,340	21,261	28,964	40,035
Exploitable resources:	29,528	29,528	29,528	29,528	29,528
Deficits	—	—	—	—	**10,507**

Source: *Africa Insight*

1 million GWh. . . .

On the question of water, the fact that South Africa's resources are meagre is already widely known. What is appreciated less is the fact that about three-quarters of the surface water-resources occur in rivers that either rise in or flow through neighboring sovereign, national, or self-governing states. It can therefore be misleading to compare, on a global basis, the exploitable water resources of the country (*viz* about 34,000 million cubic meters per annum) with South Africa's projected total water demands (say 32,000 million cubic meters per annum by the year 2020) and to decide from this that there is enough water to meet future needs for the next generation or so! In the first place, neighbor countries have legitimate claims to much of the same water, and secondly, there are regional constraints to the transfer of water from some of the areas of surplus to the identifiable areas of shortage. . . .

Dr. Van der Riet [of the Hydrological Research Unit of the University of Witwatersrand, author of report HRU 5/80, "Cooperative Water Resources Development in Southern Africa"] projected South Africa's demands under various categories on a regional basis in such a way that they could be compared with the regional exploitable water resources. He based his estimates of the irrigation water demand on the assumption that South Africa would have to aim for self-sufficiency in food production, and accordingly, that irrigation development would have to expand at the rate of at least 2% per annum. . . .

Dr. Van der Riet carefully went into future requirements of water for power station cooling (allowing for the introduction of dry-cooling), water for expansion of oil-from-coal production, and the effects on river runoff of expanding afforestation to meet the country's timber and pulp and paper needs. The demand/resource scenarios studied are summarized in **Table 1.**

As may be seen, the deficit rises rapidly during the second decade of the next century. About 80% of the deficit would be associated with the core region surrounding the PWV complex [Pretoria/Witwatersrand/Vereeniging] and can largely be made good by transferring water from the upper Orange and Tugela river systems, but there would still be a shortfall of about 3,000 million cubic meters. . . .

The question arises: what options are open for handling the projected shortfall in the core region?

