OSE
Optimisation des Systèmes Energétiques

Specialized Master's Programme in Energy Engineering and Management

MINES PARIS

INDIA : Field Trip

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Topics

ParisTech
GRANDES ECOLES D'INGENIEURS DE PARIS
PARIS INSTITUTE OF TECHNOLOGY

Class of 2005

Introduction

India is simply a surprising country, of big contrasts and big crowds, where the elegance of the Sarees mixes with extreme poverty; here and there, one meets as many Hinduist and Buddhist temples as advertising posters of the five or ten last films produced in Bolliwood. The public transport system is also quite an experience in the cities of Mumbai and Chennai, the main battle fields of the rickshaws and Taxis 'made in India', that transport tens of millions of Indian in crazy races, with a klaxon as the only mean of survival in the streets.

India is also a country of big energy projects. Its huge population, around 1,1 billion, and its strong economical growth, experienced during the ten last years (about 7% per year) require large amounts of investments in the energy sector, around 1000 MW per year. To do so, local authorities appealed to all existing and available technologies, notably coal and nuclear power. India does not make exclusions: per inhabitant carbon dioxide emission and energy consumption rates are far lower than those of the industrialized countries. Nevertheless, the country has immense resources of biomass for electricity production. This potential is estimated at 20,000 MW and 12 million production sites of biogaz. Many project developers are seeking these types of alternatives because of low labour costs and the possibility to obtain carbon credits.

The students of Mastère OSE, attracted by the energy issues in India, came down to Mumbai, on the west coast, and Chennai, on the Gulf of Bengali to visit several sites and to participate in lectures given by the biggest energy companies, among others, Tata Power, Reliance Energy, Tarapur Power and Areva T&D. At IIT (Indian Institute of Technology), the students presented biomass issues in the European context, giving some detail regarding policies and incentives mechanisms put in place in France, Austria and Denmark among others. The visit of the biomass power unit of Jyoti Bio, 330 km N of Chennai, doubtless was the strong moment of the trip where one had the possibility to see the entire electricity production process, starting with fuel collection and processing. Finally, the trip concluded with a visit to Auroville, a self-sufficient town of 1800 inhabitants founded in 1968 near Pondicherry, which produces most of its energy needs from the sun.

The Report that is presented hereunder is a summary of the trip. It describes in chronological order every visit and summarizes the presentations of the host companies.

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INDIA

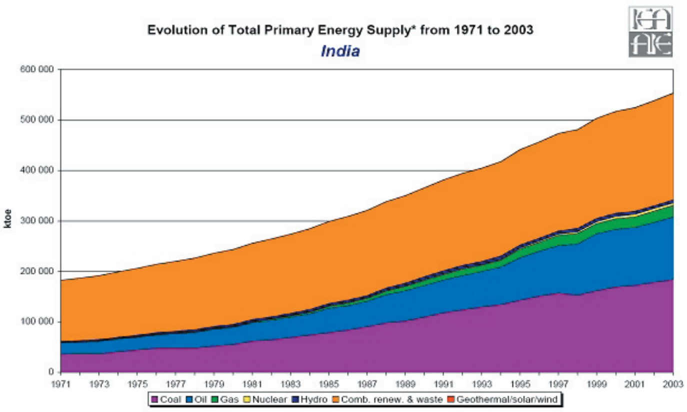
Indian Energy Context

India's population stood at 1.048 billions in 2002 and its GDP was 543.7 billion dollars (France is 1431.3). 2003 primary energy consumption reached 553.39 Mtoe (271.29 Mtoe in France) and the production was 455.29 Mtoe (136.32 Mtoe in France).

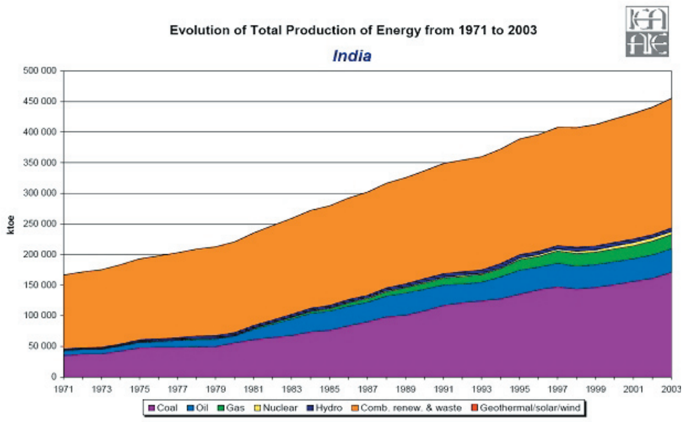
Consumption per inhabitant is very low, about 0.5 toe, of which 380 kWh is electricity. Biomass is the first energy source (38%), used more than coal (33%) and oil (22%).

Nuclear power is directly under control of the Prime Minister. In 1987, the Indian Renewable Energy Development Agency (IREDA) was created in order to finance renewable energy projects. More generally, the energy sector has progressively been liberalized since 1991.

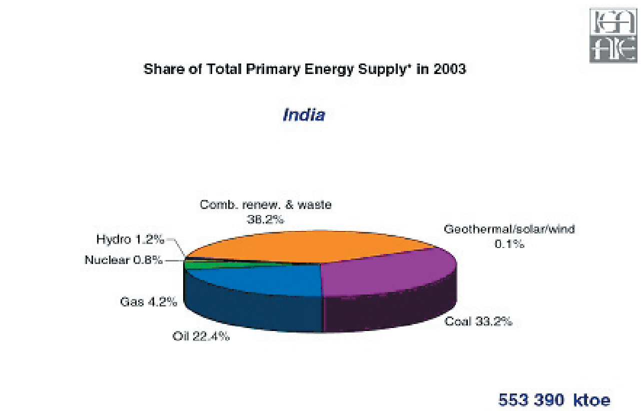
India ratified the Kyoto Protocol in August 2002.



