Report on the trip to Itajuba, Brazil by H S Mukunda

On an invitation from Prof. Pio Lobo of Escola Federal Engenharia Instituto (Federal school of engineering institute) of Itajuba, Brasil, I left Bangalore by Air India flight on 03, November 2000 at 0200 hours. The check-in staff cribbed about accepting the three-piece baggage as carry-on baggage. They gave a lecture to the old professor and let him go. Only afterwards it is that I discovered that not-so-old professors were also carrying a fair amount of carry-on baggage. The journey to Mumbai was uneventful. They announced the flight as AI 447. I was surprised. The flight became AI 101 from Mumbai. I had to get down, wait for another hour and a half before boarding was announced. The flight scheduled to leave at 0630 hours, left at 0715 hours and reached London at 1130 hours local time after traveling 7200 kms in 9 hours. The time gained was five and a half hours. At the transit area, SAS airline personnel checked me into the RG 757 flight and I waited for ten hours at the airport. I simply slept on the vacant chairs for several hours ate up apples that I had taken, drank some coffee and moved around totally disinterested in the dazzling shops of all kinds. The flight left at around 1150 hours local time and arrived at Sao Paulo at 0730 hours (local, Indian time being 1500 hours on Saturday, the 04 – 11 – 2000) ten minutes ahead of schedule after flying about 10500 km. There was routine check at the immigration and was waived through the customs and walked out of the airport to see Prof. Lobo waiting for me. I was relieved to see him. We waited for another ten minutes to see Christiano. He did not seem to be around and we left the airport by a car belonging to the university driving directly to Itajuba. About two and a half hours of drive was on highways comparable to those in USA, (for instance) and later in smaller roads, for an hour and a half. Some places that I saw were very much like villages in India. We arrived at Itajuba by 1215 hours on 04 – 11 –2000 (IST: 1945 hours). I did not seem tired at all. Relaxed for some time and went for lunch with Prof. Pio Lobo. Five minutes of walk and we entered a very interesting hotel – food to be paid by the kilogram. I was shown rice, a vegetarian gravy, and salad bar in which most of it is vegetarian. Found very good water melons, papaya, pineapple, brinjals (this is also the word in Portugese) pieces of which also formed my food. I ate 0.5 kg of food. From this day onwards, I watched that I was eating 0.45 to 0.47 kg of food every day afternoon. The weather in Itajuba (900 m altitude) is much like in Bangalore. The hotel I was staying is called Centenario and just around that is a small beautiful square with trees and sitting places around which there are eating shops.

In Itajuba which must be 4 km by 4 km size, about 80,000 inhabitants live in average size houses, 500 to 700 m^2 largely in packed houses. Most houses have a high compound wall mostly as a matter of protection. Most flowers in India are also seen here. Sampige (No mallige, that I could see) and other flowers are seen around. They are totally insensitive to flowers except as a gift, greeting, in which case one has a bouquet. I could see parthenium (congress grass) at several places. Fortunately, they are not wide spread. The first two days – 6th and 7th November 2000 were spent in lectures using most of the material that I had. There were ten students. Most of the local students did not know English at all. Even the TV did not have anything in English. Even the US movies that are dubbed do not have English sub-titles. I told many of them that this is a serious defect and unless the large younger population learns English, it will be difficult for them to compete in the new economic world dominated by USA, UK, Germany, India all of whose activities which are international are based on English. I was supposed to give more lectures, but there was nothing new on the subject that I could keep talking indefinitely. In one blank session, they asked about economics of biomass power generation and I worked with them with the numbers that they provided. It showed that the costs of fuels are about the same as in India and the economics similar. But there is an exception. The domestic rates for electricity are double that of industrial electricity. Two days were spent in building a mall gasifier that works! The workshop staff cooperated, an old blower was searched and brought out from junkyard, and the entire system was fixed by Friday morning. I had to look for charcoal in the junkyard and brought out a few kg for use in the gasifier. Every body clapped (!) when the gas burnt in a small stove meant for smithy. The show was over by 1130 hours. I really wondered if the gadget would work at all afterwards. I understood from Prof Joule, who had helped put together the system (he and three others had literally carried the heavy fire box with blower mounted on it for a hundred meters to bring it from the backyard (another name for junk yard) the previous day evening using two long wooden poles!). Prof Joule and two of the mechanics managed to restart the gasifier and run it in the afternoon, it seems – very gratifying!