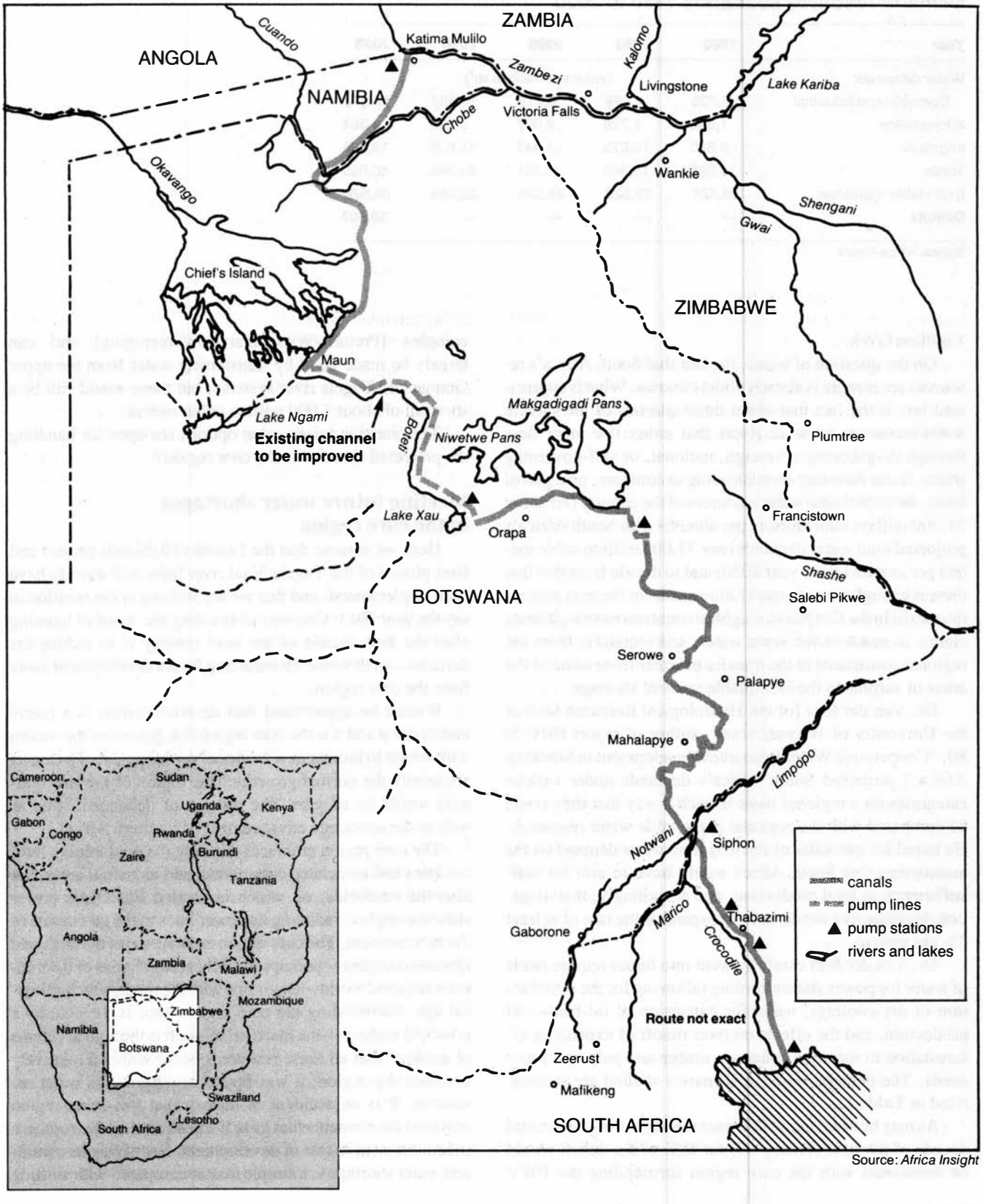
Meeting future water shortages in the core region

Here we assume that the Lesotho Highlands project and later phases of the Tugela-Vaal river links will already have been implemented, and that we are looking at the position in say the year 2011. One way of avoiding the shortfall looming after the first decade of the next century is to reduce the demand—in this case by attracting future development away from the core region. . . .

It must be appreciated that deconcentration is a costly undertaking and it is the core region that generates the wealth with which to initiate new modes of development. To restrict artificially the normal growth of the region of the subcontinent would be to retard the process of deconcentration as well as the economic advancement of southern Africa.

The core region embraces not only the gold mining Reef complex and associated commercial and industrial areas, but also the coalfields, on which is located ESCOM's power station complex, radiating its power lines to the far corners of the subcontinent. The core region embraces also the bushveld igneous complex—perhaps the richest storehouse of the minerals required worldwide to cope with the modern technological age. Surrounding the core region, too, is the country's principal granary—the maize triangle. It is through accidents of geology that all these resources occur within a relatively confined dry region; it was bound to outgrow its water resources. It is an accident of history that this same region acquired the elements that gave it a head start on the southern subcontinent in its rate of development. Rectifying its continued water shortage is a simple matter compared with shifting

Proposed Okavango and Zambezi water transfer projects



Source: *Africa Insight*

the center of gravity of growth.

Overcoming the water shortage by importation from neighboring countries, in preference to pumping desalinated seawater to the interior, has many advantages. As long as the huge market for water in the core region continues to grow, the prospects for cooperative water supply schemes remain rosy. . . .