* Excluding electricity trade.



The energy sector is managed by four ministries:
- The Ministry of Power
- The Ministry of Coal
- The Ministry of Petroleum and Natural Gas
- The Ministry of Non-conventional Energy Sources



* Share of TPES excludes electricity trade.
Note: For presentational purposes, shares of under 0.1% are not included and consequently the total may not add up to 100%.

Oil

Indian proved reserves are at about 730 Mt (0.5% of global proved reserves). India produces nearly a quarter of its consumption of crude oil. Exploration and production are under control of two public companies: the ONGC (Oil and National Gas Commission) and the OIL (Oil India Limited). The ONGC represents 80% of oil production and 100% of gas production. This company is also present abroad in the exploration field through its subsidiary OVC. OVC for example takes part in the Sakhalin 1 Project in Russia.

Oil imports represent 70% of Indian needs. Refining capacity is 2.1 Mbl/d, with 17 refineries. India is net exporter of oil products (8 Mt in 2002). The government controls the biggest refining company (42% of the national capacity), the IOC (Indian Oil Company). There are 8 other public companies and a private one, Reliance Petroleum (27% of the national capacity).

INDIA

Nevertheless resource depletion forces the government to multiply exploration licenses as well as investments abroad in fields under Indian control.

Gas

Natural gas reserves are estimated at 880 Gm^3 (0.5% of 2004 world proved reserves).

Indian natural gas production was 25.5 Gm^3 in 2003 and might reach 66 Gm^3 in 2006. Gas is produced offshore, near Mumbai, and then feeds the HBJ pipeline (Hazira-Bijaipur-Hagdishpur).

Petronet LNG (PLL) was created in order to develop gas supply via LNG. In 2001, Gaz de France entered its capital in 2001 at the level of 10%. LNG is developing fast in India (3 terminals were already in use in 2003).

The gas grid is growing too and there are more and more contracts with neighbouring countries (Turkmenistan, Pakistan, Afghanistan, Iran).

Coal

India owns important coal reserves (68 Gt proved reserves, 7.5% of 2004 world proved reserves), representing 185 years of production. In 2003, total coal production was 381 Mt. India is the third global producer, behind China and United States. 75% of exploitations are open sky mines. In this sector again the state plays a major role. The world's biggest coal company, the CIL (Coal India Limited), which represents 90% of the national production, is mainly public.

Nuclear

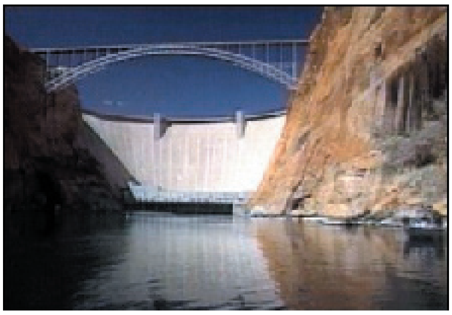
India has six nuclear power plants, that is to say 12 reactors. Each reactor has a capacity of approximately 220 MW, which means 2720 MW overall.

The first reactor of Indian design started to generate power in October 1999 (220 MW). Those power plants are PWR, except the oldest, built in 1969, which uses the BWR technology. Nuclear Power Department considers

building new plants to reach a capacity of 20 000 MW before 2020.

Indian nuclear power plants (2005)

Hydraulic, wind



Tehri dam

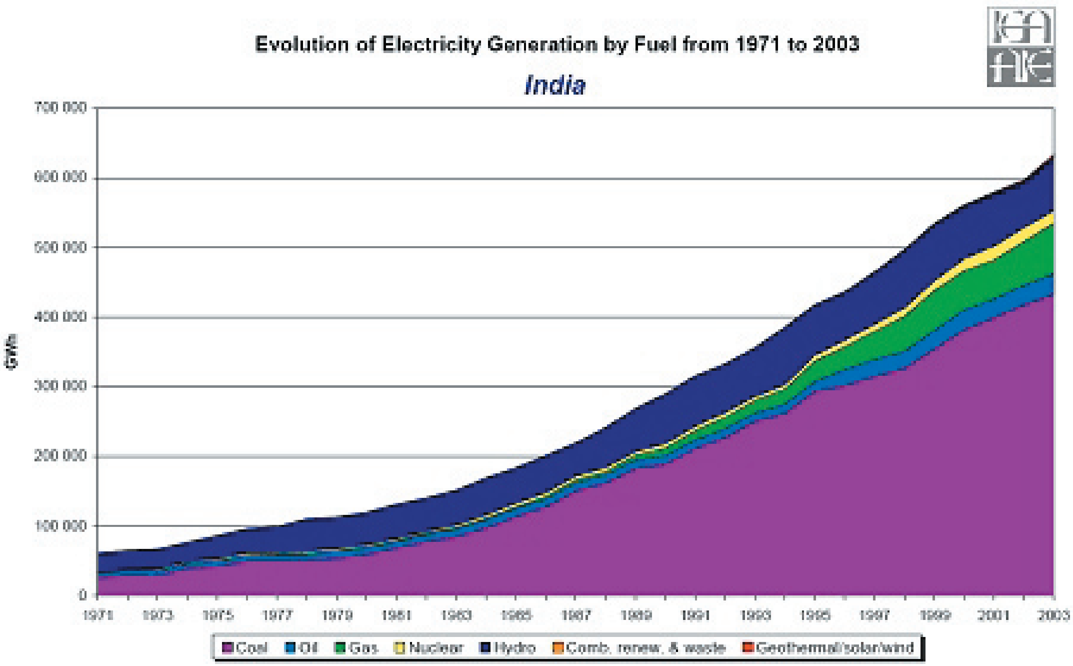
Indian hydroelectric potential is estimated at 84 GW.
Installed wind capacity was 2100 MW in 2003, and the objective for 2012 is 6000 MW.

