1. INTRODUCTION

Our country is facing a number of problems on power pant. The original target of increasing the generating capacity by 30,000 MW during eight plan got reduced to 20,000 MW and fears are now being expressed about by achieving even this reduced target. This is ascribed essentially to a lack of sufficient financial resources. Privatisation of generation with a view to attracting private investors, Indian & foreign, is now considered a remedy to overcome this difficulty. There has been some progress in this direction, although far from the earlier expectations. Thus, foreign investors like AES Transpower in Orissa, Enron in Maharastra, Siemens- Torrent in Gujrat and so on in the picture.

There seems to be considerable uncertainty in regard to many of these projects taking off the ground. In any case, with Rs. 4 to Rs. 4.5 crore per MW of installed capacity and at least Rs 3 crore for transmission and distribution, if not an equal amount, as it should be, and a guaranteed return of 16 per cent on equity for generation, one can see easily the trend of the cost per unit cost per unit of electricity delivered. That would easily be around Rs 3.50 per unit.

The Process of involving foreign enterprises in the power sector has been long & arduous. Meanwhile, the load demands are increasing fast while the additions to generating capacities are slow and relatively small, and the reliabilities and quantity of power supply are deteriorating resulting in frequent interruptions and low voltages thus affecting industrial and agricultural production and causing inconvenience to the public in a variety of ways. Due to the demands outstripping availability, the grid systems are being operated at sub-standard frequencies resulting in serious systems disturbances and black - outs.

2.WIND AND SOLAR ENERGY

2.1 WIND ENERGY

India is a country with diverse climate & vast potential, untapped resources. Abundant natural resources like wind, sun & water are available & can be made use of. Wind, being the most available of resources, has turned out to be the most popular & with the new thrust on generating power to meet the needs of tomorrow, there are a host of entrepreneurs willing to tap this form of energy. Being unlimited, renewable & pollution-free resource, there has been a movement world over, to develop highly sophisticated technology to convert this kinetic energy into its Mechanical & Electrical form. Winds result from differential heating of the earth & its atmosphere by the sun & are subjected to several forces altering their direction & speed of flow; about one per cent of total solar radiation that reaches the earth is converted into wind energy.

2.2 SOLAR ENERGY IN INDIA

If the vast expanse of the Thar Desert in Northwestern India was harnessed to produce solar energy, it could light up five of Asia's most populated cities. Scientists say the endless sands of Rajasthan State could well earn the distinction of being the "biggest" solar powerhouse by 2010, producing 10,000 MW of electricity. The Rajasthan Energy Development Agency (REDA) has started the spadework on an ambitious project. "A major chunk of the desert, about 13,500 square miles, will be declared a Solar Energy Enterprise Zone like the one in Nevada (in the United States)", says director Probhat Dayal. He thinks that if the state were to install solar collectors in just one Percent of its desert, which stretches over 77,200 square miles, "we could generate 6,000 megawatts of electricity".

A city the size of Delhi with 10 Million people needs 1,800 megawatts. "This solar bowl of the desert will become the world's biggest center for Solar power generation, research and development", he declares. The earth receives some 4,000 trillion-kilowatt hours of electromagnetic Radiation from the sun- about hundred times the world's current energy consumption needs. At present, a 354 megawatt solar power project in southern California is the world's largest, providing 90 percent of global solar energy.

2.3 ECONOMICS OF WIND FARMS

The Non-Conventional Energy sources wind energy is the best alternative for the following reasons. Since the raw material costs are almost negligible, it is economically viable. A cost analysis between available sources shows that the cost of producing one KW of power works out to : Solar Rs. 1 Lakh , Photo-voltaic Rs. 3 Lakh

Biomass Rs. 0.5 Lakh , Wind Rs. 0.3 Lakh

Wind is the only raw material, which is free, abundant, & after setting up capital machinery the maintenance costs are minimal. Besides this the technology is uncomplicated & gestation period is short. It also has the advantage of generation of power immediately after installation. An analysis of the cost of power generation shows that conventional forms of thermal & diesel costs Rs.2.5 per KWh & in a period of four years, it escalates approximately Rs.6 & Rs.5 respectively. But in wind power it is the reverse as it reduces to about Rs. 0.30 per kW. With the viability & commercial benefits established, wind energy will soon be a thrust area to cater to an ever-increasing population. It does make a lot of sense when you consider the fact that a third of the oil produced in the world is burned for the production of power. Whereas the installation of one MW of wind saves close to 5000 barrels a day.