One of the remarkable features of Brazil not adequately publicized by Brazil itself (!?), and not known outside as much as required is that all the gasoline used in Brazil has 26 % ethyl alcohol. The total number of spark-ignition based engines is about 6 million out of which a million or so at present are 100 % alcohol based vehicles. This by no means is small. This is also remarkable. One can see that they have made a tremendous progress in

renewable energy. Fiat, General Motors, Volksvagon, and Ford all produce both gasoline engines for 26 % alcohol mixed gasoline and 100 % alcohol engines. Right now they are not producing pure alcohol engines because of "government policy" related to renewable fuels. Their attention is being diverted to natural gas based electricity, for reasons that are more political than technical. They get 95 % of the electricity from hydro-sources and the rest from coal in the south. The total installed capacity is 60,000 MW for a population of 160 million (compare it with 100,000 MW for a population of 1000 million in India – this works out to an installed capacity of an average of 350 W per person in Brazil and 100 W per person in India; of course, availability of energy is quite another matter). They are a very rich country in terms of natural sources and the population is fairly inventive – for otherwise how do you account for their substantial strength in renewables. There is much we can learn from them. There is a significant sugar economy. They crush 300 million tonnes of cane; produce about 18 million tonnes of sugar and 3.2 million m^3 of ethyl alcohol. Why cannot India do this is what they asked and I had no answer to give. This will be a major contribution of renewables in India. This will be an important fuel for transport. They are also trying to introduce 3 % and 5 % alcohol in diesel engines largely to reduce the emissions. Apparently, this is significant, as many experiments have shown. Curiously, no more pure alcohol cars are being produced, since at one time, the sugar cane producers arbitrarily reduced the production of alcohol and increased the production of sugar looking at their own returns (at this time the sugar prices were high) and no alcohol was available in the market. People could not rely on alcohol and they switched to gasoline cars. Since, fortunately, they are mixing 26 % alcohol in their gasoline, it is not entirely a washout. But many thinkers believe that a golden opportunity of moving ahead with renewable economy has been lost by the reversal of trends. A recent problem that has occurred is the invasion of natural gas into the power generation segment. Since Bolivia offered their natural gas cheap in US dollars at one time when Brazilian Real was measuring at 1.2 US $ for a Real, and subsequently, the currency exchange rate went to 2 Reals for a US dollar, and the investments in the long pipe line and pumping equipment became excessive load on the costs in US $, the entire project appears to be in jeopardy. Thus instead of solving by internal regulation, involving oneself in external dealings has led the country into some mess which can be overcome with determination. The sugar lobbies in Brazil are essentially family concerns and cannot think beyond subsidies. Their lobby is powerful, but not focused excepting when it hurts them. Added to this is the petroleum lobby that wants to credit itself with

more production and sales rather than help out in the national crisis on a more rational basis.

One tonne of sugar cane produces on the average 130 kg sugar or 130 liters of ethyl alcohol. It is possible to judiciously operate the industry to apportion the relative outputs. It is simply a matter of government regulation that the sugar industries could be told that they choose the mix within bounds. If this was done, the interests of the sugar mill owners could be taken into account by keeping in mind the national economy. Allowing wide and wild fluctuations has led to the current reversal of trends in renewables. There are lessons for India. It is clear that India is the second country in terms of sugarcane production – 250 million tonnes against 300 million tonnes of Brazil. Our own gasoline use is in the range of 5 million tonnes ???. We can produce 65 million liters of ethyl alcohol at 50 % use for alcohol. This can replace about 40 million liters of petroleum fuel either in gasoline engines or as additives in diesel engines. The non-tree based fuel oil component will be in addition to this and can burn in diesel engines and run all the rural economy based vehicles – tractors and the like. The next step would be to examine how the truck transport fuel can be managed from renewables.