INDIA

Electricity

Power generation capacity was 125 GW in 2003 (117 GW in France).

Electricity production is 10% below needs, but capacity is 40% higher than peak demand. It can be explained by the age of the installations and a rate of use of under 35%. Self-production is developing and reached 9% of total production in 2003.



The Indian electric sector is organized at the state level by the SEB (State Electricity Board), vertically integrated. These SEB are coordinated at the national level by the Central Electricity Authority (CEA).
The "Electricity Act 2003" makes the creation of regulation bodies at the state level compulsory. In 2003, 22 states had their regulation bodies : the SERC (State Electricity Regulatory Commission).

The Indian electrical system is not very efficient because it used to perceive subventions. Today, the State is trying to incite investments and a larger use of existing installations. The electrical market is totally open to competition for production and distribution (concessions). But private companies represent only 5% of the installed capacity, against 63% in 1950.

The biggest electricity companies are under the control of the Ministry of Power. The most important one is the National Thermal Power Corp which represents 20% of the national capacity (20,500 MW). The transport grid is the property of the public company Powergrid Co Ltd.

Electrification rate is about 40%, and 84% of the villages are electrified.

Energy challenges

India has a major challenge in the field of energy. On the one hand, oil production is decreasing whereas demand is growing. On the other hand, industry and other sectors need more energy efficiency to develop themselves.

Many investments should be realized in this sector to continue development. Policies try to encourage foreign investments.

Many investments are required : the CEA forecasts that the installed capacity should grow from 125,000 MW to 225,000 MW before 2012. A huge effort is needed for production, but also for transport.

In the gas sector, many investments have already been realized and must go on. International pipelines projects have begun. But they have been slowed since the discovery of a big gas field in 2002.

Coal will continue to retain the major place in the energy mix because of the large reserves. But Indian coal is not of good quality, so the country will still need to import some to satisfy its needs.

To conclude, the Indian energy sector is still under construction. Access to energy for everybody will be the major challenge. India can't neglect its energy supply if it wants to succeed in its economic ambitions. For instance, Chinese electricity production is twice the Indian.

INDIA

Key Figures (IEA 2003)		India	France	EU 25	World
Primary Energy Production (Mtoe)		**455**	**136**	**897**	**10709**
Primary Energy Consumption (Mtoe)		**553**	**271**	**1737**	**10579**
Security of supply (%)		**82**	**50**	**52**	**-**
Primary Energy Demand (Mtoe)	*Oil*	130,99	85,67	674,07	3875,44
	Coal	183,77	14,35	314,5	2583,57
	Gas	24	39,37	408,02	2244,14
	Biomass & Wastes	211,2	11,95	71,81	1143,11
	Nuclear	4,63	114,95	253,86	687,31
	Hydro	6,48	5,09	24,91	227,5
	Other	0,31	0,23	9,98	54,03
	Electricity Imports	0,15	-5,68	0,65	0
Primary Energy Consumption (%)	*Oil*	23,7	31,6	38,8	36,6
	Coal	33,2	5,3	18,1	24,4
	Gas	4,3	14,5	23,5	21,2
	Biomass & Wastes	38,2	4,4	4,1	10,8
	Nuclear	0,8	42,4	14,6	6,5
	Hydro	1,2	1,9	1,4	2,2
	Other	0,1	0,1	0,6	0,5
Electricity Production (TWh)		**633**	**567**	**3119**	**16742**
Share of Electricity Production (%)	*Coal*	68	5	32	40
	Oil	5	2	5	7
	Gas	11	3	18	19
	Biomass	0	0	1	1
	Wastes	0	1	1	0
	Nuclear	3	78	31	16
	Hydro	12	11	10	16
	Geothermal Energy	0	0	0	0
	Other	1	0	1	0
Final Energy Consumption (%)	*Domestic*	58	40	38	39
	Transport	12	30	29	26
	Industry	24	21	30	32
	Non energetic uses	6	9	3	3
CO2	*Global Emissions (Mt CO2)*	1050	390	3884	24983
	Emissions per capita (t CO2)	0,99	6,33	8,5	3,99
	CO2/TOE (t CO2 / toe)	1,9	1,44	2,24	2,36
	CO2/PIB (kg CO2 / 2000 US$)	1,93	0,29	0,45	0,75

RELIANCE ENERGY

Reliance Energy
A Dhirubhai Ambani Enterprise

Energy is life

Mumbai, Monday March 20.

Greetings and Presentation
Presented by : Sh.D.R. Sukhtankar Kale

Reliance Energy, formely Bombay Suburban Electric Supply (BSES), is a subsidiary of Reliance Industries Limited, one of India's largest industrial groups. Reliance distributes electricity to the Mumbai suburbs, while the municipality is in charge of the center. The suburbs of Mumbai are divided into five zones : North, Central, South Central, South and East covering a 385 square kilometre area.
Reliance Energy has close to 2.5 million customers representing 1380 MW. Reliance owns a 500 MW thermal group for production. The remaining energy is bought from Tata Power Company (TPC) which is connected to the grid.

