

and technical community around a set of criticisms to be made of the nuclear agreement between Brazil and Germany . . . With the present difference in cost between nuclear and hydroelectric plants, and the availability of hydroelectric sites to the end of this century, there is no need to install nuclear plants before 1990." Indeed, Professor Jose Goldemberg, president of the Brazilian Physical Society, points out that hydroelectric reserves had been purposely underestimated by a factor of two (at 100,000 MW) by FURNAS's Plan 1990.

David Simon makes a detailed cost comparison between the Angra II and III projects and an equivalent 3,400 MW hydroelectric plant. While Angra I and II together will cost \$5,000 million, the hydroelectric plant would cost \$2,700 million. The fuel costs for the nuclear plants during their lifetime would be an additional \$4,000 million (water is free).

On the purely economic side, the agreement specifies that half the costs will be paid by Brazil in Deutschmarks, while hydroelectric technology would be almost entirely costed in Brazilian currency.

His testimony also pointed out that the jet-nozzle technique for uranium enrichment to be used in Brazil is still under development in West Germany (with half the costs for research and development borne by Brazil) and that its technical and economic viability have not been proved.

It is difficult to imagine the possibility of a reconciliation between the government representatives and the scientific community over the nuclear programme. Paulo Nogueira Batista, president of NUCLEBRAS, and Said Farhat, Minister of Information, called a joint press conference last month at which Nogueira discarded FURNAS' revised Plan 1992, because "the 7.5% growth rate demand envisaged in the plan is perilously below a reliable value", and Farhat emphasized "the Brazilian decision to follow through with the international agreements linked to the execution of the nuclear programme. Being a decision of the government, this is no more subject to either divergences or dissensions. To build the nuclear plants we shall spend US \$15 billion. For the nuclear fuel cycle, we estimate an investment of US \$2.5 billion."

On the other side, Professor Luiz Pinguelli Rosa, Secretary of the Brazilian Physical Society, told *Nature* that the scientific community today demands "democratic and public discussions of energy needs, involving various sectors of the population. We, as scientists, should not fall into the temptation to propose a progressive solution as a substitute for the technocrats' miracle. The illiterate majority of the Brazilian population must first obtain the means to evaluate what nuclear energy is. Before it really needs nuclear reactors, I hope that Brazil can reach the stage of a democracy with popular participation." □



Angra II columns . . . not enough

## Trouble on the beach of rotting stone

ANGRA I is a standard PWR reactor of the type sold by Westinghouse all over the world under turn-key contract. Its construction made no use of the national manufacturing capacity: the share of local suppliers in the project was only 8%, made up of civil engineering works.

Start up is promised for next year. It uses enriched uranium provided exclusively by the US, paid for via a loan from the Industrial Development Corporation of South Africa. Used fuel will be shipped back to the US, so the electrical company which will operate Angra I will not

comment on wastes on fuel reprocessing.

The doubling of the construction time is blamed on the agreement with West Germany to build two plants (Angra II and III) on the same site. Besides the obvious dangers involved in having three nuclear plants on one beach, there were other problems. While the water table was being lowered to construct the foundations, the already existing buildings slid 10 millimeters from their position. It was decided to build an "armoured diaphragm wall" around the site, 250 meters long and 17 meters deep. As work proceeded on the anchoring of foundation columns for the reactor platform, it was discovered that the ground below the beach was scattered with huge boulders which had to be pierced to reach bed-rock at a depth of 60 meters. This difficulty could have been anticipated had the engineers recalled the difficulties encountered while building the road to Angra, when a tunnel collapsed to form a huge open trench, through which the road now passes; or had they recalled that the beach's name, "Itaorna", comes from Tupi, the language most spoken in Brazil 250 years ago, meaning "rotting stone".

Setbacks also affected the construction of Angra II. Last year, the National Commission on Nuclear Energy, CNEN, which is responsible for safety, decided that the 280 columns already in the ground were not strong enough against earthquakes. As a result, the construction of the reactor base plate was halted for a year, and CNEN ordered an additional 88 columns and reinforcement of 202 of the already existing ones.

It has been pointed out that CNEN's director has always been considered pro-American, while NUCLEBRAS' is pro-German; stronger rifts could exist between them than soil vibrations.

The overall financial charges from these modifications and delays amount to \$320 million, mainly in the form of interest payments. All these costs will be borne by the electrical company FURNAS alone; it has already announced that it will raise its prices by 60% when Angra I comes on-line next year. There are clauses in the German contracts which pass the cost of technical difficulties onto the Brazilian user company; these clauses remain secret and a Sao Paulo newspaper was seized last year for publishing one of them.

The financing of the German programme is the largest loan ever obtained for a Brazilian project: it amounts to \$1,700 million, and with costs tripled from the original predictions, money is getting short. No electrical company is willing to take on the responsibility for the construction of any further plant beyond Angra III. The government and NUCLEBRAS are pressuring CESP, the utilities company of Sao Paulo, to build a fourth plant (the third of the German agreement), but CESP prefers to build more hydroelectric plants at a quarter of the cost of nuclear plants. □