Specific discussions:

The technology center of Copersucer, Perisacaba:

Manoel Regis Lima Verde Leal – Manager Industrial Technology
Jose Antonia Ghiraidini – Chief, Process technology section

Two others participated, including the general manager who is the first student of Prof. Pio Lobo.
The manager, Leal was very competent and knew what he was talking. He is the partner in the BIG-GT project funded by World Bank/UNDP with TPS as the technology institution.

They are a private company with money coming from sugar cooperatives with 1 % gross profit being a part of their budget. However, this money cannot all be spent on technology; they are used to maintain the senators and congressman towards subsidies. They have a ISO 9002 certified laboratory for checking the quality of sugar and ethanol. They have a modern plant science laboratory. They specifically do DNA typing of new varieties, test grow them in their fields to check pest resistance, growth rate on a 5 year

cycle basis, etc, etc. The harvesting schemes are also considered important. They develop mechanical harvesters which can harvest 8 to 10 tonnes per day compared to 5 to 7 tonnes per day from manual harvesting. This also allows one to use the tops and leaves in the boiler. From the point of view of cogeneration, India has progressed much more than Brazil. They are attempting to catch up now. One of the special developments is the biodegradable plastic from bagasse. They are currently industrializing the process. Also, they are involved in obtaining alcohol from Bagasse. They believe that if this stream is added to an existing alcohol producing system in a sugar factory, one can produce alcohol much cheaper than the classical route to convert biomass into alcohol. He also indicated that this route for use of bagasse appears far superior to other routes. When I enquired what he would with the lignin, he stated that lignin itself has separate uses or it can be used for other chemicals. *This route of using bagasse appealed to me since here is an opportunity to produce ethyl alcohol which is renewable and can insulate a country from the fluctuating oil prices.* He claimed that they concentrate on specific areas after considering all the implications and work hard towards the goal. This also appealed to me immensely.

From his statements on the project with TPS, it appears that wood chips have been processed successful (this must have been completed even when we were there on a visit to Royal Institute of Technology, Sweden), bagasse without drying has also gone through what he called one week run the results of which are with him (secret!). Now they are trying chaff-cut tops and leaves. His perception is that feeding bagasse is the biggest problem. Drying bagasse is something that should not even to be attempted. Briquetting bagasse is very difficult. They tried hydrolyzed bagasse with an industry to pelletize it. The company did the job apparently with lot of difficulty and did not want to try again. His opinion of the situation as formed from these experiences. He prefers the atmospheric gasification route since it is reliable even though there is loss of efficiency. The Vernamo "high pressure gasification – GT engine" plant seems to have been shut down with the consideration that the plant would not be useful for anything other than wood chips and their experiences with candle filter were not encouraging. I am unable to appreciate this logic. This should be verified with Mr. Buhler. During the conversation he brought up the experience in Hawaii and stated that feeding bagasse in the high-pressure system gave him scare by looking at briquetted biomass in the feed system at Hawaii plant. This was also a bit of news to me.

We adjourned for lunch and after lunch we were shown around and we met again. This time he wanted me to speak about our work. I began by stating that for some body who knows what is important and where he is going I do not know if he would be interested in kWs at all. He genuinely showed interest and I explained to him with the material on my laptop. He appeared very interested, deeply impressed and indicated that Brazil has considerable need for the 100 kW class technology in various parts where grid cannot reach, etc. He suggested that we should talk to Alfonso, Horta, and a few others in Brasilia to which Prof. Pio stated that it is planned to see all of them. I also described the high pressure gasifier work as well as the plans for drying bagasse and briquetting – gave him the numbers on energy for briquetting (80 units per tonnes) and the sizes at which these were intended to be made, etc. He made extensive notes at this time.

