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Cell Phone/Tower Radiation Hazards and Solutions

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Advantages and disadvantages of cell phone technology

Cell phone technology has revolutionized the telecommunication scenario in India. It was started in 1995 and due to its several advantages, cell phone technology has grown exponentially in the last decade. From 2000 to 2012, number of cell phone subscribers increased from 28 Million to more than 900 Million (90 crore). There are nearly 4.5 lakh cell phone towers to meet the communication demand. The numbers of cell phones and cell towers are increasing without giving due respect to its disadvantages. All over the world, people have been debating about associated health risk due to radiation from cell phones and cell towers. Radiation effects are divided into thermal and non-thermal effects. Thermal effects are similar to that of cooking in a microwave oven. Non-thermal effects are not well defined but it has been reported that non-thermal effects are 3 to 4 times more harmful than thermal effects.

Radiation from the cell phone

There are different methods of cell phone transmission that are used by different companies. Each type is allotted a specific frequency range. A cell phone transmits 1 to 2 Watt of power in the frequency range of 824-849 MHz (for CDMA), 890-915 MHz (for GSM900), 1710-1780 MHz (for GSM1800), and 1920-1980 MHz (for 3G). Each cell phone has a SAR (Specific Absorption Rate) rating, which is a measure of the rate at which energy is absorbed by the body when exposed to its electromagnetic field. In USA, SAR limit for cell phones is 1.6W/Kg which is actually for 6 minutes per day usage. It has a safety margin of 3 to 4, so a person should not use cell phone for more than 18 to 24 minutes per day. This information is not commonly known to the people in India, so crores of people use cell phones for more than an hour per day without realizing its associated health risks.

A research programme initiated by the World Health Organization, called the "Interphone Study", reported in May 2010 that excessive users of mobile phones (i.e., 1/2 hour/day over 8 to 10 years) have doubled to quadrupled brain tumor risk. Children are at higher risk than adults due to the fact that their skulls are thinner and still developing. Due to these reasons countries like Belgium, France, Finland, Germany, Russia and Israel have publicly discouraged use of cell phones by children.

On May 31, 2011, International Agency for Research in Cancer (IARC), part of WHO (World Health Organization), designated cell phones as "Possible Human Carcinogen" (Class 2B). They found evidence of increase

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in glioma and acoustic neuroma brain cancer for excessive cell phone users.

However, before cancer and several other health effects occur due to prolonged use of cell phones. People have experienced that their ear gets warm when they use of cell phone. It is because microwave radiation from cell phone heats the blood in the ear lobe, and its temperature increases by nearly 1°C = 1.8°F, so normal body (ear lobe) temperature of 98.4°F increases to 100.2°F. This leads to pain in the ear, hearing loss and ear tumor. Moreover, the brain is placed right behind the ear, which might also get affected.

Even when cell phones are not in use, they transmit one pulse/minute to the base station. If one keeps a phone in the pocket for 6 hours a day, it will imply a release of 360 pulses of 1W, and even if half of it is absorbed by the body, it is 180W of power. Many people sleep with the cell phones near their pillows every night without realizing the health hazards. If possible, they should keep cell phones in the other room or atleast at arm's length (a few feet away) from them.

In the Blackberry manual[1], it is written, "Keep the blackberry device at least 25 mm from your body (including abdomen of pregnant women) and reduce the time spent on calls." If there are no health hazards, why will they write these warnings?

This does not mean that we have to stop using cell phones. One can take the following precautions:

- Limit the use of cell phones
- Talk for short duration
- If possible, use SMS
- Use a cell phone with lower SAR value
- You may use speakerphone or wired hands-free or Bluetooth, but keep the cell phone at a distance of at least 12 inches from your body
- Use land-line phone whenever possible
- Do not keep cell phones in your hand/pocket for long.
- At home/office, keep phone away from you.

Radiation from the cell tower

Cell tower antennas transmit in the frequency range of 869-894 MHz (CDMA), 935-960 MHz (GSM900), 1810-1880 MHz (GSM1800), and 2110-2170 MHz (3G). A base station and its transmitting power are designed in such a way that mobile phones should be able to transmit and receive enough signal for proper communication up to a few kilometers. Majority of these towers are mounted near the residential and office buildings to provide good mobile phone coverage to the users. These cell towers transmit radiation non-stop 24 hours a day, 7 days a week. So people living within 10's of meters from the tower will receive 10,000 to 10,000,000 times stronger signal than required for mobile communication. In India, crores of people reside within these high radiation zones.

A GSM900 base station antenna transmits in the frequency range of 935-960 MHz. This frequency band of 25 MHz is divided into twenty sub-bands of 1.2 MHz, which are allocated to various operators. There may be several carrier frequencies (1 to 5) allotted to one operator with upper limit of 6.2 MHz bandwidth. Each carrier frequency may transmit 10 to 20W of power. So, one operator may transmit 50 to 100W of power and there may be 3-4 operators on the same roof top or tower, thereby the total transmitted power may be 200 to 400W. In addition, directional antennas are

[1] http://docs.blackberry.com/en/smartphone_users/deliverables/11261/BlackBerry_Bold_9700_Smartphone-US.pdf

Cell-phone towers installed in such busy neighbourhoods pose particular health risks for those living in close vicinity.

used, which typically may have a gain of around 17 dB (numeric value is 50), so effectively, several KW of power may be transmitted in the main beam direction[2].

The power density P_d at a distance R is given by

$$P_d = \frac{P_t \times G_t}{4\pi R^2} \quad \text{Watt/m}^2$$

where,
P_t = Transmitter power in Watts
G_t = Gain of transmitting antenna
R = Distance from the antenna in meters.

For P_t = 20 W, G_t = 17 dB = 50, P_d for various values of R is given in Table 1.

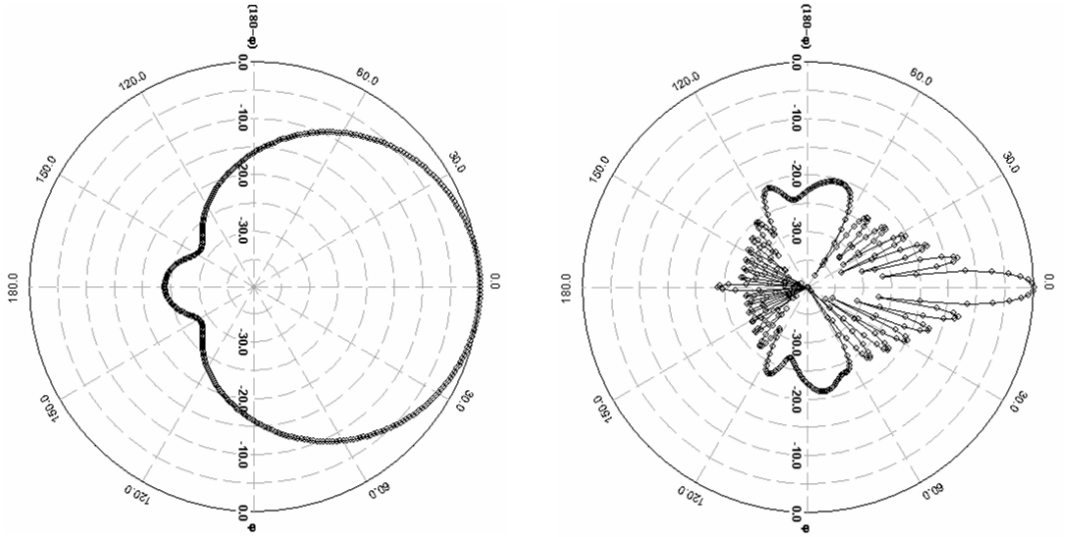
The power density values given in Table 1 are for a single carrier and a single operator. If multiple carriers are being used and multiple operators are present on the same roof top or tower, then the above values will increase manifold. Radiation pattern of a typical GSM900 antenna in the horizontal and vertical planes is shown in Fig. 1. There is one main lobe and several side lobes. For the main lobe, beam is wide in the horizontal direction and narrow in the vertical direction. For the side lobes, maximum levels are about -13 to -20 dB below the main level.

Table 1: Power density at various distances from the transmitting tower

Distance R (m)	Power density P_d in mW/m^2
1	79,600
3	8,840
5	3,180
10	796
50	31.8
100	8.0
500	0.3

It was reported in Mid-day, Mumbai, dated Jan. 3, 2010, that the four cancer cases in Mumbai's swanky Usha Kiran building could be linked to mobile towers

[2]An antenna's power gain is a key performance figure which describes how well the antenna converts input power into radio waves headed in a specified direction. It is almost always expressed in decibels (dB), a logarithmic scale. From the gain factor G, one finds the gain in decibels as $G_{dBi} = 10 \cdot \log_{10}(G)$



(a) (b)

Figure 1: (a) Horizontal and (b) vertical radiation pattern of a 17 dB gain antenna

installed on the facing Vijay Apartments[3]. Several antennas were installed on the seventh floor of Vijay Apartments, so, people living in the 6th, 7th and 8th floor in the opposite building at 50 m distance will get maximum radiation as they are in the main beam. People living on the other floors will receive lesser radiation as beam maximum is reduced considerably as can be observed from vertical radiation pattern.

At many places, cell phone towers are mounted on the roof top of residential /commercial buildings. Even though an antenna radiates less power vertically down but the distance between the antenna and top floor is usually a few meters, so the radiation level in the top two floors remain very high. From Table 1, the power density at $R = 3$m is equal to 8,840 mW/m^2 in the main beam. In the vertically down direction, radiation is approximately 20-22 dB less and the roof may provide attenuation of 6 to 10 dB depending on the construction (implying 1/1000th power), thus radiation density will be around 8.8 mW/m^2, which is still very high.

Radiation norms adopted in different countries

India had adopted the radiation norms given by ICNIRP (International Commission on Non-ionizing Radiation Protection) guidelines of 1998 for safe power density of $f/200$, where frequency (f) is in MHz. Hence, for GSM900 transmitting band (935-960 MHz), the power density is 4.7 W/m^2 and for GSM1800 transmitting band (1810-1880 MHz), it is 9.2 W/m^2. The ICNIRP guidelines clearly state that it is for short term exposure, which is actually for 6 minutes. From Sep. 1, 2012, India has adopted 1/10th of ICNIRP guidelines, which is still very high. Some of the people (especially older people, house wives, small children) living near the towers are exposed

[3]http://www.mid-day.com/news/2010/jan/030110-mobile-tower-cancer-cases-carmichael-road-posh-areas.htm

to this radiation 24 hours a day.

The Bio-Initiative Report[4] concluded that the existing standards for public safety are inadequate to protect public health and proposed 0.1 mW/m^2 for indoor, cumulative RF exposure. Bio-Initiative Report of 2012 has reported the adverse effects with certainty and has given 1800 references.

The Building Biology Institute, Germany, provided the following guidelines for exposure:

a. < 0.0001 mW/m^2 – no concern
b. 0.0001-0.01 mW/m^2 – slight concern
c. 0.010-1 mW/m^2 – severe concern
d. > 1 mW/m^2 – extreme concern

H Thomas et al., Germany, recommend that power densities should not exceed $0.1 mW/m^2$

The EU Parliament (STOA 2001) recommends 0.1 mW/m^2.

Over 100 physicians and scientists at Harvard and Boston University Schools of Public Health have called cellular towers a radiation hazard. And, 33 delegate physicians from 7 countries have declared cell phone towers a "public health emergency". Many countries in the world have adopted much stricter maximum radiation density values of 0.001 to 0.24 W/m^2 (1/100th to 1/1000th of ICNIRP guidelines) as shown in Table 2. The people in these countries have studied extensively the health hazards of cell tower radiation to adopt stricter radiation norms.

Biological effects of microwave radiation

When a human body is exposed to the electromagnetic radiation, it absorbs radiation, because human body consists of 70% liquid. It is similar to that of cooking in the microwave oven where the water in the food content is heated first. Microwave absorption effect is much more significant by the body parts which contain more fluid (water, blood, etc.), like the brain which consists of about 90% water. Effect is more pronounced where the movement of the fluid is less, for example, eyes, brain, joints, heart, abdomen, etc. Also, human height is much greater than the wavelength of the cell tower transmitting frequencies, so there will be multiple resonances in the body, which creates localized heating inside the body. This results in boils, drying up of the fluids around eyes, brain, joints, heart, abdomen, etc.