Electricity Sector Regulatory Aspects
Presented by: Sh.Makarand Kale

The market for electricity has developed gradually in India since the beginning of the 20th century with the Indian Electricity Act in 1910, the Electricity Supply Act in 1943 and the Indian Electricity Rules in 1956. From 1943, the market has developed in each state around the State Electricity Boards (SEBs), in charge of production and distribution grids, and of the Exchange Electricity Authority, in charge of national problems. The SEBs - in particular Maharashtra Electricity Board in the area of Mumbai- allowed the electrification of the Indian sub-continent and made possible its agricultural industrialization and its revolutions.

In 1998, the Electricity Regulatory Commission's Act allowed the creation of the Indian electricity regulation commission, the CERC (Central Electricity Regulatory Commission) and regulation commissions in each state (State Electricity Regulatory Commissions, SERCs), independent of the government. The purpose of the creation of these regulation commissions was to adjust tariffs for SEBs by the emission of «Tariff orders».

In 2003, the Electricity Act made it possible to intensify the development of the market and the opening to competition : dismemberment of SEBs into different companies specialized in production, transport and distribution, privatization of the production, transport and distribution compagnies

It is within this framework that Reliance Energy was created to succeed BSES in 2002 following the decision of the government of Maharashtra to turn the company private. Reliance Energy finds its place at all the levels of the market. The company is not only the single distributor of electricity to the consumers in the suburbs of Mumbai but is also implied in the production of electricity, transport and the distribution in other parts of Maharashtra.

Commercial Aspects
Presented by: Sh.S.P.Joglekar

The commercial aspect covers four main points

1) Contacting the clients

If someone wants to be connected to the distribution network, he must first fill a standardized form provided by Reliance. Then, three scenarios are possible.
If a line going to the client's home already exists with enough free capacity then the client is immediately connected.
If a line exists but without any margin then a new substation must be created. By law, Reliance is authorised to take land from a new project to build a sub station.
Finally, if there is no line, Reliance needs permissions which takes roughly two weeks to get.

2) Meter reading

All meters must be certified by an independant electrical tester before they can be installed. They used to be read once every two months, but this was considered too rare, so Reliance now reads the meters every month in order to disconnect sooner those who don't pay. The 2.5 million meters are read every month by 400 people. This represents around 300 meters per day and per person.

RELIANCE ENERGY

Energy is life

3)Billing

For now, a two parts tariff (power and energy) is used only for customers using more than 37.5 kWh per month. Reliance has a goal of applying this tariff to all its customers in the near future.

4) Collecting Money

Reliance has a department dedicated to collecting money. It is in charge of going to the customers and asking bad payers to pay their bills. If all else fails, it is also in charge of cutting off electricity, and makes sure that there are no energy thefts.

Dispatching : SCADA Master Control Centre
Presented by: Sh.P.M.Hundiwale et Sh.S.Yeole

The control center allows Reliance to know in real time the state of all the system's elements.
The process is completely automatic. Visual and sound indicators help the technicians in their task by telling them where to focus their attention.

Technical Aspects of REL Mumbai Distribution Business
Presented by Sh.R.D.Uchil, Sh.P .S.Deo

Electricity generation comes from a coal fired power plant : Reliance owns a 2x250 MW coal-based thermal power station at Dahanu that is about 100 kms from the supply area in Mumbai. The 16.5 kV voltage generated is transformed to 220 kV for transmission through the country. For sub-transmission around the city, there are 3 power transformers that generate a 33 kV voltage level.

At the 33 kV receiving stations, power is further stepped down to the 11 kV level and distributed to 4000 transformers (11/0.433 kV) via an 11 kV underground cable network. At the 11 kV substations, power is stepped down to 415 V and distributed to consumers via undergrounded cables.

At Reliance Energy, the divisional engineering activities are broadly divided into different sections : maintenance, safeguarding, construction of cables…
Reliance also provides services to the consumers:
Progress Department processes applications from consumers regarding new supply, reinforcements, shifting etc. and prepares the requisite estimates.

After completion of the formalities, the application file is sent to the Services section for execution. This section then issues Job Orders pertaining to the application file.

Reliance Energy
A Dhirubhai Ambani Enterprise

TATA POWER

TATA POWER Description

Mumbai, Monday March 20.

The Tata Group is one of India's oldest, largest and most respected business conglomerates.
The Group's businesses are spread over seven business sectors. It comprises 93 companies and operates in six continents. It employs some 220,000 people.

Tata Power (TPL) is a pioneer in the Indian power sector and is one of India's largest energy utilities. Started as the Tata Hydroelectric Power Supply Company in 1911, it is an amalgamation of two entities: Tata Hydroelectric Power Supply Company and Andhra Valley Power Supply Company.

TPL provides services in power generation, distribution and transmission, oil and gas, and broadband and communications. The company has big overseas power projects in a number of countries, including the UAE, Malaysia, Saudi Arabia, Kuwait and Algeria. It has also undertaken projects in power plant / utility operations and management in Saudi Arabia, Liberia, Iran, Sierra Leone and Algeria.

TPL is India's largest private sector electricity generating company with an installed generation capacity of over 2300 MW. Tata Power has a presence in all areas of power sector generation (thermal, hydro, solar and wind) transmission and distribution.

The thermal power stations of the company are located at Trombay in Mumbai, Jojobera in Jharkhand and Belgaum in Karnataka. The hydro stations are located in the Western Ghats of Maharashtra and the wind farm in Ahmednagar.