3.SOLAR CHIMNEY TECHNOLOGY

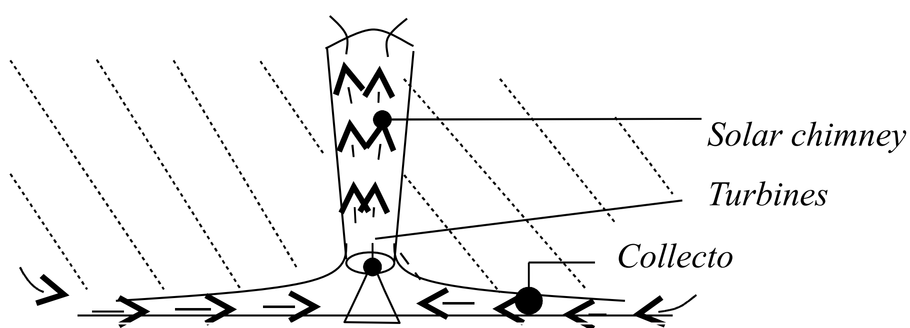
The new technology called Solar Chimney Technology; foresees to produce bulk electricity in sunny regions of the plant, by creating breeze of sufficient speed (more than 20 to 30 kph.) to run wind turbines coupled to electric generators of total o/p of 30 to 200 MW.

This Technology -

- is simple & reliable.
- does not need cooling water or produced waste heat.
- is open to environmentally neutral.
- can be install to the technologically less developed countries.

3.1 A NEW USE FOR THREE OLD TECHNOLOGIES

Man learned to make active use of solar energy at a very early stage; greenhouses helped to grow food, chimney suction ventilated & cooled building & windmills ground corn & pumped water. A Solar - Thermal Chimney simply combines them in a new way. The Solar Chimney contains three essential elements: collector, chimney, wind Turbines.



ELEMENTS OF SOLAR CHIMNEY POWER PLANT

Air is heated by solar radiation under a circular glass roof open at the periphery, this and natural ground below it form a hot air collector. In the middle of the roof is a vertical chimney with large air inlets at its base. The joint between the roof and chimney base is airtight.

As hot air is too lighter than cold air it rises up the chimney suction from the chimney then draws in more hot air from the collector and cold air comes in from the outside. Thus, solar radiation causes a constant up draught in the chimney. The energy this contains is converted into the mechanical energy by pressure stepped wind turbines at the base of chimney and into electrical energy by conventional generators.

3.2 THE COLLECTOR

Hot air for the chimney is produced by greenhouse effect in a simple air collector consisting only of a glass of plastic film covering stretched horizontally 2 to 6 m above the ground. Height increases only adjacent to the chimney base, so that the air can be diverted to vertical movement without friction loss. This covering admits short wave solar radiation component and retains long-wave radiation from the heated ground. Thus, ground under the roof heats up and transfers its heat to the air flowing radially above it from the outside to the chimney, like flow heater. The air temp. rise could be 35^0C in a well-designed collector. The total radius requires for 5MW, 30MW, 100MW is 500, 1000 and 1800 m respectively.

Peripheral area of the collector can be used as greenhouse or drying plants, at no extra cost and without significant performance loss. A collector roof of this kind is of long span and continuous maintenance can give service up to 60 years or more. Collector efficiency is improved as rise in temp. decreases. Thus, a solar chimney collector is economic, simple in operation and has a high-energy efficiency level.

OPTICAL PARAMETER OF VARIOUS GLASS ROOF MATERIALS

	GREEN	WHITE	IR REFLEX
Glass thickness (mm)	4	4	4
Long waves absorption	0. 918	0.918	0.15
Long wave transmission	0.000018	0.000018	0.000018
Short wave absorption	0.05	0.01	0.07
Short wave transmission	0.886	0.97	0.81
Refractive index	1.50	1.50	1.50
Specific heat capacity (J/kg ^{o}c)	481	481	481
Density (kg/m^3)	2580	2580	2580
Thermal conductivity (W/mK)	0.9	0.9	0.9

3.3 THE CHIMNEY

The chimney itself is the plant's actual thermal engine. It is a pressure tube with low friction and loss (like a hydroelectric tube) because of its optimum surface-volume ratio. The up-thrust of the air heated in collector is approximately proportional to air temp. rise ΔT in collector and volume (i.e. height and diameter of the chimney). In a large solar chimneys the collector raises the temp. of air by $\Delta T=35^0C$. This produces an up-draught velocity in chimney of about V=15 m/s. The efficiency of the chimney (i.e. conversion of heat into kinetic energy) is practically independent of ΔT in collector and determined by outside temp. To (lower the better) and height of chimney (higher the better).