There are several health hazards associated with cell phones and cell towers. Some of these are: sleep disorder, headache, irritation, lack of concentration, memory loss, ear and eyes problems, irreversible infertility, DNA damage, melatonin reduction, neurodegenerative diseases, increase in Cancer risk, etc.

There have been several epidemiological studies of people living near cell phone antennas in Spain, Netherlands, Israel, Germany, Egypt, Austria, Brazil, etc. All these studies document adverse health effects at exposures much lesser than the ICNIRP guidelines. In India, there have been several clusters of cancer cases in Mumbai, Jaipur, Delhi, and other cities. In addition, large number of people living in the vicinity of cell towers are complaining about headaches, sleep disorder, memory loss, miscarriage, etc.

Adverse effect on birds, animals, trees and environment

Electromagnetic radiation from cell phones and cell towers affects the birds, animals, plant and environment. One would never see a bee, sparrow, pigeon, or any bird fly-

[4]The BioInitiative Report is a report on the relationship between the electromagnetic fields associated with powerlines and wireless devices and health, published online on 31 August 2007 by a group of 14 scientists, and public health policy professionals.

Table 2: International Radiation Density Limits for GSM900

Country	Milliwatt / m^2
INDIA (adopted ICNIRP)	4500
INDIA (Adopted 1/10th of ICNIRP from Sep. 1, 2012)	450
AUSTRALIA (New South Wales proposed)	0.01
AUSTRIA (Salzburg city)	1
BELGIUM	45 to 1125
BELGIUM (Luxembourg)	24
BIO-INITIATIVE REPORT (Outdoor)	1
BIO-INITIATIVE REPORT (Indoor)	0.1
CANADA (Toronto Board of Health – proposed)	100
CHINA	400
FRANCE (Paris)	100
GERMANY (ECOLOG 1998 – Precautionary Recommendation)	90
GERMANY (BUND 2007 – Precautionary Recommendation)	0.1
ITALY	100
NEW ZELAND (Aukland)	500
POLAND	100
RUSSIA	100
SWITZERLAND (Apartments, Schools, Hospitals, Offices, Playgrounds)	42
USA (Implementation is strict)*	3000
Final Recommendations	
Indoor – include apartments, schools, hospitals, offices & playgrounds	0.1
Outdoor – where people spend few minutes a day	10

* USA – FCC Guidelines: $f/300$ if averaged over 6 min. and $f/1500$ if averaged over 30 min.

ing and staying near the cell tower. The reason is that the surface area of a bird is relatively larger compared to their weight in comparison to human body, so they absorb more radiation (power = power density $\times$ area). Since fluid content is small due to less weight, it gets heated up very fast and also the magnetic field disturbs their navigational skills.

Ten eminent scientists of India have submitted a report on "Possible Impacts of Communication Towers on wildlife including birds and bees", to the Environment Minister in Nov. 2011. They have given 919 technical/scientific references. Out of 919 research studies collected, 593 papers reported there is an adverse impact, 130 papers reported there is no impact and 196 papers reported neutral or inconclusive impact.

Dairy people have mentioned that milk yield of their cows has significantly reduced after installation of the towers in the vicinity. Many people have reported serious health problems to their domestic animals living near cell towers. During a study, in a free-tailed bat colony, the number of bats decreased when several phone masts were placed 80m from the colony.

Electromagnetic radiation emanating from cell towers can also affect vegetables, crops and plants in its vicinity. Studies show definitive clues that cell phone EMF can choke seeds, inhibit germination and

root growth, thereby affecting the overall growth of agricultural crops and plants. Trees located inside the main lobe (beam) have dried tops, show slow growth and high susceptibility to illnesses and plagues. Fruit yield of the trees has gone down substantially in the vicinity of cell towers due to high radiation. For example, in a farm house near Gurgaon, lemon output has gone down from 100% to less than 5%, i.e., a reduction of 95% in just few years. Several other fruits, such as, mango, guava, orange, coconut, etc. have suffered similar problems at various other places.

Solutions

There are several health hazards due to radiation from the cell towers to the human, birds, animals, trees and environment. From Sep. 1, 2012, India has adopted 1/10th of the ICNIRP norms, which is 0.92 W/m^2 = 920 mW/m^2 for GSM1800, which is still very high. It should be reduced to 0.001 W/m^2 = 1 mW/m^2 as adopted in Austria. It is recommended that the power transmitted must be reduced to maximum 1 to 2 W in the dense urban areas to protect the health of the people. Solution is to have more numbers of cell towers with lesser transmitted power. Currently, we have 4.5 lakhs cell towers and each tower may transmit 100's of watts of power. If low power transmitters are used, then the number of towers and/or repeaters will increase considerably, which will increase the cost of network deployment. Each tower may cost Rs. 15 lakhs, so if the number of towers increase by 5 lakhs, then the additional cost will be Rs. 75,000 crores. This cost can be recovered within 3 years by increasing charges of per minute usage by only 5 paisa.

The cell phone industry is becoming another cigarette industry, which kept claiming that smoking is not harmful and now there are millions of people around the world who have suffered from smoking. In fact, cell phone/tower radiation is worse than smoking; as one cannot see it or smell it, and its effect on health is noted after a long period of exposure.

If there is a cell tower in the vicinity of your premises, please try to convince the operators to reduce the transmitted power or remove the tower or go for shielding solutions, such as, special window films, shielding curtains, shielding wall papers, etc.

In addition to the continuous radiation from cell towers, there is radiation from cell phones, wireless phones, computers, laptops, TV towers, FM towers, AM towers, microwave ovens, etc. The use of these appliances is additive in nature. We are exposed to all these radiations. Hence, it is imperative that stricter radiation norms must be enforced by the policy makers.

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Hazards of Electromagnetic Radiation

Madhusudan Jana*

Introduction

Life of the present generation is significantly different from that of a generation back. We are now blessed with a large number of scientific inventions and technological advancements. Technology has taken over many aspects of modern life, which we consider so normal, that we never look into the dark side of those fantasies. We can contact our home using cell phone from anywhere. We can send an email with the click of a button, and stay in touch with our family and friends far away. We can make our dinner in the microwave oven in 3-6 minutes. We can use a remote control to change channels on the TV, to open a garage door, to change songs on our stereo or MP3 player. Just sitting in front of our computer we can pay our bills without stamps, envelopes, or a trip to the post office.

Technology helps us in countless ways, yet most people are totally unaware of the high cost to our health and well-being. What happens to our bodies when we sit in front of our computer or talk on our cell phone all day? What is happening to us as we are exposed to the ever-increasing number of TV, radio, cell phone, satellite, and microwave frequencies in today's world? Most people have no clue. These electromagnetic (e.m.) radiations can interfere with the normal functioning of the human body. We get headaches; feel tired; and often develop immune system disorders. As the body begins to break down from the overload of disruptive frequencies, the immune system is frequently the first to dysfunction, since it has to overwork to accomplish the nearly impossible task of protecting the body. Many of the immune system disorders today (allergies, Chronic Fatigue Syndrome, candida, asthma, cancer, Alzheimer's disease, fibromyalgia, and other inflammatory illnesses) are created or exacerbated by living in the overwhelming electromagnetic soup in which we all find ourselves. So when we sit in an office building all day, surrounded by electrical and electronic equipment and under fluorescent lights, it is no wonder that we often feel drained by the end of the day. Even at home we cannot escape those effects because our houses are totally wired for electricity, we live inside one huge electromagnetic field all the time. In addition, people now spend much of their evenings on their computers, surfing the net. The purpose of this article is to make people aware about these issues so that they can consciously minimize the effects.

What is E.M. radiation?

Electromagnetic waves are emitted by many natural and man made sources and play an important part in our lives. We are warmed by e.m. emission of the sun and we see using a part of the e.m. spectrum that our eyes detect as visible light. E.M. waves can self-propagate in space or through transparent media. The electromagnetic radia-

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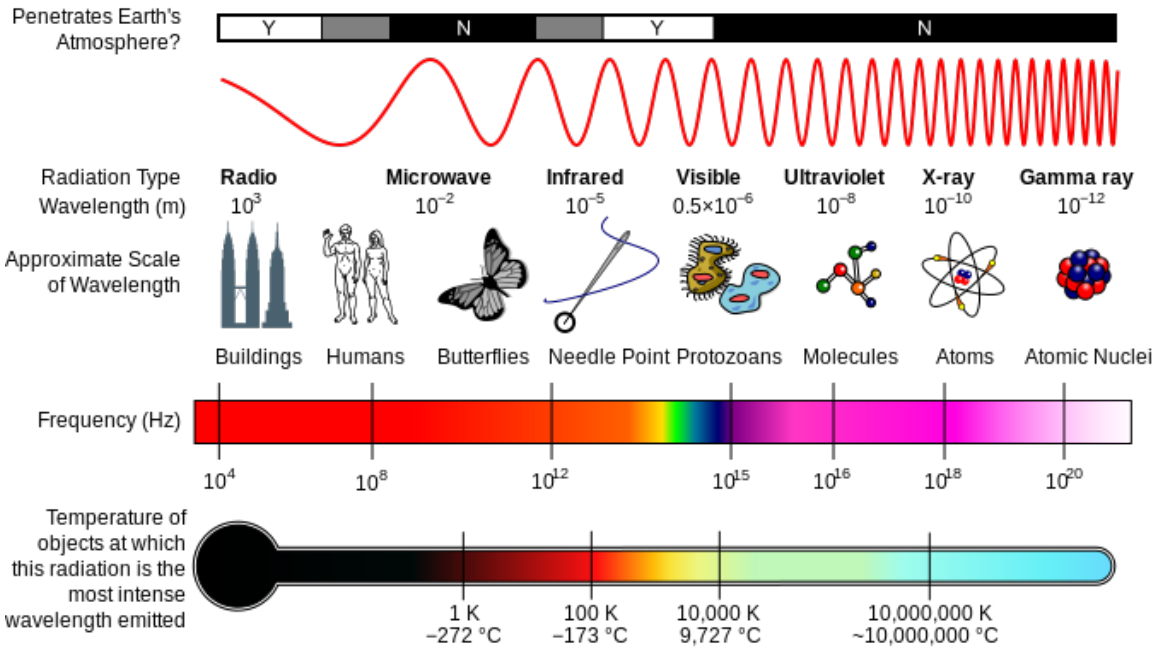

Figure 1: Schematic diagram of the electromagnetic spectrum. Courtesy: www.en.wikipedia.org

tion has an electric and a magnetic field component which oscillate in phase perpendicular to each other and also perpendicular to the direction of energy propagation.

Natural sources of e.m. radiation

In addition to the sun's rays there are some other natural sources of radiation, namely, thunderstorms, Earth's magnetic field and geopathic stress. Electromagnetic radiation (EMR) is classified according to the frequency of the waves. In order of increasing frequency it consists of Radio, Microwave, Infra-red, Visible, Ultra-violet, X-ray and Gama-rays. Electromagnetic radiation interacts with matter in different ways in different parts of the spectrum. The types of interaction can be so different that it seems to be justified to refer to different types of radiation. At the same time, there is a continuum containing all these "different kinds" of electromagnetic radiation. Thus we refer to a spectrum, but divide it up based on the different interactions with matter, as given in Table 1.