The Company has been an innovator in introducing state-of-the-art power technologies. Among its achievements, the company has to its credit the installation of India's first 500 MW unit at Trombay, the first 150 MW pumped storage unit at Bhira, and a flue gas desulphurization plant for pollution control at Trombay. The Company's transmission & distribution losses are among the lowest in the country, only 2.4%.

The Company has also executed several overseas projects in the Middle East, Africa and South East Asia. Of particular interest are the Jebel Ali 'G' station (4 x 100 MW + desalination plant) in Dubai, Al-Khobar II (5 x 150 MW + desalination plant) and Jeddah III (4 x 64 MW + desalination plant) in Saudi Arabia, Shuwaikh (5 x 50 MW) in Kuwait, EHV substations in UAE and Algeria, and power plant operation and maintenance contracts in Iran and Saudi Arabia.

VISIT TO THE TROMBAY POWER COMPLEX:

During March 2006 students form Mastere OSE, visited the Trombay Power Complex.

Thermal units

This site consists of 4 thermal generating units.
This plants are operated in close coordination with hydroelectric power plants also belonging to TATA Power.

Power dispatching

TATA Power has been chosen as Regional Power Dispatch Center, this means that the Indian authority have given them the responsibility of coordinating, operating and balancing the western regions' electric system.

Power trading

Another important area of activity is Power Trading. It is the business of trading electrical power. The company sources surplus power from various states / private sector power generation utilities, captive power plants and state-owned electricity boards.

New thermal unit at Trombay

Tata Power announced the setting up of a new 250 MW power plant at its Trombay Thermal Station Unit # 8 will use imported coal with very low sulphur and ash content, in strict adherence to environmental guidelines. The total investment in the project is expected to be around 165 million € and is scheduled to be completed in 28 months. This new plant will supply electricity to parts of the Greater Mumbai, which are presently facing daily power shortages of about 200-250 MW.
It is expected that Unit 9 will also start soon.

For more information :
http://www.tatapower.com/

Unité	Capacité (MW)	Type
Trombay unit 4	150	Thermal (gas)
Trombay unit 5	500	Thermal (oil, gas, coal)
Trombay unit 6	500	Thermal (oil, gas)
Trombay unit 7	180	Thermal (Combined cycle gas fired)

Tarapur Nuclear Power Plant

Tarapur, Tuesday March 21.

The National Power Corporation of India Limited manages all nuclear power plants in India. In 2003, nuclear power represented 3% of the installed power capacity (112 Gwe). In 2050 the total capacity needed will reach 1344 GWe, so, in this context, nuclear power will have an important place even if India massively uses its own coal.
Currently, 15 reactors are in use in 8 plants. PHWR (Pressurised Heavy Water Reactor) is the main technology in service but 2 BWR (Boiling Water Reactor) are in use in Tarapur (1&2).

Five other reactors are under construction and both are PWR (Pressurised Water Reactor) of 1,000 MW each.
This PWR technology doesn't need heavy water but enriched uranium is required. India has also developed research in fast breed reactors using liquid sodium and one reactor is already in construction.
Concerning nuclear wastes, India has its own treatment system.

For the future, India is aware that it doesn't have enough uranium, so India wants to use its great reserve in thorium. This appears very interesting but there has not been much research around the world. India wishes to become a leader in this technology in the next year in order to ensure its security of supply. Resources are estimated at up to 300 years with thorium technology.

During our trip, we visited the Tarapur Nuclear Power Plant. The last reactors (TAPP 3&4) using PHWR technology have been started last year. These two reactors were built in a very short time, 5 years, which is less than the last French power plant of Civaux. Even if the technology is different, it's a great performance!

We started our visit with a brief presentation of the energy stakes and nuclear industry in India.
Then we visited the control room of TAPP 4, the turbines and we finished with the simulator for operator training and safety show room.

Indian nuclear development could frighten us because all technologies produce plutonium that could be use for nuclear weapons. So, how can we forbid access to nuclear energy for countries like Iran if we allow it for India? This is an important question which the International Community tries to answer. But, development of India and reduction of poverty could not be considered without a great energy program where nuclear power will have an important role to play.

Finally during our this visit, we had a very cordial welcome and every question was answered

IIT CHENNAI भारतीय प्रौद्योगिकी संस्थान मद्रास

Indian Institute of Technology Madras

Chennai, Wednesday March 22.

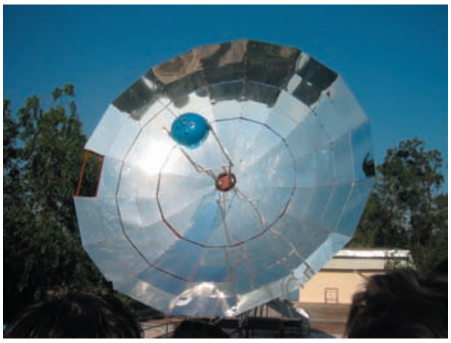
The Indian Institute of Technology, Madras, is one of the 7 national institutes dedicated to technological education and applied research. With nearly 4500 students, the Institute is composed of 15 departments and nearly 100 laboratories for engineering and pure sciences.

The Department of Mechanical Engineering consisting of 2 sections and 8 laboratories is one of the largest departments. Heat transfer, solar energy and automotive engine technology are studied also at a PhD level.