Prof. Electo de Silva, EFEI.

Prof. Electo has created a group called NEST and Prof. Pio belonged to that group earlier. They seem to work independently since intellectual independence and freedom of work are the points of weakness in NEST. Prof. Electo seems to moved around the world quite a bit, made connections, written books – about six and is known better, something he always attempts to establish in the conversation. He has a large project on developing an ambient pressure fluid bed gasifier, cool and clean the gas before compressing the gas to run a 45 kWe micro-turbine of Elliot make. A student of Jans Andries of Holland spent six months, designed the gasifier, got his masters degree and has left. The system is under construction in a company close to Compinos. He was acting secretive about this with Prof. Pio. On 15th evening when I was walking around the town taking pictures of the high sloping roads, congress grass plants, plants with flowers similar to ones at home, Prof. Electo was driving towards his office, stopped and asked me if I could go with him for a cup of tea. I said, yes and went with him. He spoke of his life – he was in Russia for nine years from where he got his Ph. D. He worked both in Odessa and St. Petersburg. He married there, had a son and divorced while leaving Russia. He stated he had nostalgic memories of Russia, etc, etc. He had a collaborative project with Jans Andres and it is in this project that a student of Jans worked here for his masters degree and designed the gasifier. He said that one year ago when he visited Jans laboratory a combustor was being tested with the gas from his high pressure gasifier. When I indicated that he had written to me indicating that he is running a gas turbine engine, he showed ignorance; just stated that some

thing must have happened in the last year and left it at that. On another side, Jans wanted to check with Prof. Pio as to what I was up to at EFEI. He may be feeling that his possible empire is being invaded, I don't know. Prof. Electo mentioned that he once got to speak to Eden Prabhu in a conference, found him to be secretive (look who is saying!). I agreed with him and looked like giving my advice that he should keep away from him. Apparently, Eden was anxious to know what Electo was doing with micro gas turbines, somewhat anxiously. I thought within myself, we should also be careful. He then showed me the thesis of the student of Jans written in English. I saw through that. He had used various correlations and put up the design. N body seems to have looked at the engine interface yet. This might create a problem. The numbers indicated in the thesis seemed to take he tar level as 1 to 10 %!. The temperature range chosen was 800 to 1000 K. When I asked why temperatures of 1000 C were not considered, he indicated that ash fusion problems are his worry. It is this temperature range that makes him get 1 to 10 % tar! I asked whether any experiments have been made at all. He indicated in the negative. I do not know how they will deliver any performance from the system. He appeared to be a collector of literature. He has our full report of tests on 75 kg/hr gasifier tests done with Swiss support. He stated that Naussbaumer is his good friend. There seemed to be some soft corner for him. Perhaps he may have given this report.

Prof. Kamal Ismail, University of Campinos, Campinas

On the way to Perisicaba, the place of Copersucar, we spent an hour talking to Prof. Kamal, a former colleague and friend of Prof. Kamal. He indicated that he was a consultant from Uni. Campinas to establish the academic profile of an university in northeast. He stated that there are large communities I the area without even the minimum facilities of electric supply. I gave the usual presentation. He found immediate possibilities of use for the technology in those areas. He asked me if I could come to that university and give a similar course and how soon. I indicated that it is not necessary for me alone to come; there are others who know the subject from our laboratory and they could give the course as well and outlined the plan. Prof. Pio explained the whole concept. Prof Kamal stated that he might be able to get money faster than Prof. Pio could do. I stated that unless there is at least one center for doing tests, demonstration, training, and supply of critical parts, it is not appropriate to introduce the technology in this country. Inevitably there will be problems of operation, maintenance and new questions will be brought up and it is essential to have a few centers for

providing technical back up and the least is one center. He generally agreed with the philosophy and stated that he would work with Prof. Pio and us in times to come.