Man made Sources

The human body is also exposed to different kinds of electromagnetic fields which are short range, i.e., which decay at a very low distance and are sustained for short times. The most interesting man made radiations originated from electric and electronic instruments are our main concern. The change of voltage and flow of electric current inside those instruments produce electric and magnetic fields respectively. The major sources of man made e.m. fields are:

Table 1:

Sl. no.	Region of the spectrum	Main interactions with matter
1	Radio	Charge carriers oscillate within the bulk of the material. Such oscillation of the charge particle under an electric field is called plasma oscillation. An example would be the oscillation of the electrons in an antenna.
2	Microwave, far infrared	Plasma oscillation within the bulk, molecular rotation
3	Near infrared	Molecular vibration, plasma oscillation (in metals only)
4	Visible	Molecular electron excitation (including pigment molecules found in the human retina), plasma oscillations (in metals only)
5	Ultraviolet	Excitation of molecular and atomic valence electrons, including ejection of the electrons (photoelectric effect)
6	X-ray	Excitation and ejection of core atomic electrons, Compton scattering (for low atomic numbers)
7	Gamma ray	Energetic ejection of core electrons in heavy elements, Compton scattering (for all atomic numbers), excitation of atomic nuclei, including dissociation of nuclei
8	High-energy gamma rays	Creation of particle-antiparticle pairs. At very high energies a single photon can create a shower of high-energy particles and antiparticles upon interaction with matter.

Cell phones, towers	Transformers
Microwaves ovens	Computers
Telephones	Electric blankets
Water beds	Electric clock
Fluorescent lights	Home wiring
RADAR	Electric razor
Hair dryers	Water heater
Toasters	Lights with dimmer
Washing machine	Radio
Stereo	Power lines

How our body reacts to e.m. fields

Even in the absence of external electric fields, very small electrical currents exist in the our body due to the chemical reactions that occur as part of the normal bodily functions. For example, nerves relay signals by transmitting electric impulses. Most biochemical reactions from digestion to brain activities go along with the rearrangement of charged particles. Even the heart is electrically active and that is why our doctor can trace the activity of heart with the help of an electrocardiogram.

The human body is influenced by low-frequency electric fields just as they influence any other material made up of charged particles. When electric fields act on conductive materials, they influence the distribution of electric charges at their surface. They cause current to flow through the body to the ground.

Low-frequency magnetic fields induce circulating currents within the human body. The strength of these currents depends on the intensity of the outside magnetic field. If sufficiently large, these currents could cause stimulation of nerves and muscles or affect other biological processes.

We have well over a trillion cells in the human body. Each of these has a nucleus where our DNA (the genetic blueprint for our body) resides. DNA is known to be receptive to resonant frequencies in much the same way as radio waves. Cells have biomagnetic and electrical properties. The cell membranes in the mitochondria have varying electrical potentials and capacitance to transport ions in and out of the cell through what is called the electron transport chain. This is how our cells produce the energy that keeps us alive. Strong electromagnetic fields can disrupt the delicate balance of the electron transport chain and interfere with energy production in our cells.

What happens in exposure to e.m. field

There are two forms of e.m. energy or fields. (i) Ionizing, like X-ray and gamma ray which can break chemical bonds (ii) Non-ionizing, which can interact with the atoms but cannot remove electrons. This radiation is not harmful because it cannot break chemical bonds.

When an X-ray hits an atom to create an ion, an electrically charged atom and a free electron are generated. An ion's electrical charge can lead to unnatural chemical reactions inside cells. Among other things, the charge can break DNA chains. A cell with a broken strand of DNA will either die or the DNA will develop a mutation. If a lot of cells die, the body can develop various diseases. If the DNA mutates, a cell may become cancerous, and this cancer may spread. If the mutation is in a semen or egg cell, it may lead to birth defects. Long term e.m. radiation can develop memory loss, ringing in the ears, cateracts, retina damage, eye cancer, skin rash, nerve damage, joint pain, muscle pains, digestive problems and brain tumors. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields. However, some gaps in knowledge about biological effects exist and need further research.

In view of these, WHO recommends that "A wide range of environmental influences causes biological effects. 'Biological effect' does not equal 'health hazard'. Special research is needed to identify and measure health hazards."

At low frequencies, external electric and magnetic fields induce small circulating currents within the body. In virtually all ordinary environments, the levels of induced currents inside the body are too small to produce obvious effects. The main effect of radiofrequency electromagnetic fields is heating of body tissues.

There is no doubt that short-term exposure to very high levels of electromagnetic fields can be harmful to health. Current public concern focuses on possible long-term health effects caused by exposure to electromagnetic fields at levels below those required to trigger acute biological responses.

WHO's International EMF Project was launched to provide scientifically sound and objective answers to public concerns about possible hazards of low level electromagnetic fields. Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health.

The focus of international research is the investigation of possible links between cancer and electromagnetic fields, at power line and radio-frequencies.

Possible Harmful effects and Precautions one by one:

Watching T.V. or Computer: The spot of electron in computer CRT monitor which sweep the screen generates pulsed e.m. ra-

diation (PEMR). At a close range it disturbs the balance of all living cells. The harmful effects of PEMR exists all around the screen, especially in front and behind the monitor, even after computer is switched off. Side and rear of monitor are more dangerous. A computer may generate a field as high as 2.0 MicroTesla. This radiation field can develop:

1. Eye-strain and fatigue (Computer Vision Syndrome). The same effects have been seen in watching TV for a long time.
2. At close range, this e.m. energy disturbs the metabolism and electrical activities of the living cells.
3. For more than four hours exposure: stress, headaches, irritability, insomnia, eye strain, abnormal fatigue, decrease in natural immunity, hormonal disturbance, menstrual cycle disorder are observed.

Most modern computers or TV give off relatively low levels of EMFs but do still try to minimise exposure by keeping the computer, especially the screen, as far away as practical. Laptops generally emit low EMFs but when used with a mains adaptor plugged in they can cause dizziness and faint spells. Try to recharge it away from where you are, and then use it from the battery supply. Place a cactus in the office or computer room. The spine of cacti attracts charged ions and can change ionization levels in the room. Take breaks when needed. Finally, try to use a modern computer. In fact, modern computers have conductive screens which reduce the static field from the screen to a level similar to that of the normal background in the home or workplace. At the position of operators (30 to 50 cm from the screen), alternating magnetic fields are typically below 0.7 μT in flux density (at power frequencies). Alternating electric field strengths at operator positions range from below 1 V/m up to 10 V/m.

Cell Phone: This most useful thing may generate a field as high as 10.0 MicroTesla. Headaches, skin tingling and heating, fatigue, neck growths, lack of concentration and memory loss, irritability, restlessness, depletion, even tumours, cancer and cataracts have also been associated the use of cell phones. Use only for short periods at a time, keep it in a bag or outer layer of clothing, turn off in places like hospitals as radiation levels are normally high enough, do not get a talk plan with lots of free minutes enticing you to use them all up, swap ears from time to time, put volume higher and hold further away from head.

Cosmic rays: We are exposed to ionizing radiation from natural sources in two ways: We are surrounded by naturally-occurring radioactive elements in the soil and stones, and are bathed with cosmic rays entering the earth's atmosphere from outer space. The Sun emits significant UV radiation (about 10% of its total power), including extremely short wavelength UV that could potentially destroy most life on land (ocean water would provide some protection for life there). However, most of the Sun's most-damaging UV wavelengths are absorbed by the atmosphere's oxygen, nitrogen, and ozone layer before they reach the surface. The amount that reaches us is not harmless and does cause oxygen radicals, mutation and skin damage.

We receive internal exposure from radioactive elements which we take into our bodies through food and water, and through the air we breathe. In addition, we have radioactive elements (Potassium 40, Carbon 14, Radium 226) in our blood or bones.

High Tension Line: Strong radiation can induce current capable of delivering an electric shock to persons or animals. It can

also overload and destroy electrical equipment. The induction of currents by oscillating magnetic fields is also the way in which solar storms disrupt the operation of electrical and electronic systems, causing damage to and even the explosion of power distribution transformers, and interference with electromagnetic signals (e.g. radio, TV, and telephone signals.

In homes not located near power lines this background field may be up to about 0.2 μT. Directly beneath power lines the fields are much stronger. Magnetic flux densities at ground level can range up to several μT. Electric field levels underneath power lines can be as high as 10 kV/m. However, the fields (both electric and magnetic) drop off with distance from the lines. At 50 m to 100 m distance the fields are normally at levels that are found in areas away from high voltage power lines. In addition, house walls substantially reduce the electric field levels from those found at similar locations outside the house.

Cell Tower Radiation: Another area of concern is the radiation emitted by the fixed infrastructure used in mobile telephony, such as base stations and their antennas, which provide the link to and from mobile phones. This is because, in contrast to mobile handsets, microwave radiation is emitted continuously and is more powerful at close quarters. If you are living in the main beam of cell phone towers you are exposed to comparatively high radiation levels, you need particular help.

Radiation from cell phone towers is 24×7, people living in the near vicinity absorb this radiation continuously.

Diagnostic X-rays, SCANs MRI, etc.: In all these life saving diagnostic technique high frequency e.m. radiations are utilized. When our body is exposed to this type of high energetic beam, some bio-molecules may ionize leading to mutation and even cancer.

Radio-active materials: Radioactive materials that decay spontaneously produce ionizing radiation, which has sufficient energy to strip away electrons from atoms or to break some chemical bonds. Any living tissue in the human body can be damaged by ionizing radiation in a unique manner. The body attempts to repair the damage, but sometimes the damage is of a nature that cannot be repaired or it is too severe or widespread to be repaired. Also mistakes made in the natural repair process can lead to cancerous cells. The most common forms of ionizing radiation are alpha and beta particles, and gamma ray.

How much is Harmful!

It is the distance, strength and length of exposure that determines our health risk. There are four main categories of electro-magnetic emissions.

a) Electric: Anything carrying electricity including electric power lines, transformers, etc., can generate field. It should be limited to 5000 Volt/m at 50 Hz frequency at 30 cm from source (as per WHO recommendation) for the safety of living beings.

b) Magnetic: Magnetic fields arise from two sources: (a) From varying electric currents, and (b) from electron motion (orbital or spin). So all electric sources mentioned above will have magnetic field. It strength should be below 100 MicroTesla at 50 Hz at a distance of 30 cm.

c) Wireless: This includes WiFi, RF, MW, Cellular EMF emissions caused by the devices such as computers, mobile phones, wireless house phones, laptops, Cell Towers, GPS etc. These wireless microwave radiations are more harmful than radiation from household wiring and electric appliances. So whenever possible we should use hardwired connection instead of wireless.

d) Ionizing: Since ionizing EMF emission can destroy DNA in living cells, it should be kept as low as possible.

The regulations in vogue

WHO has recommended that 'National authorities should adopt international standards to protect their citizens against adverse levels of RF fields. They should restrict access to areas where exposure limits may be exceeded.' WHO has referred to the International Exposure Guidelines developed by International Commission on Non-Ionizing Radiation Protection (ICNIRP). Department of Telecommunications (DoT), in the year 2008, adopted the Electromagnetic Fields (EMF) norms prescribed by ICNIRP in respect of mobile towers.

Further, based on the recommendations of the Inter-Ministerial Committee, the Base Transmitting Station (BTS) radiation limits have been reduced to 1/10th of the limits prescribed by ICNIRP with effect from 01.09.2012. The Telecom Enforcement, Resource & Monitoring (TERM) Cells of DoT test upto 10% of BTS sites randomly. Additionally, the BTS sites against which there are public complaints are also tested by TERM Cell.

What can you do now?

We are accustomed with so many electronic and electrical appliances that it is not possible to avoid all negative effects of those. Rather, if we are aware, we can develop such habits that would minimize our exposure and thereby restrict the harmful effects. The followings are the simple steps to be taken.

1. Do not sit very close to TV Keep at least 6 ft distance.
2. Rearrange the electrical appliances like computers etc. in office or home in such a way that you do not have to be exposed for a long period whenever you are not using it directly.
3. Computers, TV, Refrigerators, etc., are to be placed against a wall.
4. Do not sleep under an electric blanket or on a water bed.
5. Do not stand close to a microwave oven
6. Unplug all electrical devices when not in use.
7. Avoid the use of watches with radium dial
8. Do not use computer or TV in children's room or bed room.
9. Do not keep mobile phones close to you while sleeping
10. Do not give mobile phones to children
11. Use hands-free sets to decrease the radiation to the head.
12. Keep the mobile phone away from the body.
13. Do not use telephone in a car without an external antenna.
14. Replace CRT monitor and TV by LCD screens.
15. Keep electrically operated clocks at least 4 ft away from your head
16. When using a photocopying machine stand at a distance of 30 inches while copying is in progress.
17. Keep electrical appliances at least 3 ft away from a bed head area.
18. If you are pregnant, minimize the use video-display terminals, use of cell phones and microwave ovens.
19. Avoid living in areas where EMF exposure could be high.