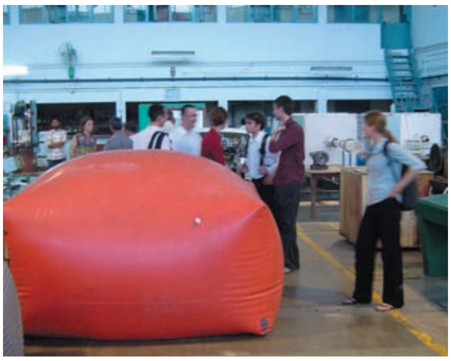
In the combustion and heat transfer laboratory, we saw a fluidized bed used to study the combustion efficiency of a biomass-coal mix. Moreover, the biomass fragmentation is also analyzed to improve heat transfer during combustion.

In another laboratory, are studied vehicles engines using non conventional fuels like: vegetable oils, biogas, biodiesel, hydrogen, LPG and CNG . The studies aim at optimizing efficiency and at the same time limiting pollutant emissions such as NOx, CH_4, CO, CO_2. Injection and combustion systems are also modeled.

We visited outside several solar energy devices. First of all, a parabolic solar concentrator generates steam at 400-500°C.



It is foreseen to add a steam turbine for power generation. The power of the concentrator is about 5 kWth, with a concentration ratio of 100. The concentrator diameter is 45cm and the reflecting surfaces are $20m^2$.
Two others devices were presented : a 10 kW solar cooling system constituted of $2m^2$ solar panels, and an hybrid thermal-photovoltaic solar system.
Then, a metal hybrid system for hydrogen storage was shown. In this case, hydrogen is absorbed by heating metal structure then desorbed by cooling it.



Indian Institute of Technology Madras

CONFERENCE

This visit was the occasion to present our work on the theme: 'Current challenges for renewable energies in Europe'. The European energy context, the renewable energies were developed with a special regard to biomass power.

The European Union has committed itself internationally to reducing greenhouse gas emissions and has put in place directives since 2001 which aim to increase the share of electricity produced from renewable energy sources in the EU to 21 % by 2010. They are an attractive option to diversify the EU energy supply and bring environmental benefits. Thus, supports for renewable energy must be enhanced as long as technologies are still developing.

Biomass offers a great potential, with a wide range of available resources, as residues from industrial processes, crops and animal husbandry ; wood and by-products from wood processing and dedicated 'energy plantations'. Bioelectricity is of key importance : as it is easy to stock, electricity production is permanent and foreseeable. As a forested and agricultural country, France has significant biomass resources but it is difficult to estimate which proportion can be exploited at reasonable costs. Taking into account that fuel costs in biomass power units are an important share in the total cost of electricity produced, project developers bear significant business risks.

JYOTI BIO

Bio-mass Power Plant

Jyoti Bio, Thursday March 23.

Thursday, we went to the state of Andhra Pradesh, more exactly to Ongole (350km in the North of Chennaï) to visit the biomass power plant JYOTI BIO. This was the occasion to study the production of bio-electricity after 6 months spent working on the subject.

Accompanied by two persons from Areva who had organized the visit, we were welcomed by the people in charge of the site for a rapid presentation of the power plant and its functioning. JYOTI BIO consists of 2 power plants, 5 and 8 MW, built respectively in 1999 and 2003 to improve the supply of electricity in the state. The two power plants are fed with residues (rice husk, cotton stalk, sawdust, wooden waste) for the greater part, but also with specific cultures (10 %), cultivated on the site: the julia flower (variety of eucalyptus which offers the advantage of growing quickly). The site extends over 13 hectares (5 for the factory, 5 for the storage and 3 for the cultures) and requires the presence of 150 persons permanently to insure the good operation of the process.

After this first approach, we began the visit of the site with the storage. The heaps of wood, barks and agricultural waste dry under a blazing sun. With each inspiration, the fine particles of dust are felt. Nevertheless, even if around this immense space, julia flower cultures limit the flight of dusts, nobody works with a mask.

At the feet of the power plant, about fifteen persons are in charge of receiving the biomass and of sending it towards a powerful crusher. Then, a travelator steer it to the feeder of boilers. Seven tons per hour are thus sent towards boilers.

Boilers are chambers with combustion by fixed bed. The large variety of fuels used forces to use this technology which lets burn all biomass types. The efficiency depends on the fuels used, but globally it is estimated at 35 %. But the first preoccupation of these power plants is the problem of corrosion, inevitable by the presence of potassium and chlorides which accelerate the degradation from 500°C. So, boilers work at 440°C, obliging to adjust the pressure to 45 bars.

At the exit of the boiler, we observe electrostatic precipitators. These monstrous treatment plants reduce ashes contained in fumes from 50g/Nm^3 to 0.115g/Nm^3 in exit of chimney. The recovered ashes are used as fertilizer in the region. Sulfer is absent from the discharges and only 600ppm of NOx are counted thanks to the low temperature of combustion. For the carbon, the global assessment is neutral for the biomass if we consider the complete cycle of the resource.

The visit continues following the vapor stemming from the boilers, towards the turbines and alternators. The noise floods all the room, only the control room offers a soothing refuge. In front of us, the control board and the synopsis of the cycle of two power plants. Outside, transformers raise the tension from 11 to 33 kV to send the electricity produced towards the network at a few hundreds of meters.

The cheaper hand labour allows to reduce equipments and to simplify the techniques used, offering a low investment from 500 to 700€/kW for this type of biomass power plant, while in the European Union it is about 2000€/kW. Furthermore, India takes advantage of a fuel of 10 to 15€/t while in Europe it varies between 40 to 50€/t, so favoring the development of the biomass.

The visit of the power plant JYOTI have been an enriching experience, illustrating how a developing country develops a promising renewable energy for the world.

PONDICHERRY

IT Power India & Auroville

Pondicherry,
Friday March 24.

