ENERGY CONUNDRUM On the one hand, carbon dioxide emissions are sought to be cut while on the other, fossil fuels like are likely to dominate steadily increasing power production. GETTY IMAGES

Upper limits of power production

GLOBAL ENERGY To maintain the 450 ppm level by 2050, not more than about 200 bn tons of CO2 can be added in 40 years, implying that less than 2TW can be produced by coal, oil, etc. In countries like India and China, coal accounts for over 50 pc of commercial energy consumption, notes **C Sivaram**

Concerns about global warming and climate change have reached a crescendo in recent years. Policy makers and environmentalists look forward to the UN climate change summit scheduled in Copenhagen.

On the one hand, carbon dioxide emissions are sought to be cut while on the other hand, fossil fuels like coal are expected to continue to dominate steadily increasing power production which at present corresponds to a global installed capacity of almost 15 terawatt (TW). Of this barely 0.9 TW (less than one TW) is produced by all the nuclear reactors in the world.

Even with a very modest growth rate, a global power production of at least 30 TW (if not 40 or 50 TW) is anticipated by 2050. If by then, the global carbon dioxide concentration is to be maintained to at least 450 ppm, we can easily estimate that at the most three to four TW can be produced by fossil fuels. Therefore, at least 25 to 30 TW should be produced by alternate (non-fossil) fuel. The present quantity of CO2 present is about two trillion tons.

Towards maintaining 450 ppm

So to maintain 450 ppm by 2050, not more than about 200 billion tons can be added in 40 years, implying that less than 2TW can be produced by coal, oil, etc. At present in countries like India and China, coal accounts for over fifty per cent of commercial energy consumption.

How realistic are the alternatives? Say by 2040, we have to generate ten terawatts of nuclear power. To do this, we have to build at least ten thousand new reactors, or one every alternate day till 2040! Considering that hardly 400 reactors are operating worldwide, (many of them at below their commercial capacity for various reasons) this is tantamount to about a thirty-fold increase with all the attendant problems of nuclear waste and its disposal.

Nuclear power capacity

Also following the recent nuclear accord with the US and lifting of sanctions (against India), very wild projections are being made by Indian experts to accelerate nuclear power capacity to an enormous 400,000 megawatts by 2050, which is a hundred-fold increase from the present. This would necessitate construction of at least a 1,000 nuclear reactors in the next thirty or forty years (that is, two new reactors every month for the next forty years). Considering that in 2009, even the small capacity of 3779 MW was running at half its capacity due to nuclear fuel shortage, this is very tall order indeed.

Moreover, this vast nuclear power planned would have to be sustained almost entirely by imported nuclear fuel. We would need something like toe tons per day of enriched uranium, as the thorium fuel cycle is has yet to be fully developed (our vast reserves of this cannot yet be used). As it is, India imports over seventy per cent of its oil requirements and about half of its domestic natural gas.

What about wind power on a global scale? This is much constrained. Even taking into account every single breeze on land or sea, at the most five terawatts can be usefully tapped. To effectively utilise this 5TW, about two million state of the art turbines have to be build with devices to store energy (when there is no wind!). About 200 turbines everyday have to be built. Tidal power has a maximum world wide potential of at most 2 TW (over the entire ocean surface). This leaves the ubiquitous solar energy, perhaps the cleanest source of all. However sunlight is very diffuse (corresponding to an electric field strength of hardly 10 volts/cm).

A square metre of area exposed to sunlight can at most capture one kilowatt. So to obtain ten terawatts of solar power by 2050, we have to cover an area of hundred billion square metres. This means that we have to cover a few million roofs, every day, with solar panels starting from now. This would need a large work force apart from the costly materials required (like gallium, etc.). There is an upper limit here. Even covering the entire earth's surface would generate at most 1010 megawatts. (So there is an upper limit to growth, if we are not to create severe thermal imbalance in nature).

Tapping sunlight

One needs revolutionary new materials to tap sunlight. Perhaps photosynthesis occurring in nature should be studied, suitable catalysts developed but without production of CO2 unlike in the plant world!

The ultimate message is clear, whatever sources of power production come into play in the next few decades; there are upper limits to both population growth and power production. World human population cannot be much larger than ten to fifteen billion if CO2 levels are to be maintained (with each breath we exhale substantially more CO2 than we inhale), same hold for power production.

If we do not consider for the present exotic space borne power systems, even producing or utilising as much as a third of the total solar energy falling on earth could cause drastic climate changes. These aspects are under study.

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EMPOWERED?

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