Conclusions

As we grow technologically and utilize electrical and electronic gadgets more and

more, we should be aware of the possible health hazards, and should know how to minimize the effects. The government should take proactive role to formulate regulations to minimize these effects, and should spread the consciousness among the people. The effects should be specified on the product detail, and statutory warning should be given—similar to the statutory warning on smoking products. Unfortunately these products form a huge market, and such regulations in the interest of the people may reduce the profit of the producers. □

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Nuclear Energy—Facts and Fiction, Part II

Satish K. G. *

1. Corruption and the Nuclear Establishment

It would be absurd to think that corruption—so endemic in the system—has spared the nuclear establishment. The 'cash-for-votes' scam erupted in July 2008 when the UPA government was trying to get through the vote of confidence in Parliament against the background of the Indo-US nuclear deal. On 17 July 2008, WikiLeaks revealed a cable sent from the US Embassy in New Delhi to the US State Department which said that, out of a total amount of Rs.50-60 crore set aside for pay-offs, four MPs belonging to Rashtriya Lok Dal (RLD) had been paid Rs. 10 crore each to support the government.[1]

Even the process of selecting the foreign vendors for building nuclear plants is beset with anomalies. Prof Brahma Chellaney, a leading strategic thinker and analyst, has criticised the nuclear establishment for 'pampering' foreign companies such as General Electric and Westinghouse (USA), Areva (France) and Atomstroyexport (the engineering firm under Russia's state corporation Rosatom). He has identified the following irregularities which—as he says—is no way to meet energy needs, or to reduce carbon emissions, or to help India's poor[2]:

- Foreign reactor builders need not worry about producing electricity at marketable rates since the Government will run the reactors through the state operator, NPCIL, and will have to subsidise the high-priced electricity generated,
- Exclusive reservation of a nuclear park for each foreign vendor even before the deal is negotiated,
- Land acquisition by the government on behalf of foreign firms,
- The deals signed with select foreign companies without open bidding and transparency,
- Skewed accident liability that shields the foreign reactor builders in case of an accident.

Such corrupt practices coupled with the manifest lack of safety culture render any assurances by the nuclear establishment on the safety or viability of nuclear power, completely hollow.

2. Non-nuclear sources: Potential vs. Performance

Let us look at the available alternatives to nuclear energy and check how safe, plenty, cheap or clean they are.

2.1 Solar energy

A study by two professors at the Indian Institute of Science (IISc) in Bangalore, Hiremath Mitavachan and Jayaraman Srinivasan, published in the journal Current Science in July, 2012 shows that India's energy needs can be met entirely by solar and other renewable sources.

The analysis overturns the argument that nuclear power is essential for India because

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the country does not have enough land to exploit the potential of solar energy.

According to their study, just 4.1% of the total uncultivable and waste land area in India is enough to meet the projected annual demand of 3,400 terawatt-hour (TWh) by 2070 using solar energy alone (1 TWh per year requires 114 MW capacity). The land area required will be further reduced to 3.1% if we bring the other potential renewable energy sources like wind and biomass into the picture. Thus they conclude that land availability is not a limiting constraint for harnessing solar energy.

Their calculations are based on present-day solar photovoltaic (PV) technology and do not include higher efficiencies achieved by new solar cells. Neither have they considered roof-top PV systems that can be established without any need for additional land.

The IISc researchers' conclusion is in conformity with that of a report prepared in 2011 by the Australian government which said: 'There is more than enough suitable land in India, with high direct beam solar, to meet the entire nation's electricity needs in principle.'[3]

The researchers compared the land-use pattern of three energy sources—coal, hydro and nuclear—with solar energy. They found that solar land requirement is comparable with that of coal and nuclear power when it includes the area for setting up the plant, fuel mining, transportation and waste disposal across the lifetime of the power plant.

While nuclear and fossil fuel-based technologies must continuously transform some land to extract the fuels or dispose of the waste, this is not the case with solar plants. In fact, the same land used for PV solar power plants can be utilised for other purposes like grazing.

'The roof-top solar power technology, along with that proposed by the IISc professors, will be able to meet most of the electricity demand, and has the potential to transform the power sector', says Shankar Sarma, a power policy analyst and author of a forthcoming book 'Integrated Power Policy'.

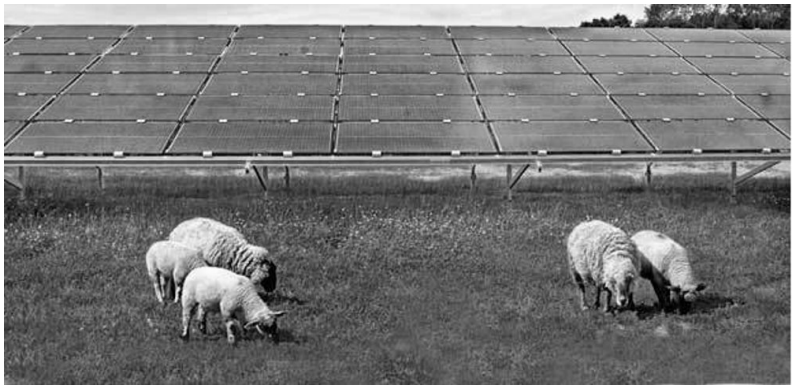
Atul Chokshi of the IISc Department of Materials Engineering agrees. He reported recently that a three kilowatt rooftop solar panel system on the 425 million households can generate a total energy per year of 1900 TWh – half of the projected energy demand by 2070.[3]

Germany installed a record 4,300 MW of solar power capacity in the first half of 2012. Tunisia is working on a 2000 MW solar plant to open in 2016. Dubai is building a 1000 MW solar park to be completed in 2013. California has approved nine solar power projects including a 1000 MW plant with a total potential to generate a massive 4300 MW capacity once completed. Projects with an additional 1500 MW capacity are under review.[4]

Is it unreasonable to expect solar power exploration to set the direction for further research and investment in energy in our country?

2.2 Wind energy

Wind energy is another renewable energy source which—as Indian Wind Energy Association says—is affordable, clean and helps provide energy security. The Ministry of New and Renewable Energy has released its estimate of the potential wind resources at a massive 1,02,300 MW—at 80m hub heights—which is more than six times the currently installed wind capacity. Hub height is the distance between the platform and the rotor of a wind turbine i.e., the distance from the ground to the center of the turbine and it does not include the length of the turbine blades. Normally, the more



Sheep grazing at a 15MW solar plant at Anglesey, Wales

the hub height, the better the power generation.

The wind resources at higher hub heights are possibly even more. A new assessment of wind energy in India in March, 2012 by Lawrence Berkeley National Laboratory has found that the potential for wind energy in India is between a gigantic 20-30 times higher than the government estimates given above! Dr. Amol Phadke, the lead author of the report, says 'wind energy is one of the most cost-effective and mature renewable energy sources available in India'. In fact, the cost of wind power has actually dropped below the coal-based energy in parts of India such as Maharashtra thanks to advanced wind turbines. A major EU funded research study undertaken over the period of 1995 to 2005 found that the environmental and health costs are the least for wind energy among all energy sources.

Incidentally, not far from the Koodankulam nuclear power plant, thousands of windmills around Koodankulam are rotating to produce power. This corridor—with its ideal geography between the sea and the hills with winds from advancing and receding monsoons—is the hub of wind energy forming the country's highest concentration of windmills. As per estimates, the wind capacity in this region is nearly twice the nuclear capacity of Koodankulam nuclear plant. What's more, eight wind turbines are installed at the Koodankulam nuclear power plant itself with a total capacity of 10MW![5]

Obviously, harnessing wind energy is another area for further research and investment.

2.3 Hydro, waste-to-energy and other sources

Coming to yet another important renewable, safe, reliable and clean source of electricity, namely water, a study published in International Journal of Arts and Science in 2010 finds that the hydro power potential in India is about 1,49,000 MW out of which only about 38,000 MW has been so far harnessed. This means about 75% of the total hydro potential is yet to be exploited[6] but in a manner that properly addresses the environmental concerns associated with large hydro-electric projects.

Waste-to-energy is a neglected domain in India. There are new technologies such as plasma gasification where both organic and inorganic waste (plastic, glass, sewage, industrial waste, oil sludge) will be heated to high temperature (4000°C–5000°C) to produce 'syngas' which is used as fuel to produce electricity. Already, Pune Municipal

Corporation has set up a gasification plant which is successfully treating 650 tons of waste every day generating 2.2 lakh units of electricity.[7] If Bangalore had adopted this 'treasure out of trash' model, the recent crisis surrounding garbage disposal could, perhaps, have been avoided.

Overall, renewable energy in India—including other sources such as biomass, biofuel (Jetropha), geothermal—is a sector that is still underdeveloped and underexplored in relation to its enormous potential to fulfil the energy needs of the country in an affordable, clean, safe and sustainable way.

2.4 Clean Coal Technology

It is true that fossil fuel-based power generation produces greenhouse gas emissions that have been linked to climate change. But, there are clean coal technologies available to improve efficiency of the conversion cycle and to reduce emission. Clean coal technologies include:

(a) *Advanced pulverized coal–supercritical steam generation* — Coal is ground into fine particles and blown into the furnace. Combustion of coal is used to produce superheated steam (i.e., steam at a temperature higher than water's boiling point) without boiling. Two experts from Harvard University, Ananth Chikkatur and Ambuj Sagar believe that this is the best option for the short-to-medium term future of coal in India.[8]

(b) *Fluidized-bed combustion (bubbling, circulating, pressurized)* — A fluid (air, pure oxygen or liquid) is passed through suspended solid fuels at high velocity resulting in more effective chemical reactions and heat transfer.

(c) *Flue gas desulphurization* — Technology used to remove sulfur dioxide (SO_2) from exhaust flue gases of a power plant.

(d) *Integrated gasification combined cycle (IGCC)* —Technology that turns coal and other carbon based fuels into gas—synthesis gas (syngas). It then removes impurities from the syngas before it is combusted.

(e) *Carbon capture and storage (CCS)* — the process of capturing waste carbon dioxide (CO_2) from fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally underground.

Millions of tons of CO_2 are already captured and stored hundreds of meters below ground at the 8 large-scale CCS plants in the US, Norway, Canada and Algeria. Norway opened an R&D centre for CCS technologies in May, 2012. However, India is yet to make any real headway in this regard and CCS should be taken as a research and investment area in the short term given India's heavy dependence on electricity production from fossil fuels.

2.5 Power saved is power produced!

Union power ministry proclaims that 'Power saved is power produced'. However, the ministry statistics reveal that the Aggregate Technical and Commercial losses (AT&C losses) which include transmission and distribution losses, power theft and billing deficiencies account for 27% of the total power generated in 2009-10.[9] An International Energy Agency study shows that the power losses in India are among the highest in the world.[10] In most of the developed countries, the loss levels do not exceed a single-digit figure. In South Korea, the losses are 9%, in Singapore 3% and in the USA 6%.[11]

Even if the power losses are reduced by a mere 1% in 2013, it would make more than 2000MW available for consumption—more than what KKNPP is expected to produce even at its most optimal load factor! While better technology can certainly help reduce

Why solar and wind are not common?

losses, a Joint Secretary with the power ministry says that even measures such as proper energy audit and metering, fixing responsibility and accountability, and displaying political will can help reduce the AT&C losses by 10%.[11] Is the government listening?

3. The rural poor and nuclear energy

The Planning Commission estimates that 60 crore Indians do not have access to electricity and about 70 crore Indians use biomass (read dung cakes or firewood) as their primary energy resource for cooking. The UPA government launched Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) in April, 2005 with the slogan of achieving 100% rural electrification by 2012. But here comes the cruel twist: under the scheme, a village is declared electrified if the number of electrified households is just 10% of the total number of households in the village!