Discussions with the chief of incubator, Mr. Pilnio Rebeiro Lalte

This took place on 11 – 11 – 2000 with Prof. Pio Lobo taking me to his office, which turned out to be a hundred steps from Centenario hotel. Having reached there, I came back to the hotel and took the laptop and went to see them at the office of incubation. This office created by a consortium of EFEI, local municipality, and the federation of industries, is interested in providing incubatory support to technologies from any individual/industry/innovator with the help of EFEI and internet connection with 134 other such outfits throughout Brazil. Any one of these institutions can reflect an unsolved problem and others may facilitate by providing connectivity with other institutions, leads in any possible way. This appeared to be a very interesting idea and things seemed to be happening in many ways. After my presentation, discussions took place of the role of Incubator in future expansion of the activity. The incubator man seemed to see the overall extent of the activity and possible contribution that the incubator can make in bringing in venture capital for the growth of the industry.

Christiano Richers

Christiano Richers from DASAG – Brazil came to visit me on 11, Nov. 2000 driving from Sao Paulo at 1140 hours directly to the hotel – Centenario. Prof. Pio Lobo and myself had returned from the discussions with the incubator man. We spent some time talking generalities, energy issues of Brazil. Christiano had right views of the way Brazil does not realize the most important contributions made to renewable energy through alcohol program, and does not take further initiatives to establish the program using the strong base already available – as to why 100 % alcohol action cannot be progressed by assuring a minimum production of alcohol through negotiated settlement with the sugar industrial lobby so that production of 100 % alcohol engines is possible and more vehicles run on alcohol. I agreed with him entirely. I outlined the plan of promoting bio-energy in Brazil via gasification. I indicated that unless there was an institution to provide technical back up and support for field related issues, it would not be possible for technology diffusion to take place. It is for this reason that collaborative arrangements by which the gasification systems will be set up

at a university, in the present case, EFEI, Itajuba, so that local training, problem check out and problem solving can be done so that field related questions can be solved within Brazil itself. He seemed to see the point, particularly after uncovering that he himself has not been able to promote the technology in Brazil. I also do not know how educated he is with respect to techno-political aspects and unless he becomes aware of these issues, nothing will get promoted. He is at best a consultant with some understanding of international issues and several segments of national issues and therefore can be of benefit to progressing the technology. He left Itajuba at about 5 pm by his car.

Visit to Helibras, and Director Industrial, Joao Bosco C. Ferreira

Prof. Joule, head of the mechanical production group who had helped build the gasifier in his workshops was undergoing the training program for becoming a helicopter pilot. He took us on 14 Nov 2000 to helibras. In this factory, they build (licensed by French company) 20 to 30 helicopters for civil and military applications; do periodic and statutory maintenance with about 250 workers. The factory looks compact, but the work very vigorous. That this is happening in Itajuba, a small town surprised me. They have all the expertise and I learnt several interesting things. The masses of the blades need to be accurately tuned to less than a gm in 300 kg. They have a very sensitive measuring system for this purpose. Even a handshake near the sensor seemed to produce mass of the order of 1 gm. To make these measurements, they do it a room that does not look great, but precautions of no ambient wind, etc are taken care. The blade profiles used earlier were symmetrical in shape, but these days for Dolphin class copters, they use laminar flow airfoils (with thickness to chord ratio remaining nearly same over the chord. The method of using optical technique for determining the out of balance of the tip of the blades when they are rotating also appeared interesting. No comments are possible for comparison, since I have not seen the HAL helicopter factory.