Thanks to its location, India benefits from a daily average solar energy incidence varying from 4 to 7 KWh/m² under clear sky. As there are 250-300 sunny days a year in most parts of the country, India receives solar energy equivalent to more than 5,000 trillion kWh/year and can thus try to take advantage of such a huge source of energy. In the area of Chennai, we have had the chance to visit two actors involved in solar energy: **IT Power India and Auroville community.**

IT Power India is a consultancy working in the renewable energy and environmental management fields. The group designs and executes projects (solar energy, biomass, biogas watermills...). They also lead training programs; for example, one teaches the technicians repairing air conditioning systems how to replace the CFC. Located in Pondicherry, the center we visited develops, among other works, solar concentrators for the melting of syringes. In fact the disposal of syringes has to be done properly, as it happens that people sort the wastes manually. Thermal processing is a way to decontaminate the syringes and the solar melters can provide a solution for health centers where grid supply is poor or unavailable. ITPI has already installed a first generation of solar melters in 3 health posts near St. Louis, Senegal, in February 2003. The solar radiation is focused on a transparent box containing the syringes; the heat melts those.

The team now develops a modified version of self-tracking melters. In their approach, no sophisticated electronic process is to be found, but only cheap materials available anywhere. For example, one model uses a tank of water with a small hole as a counterweight for the solar concentrator. During the day the leakage of water makes the tank lighter and the solar concentrator moves, following the sun if all adjustments are properly done.

Auroville is an international township, near Pondicherry. It was founded in February 1968 and currently stands at around 1,700 people. Auroville is committed to a life free of violence, and in harmony with nature and the environment. Therefore, sustainability is an important cornerstone and part of the energy comes from renewable sources. Solar energy is used mainly for home lighting systems, heating water for domestic purposes, and food processing.

Here we especially take a look at two technologies :

first a 36.3 kW solar power plant was commissioned in September 1997 and provides lighting for the inside of Matrimandir as well as for the surrounding gardens. It consists of about 450 panels of 75W angled at about 10-12°.

The panels have become slightly less efficient due to the

PONDICHERRY

IT Power India & Auroville

continuous exposure of the sun during the last ten years but they will probably be used for about 8 to 10 more years.

The huge solar bowl is certainly the most impressive thing in Auroville – apart from the community itself.

This stationary bowl is 15 meters in diameter and 7 meters above ground level. The sun rays, trapped by a huge hemispherical mirror, focus on a cylindrical boiler. The boiler generates steam for the collective kitchen.

On a clear day the steam at a temperature of 150°C is sufficient for the needs of the kitchen, allowing to cook around one thousand meals. The design of the boiler and concentrator are based on a French model.

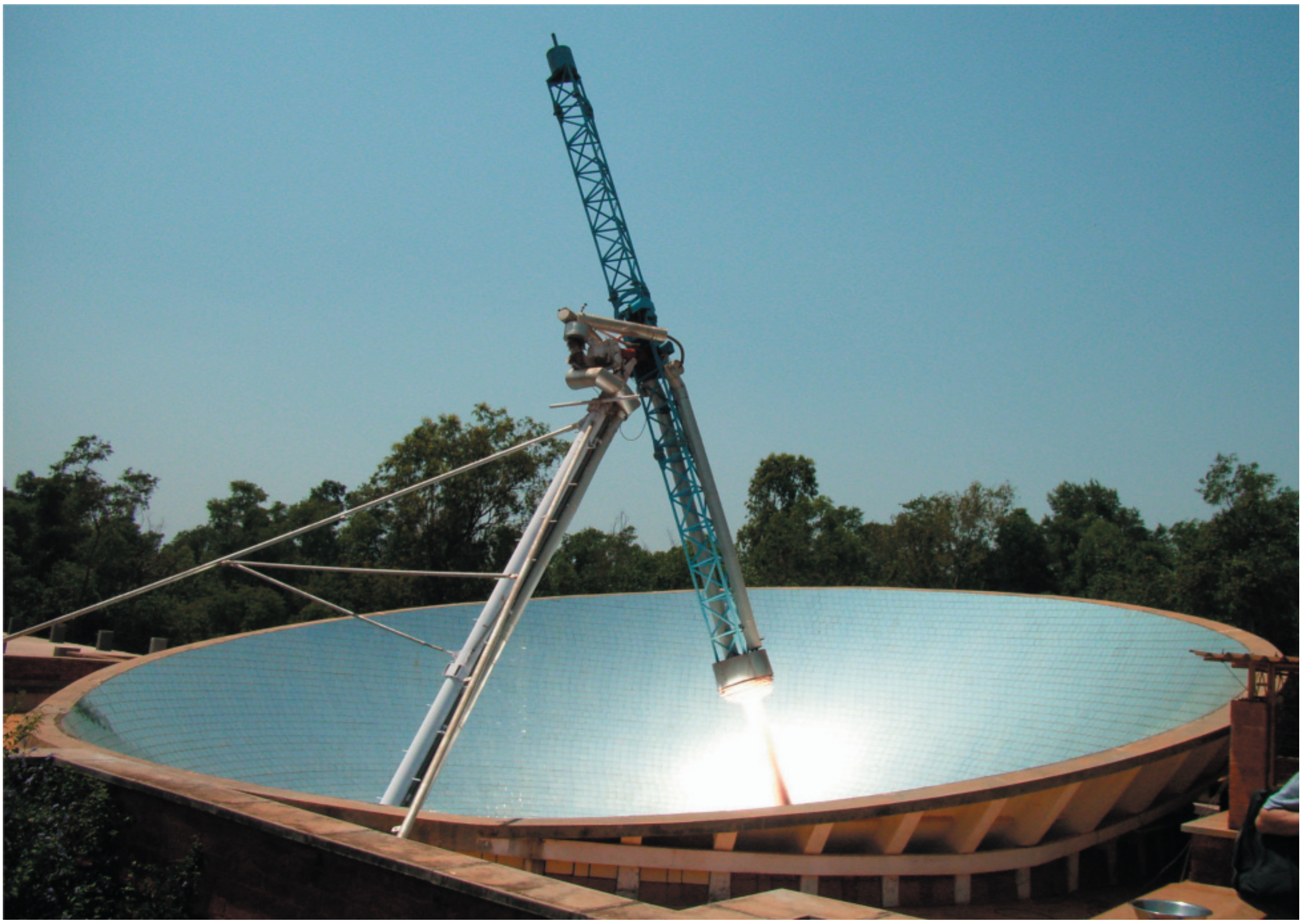
A complex tracking system was conceived so that the boiler follows the sun position automatically. Thanks to a computer and several sensors, the system is able to detect a cloudy weather, so that it avoids erratic moves.