Clearly, there is a lot to be done. The renewable energy sources namely solar, wind and biomass are known to be best suited for rural electrification. The Alliance for Rural Electrification (ARE) believes that renewable energy technologies, utilised in off-grid and mini-grid power systems, can sustainably meet the energy needs of rural communities at an affordable price rather than extending the electricity grid.[12] When viewed from the perspective of the rural poor, the overzealous thrust on nuclear energy is clearly a skewed outlook meant to support big business and corporate houses and not the common masses. No wonder that Dr S.P.Udayakumar feels that nuclear power benefits only industrial India and not the common man.[13]

4. Is anti-nuclear stand same as anti-technology?

The nuclear protagonists try to brand anyone who has concerns against nuclear technology — concerns that have been substantiated to considerable depth in the above sections — as being 'anti-technology'. Of course, this is not true.

It needs to be emphasised that the principal demand from the nuclear skeptics — which includes nuclear energy experts — is that technology must have the goal of bettering the life of the common man and not to serve the interests of profit-greedy domestic and foreign monopolies. In fact, as this article has strived to show, further research in technologies for tapping renewable energy sources more efficiently can better serve the interests of the common people including the rural poor, provided the government seriously and sincerely worries about them. Accordingly, priorities should be set right by channelising the funds doled out to R&D in nuclear sector into these technology areas as well as by augmenting these research grants.

While absolute opposition to nuclear technology under all conditions is not a tenable stand, today's reality is that firstly, there is a lack of fool-proof mechanism of radioactive waste disposal and of preventing or even, adequately handling radioactive hazards including accidents. Secondly, there are other cleaner, safer, more plentiful and even cheaper alternatives available

that are sustainable in the long run and are yet to be explored fully as this article has attempted to show. Thus, today, nuclear energy has to be necessarily ruled out as an option.

5. Why is the government so bent upon going ahead?

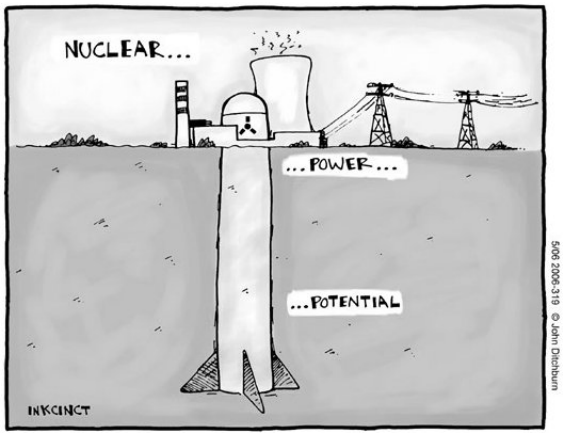
Now, to the billion dollar question: why is the government so adamant to go forward with the Koodankulam and other nuclear energy projects despite facing ceaseless and massive mass protests and objections from experts? Let us investigate further to arrive at a conclusion.

5.1 Nuclear energy and India's status as 'regional super power'

Let us quote from a pro-nuclear voice, Prof. Rahul Siddharthan (IMS, Chennai): 'Unfortunately, for most of its history in India, civilian nuclear power has been deeply intertwined with the nuclear weapons project'.[14] Why? Because, while nuclear energy can be used for electricity generation, the same process is also necessary for making nuclear bombs.

Let us see how this works. In 1954, under the US-sponsored 'Atoms for Peace' program, India acquired a Cirus 40 MW research reactor from Canada. In 1964, India commissioned a reprocessing facility at Trombay to separate out the plutonium produced by the Cirus research reactor. This plutonium was used in developing the nuclear bomb that was tested on May 18, 1974 at Pokhran.[15] This is how the civilian and military uses of nuclear energy in India are intertwined and this is how, India joined the select club of nine nuclear weapon states.[16]

Significantly, in the debate on nuclear energy in the Constituent Assembly in 1948, Nehru himself stated: 'I do not know how you are to distinguish between the two [peaceful and military] uses of atomic energy'.[17] Prof. John Hariss from London School of Economics concludes that 'right from the time of Independence, India has entertained the possibility of developing nuclear weapons'.[18] Prof. Amulya KN Reddy was absolutely unequivocal when he said that India's nuclear power programme can be justified only by the fact that it enabled the nuclear weapons programme.[19]



Does this not adequately explain the need for secrecy in the India's nuclear energy pursuit?

India signed a Safeguards Agreement with the International Atomic Energy Agency (IAEA) — an international agency with a stated purpose to prevent nuclear proliferation — in 2008. As part of the agreement, a total of 14 Indian reactors would be open to Agency inspections by 2014 while 8 reactors — 4 in Kaiga, 2 in Kalpakkam, 2 in Tarapur — and associated facilities would not be subject to any international examination. In other words, they can be used for military purposes. But, make no mistake. These safeguards are mainly concerned with checking nuclear proliferation, not with the safety of the plant itself.[14]

Ashley J. Tellis, a key US adviser to the Indo-US nuclear agreement, estimates that these eight unsafeguarded reactors in India can produce sufficient Weapon Grade Plutonium for more than 2000 nuclear weapons to add to the existing arsenal of 50 to 100 nuclear weapons.[20]

The imported reactors at Koodankulam and Jaitapur plants are reported to be incapable of producing weapon grade plutonium. But, they can still help the weapons program in an indirect manner. How? Joseph Cirincione, former director at Carnegie Endowment for International Peace asserts that the Indo-US nuclear deal (and other deals with France, Russia etc.) frees up India's limited uranium reserves to make nuclear weapons[20] while the imported uranium would be used in the civilian reactors.

K. Subramanyam, former head of the National Security Advisory Board, provides ample proof for this line of thinking. In December 2005, he advised: 'Given India's uranium ore crunch, it is to India's advantage to categorise as many power reactors as possible as civilian ones to be refueled by imported uranium and conserve our native uranium fuel for weapons grade plutonium production'.[21]

One month after signing the Safeguards Agreement, the Nuclear Suppliers Group (NSG), a 45-nation group led by the US to oversee global nuclear trade, allowed India to be part of global nuclear commerce. Thus India became the only nuclear weapons state to be part of nuclear trade without signing either the Nuclear Non-proliferation Treaty (NPT) or the Comprehensive Test Ban Treaty (CTBT). The US lobbied heavily to get this proposal through, supported by France and Russia among other countries.

In the subsequent months, nuclear firms from these three countries — such as Areva (France), Westinghouse & GE-Hitachi (US), Rosatom (Russia) — were in talks with NPCIL to sell reactors, to supply raw materials and technical know-how. India signed bilateral deals on civilian nuclear energy technology cooperation with several NSG member countries including the US, France, UK, Canada, Kazakhstan, and South Korea.

Let us listen to a telling remark from Dr A.Gopalakrishnan: 'The ethical standards of DAE, NPCIL and AERB have fallen considerably, especially since 2004, perhaps because of the current prime minister's direct interference with these institutions to meet the political ends of getting the Indo-US nuclear deal passed through parliament'.

In summary, India agrees to separate its military and civilian nuclear facilities and continue its nuclear weapons ambitions to sustain and enhance its 'regional super power' status. In return, foreign companies get a large share of the Indian nuclear market pie! So, you see, this is how the principle of give-and-take operates in the exclusive nuclear club!

Is this not a reason why the government is so aggressive on its nuclear plans?

5.2 Nuclear business — a mine of opportunities for the corporates

Currently, Uranium and Thorium exploration, mining and nuclear power generation are in the public sector domain in India. However, in 2010, a DAE communiqué to the Lok Sabha says 'Private sector in India is in a position to participate in setting up nuclear power plants through supply of components, equipment and works contracts'. But, having limited their role to erection, procurement and construction of nuclear plants and supply of infrastructure equipment so long, the corporate bigwigs have started their foray into the nu-

clear sector in India in a bigger way.

Federation of Indian Chambers of Commerce and Industry (FICCI) — the apex industry body in India — has a nuclear subgroup. Significantly, the chairman of this sub-group is an ex-vice chairman of AERB. As part of the Indo-US nuclear agreement in December, 2009, this sub-group recommended that '100% privatisation in nuclear sector should be achieved in a cautious, stepwise and smooth manner to make it sustainable and irreversible. The initial steps could be Public Private Partnership (PPP) or Joint Venture (JV) with NPCIL leading to 100% privatisation'.[22] So, does this not mean the die has already been cast?

US-based investment guide, iStockAnalyst estimates the size of India's nuclear power sector to be a mammoth Rs.7.5 lakh crores! As many as 400 Indian and foreign firms are seen as the beneficiaries of the far-reaching NSG verdict.

'We have (in India) at least a dozen technologically-competent players who can rope in strategic alliances and joint ventures with reactor manufacturers. Eventually, these players can go on to become reactor manufacturers themselves' said V. K. Chaturvedi, former CMD, NPCIL and interestingly, a Director on the Board of Reliance Power.

To name a few, L&T, India's biggest engineering company is tied with NPCIL for the erection, procurement and construction of nuclear plants including Koodankulam. Reliance Infrastructure (formerly Reliance Energy) reportedly plans to invest Rs.12,000 crore to install 2000 MW of nuclear power capacity. Tata Power tied up with some major nuclear equipment suppliers like Areva and Toshiba (which has acquired Westinghouse). Gammon India, India's largest civil engineering company which built the nuclear plants in Rajasthan and Tarapur along with L&T are now involved in building India's first Prototype Fast Breeder Reactor plant at Kalpakkam, Rolta India, in association with Stone and Webster offers reactor-building technology. Hindustan Construction Company has so far constructed four nuclear power projects in India and is well-placed to get turnkey construction contracts in nuclear projects. Crompton Greaves completed a switchyard project for NPCIL.[23] L&T and Tata Power were also involved in the construction of India's first-ever indigenous nuclear submarine — INS Arihant.

Significantly, former DAE head, Dr Anil Kakodkar, admitted in an article published in a Marathi daily earlier this year that India must import reactors worth billions of dollars because 'we also have to keep in mind the commercial interests of foreign countries and of the companies there'.[24] One is tempted to ask the Prime Minister whether the foreign hand operates in the anti-nuclear protests or in the nuclear establishment!

Dr A.Gopalakrishnan, in an article in DNA on 17 March, 2011, steps up his fierce attack and drops the bombshell: 'All along, these nuclear agencies of the government have also colluded with, and were assisted by, large Indian and foreign corporate houses and their federations interested in the sizeable nuclear power market they are helping to create in India. Even in the evaluations and negotiations of cost, the safety and liability of imported reactors, the official nuclear agencies today are operating hand-in-glove with their friends in the corporate houses and federations.'

Indian corporates are not limiting their nuclear ambitions only to India. Last December, Times of India carried a significant piece of news that said Reliance Industries Limited — an Indian monopoly corporate house with global investments — acquired a stake in the US-based nuclear de-

sign & engineering firm, Terra Power. RIL already has a 49% stake in Australia-based UXA resources. This clearly indicates the aspirations of RIL in nuclear power generation. In 2010, Indian mining company, Dharni Sampda, acquired Uranium mining licenses in 3000 sq. km area in Niger.

Now, it is an open secret that the political parties are funded by the corporates only to reap the policy fruits when governments are formed. So, the governments are destined to implement what the corporates demand.

Is this not another reason why the government is so aggressive on its nuclear plans?

6. Nuclear policy decisions — democratic or autocratic?

In a democracy, it is expected that the government involves and consults the people, and addresses their concerns in policy decisions that have direct impact on their lives and livelihoods, that the process should be democratic instead of forcing the decisions down people's throats.

However, it is evident that this basic principle of democracy is bypassed in the decision making process concerning nuclear power projects in India. This article has aimed to establish that a nuclear disaster can by no means be compared with any other disaster or calamity in its terrible magnitude and long-term pernicious effects. So, it can be well understood that those who are protesting against nuclear plants are doing it not only for their own sake but for the sake of the future generations and in the larger interest of the people of the country as well.