As the map shows, water could be abstracted from the Zambezi on the border between Zambia and Namibia, at Katimo Mulilo, from where the water carrier would traverse the Caprivi Strip, the Chobe Valley and the Chobe-Okavango watershed and, skirting the Okavango delta, discharge into the Boteti River near Maun. From Maun to Mopipi the aqueduct would be the natural channel of the Boteti suitably modified to minimize losses. Near Mopipi there would be a pump station to boost the flow into a canal leading to the southern extremity of the Makgadigadi Pans where the water would have to be lifted about 200 meters to the Limpopo watershed. From here a gravity canal would lead the flow southward, past Serowe, through the water-short ranching areas of eastern Botswana. There would be a tunnel south of Mahalapye and the main aqueduct would cross the Notwani and Limpopo rivers by siphon to proceed up the Crocodile valley through a series of pump stations as far as Hartbeespoort Dam.

Branch lines could be taken off to Gaborone, the capital of Botswana, and to other growth points, such as Selibi Pikwe in Botswana and Thabazimbi, Mafikeng, and other towns in Bophuthatswana. . . .

Desk studies of schemes to import water from the Zambezi and/or the Okavango system at rates of up to about 3,000 million cubic meters per annum were made some time ago. With its 1,340 kilometers of canals and 80 kilometers of tunnels, pipelines and siphons, the Zambezi-Transvaal link would constitute one of the world's largest water transfer projects. At 1980 prices the capital cost was estimated at close to 3,000 million rands [South African currency], which is comparable with that of one of ESCOM's modern power stations. Operating cost would run to 262 million rands for delivery of roughly 100 cubic meters per second (over 3,000 million cubic meters per annum). Desalination of sea water and pumping to the Reef would involve seven times the capital outlay and six times the operating costs!

There is another way of helping to forestall the predicted water shortage and that is by importing electric power. Even with the introduction of dry cooling, the water requirements of the power complex are substantial. Imported, in place of locally generated, electricity holds attractive mutual advantages similar to those associated with the importation of water from neighboring states.

A subcontinental electricity grid

The hydro-electric resources of the African continent amount to more than 16% of the world total. Zaire, Angola, and Mozambique alone account for 63% of the African total. In sharp contrast to the position in the developed part of the world, where future hydro expansion is likely to be constrained by social, economic, and environmental factors, most of the potential in Africa is likely to lie untapped for generations unless cooperative schemes to take advantage of the huge South African market can materialize.

As indicated earlier, the South African energy demand is likely to exceed 300,000 GWh per annum by the close of the century and to pass the 1 million GWh mark within the following two decades. If these demands are to be met entirely from local sources, most of the country's non-renewable energy resources may be fully committed, unless nuclear breeder stations will have become viable by that time. On the other hand, Zaire, Angola, and Mozambique will still have about 700,000 GWh per annum of surplus hydro potential. In fact the largest concentration of potential hydropower in the world is to be found at the Inga site on the Zaire River, where a 120-meter-high dam could be equipped with up to 35,000 MW to generate 300,000 GWh per annum of firm power. The whole output could be absorbed in the South African grid within a period of about 11 years. The distance from Inga to the nearest connection to the ESCOM grid is much the same as that from Cabora Bassa Dam to Irene. In 1980 the unit cost of energy from Inga was estimated at 0.98 cents per kWh compared with coal-fired energy at 1.55 cents per kWh. The net annual benefit of establishing an energy supply from Inga would be sufficient to provide the capital to build a cooperative water supply from the Zambezi.

The potential for large-scale base load hydro-energy export is not confined to Inga. In both Angola and Mozambique there are many large rivers on which substantial hydrostations could be built and linked into the expanding network. The installed capacity at Cabora Bassa could be doubled by building the north bank power plant and additional stations on the Zambezi could increase the total capacity to 9,000 MW. . . .

Conclusion

The relatively developed, dry south of the southern subcontinent of Africa contrasts markedly with the less developed but well-watered north.

It is the common interest that economic advancement and living standards should be raised to equivalent levels throughout southern Africa. Substantial steps in this direction can be achieved by implementing cooperative schemes for the transfer of water and water-generated electrical energy from areas of surplus to the centers of demand. . . .

The present worth of cooperative schemes to bring water and electrical energy into South Africa from neighboring states amounts to thousands of millions of rands. There is not one state in the southern subcontinent that would not benefit from one or other of the potential water or power schemes.