Wood factory 30 km from Itjuba

In the afternoon of 14th Nov 2000, Prof. Joule took us to a wood factory about 30 km from Itajuba. It was mildly raining and temperature was about 20 C. The drive through the mountains was exhilarating. There were several beautiful towns/villages along way tucked into the valleys of the mountains. It must have been an expensive affair to take electricity to these towns. The

wood factory processed Canadian Pine grown in the mountains around. Incidentally all the mountains are owned by private individuals like land being owned. Canadians have taken about 300 Ha of land, leased it to the owners of this factory, and provided the seedlings to grow the plantations. The reason they do this is due to the fact that the same seedlings take 60 years to grow into an acceptable mature tree in Canada, but take 28 years to grow to the same maturity in Brazil. The claim is the soil and climate here are more suitable for the appropriate growth. This appears also the reason for very good Eucalyptus output from plantations in Brazil – 15 to 25 tonnes (dry) per hectare per year in a five-year cycle. The factory is very old – thirty years. It has a boiler built in 1938. This is similar to the approach in India. It is otherwise managed efficiently. The pine trees exhude a very nice smelling resin typical of these trees. The whole trunk is sized into pieces, dried and cured at 60 C for 24 hours using indirect steam fired system and machined to several forms and shipped away to Canada. Sawdust is simply washed away by a stream of water that goes out of the factory, the water is filtered in a bed, and the sawdust remains a mound with water going away into another mountainous stream. There are cubical pieces 100 to 150 mm size at 50 to 60 % moisture converted to charcoal in an Igloo like civil structure, a part of which is put together with bricks and mud every batch (much like pit method, but over ground, that is all). Long pieces of wet wood unsuitable as furniture material are used to fire the boiler. The exhaust from the chimney looked very clean. This must have been due to firing 50 % wet wood and possible excess air. The aim of the visit was (a) to find out if wood chips could be obtained from them and/or (b) improve the operations so that heat or electricity generation was possible. I indicated that the loss of volatiles in the charcoal making process could be eliminated with the use of new technologies. The idea was to separate the drying and charcoal making process. Drying could be accomplished with low-grade heat including the exhaust of the boiler fired with dry wood – extract more energy and also use the exhaust for drying. The dried material goes into a gasifier filled with dried wood blocks and all the stuff, closed from the top and supplied air from the top only (with air nozzles closed after lighting the biomass). When the flame reaches the top simply stop this system and shift to another down draft system. Thus there is need for four reactors. Two are for drying and two for gasification. The entire boiler system will run on gas. If necessary, it will also use wood pieces. Also Prof Joule had an idea – if we condense the vapors from drying chambers – both with the actual product drying as well as waste wood – we can obtain the resin and it is possible it will have commercial value in the perfume industry. All these have not still been

communicated. May be we will work out some costs and tell them the numbers. This completed the visits. Wednesday was a local holiday.

Official Meetings at Itajuba

On 10th November, the Friday, we met the chairman of the department. He appeared cooperative and nice. He indicated support to the collaboration.

On Tuesday, the 14th November we met Dr. Germano Lambert Torres, the Pro-director of the post graduate school. He was enthusiastic and he gave a copy of a possible MoU between IISc/ABETS and EFEI. It was in Portuguese. Subsequenty, Prof Pio Lobo translated it into English and has sent it to me. It needs substantial modifications before being accepted. We need to work on it after return.

On Thursday, the 16th, we met the director of the school, Mr. Jose Carles Goulart de Siqueira,. He appeared very supportive of the efforts being made. I spoke to him indicating how important this will be for Brazil to do this in a systematic manner an he should view it in a national perspective and support the international collaboration. He indicated that he would do the needful to help build the center for biomass energy at the school.

On Thursday afternoon I left Itajuba to go to Sao Paulo to get the flight to Joao Pessoa in the north east of the country.

Visit to Joao Pessoa and Prof. Emerson Freitas Jaguaribe, university of Pariba

The ticket arrangement for the visit was interesting. The ticket was bought at J. Pessoa and a code number was provided. I was supposed to go to Sao Paulo airport and give this information to ticket issue counter. They would then issue the ticket. The driver of the vehicle knew all the ropes and helped me get the ticket. He was supposed to have arrived at Hotel Centenario at 1430 hours (local), but came only at 1505 hours. This caused some concern, telephone calls, etc. But the driver promised that I would be delivered at Sao Paulo before 1800 hours for a flight leaving at 1908 hours. We left and he drove very well through a different route (apparently, there are four to five routes from Itajuba to Sao Paulo.). He drove some times at 140 km per hour, but very carefully. We spoke a few words in between haltingly. We reached the airport without stopping anywhere for agua (water) or coffe (as they call