If the term 'Nation' includes the people and the environment in the national territory, then the protesters are fighting to protect the national interest. If so, framing false charges or slandering them or branding them traitors and anti-nationals, or letting loose state repression on them — can any of these be regarded as proper or democratic?

Rather, the government and the nuclear establishment should address the genuine concerns of the people, and be as prepared to be convinced as they are out to convince, and be prepared to concede to the people's demands including that of a 'No' to nuclear plants if the demands are found to be just and legitimate—all these with an open mind and total transparency.

To set the ground for such a free and fair discussion, all false cases filed against the protesting people and their leaders must be immediately withdrawn, all arrested people rotting in jails should be released forthwith, prohibitory orders in the affected areas should be lifted without further delay, and those who have suffered from injuries and loss of life and property should be adequately compensated.

Finally, steps must be taken to ensure people's participation in making all policy decisions that affect their lives and livelihoods and to protect their right to protest against what they feel is not just and not in their common interest.

7. Experts and intellectuals — on which side?

As we have seen, the nuclear establishment has leveraged its heavyweights in its campaign for nuclear power. At the same time, the movements at Koodankulam, Jaitapur, Gorakhpur and other places have stirred the conscience of pro-people intellectuals and experts across the globe. Support is still pouring in.

Noam Chomsky, internationally acclaimed intellectual who was voted 'World's top public intellectual' in 2005 has cautioned that Koodankulam could be another Bhopal disaster waiting to happen. In a letter of solidarity, he said: 'Nuclear energy

is a very dangerous initiative, particularly in countries like India, which has had more than its share of industrial disasters. I would like to express my support for the courageous people's movement protesting the opening of the Koodankulam Nuclear Power Plant'.

Other prominent intellectuals, nuclear energy experts, scientists, jurists, artists, writers, journalists who have either actively taken part in the struggle or lent their support include:

- Eminent Jurists like Justice VR Krishna Iyer (former judge, Supreme Court of India), Justice A P Shah (former Chief Justice of Delhi High Court), Justice B.G. Kolse Patil (former judge of the Bombay High Court)
- Former West Bengal Governor Gopalkrishna Gandhi,
- Former navy chief Admiral L Ramdas, former Army Chief General V.K.Singh
- Former Union Power Secretary, Dr. EAS Sarma (India Today magazine says 'a testimony to his honesty is the fact that he was transferred 26 times in his 35-year tenure'),
- Former Chairman of Haryana State Electricity Board, MG Devasahayam
- Social activists and environmentalists like Medha Patkar, Prof.T.Shivaji Rao, Lalita Ramdas
- Scientists, energy experts and physicists like Prof. Ram Puniyani, Dr Surendra Gadekar, Dr Sangamitra Gadekar, Dr PM Bhargava, Dr Suvrat Raju, Shankar Sharma, Dr Partho Sarothi Ray,
- Economists like Dr. Sulabha Brahme
- Noted writers, columnists, film makers and journalists like Praful Bidwai, Vandana Shiva, Anand Patwardhan, Nagesh Hegde,
- Anti-corruption activists like Prashant Bhushan, Aruna Roy,
- Political scientists like Prof. Achin Vanaik,
- Human rights activists like Dr Binayak Sen,
- And hundreds of eminent citizens in various fields

8. The last word

Due to the well-orchestrated and relentless campaign by the nuclear establishment, a section of the people has become confused on the issue. This article is meant to distinguish facts from fiction and thus, to establish the correctness of the anti-nuclear line on the intellectual front to clear the confusions and dispel the wrong notions.

Finally, a question that keeps popping up is that since thousands of crores of rupees have been already spent on the KKNPP, would it not be unwise to pull the plug now? PMANE Expert Team headed by M. G. Devasahayam has suggested fuel-switching and to make KKNPP a liquefied gas-based power plant and that this can be supplemented with wind, solar and tidal power for which there is huge potential in Koodankulam and adjoining areas.[25]

There are precedents elsewhere. For instance, Shoreham nuclear power plant in the USA was decommissioned following protests by the local residents even before it started commercial operations. As of July 2012, there is a proposal to build a natural gas-fired power plant at the nuclear site. There is another proposal to build a wind farm. Both taken together have a combined capacity which is about 300 MW more than the capacity of the shuttered nuclear facility. The existing substation and transmission & distribution system is planned to be reused by both power plants.[26]

In January 2013, Japan announced

plans to build the largest wind farm in the world — with 1000 MW capacity — just 15 km off the coast of Fukushima![27] The Japan government has also instituted a Feed-in-Tariff (FIT) incentive program for solar energy producers under which the producers are assured of a stable income for 20 years. Thanks to the scheme, solar projects with a capacity of more than 1000MW have taken off since the Fukushima accident.[28]

It means that, since the plans on Jaitapur, Gorakhpur and other nuclear plants are not yet in advanced stages, it is completely feasible to correct the course if the government acts NOW without any delay.

Thus, the money already spent can, at last, be put to some good use!

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A Brief History of Science
Part 3: The Dark Age

Soumitro Banerjee*

The decline of science

We have seen in the last part that after the death of Alexander there was a vacuum in Greek leadership, and a civil-war like situation prevailed in the mainland Greece. The centre of intellectual activity shifted to the Egyptian port of Alexandria, but no military power emerged there either. This vacuum in military leadership resulted in the ascent of Rome as a military power. In fact, there is a period of overlap between the Hellenistic period and the Roman period, and some historians identify a fourth phase of Greek civilization—the so-called Roman phase—when the glory of the Greeks was on a decent and the military might of the Romans was on an ascent. Archimedes, Chaudius Ptolemy, and Galen belonged to this period.

We have also seen that Greek philosophy started out by trying to make sense of the world that they saw, by trying to speculate why things are as they are. But in the hands of Plato and Aristotle it took a different shape. Their emphasis on pure thought instead of observation paved way for a mystic, idealistic way of thinking which inevitably leads to the development of imaginary and self-contained systems of belief. This is what happened in the early Roman period: many systems of belief sprouted. Then one would look at the external world on the basis of the belief system one subscribes to. If some observation is consistent with the belief system, that would constitute the "truth"; and if some observation is inconsistent with it, that would be treated as insignificant, false, or unfit for intellectual attention. The Hellenistic period saw some instances of departure from this trend of thought, but this "Platonic" system ran as an undercurrent all through this period, and became dominant at the onset of the Roman era. The "neo-Platonism" gave rise to beliefs in supernatural powers, in fate, in various shades of mysticism, occult, and the practice of magical powers to reach the divine. In this cultural atmosphere, the cultivation of science died down.

The transition from slavery to feudalism

The Roman empire started with the same social structure as the Greeks: it was also a slave owning society. With the passage of time, slavery grew more and more brutal. At the same time the condition for a major change was slowly maturing. By that time the iron age was in an advanced stage, and the methods of agriculture and its implements, the method of the production of textile, and the production of iron and brass implements had advanced significantly. But the people engaged in production were slaves—who had no reason to be interested in an increase in production. Thus there prevailed a situation where the productive forces had advanced, but the

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master-slave production relation was holding back the advancement of production.

The catalyst for the change was provided by a slave revolt that started in 73 BC. Under the able leadership of the gladiator Spartacus, the slaves grouped themselves into an 1,00,000 strong army, and challenged the Roman legions. The battle continued for two years, and finally Spartacus' army was defeated in 71 BC. All the slaves taking part in the slave-army were murdered by the Roman generals Crassus and Pompey.

True, it was a failed revolt, but it changed the course of history. Following the revolt the common slave masters began to treat the slaves less harshly than before, out of sheer fear. With a large population of slaves killed, the number of available slaves reduced. The weakened army could not embark on fresh conquest of foreign land for some time, and so there was no fresh supply of slaves. In this situation the land-owners changed their strategy: Instead of getting the work done by the forced labour of slaves, they started engaging poor people and freed slaves as serfs. In this arrangement, a piece of land would be "allotted" to a serf, where he can produce a crop. The serf can keep a portion of the produce and has to give a lion's share to the land-owner. In this arrangement, even though the condition of the serfs continued to be wretched, they had reason to try to increase the production—because that would increase the fraction that he can keep for himself.

Thus started a phase of society which we call feudalism. It took a few centuries for this method of production to become widespread. By the time which we call the "middle age", the feudal form of production entrenched itself strongly in the whole of Europe.

By that time the glorious days of the Roman empire were gone. The peak phase of the Roman empire lasted about three centuries: from the first century BC to the second century AD. Starting from the 4th century AD, the Roman empire failed to hold its ground in face of a series of invasions: The Goths invaded in 410 AD, Attila the Hun captured much of its territory in 451 AD, the Vandals pillaged Rome in 455 AD. Much of Europe, which was earlier under the Roman empire, went into a phase of uncertainty, chaos, and periodic waves of loot and plunder by warlords. The rich and powerful considered it unsafe to live in the cities and moved to their estates in the countryside. Slowly a stable form of feudal society developed.

What was the social condition then?

Firstly, the villages developed self-sufficient rural economy where most of the basic necessities of the people—food, clothing, pottery, furniture, metal implements, etc., were produced by serfs and local artisans in the village itself. The need for trade reduced, and became limited to the luxury goods for the aristocratic land-owners.

Secondly, the people became tied to the land as serfs for generations. Due to the lack of trade and commerce, the inter-regional cultural intercourse practically stopped. The conditions of feudal production put no fresh demand on scientific and technical inventions. Thus, a static form of society developed.

Every society creates a culture and a value system needed to maintain itself. The feudal society also created a value system which went to propagate and maintain the static nature of the society. The Platonic trend of philosophy had already created an ideal backdrop for it, by fathering many systems of belief. But in the late Greek or early Roman societies it was still in the form of individual beliefs, practised by groups of people. With the development of feudalism

a new feature was added: the development of *organized* religious faiths whose characteristic features were (a) hierarchic priesthood, (b) fixed rituals, (c) creeds involving the belief in an order of the universe, and (d) sacred books. In Europe the organized religious faith was provided by Christianity. But these characteristics were by no means the features of Christianity alone. The religions that developed in feudal times in other countries, like Buddhism in China and Japan, Hinduism in India, and Islam in the Arab world, all shared the same features.

The age of faith

Jesus Christ was born in Judea during the reign of Augustus Caesar (27 BC to 14 AD). As we have seen in the first instalment of this article, by then the idea of a God had already appeared in the society, and was prevalent in the Jewish community in which he was born. Jesus introduced the idea of a "Kingdom of Heaven" where all men were equal. All men were seen as children of a righteous God. However sinful, unjust and polluted the peoples' lives may seem to be, there was justice waiting for them in the kingdom of God. It was a revolutionary idea. It struck at the heart of the oppressed, and in the initial phase played an important role in the struggle of the slaves.

But with the advent of feudalism, Christianity lost its revolutionary character and slowly assumed the role of defending the existing order of the society, and hence was welcomed by the ruling elite. It created a worldview of a static unchanging universe which was conducive to the static feudal economic order. In order to do that, it absorbed the ideas of Plato, Aristotle, and Ptolemy.

What was the worldview like? First, absorbing the ideas from tribal mythologies, it created the idea that God created the world in a single stroke, in a span of just six days.[1] After the creation event, the world has been the same ever since. In this picture, everything has a "purpose" (see the link with "final cause" of Aristotle): the purpose of the cow is to provide milk to the humans; the purpose of grass is to provide food to the cow; so on and so forth. This is because God created everything with a purpose.

What is the universe like? By then it was known that the Earth was round. It was believed that this spherical Earth is at the centre of the universe, because it was the abode of man, whom the God created "in his own image". Around the Earth, rotates the moon. But, we do see dark spots on the moon, that is, it is not "perfect". Therefore it was believed that the moon is inside the Earth's atmosphere. Everything outside the Earth's atmosphere was believed to be perfect, divine, and unchanging.