It is important to note that such a technology is profitable because of the low cost work force. In industrialized countries, the shelf life of such a system would probably be too short to cover the capital cost.

A member of the community, Carsten Michelsen, has created a firm, Phocos, which provides technology and components for autonomous electricity supply systems based on photovoltaic and other renewable energy sources.

The company manufactures a wide range of systems such as charge regulators, SPS system controller, DC lamps, refrigerators, etc.

We can for example focus on the charge regulators. Their basic components are bought on the local market and the company is in charge of the assembly, calibration and testing.
65% of the charge regulators are then exported to Bangladesh and Sri Lanka. In this sector, the company control 3% of the world market.



AREVA T&D

BIO-MASS BASED POWER PLANTS OVERVIEW

Chennai, Saturday March 25.

This presentation was made by M. Rajan and gives a brief review of Areva operations in India.
The Areva Group is composed of four departments: the front end division, the reactor and services division, the backend division and the Transport and Distribution department (T&D).
Renewable energy projects are part of the 'Distributed & Renewable Energy Division'.
T&D represent 1/3 of the group and is mainly located in Europe (63%).

Even if employees are mostly in Europe, the group increase his worldwide activity.
There are power plant projects in Germany and in India, but Areva is also present in Spain (using tomato stock waste), Brazil and China.

As the initial cost and price of the resources are higher in Europe than in other countries like India, we can estimate that the cost of the whole power plant in India is around 25% of the cost we would have in Europe. That's the reason why Areva is present in India.

The activity in India started in 2003 with wind power, cogeneration and biomass.
In India, Areva T&D is implicated in six biomass units: Chennai, Pondichery, Bangalore, Noida, Lucknow and Kofkala. The resources in India are mainly the bagasse, rice husk, mustard husk, sunflower husk, cotton stalk and chilly stalk. Biomass based power plants are typically in the size range of 6 MW to 12 MW. This is due to the availability of fuel and water, the project cost and the available interconnection to grid network.

We saw in detail a 7.5 MW biomass based power plant, called Satyamaharishi, which uses chilly and cotton as fuel, supplemented by other fuels like rice husk, julie flora and wood chips.

Avant-Garde is an engineering and consulting private company specialized in non conventional electricity. They provide services for many operating plants : 505.6 MW of cogeneration and 111.8 MW of biomass. The projects under implementation concern 547 MW of cogeneration and 158 MW of biomass. The commissioning will be in 2007.

Three technologies can be used for biomass: pyrolisis, gasification and combustion. In India most of the power plants are based on combustion.

When starting a biomass project, several aspect must be taken into consideration; the most important is the fuel: availability (seasons), collection, transport (a 6 MW power plant needs about 50 trucks per day); then an environmental study, an emergency plan, a water survey and water analysis are led. You have to analyze the fuel and ash to find the best design for the boiler and finally you have to think about the power evacuation system.

All biomass based power plants are generally designed with an additional coal firing system as stabilization fuel.

The statutory clearances required in India are the clearance for power generation from the state government, the water availability from the irrigation department, the pollution clearance from the pollution control board, the forest clearance from the forest department, the civil aviation clearance for chimney height from the national airport authority and the power purchase agreement from the electricity board. Some permits and licenses during construction are required. Boiler and other pressure parts including pipes and valves need licenses. All those clearances require 4 to 6 months.

The benefits of biomass power are multiple. Power generation from renewable sources will bring down the dependency on fossil fuels. Eco-friendly power from biomass prevents addition of green house gases to the atmosphere.

But, of course there are some problems associated with biomass utilization. The specific energy content is lower, the price is sensitive to the localization and seasonal availability, and a large storage space is required due to the low bulk density and seasonal production. For instance, the stock for one month production needs 400 times the space occupied by the plant itself.

Clémence Fischer then presented us the Clean Development Mechanism (CDM).

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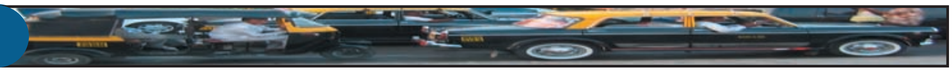

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We have been very impressed with the high level of the presentations and the speakers who have been most competent and made themselves available.

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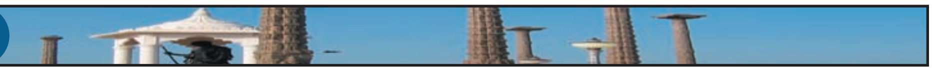

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