it) and arrived at the airport at 1750 hours and went to the spot for getting the ticket. It was very smooth. The lady asked for my passport and handed in the ticket. The flight was from Sao Paulo to Salvador. At this place there would be a change of plane to go to Joao Pessoa. As soon as we got down from the plane, we were physically herded on the tarmac to the next plane. The next segment of the flight also seemingly came to an end and I got down, went to the airport to look for my baggage – did not get it and went in search of the person to get my baggage. He stated that the baggage was to go to J. Pessoa. I said I also want to go to Joao Pessoa (!). He said that this Aracaju (Caju in Portuguese and Hindi mean the same). I was shocked. The person did not seem concerned at all. He just said – let us go to the aircraft. I went back into the aircraft and asked the attendant there as to how come, the boarding pass does not show Aracaju as a possible intermediate point. They simply said sorry and moved away. Any way I landed at Joao Pessoa at 2230 hours (local), 0030 hours (17th Nov 2000) according to Itajuba time (0730 hours, 17th Nov, 2000 according to Indian time), got the baggage intact and was picked up by Prof. Emerson and driven to a hotel near the beach. I slept about five hours and found that the sun was bright even at 0530 hours (local). Got ready, finished the breakfast of watermelon pieces, pineapple pieces and bread pieces and got ready to go with him to the university by 0750 hours. We went to his laboratory at the university and he showed around the equipment meant for determining the properties of activated charcoal. They have a PSA (Pressure Swing Adsorption system that we also wanted to get) apparatus for getting 100 % pure nitrogen. This is used for BET apparatus. They have made measurements of Iodine number and BET surface area. The measurements also give the data of the volume adsorbed as a function of pore size. The curves are plotted on a semi-log paper. For many cases they get the results like the volume of 0.12 to 0.14 cc/g at 20 A size going down to 0.01 cc/g at 1000 A size. If he does it with the outer part of the coconut shell he gets a curve which is like a delta function at 800 to 900 A. He believes that this is very good for removing chlorine from water. His point was that manufacturers of drinking water, coca cola, pepsi, etc all have to first chlorinate the water to remove bacteria and then have to reduce the chlorine below the acceptable limits for human consumption and this can be accomplished well by this kind of activated carbon. I asked him if he knew the correlations for Iodine number, Methylene Blue number, and BE. He indicated that he did not have data, but he had many useful comments to make. He indicated that they have an intense Japanese collaboration for the last six years with the University of Yokahama with visits both ways and equipment from Japan. Japanese use Benzene as the adsorbant, but do not

talk about it because, Benzene is considered carcinogenic and therefore should not be used in industrial laboratories, etc. He himself did not have experience in using Benzene, but indicated that Iodine is a good reagent. I just speculated that various reagents could have use in different applications since the molecular size of the substance to be adsorbed would matter and perhaps, Iodine is representative of many materials that are to be adsorbed and that is how it has become the standard. He had no special comment to make on this. It appears that the science of activation should be explored from more fundamental grounds and perhaps some collaboration on this subject with somebody in IPC/SSCU might be useful. His activation technique involved high temperature furnace and a steam generation system. He has fair number of coconut shells being readied for charcoal making. The university home page is http:///www.ufpb.br.

Regarding costs of fuels:

Fuel	cost	Cost in R$ per MJ
Diesel	0.73 to 0.75 R $/liter	0.02 to 0.021
Gasoline (gasoline + 26 % alcohol)	1.54 to 1.59 R $/liter	0.042 to 0.044
Ethyl alcohol	1.00 to 1.19 R $/liter	0.055 to 0.057
Biomass	0.03 to 0.05 R $/kg	0.002 to 0.004
Charcoal	0.15 to 0.22 R $/kg	0.01 to 0.015

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