What lies beyond the moon's orbit? First, the sun, revolving around the Earth. The sun's shape was believed to be a perfect circle, moving in circular orbit—because, following Pythagoras, it was believed that the circle is a "perfect" shape. Then come the planets. But there was a problem with the planets: Their motion was known to be quite complicated, at any rate their orbits cannot be circular. If one observes a planet like Mars for a few months, one would see the planet moving steadily against the starry background. Then its motion would slow down and stop. And then it would *turn backwards*. Again for some time it would continue in its backward motion, then stop, and then would resume its forward motion.

Two types of "explanation" of this motion went into the belief system. One said that

[1] Notice that in Christian belief, God creates by the spoken command "Let there be $\cdots$", suggesting a comparison with a king—an aspect we have highlighted in the first instalment of this article.

The apparent motion of the planet Mars, and Ptolemy's explanation based on epicycles.

there are concentric transparent crystal spheres on which the planets are embedded. God moves these crystal spheres, and the planets move as a result of that. There was another explanation due to Ptolemy, which was also included in the Christian cosmology. It said that the planets do not move in circles, but there are circles over circles, called "epicycles". As a result of this combined motion, the planets sometimes appear to move backwards. At that time five planets were known: Mercury, Venus, Mars, Jupiter, and Saturn. Their apparent motions had already been observed in great detail by Aristarchus and Hipparchus in the Hellenistic period. If one tried to tally the Ptolemaic picture with these observations, one would find that great many epicycles were needed in order to explain their apparent motions. But that was not considered to be any big problem, because so long as you do not probe deep, it offered a mental picture that could be believed.

What lies beyond the realm of planets? Here also Christian cosmology borrowed ideas from Aristotle. It was believed that there is a solid dark canopy that marks the end of the universe. The fixed stars are embedded on this dark sphere, which was, again, perfect, static, unchanging, and unchangeable.

Such beliefs became so deep-rooted, that when something at odds with the belief was observed, people would disbelieve their own eyes and would ignore the event. For example, in the year 1054 a star exploded—a stellar event that we now call supernova—emitting very bright light that lasted a few days[2]. The normally dim star became so bright that its intensity was comparable to that of the moon. And it was observable from the whole of the northern hemisphere. Yet, nobody in Europe reported having seen it. Nobody recorded it.

In the area of mechanics, Aristotle's ideas held sway. As we have seen in the last instalment, the central theme of Aristotle's mechanics was that force produces motion. Wherever there was motion, people assumed the application of force, and if the agent applying force was not clearly visible (as the horse pulling the cart), people assumed a divine role in making things move. Moreover, if force produces motion, a bigger force would produce a bigger motion. That is why it was believed that a heavier body would fall faster than a lighter body.

The biggest victim of this belief system was biology. Since it was believed that all living beings were created by God with some purpose, the study of biology boiled down to speculating about the *purpose* of each living thing. Moreover, since all species were

[2]We know about the event from the records of the Chinese astronomers, and by observing the remnant of that explosion—the Crab Nebula.

believed to have been created by God in a single stroke, there was no question of any change or evolution. It took a long and arduous struggle for man to come out of this mindset.

After the phase of uncertainty and invasions, a stable form of governance emerged from the time of Charlemagne (742 AD to 814 AD). It was a system of dual rule of the king and the Church. The king governed the political and economic affairs and the Church governed the religious, cultural, and moral affairs, both helping each other. The king actively propagated Christianity, and the Church projected the king as the messenger of God, assigned the task of ruling. As the Church increased its hold over the minds of the population, it also increased its physical property. At the height of the middle age, the Church owned about one third the cultivable land of Europe.

In the medieval times, especially in the 12th century onwards, several universities were established in Oxford, Cambridge, Paris, and other places. But their purpose was mainly to train clergymen and officials for various roles in the Church and state hierarchy. The universities slowly became the centres for the study and propagation of the Christian belief system. The role of the professors was limited to studying the Bible and the writings of Aristotle at great lengths, and to provide interpretation of the world on that basis. This trend came to be known as 'scholasticism'.

Since the method of checking beliefs through observation and experimentation had not developed at that time, there was nothing to limit the subjective flights of fancy. Moreover the free practice of speculative philosophy of the Greek times gave way to one system of "official belief." Anything outside this system of belief amounted to questioning God in some way or other. Perpetuation of the belief system required mechanisms of punishing the heretics. Thus a system of "inquisition" developed—a system of investigating and punishing those whose beliefs did not exactly fall in line with the official beliefs.

In such a cultural atmosphere, science died a silent death. For about a millennium and a half, no new discovery was made. Most of the developments of the Greek period fell into disuse, and were forgotten. It was a period of complete dominance of idealism and subjective thought, mixed with mysticism, obscurantism, and religious bigotry.

The veil over the dark age was to be lifted in the 15th and 16th centuries through a sweeping cultural transition that we call the renaissance. The social and economic conditions that created it, and the outcome of the great upheaval will be the subject matter of the next instalment of this essay. □

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Organizational news

All India Convention on "APPROACH TO THE POWER QUESTION IN THE COUNTRY"

The People's Committee for Safe Energy (PECOSE) and Breakthrough Science Society (BSS) jointly held the All India Convention on "Approach to the Power Question in the Country" at Chennai on Saturday, 6th April, 2013. The objective of the convention was to facilitate a free and open discussion on the issue of the existing power shortages in the country and to explore possible solutions. The viability of the nuclear option was also discussed, especially in the light of sustained people's movement against the Koodankulam nuclear plant in Tamilnadu and people's opposition to setting up nuclear plants in Jaitapur in Maharastra, Kovada in Andhra Pradesh, Mithi Virdhi in Gujrat, and Haripur in West Bengal.

The convention was inaugurated through the opening address by Prof. Dhrubajyoti Mukherjee, Retd Professor of Geology, University of Calcutta. Welcoming the distinguished speakers and delegates he suggested to evolve a guideline in framing our future energy policy based on comparative assessment of resource position, hazards and cost.

Dr. A Gopalakrishnan, Former Chairman, Atomic Energy Regulatory Board said that the Indian Nuclear Power Program is being guided along a reckless track and Bhabha's plan of indigenization of this sector has been thrown to the winds. He said that corporate interests dictate the nuclear policy framing in India.

On the Koodankulam reactor, he expressed serious doubts about its safety on the ground that in recent weeks there were a few critical failures of plant equipment during 'hot testing' in the run up to its commissioning, and several disturbing revelations have come in from abroad regarding the quality of Russian nuclear supplies. These started with the arrest of Sergei Shutov, a director of Zio-Podolsk, a subsidiary of Russian public sector company Rosatom, on charges of corruption, fraud and supplying of cheap Ukrainian steel blanks and steam generators in VVER nuclear reactors, two of which are being set up at Kudankulam. In this context Dr.Gopalakrishnan strongly demanded an immediate investigation into the safety of KKNPP, especially since it was Zio-Podolsk that seems to have supplied the poor-quality components for these reactors.

Shri. Shankar Sharma, Power Policy Analyst, made a detailed presentation on the application of Cost-Benefit Analysis as a decision making tool in the Indian Power Sector. He emphasised the need for such an approach in order to arrive at an optimal set of solutions from the perspective of overall welfare of our communities. He demonstrated how one hydel power project of 400 MW capacity in Western Ghats, one Mega Power Project (4,000 MW) based on coal of NTPC and the proposed nuclear power park at Jaitapura, Maharastra (9,600 MW) have more costs to the society than the net benefits. At the same time he also provided many benign alternatives for each of these proposed projects at much lower

The speakers of the Convention seated on the dias: (from Left) Sri S. Gandhi, Shri. M G Devasahayam, Dr. A Gopalakrishnan, Prof. D. Mukherjee, Sri S. Sharma, and Dr. S. Banerjee.

overall costs. He stressed that an integrated power policy essentially involves highest possible efficiency in the existing electricity infrastructure, optimal demand side management and energy conservation, and widespread use of distributed renewable energy sources.

Shri. S. Gandhi, President, Power Engineers Society of Tamilnadu (PESOT), talked on the subject "Electricity crisis—Present scenario". He showed how the Indian power sector has plunged into a crissi following the deregulation in this sector.

Shri. M G Devasahayam, IAS (Retd), Former Chairman, Haryana State Electricity Board explained the necessity for a 'prudential management paradigm' in approaching the power question in India. The present power crisis is mainly due to the policy changes made in 1995-96 and subsequently in 2003. As a result massive privatization began in every sector including the Coal sector and that led to the collapse of power sector. Augmentation by generation of power was given the stress rather than optimization such as local grid distribution (for efficiency), transmission loss minimization and demand-side management. Structural changes creating independent organizations with 'unbundled functions' — Generation, Transmission and Distribution — replacing integrated power management by State electricity boards led to chaos in the power sector.

Messages from dignitaries Justice V R Krishna Iyer, E A S Sharma (Former Union Power Secretory), Major Gen.(Retd) SG Vombatkere, Justice Suresh Hosbet and Prof. Sujay Basu were read out.

In the afternoon session, Dr Soumitro Banerjee stressed the fact that India is rich in natural resources like coal, water, gas, wind and solar energy, and there is no justification in relying on imported uranium using imported technology. He felt that, in view of the inherent problems of nuclear energy, the country should now shelve the nuclear program, and should instead invest on developing the renewable energies.

This was followed by a Question-Answer session. After that, representatives from the peoples' movements at the nuclear plant sites presented accounts of their experiences. Shri Manubhai Joshi and Shri Maldev Singh Jadeja from Jaspara village of Bhavnagar district of Gujrat narrated the struggle agaist the nuclear Plant at MithiVirdi. Shri JaniBasha, representing the people resisting the nuclear plant being planned at Kovada in Andhra Pradesh, spoke about their experiences. A message from the people who had successfully fought against the nuclear plant project in Haripur, West Bengal was read out.

In the conclusion, a resolution was placed in and adopted by the house. Prof

Dhruba Mukherjee closed the days discussions with a call to make this the first in a series of discussions around the country to create awareness among the general public of the approach to be adopted to the issue of power generation in the country, keeping the interests of the people and the environment always in mind, and the need for pressurizing governments not to impose such policies on the people that would endanger their safety, lives and livelihoods.

RESOLUTION

This Convention is of the firm opinion that we should rely more on renewable and sustainable resources including sun and wind, evolve an integrated power policy based on cost-benefit analysis and energy efficiency measures which would resolve the power problems to a very large extent. This should be combined with decentralized and distributed generation for renewable energy.

The government should give way to greater allocation of funds for development of appropriate technologies for generation of power from these sources instead of spending disproportionately on setting up nuclear plants as it is doing today.

Having critically examined the different options for power generation, this Convention feels that the dangers associated with nuclear energy poses a far greater risk and that satisfactory solutions to the hazards associated with nuclear power generation have not yet been found. Therefore, it resolves that going for nuclear power generation is not suitable for the country today in view of the various hazards associated with the entire nuclear fuel cycle.

This Convention firmly opines that any policy decision concerning the lives and livelihoods of the people must be evolved through direct consultations with the concerned people and should not be arbitrarily imposed.

Uttar Pradesh

On 9th of February, there was talk given by Mr. Manabendra Nath Bera on 'Life cycle of stars' at TD College, Jaunpur, UP.

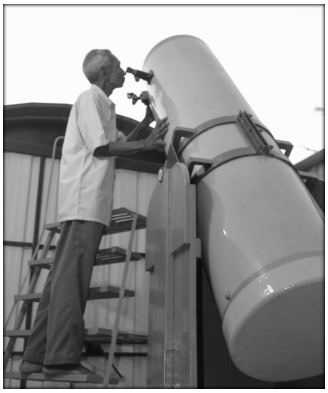
On 1st April, BSS organized a discussion on 'Jatibad evang sampradayikta (casteism and communalism)' in Allahabad Medical College, Allahabad. The discussion was conducted by Kamlesh Singh and Manabendra Nath Bera.

On 17th of April, An institute-level seminar on 'God-particle' was organized at Allahabad Agricultural University (SHIATS), Allahabad by BSS. The speaker was Manabendra Nath Bera.