Power = K. (Hc/To)*(Solar radiation at location)*(Area of collector)

Thus, solar chimneys can make particularly good use of the low rise in air temp. produced by heat emitted by the ground during the night and even the Meagre solar radiation of a cold winter's day!

However, compared with the collector and the turbines, the chimneys efficiency is relatively low, hence the importance of size in its efficiency curves. The chimney should be as tall as possible e.g.: at 1000m height can be built without difficulty. (Let it be remind that T.V. Tower in Toronto, is almost 600m height and serious plans are being made for 2000 m skyscrapers in earth-quake-ridden Japan.)

3.4 THE TURBINES

Mechanical output in the form of rotational energy can now he derived from the vertical air-current in the chimney by turbines. Turbines in a solar chimney do not work with stepped velocity like a free-running wind energy converter, but as a cased pressure-stepped wind turbo-generator, in which, similar to a hydroelectric power station, static pressure is converted into a pipe. The energy yield of a cased pressure-stepped turbine of this kind is about eight times greater than that of the same diameter. Air speed before and after the turbine is about the same. The output achieved is proportional to the product of volume flow per time unit and the fall in pressure at the turbine. With a view to maximum energy yield the aim of the turbine regulation concept is to maximize this product under all operating conditions.

The turbine regulates air speed and air flow by means of blade tilt. If the blades are horizontal, the turbine does not turn. If the blades are vertical and allow the air to flow through undisturbed, there is no drop in pressure at the turbine and no electricity is generated. Between these two extremes there is an optimum blade setting; the output is maximized if the pressure drop at the turbine is about two thirds of the total pressure differential available. If the air stream is throttled the air takes longer to heat up. This increases the rise in temperature in the collector. This in its turn causes increase ground storage and thus enhanced night output, but also greater loss from the collector (infrared emissions and convection). Turbines are always placed at the base of the chimney. Vertical axis turbines are particularly robust and quiet in operation. The choice is between one turbine whose blades cover the whole cross-section of the chimney or six smaller turbines distributed around the circumference of the chimney wall, here the blade length of each turbine will a sixth of the chimney diameter. The diversion channel at the base of the chimney is designed for one or six turbines as appropriate. But it is also possible to arrange a lot of small turbines with horizontal axes (as used in cooling tower fans) at the periphery of the transitional area between canopy and available technology. Generator and transmission are conventional, as used in related spheres.

In a solar chimney there are no critical dynamic loads on blades, hubs and setting equipment of the kind met in free-running wind energy converters due to gustiness of the natural wind as the canopy forms an effective buffer against rapid pressure and speed changes. This makes these components structurally simple and cheap to manufacture, and they also have a long life span.

3.5 A"HYDROELECTRIC POWER STATION FOR THE DESERT"

Solar chimneys are technically very similar to hydroelectric power stations- so far the only really successful renewable energy source, the collector roof is the equivalent of the reservoir, & the chimney of the pressure pipes. Both power generation systems work with pressure-stepped turbines, & both achieve low power production costs because of their extremely long life span & low running costs. The collector roof & reservoir areas required are also comparable in size for the same electrical output. But the collector roof can be built in arid deserts & removed without any difficulty whereas useful (often even populated) land is submerged under reservoirs.

Solar chimneys work on dry air & can be operated without the corrosion & cavitation typically caused by water. They will soon be just as successful as hydroelectric power stations. Electricity yielded by a solar chimney is in proportion to the intensity of global radiation, collector area & the chimney height. Thus, there is no physical optimum. The same output can be achieved with a higher chimney & a small collector or vice-versa. Optimum dimensions can be calculated only by including specific component costs (collector, chimney, and turbines) for individual sites. And so plants of different sizes are built from site to site-but always at optimum cost, if glass is cheap & concrete dear the collector will be large with a high proportion of double glazing & a relatively low chimney, and if glass is dear there will be a smaller, largely single-glazed collector and a tall chimney.