Bihar

Patna: Under the aegis of the Galileo Science Club a candle march was organized on 31 December 2012 to protest against the gang rape of a girl student in Delhi. More than 200 people participated. The Raman Science Club of Patna organized a condolence meeting on 31 December 2012 in the campus of B. R. A. Dental College, Ramjaypal Nagar, Patna, to pay tribute to the victim of gang rape. In both programmes, the speakers demanded from both the Central and State governments to stop production and publication of vulgar films, songs and literature, and to stop promoting liquor shops in the name of earning exchequer. They also demanded stringent punishment for the culprits.

Jamalpur: On the occasion of birth anniversary of great scientist and humanist Albert Einstein, the Einstein Science club of Jamalpur organised a lecture at National Institute of Jamalpur on 10th March. The topic of the lecture was "Life and struggle of Albert Einstein". Mr Suryakar Jitendra was the main speaker and Mr Ramakant Shukla, local teacher, presided over the meeting.



The 16 inch telescope (left) and the observatory at Netaji Socio-Cultural Center, Muttom, Haripad in Alappuzha District, Kerala, being inaugurated by Mr. Arul Jerald Prakash (right).

Darbhanga: There was a discussion on Ramanujan on 11 January by Dr Radha Kanta Konar, Assistant General Secretary of West Bengal State Committee of BSS.

Kerala

Ernakulam District

March 9: The Ernakulam district chapter of Breakthrough Science Society organized a discussion on "How safe is nuclear energy", at 'CHILD', Thrippunithura. Shri. P.P. Sajeevkumar introduced the subject. Shri. C. Jayaraman, General manager of Kochin refinery presided the function. Francis Kalathungal, P.C. Thankachan, Dr. Ravi, Sunilkumar, Rajagopal P.P. Abraham and Ajith spoke.

Thiruvananthapum District

April 2 : Inauguration of Summer Camp organised by Kerala State Science and Technology Museum. Sri.Arul Jarald Prakash, S&T Museum Director, presided over. Dr. R.V.G. Menon inaugurated the Summer Camp. The summer camp featured talks by BSS activists on "Introducing a scientist".

April 18: Classes on Meghnad Saha and Galileo taken by P.S. Gopakumar and Benny Joseph respectively at Kerala State Central Library.

Alappuzha District: Giordano Bruno Observatory inaugurated

April 17: The Giordano Bruno Observatory with 16 inch telescope started functioning at Netaji Socio-Cultural Center, Muttom, Haripad in Alappuzha District. This is one of the biggest telescopes in Kerala. Director of the Kerala Science and Technology Museum Arul Jerald Prakash inaugurated the Observatory. The inaugural function was presided over by the Director of the Netaji Center Dr. V Vengopal. Prof. C S Menon, Prof. Moncy V John (St. Thamas College Kozhenchery), Prof Gopalakrishna Panicker, Prof K R Somanath (DB College Parumala), Prof Thomas Kuruvila(Principal, Bishop Moore College Mavelikkara), K Thankappan, K Sivankutty, G S Padmakumar and Prof P.N.Thankachan, spoke on the occasion.

The 16 inch telescope was constructed by amateur astronomer Mr. K Thankappan with his own labour and has been contributed to the Netaji Socio-Cultural Center at Harippad. With the telescope and astronomy exhibits, the centre has been attracting sky watchers and students in big numbers.

Andhra Pradesh

Hyderabad:
March 14: The BSS Hyderabad Chapter conducted a seminar cum photo exhibition on Einstien's life history at the University College of Science, Osmania University. Mr. K. Bharat, advisor of BSS, and Ch. Srinivas, HoD of Physics, talked about Einstein's life and explained the special thoery, general theory in simple terms.
28 February: The Hyderabad district chapter also observed the National Science Day at Stanley College of Engg. & Tech. for Women. Mr. Jani Basha, Associate Professor of the Gitam University, and Dr. V. Anuradha, Pro incipal of the College spoke on the occasion.

Delhi

18 April: The Delhi Chapter of Breakthrough Science Society organized a discussion on the life and struggle of Albert Einstein on the occasion of death anniversary of the great scientist, at the Arts Faculty lawn, North Campus, University of Delhi. Students from various colleges and institutions participated enthusiastically. It was conducted by Ravi Kumar, organzer of BSS, and the main speaker was Chanchal Ghosh, member, Breakthrough Science Society.

Tamil Nadu

A BSS team from Anna University consisting of Karthik G, Vivek Narayan, Prasanth, Sriram and Kiran conducted a Science Demonstration program on 23-1-2013 at Bal Vidya Mandir HSS, Adayar, Chennai.

An exhibition on Einstein's life and work was conducted at Vellaichamy Nadar Polytechnic College, Virudhunagar on 21st and 22nd January, 2013. A documentary in Tamil on Madam Curie was also shown.

A sky-watching program was conducted on March 7, 2013 to view Jupiter and its moons at the SOS Children's Village, Tambaram, Chennai. Mr. Sudhakar and Dr. Venkatesan conducted the program. Mr. Jayabalan, Asst. Director of SOS village and Mr. Manivannan of SOS assisted in organizing the program.

Exhibitions on the life and work of Albert Einstein and Madam Curie were put up at the Science Expo Mayaa-2013, Feb 25-26, 2013, organised by the Dept. of Chemistry, A.M.Jain College, Chennai.

Dr. Uma Ramachandran gave a talk on the 'Challenges of drug discovery' at the Intercollegiate National Seminar on "Emerging trends in the Fundamentals of Chemical Research" organized by the Department of Chemistry, A.M. Jain College, on March 8, 2013.

Exhibition on the life and work of Albert Einstein was put up at the Waves-2013, March 11-13, 2013, organised by the Society of Electrical and Electronics Engineers, Anna University, Chennai.

Madhya Pradesh

On 10th March, there was a Science Workshop organized at the office of BSS Gwalior chapter. 10 basic experiments were performed to demonstrate how laws of nature are discovered starting from some observation, formation of hypothesis to explain it, and then by checking the hypothesis by performing experiments. About 30 students attended the workshop.

A discussion by BSS activist Vinay on 'Basic and Fundamental Phenomena in Science', was organized in the Gwalior Engineering College on 18th march 2013. It was accompanied by the demonstration of experiments using the common household materials. The whole staff of GEC including the Principal and more than 200 students were present.

View of the audience in the programme in Gwalior.

The whole week from 12th Feb to 18th Feb was observed as Science Week, in which our activists went to various schools and explained the basic phenomena of science through experiments made from the household items. The following schools in Gwalior were covered:

12 Feb: Govt. Higher Secondary School Pagnawisi, Sikandarkampoo

14 Feb: Patel Govt. Secondary School Hazira

15 Feb: Sahyogi School, Jati ki line, Hazira

16 Feb: C.B.S. Public Convent School, Hazira

18 Feb: Patel Govt. Higher Secondary School Hazira.

Karnataka

Bangalore

30-3-2013: Lecture on 'Nuclear Energy – an appraisal' by Mr. G. Sathish Kumar, State Convenor, BSS, at the Raman Research Institute. Around 100 science enthusiasts participated.

15-3-2013: Lecture on life and scientific contributions of Albert Einstein at MES College, Bangalore. Around 150 BSc students participated. Ms. Rajani. K.S, Bangalore District President delivered the talk.

09-3-2013: Study class on 'Economic and Political roots of Newton's Principia' by Boris Hessen, conducted by Mr. G. Sathish Kumar, State Convenor of BSS at Raman Research Institute.

Gulbarga

Gulbarga district unit of BSS organised a one day 'Science experiments' workshop on 17th Feb 2013 at V G Women's college.

A discussion on the topic 'Role of science activists in society' was conducted by Mr. G Satish Kumar, State Convenor of BSS. Ms. Rajani. K.S, State Unit Member of BSS conducted a demonstrative hands-on experiment session.

Following the workshop the participants gave 'Science experiments' shows at 6 places, using the same set of models built in the workshop.

18th Feb. – Govt.. Urdu school, Gulbarga. Conducted by Omer Sheik and Nikitha (engineering students of PDA, Gulbarga)

19th Feb. – Govt. Technical school, Conducted by Ajay Jadhav (engineering student of KBN college) and Sneha Kattimani (Diploma student of KCT college)

23rd Feb. – Al Sharay school. Conducted by Shreya Hiremath, Vibha Gaddale and Nesar Bilgundi (Students of PDA college)

27th Feb. – MSS school. Conducted by Shakuntala and Pooja (Students of PDA college)

27th Feb. – A school associated with Gulbarga university: Conducted by Ektha and Gouri (M.Sc students from Gulbarga university)

3rd March – Morarji PU college. Conducted by Nagarjun Jadhav (student from PDA college) and Ajay Jadhav.

Mysore

1-3-2013: A miracle busting show was organised at Pooja Bhagavat Memorial Mahajana Postgraduate Centre, Mysore. Ms. Roopa Deshpande, District Convenor, and Ms. Rajani, State Unit member performed the show.

23-11-2012: A lecture on life and scientific contributions of Louis Pasteur was organised at Pooja Bhagavat Memorial Mahajana

Postgraduate Centre, Mysore. The lecture was delivered by Ms. Rajani. K.S.

West Bengal

The following programmes were conducted in West Bengal since January 2013.

6 January: Telescope Training Camp at, Mecheda, East Midnapur district. Conducted by Dr Nilesh Maity, Dr Safique-ul-Alam, Dr Radha Kanta Konar

11-15 January: Science Exhibition conducted at the Dumdam Baidyanath School

19 January: Discussion on Solar System at Bhogpur School, East Midnapore district, by Dr Pulakesh Aich

20 January: Nature Study camp conducted at Shibpur Botanical Garden

23-27 January: Breakthrough Stall organized at the Look Sanskriti Mela Champahati, Sount 24 parganas

25-27 January: Science exhibition at Duttapukur Nibadhoi High School, North 24 Parganas district

26 January: Sky watching at the Panskura Science Forum

26 January: Discussion on Astronomy and Astrology and Sky watching at Contai Science Center, East Midnapur district, by Dr Nilesh Maity

27 January: Arsenic detection test (100 samples) conducted at Duttapukur, North 24 Parganas district by team under Ms. Namita Pal

27 January: Slide show on Astronomy at the Chengail Mela, Howrah

2 February: Anti Superstition Show at the Chengail Mela, Howrah district

10-11 February: Sky watching at Bengal Engineering & Science University, Howrah District

13 February: Vigyan Manasikata Mahakuma Vigyan Utsab at Hariharpara High School, Murshidabad district, conducted by Dinesh Mahanta

16 February: Discussion on Bruno at 'Curiosity', Baidyabati, Hooghly district, by Namita Pal

17 February: Bruno Day observed by Young Scientists' Forum, at College Square, Kolkata

17 February: Discussion on Bruno at Bajkul Science Center, East Midnapur district, by Bisyajit Roy

17 February: Discussion on Bruno at Anneshon, Garia , Kolkata, by Sarifa Khatun

17 February: Discussion on Bruno at Damdam Cantonment by Asish Samanta

18 February: Discussion on Bruno at Bethune School, Kolkata, by Namita Pal

23 February: Discussion on Bruno and sky watching at Mahisadal Science Center, Mahisadal, East Midnapur district, by Dr Nilesh Maity

29 March: Discussion on 'Evolution of Man' at South 24 Parganas Science & Cultural Forum by Kumaresh de

7 April: Science Competition (quiz, model, anti-superstition) and sky watching at Jalpaiguri, conducted by Dinesh Mahanta

7 April: District Workshop at Howrah by Dr Nilesh Maity

14-15 April: Science Model Exhibition at Baidyabati Adya Vidyalaya conducted by Dr Tapan Si

15 April: Science Competition and Discussion on "Einstein and Ethics of Science" at Panskura Science Society, Panskura, East Midnapur district, by Dr Nilesh Maity

20 April: Inter-School Competition (Model, Quiz, Anti-Superstition, Drawing) at Galileo Science Forum, Nimta, Kolkata

21 April: Sky watching at Giorodano Bruno Science Society, Rashbihari, Kolkata, conducted by Asish Samanta.