4. SOLAR CHIMNEY ON THE INTERNATIONAL GRID

Generally speaking solar chimneys will feed the power they produce into a grid. The alternating current generators are linked directly in the public grid by a transformer station. The thermal inertia of solar chimneys means that there are no rapid abrupt fluctuations in output of the kind produced by wind parks and photovoltaic plants (output fluctuations up to 50% of peak output within a minute causing the familiar frequency and voltage stability problems in the grid. Solar chimney output fluctuation is a maximum of 30% of the rated load within 10 to 15 minutes; this means that grid stabilization can be easily handled by the appropriate regulation stations.

In the case of island grids, without conventional power sources and no linkage with other grids, a connection of solar chimneys to pumped storage stations is ideal. These store the excess energy produced by the solar chimney by the day or year and release it when needed. Thus available energy in independent of varying amounts of sunshine by day and night, and throughout the year.

Many countries already have hydroelectric power stations, and these can also be used as pumped storage stations, if necessary their reservoirs can be covered with membranes to prevent water evaporation. The rpm of solar chimney turbines and pumps can be uncoupled from the rigid grid 50 Hz frequency by frequency converters of the kind already used by a Badenwerk hydroelectric plant in South-West Germany.

The import of solar-produced energy, from North Africa to Europe, for example, will soon be perfectly cheap and simple, as the European grid is to be extended to North Africa. Transfer costs to Europe will then be only a few cents/kWh. A large extended grid will itself also optimize energy flow between the various producers and consumers and thus need hardly any storage facilities.

If distances between solar energy stations and consumers are large, as for example from North Africa to Europe, low loss, high voltage D.C. transmission is also available. Transfer losses over a distance of 3500 km from the Sahara to central Europe will be less than 15%.

On the other hand, hydrogen technology converting solar power into hydrogen by electrolysis, transporting this and then converting it back into electricity-makes no sense, and is conceivable only for mobile use in vehicles and aircraft.

Thus, there is no technical reason why a global solar energy economy cannot be achieved. Transfer and distribution of solar energy generated in deserts no longer presents serious problems, even of an economic nature.

But solar energy production in central Europe or other northern countries, whatever technology is used, does not make economic sense because of low solar radiation levels and intensive land use.

5.THE PROTOTYPE IN MANZANARES

Objective:-

Detailed theoretical preliminary research and a wide range of wind tunnel experiments led to the establishment plant with a peak output of 50 kW on a site made available by the Spanish utility Union Electricity Fenosa in Manzanares (about 150 km south of Madrid) in 1981-82 with funds provided by the German Ministry of Research and Technology (BMFT)

The aim of this research project was to verify theoretical data established by measurement & to examine the influence of individual component on the plant's output and efficiency under realistic engineering and meteorological conditions.

To this end a chimney 195m high and 10 m in diameter was built, surrounded by a collector 240 m in diameter. The plant was equipped with extensive measurement data acquisition facilities. The performance of the plant was registered second by second by 180 sensors.

Since the type of collector roof primarily determines a solar chimney's performance costs, different building methods and materials for the collector roof were also to be tested in Manzanares. A realistic collector roof for large-scale plants has to be built 2 to 6 m above ground level. For this reason the lowest realistic height for a collector roof for large-scale technical use, 2 m, was selected for the small Manzanares Plant. (For output a roof height of only 50 cm would in fact have been ideal.) Thus only 50 KW could be achieved in Manzanares, but this realistic roof height also permitted convenience access to the turbine at the base of the chimney. This also meant that experimental planting could be carried out under the roof to investigate additional use of the collector as a greenhouse.

5.1HOW THE PROJECT RAN

YEAR	PROGRESS
1980	Design
1981	Construction
1982	Commissioning
1983/84	Experimental phase & structural Optimization of the roof
1985/86	In operation, further improvements to collector & electric's.
1986-89	Completely automatic long-term operation phase.

5.2 TESTS DURING THE NINE-YEAR PROJECT

The experimental plant in Manzanares ran for about 15000 hours from 1982 onwards. The following tests were run in the course of the projects :

Different collector roof covering were tested for structural stability, durability and influence on output.

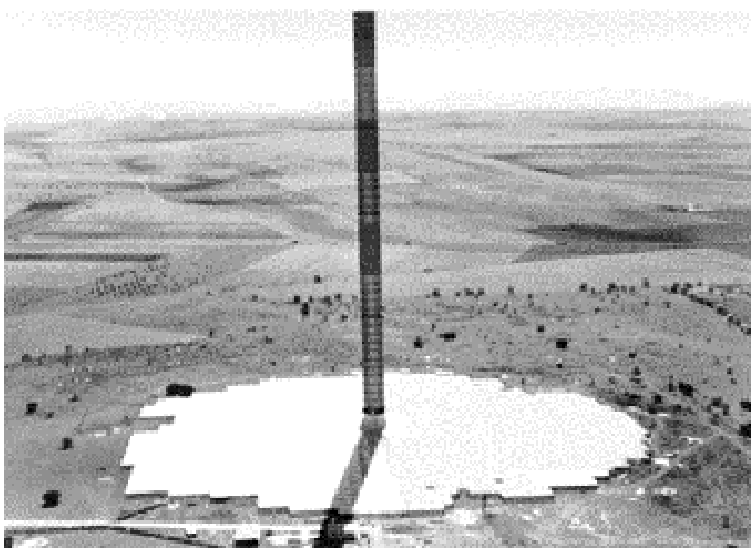
The behaviour of the plant as whole was measured second by second (ground temperature, air temperature, speed and humidity, translucency of the collector, turbine data, meteorology etc.

The ground's storage capacity was tested in terms of collector temperature and soil humidity. In order to investigate heat absorption and heat storage it was in turn left as it was, sprayed with black asphalt and covered with black plastic.

Various turbine regulation strategies were developed and tested;

Maintenance and running costs for individual components were investigated;

The thermodynamic plant simulation program developed in all details in the mean time was verified with the aid of the experimental results and accompanying wind tunnel experiments, in order to make reliable calculations for any individual site data, meteorology and plant dimensions for daily & annual energy production by large solar chimneys.



THE PROTOTYPE PLANT IN MANZANARES

TYPICAL PLANT OPERATING PARAMETERS FOR PLANT OF RATING 5,30 AND 100 MW ARE GIVEN IN TABLE

	5 MW	30 MW	100 MW
Civil Engineering			
Chimney height (m)	445	750	950
Chimney radius (m)	27	42	57.5
Collector radius (m)	555	1100	1800
Collector height, external (m)	3.5	4.5	6.5
Collector height, internal (m)	11.5	15.5	20.5
Mechanical Engineering			
Type of turbine		Propeller Type	
Number of turbine	33	35	36
Distance of turbine from Chimney Centre (m)	53	84	115
Airflow rates (m/s)	8	10.4	13.8
Shaft power rating of Individual turbines (KW)	190	1071	3472
Blade tip-to-wind speed ratio	10	10	8
Rotational speed (1/min.)	153	132	105
Torque (kNm)	11.9	77.5	314.5
Operating data at rated load			
Upward air draught speed (m/s)	9.07	12.59	15.82
Total pressure difference (pa)	383.3	767.1	1100.5
Pressure drop over turbine (pa)	314.3	629.1	902.4
Friction (N)	28.6	62.9	80.6
Temperature in collector (ºC)	25.6	31.0	35.7

6. CONCLUSION

From above treatise the author of this paper would like draw following conclusions:

1) The collector of solar chimney plant can use all solar radiation both direct and diffused. So, this plant technique is also helping hands to those countries where the sky is frequently overcast.
2) There are many regions in country which are deserts and soil don't bear any crop. And thus no contribution to mankind. But installing plant there give excellent results.
3) The technology and the material to build such plants are available in the country. Hence, such power plants are very attractive in India for bulk power generation even in deserts. The capital cost is high, nearly 7 crore/MW, which can be reduced. However, the cost of generation could be as low as Rs.1.62 per KWH in long run.

   A 200MW power plant is being built at Thar (Jaisalmar) by a consortium of Shri Lanka and Germany at the cost of US$ 450 million which is going to commissioned in year 2000, according to Rajastan Energy Development Agency (REDA).

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