Energy savings from advancing the Indian Standard Time by half an hour

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Since mechanical clocks were invented, three separate sequential adjustments have been made to timekeeping – the adoption of mean time, of time zones incorporating standard times, finally that of daylight saving time (DST). India has accepted mean times and a standard time, but has resisted adopting time zones or DST for several reasons. We propose advancing of the Indian Standard Time by half an hour to being six hours ahead of the Universal Coordinated Time. The primary benefit estimated from regional seasonal load curves is a saving in peak load electricity of nearly 16%. This is substantial given the difficulty most regions have in fulfilling the additional evening demand. There would be several other benefits that cannot be quantified easily.

Keywords: Daylight saving time, energy savings, Indian Standard Time, time zone.

IN its report on integrated energy policy, the Planning Commission asserted that the country could save a lot of energy by introducing two time zones and saving daylight[1]. Such proposals have been made in the past, but have not been adopted. In this article we review the rationales for introducing multiple time zones and daylight saving time (DST) and for rejecting both. In the northern hemisphere, DST involves setting clocks ahead by an hour in spring and setting them back by an hour in the fall. In the southern hemisphere, the two adjustments are reversed. We propose an alternative, in effect a year-long DST, which avoids the risks associated with introducing multiple time zones or with bi-annual changes in DST.

Modifications of local times

As long as sundials and shadows told the passage of time, all time was essentially local. Both travel and communications were slow. As clocks became more accurate, Geneva (in 1780) was the first to introduce mean solar time based on the average length of a day in a year. Still, time continued to be local. As east-west travel by rail, and communications by telegraph became more common, the United Kingdom (in 1840) introduced the concept of standard (railroad) time applicable to an entire region. Although the Englishman William Willet first proposed the concept of DST in 1907, it was first adopted by Germany[2] as a wartime energy-saving measure in 1916.

While the initial impetus for adopting DST came from war-time conditions or from energy crises (such as the 1973–75 oil embargo), most countries chose to retain DST in more normal times, mainly because of a preference of a majority for later summer sunsets. People's dislike of sending children to school in the dark during winter mornings prevented the adoption of year-long DST.

India extends from 68°07′ to 97°25′E. Although this spread of more than 29° is wide enough for two time zones, India has chosen a single Indian Standard Time (IST) based on the longitude passing through 82.5°E, almost the exact east-west centre of the country – five and a half hours ahead of the Universal Coordinated Time (UTC). Having two time zones has the advantage of saving daylight, as suggested recently by the Planning Commission[1] and perhaps the advantage of reducing the peak load deficit. The disadvantages are that it would increase the risk of train accidents across the zonal boundary and, some fear that it may increase separatist tendencies. Moreover, there is no obvious sparsely populated section in the middle of the country wherein to draw the boundary between the two zones. All previous analyses have concluded that the savings in energy are not large enough to justify the increased risks that two time zones would entail[3]. Interestingly by comparison, China whose east-west spread is enough to justify five hourly time zones, has chosen to have the time in its eastern part to be the standard time for the entire country.

Although the proposal to have DST avoids some of the risks associated with multiple time zones (such as fissiparous tendencies), the risks associated with bi-annual changes causing train accidents remain. Once again the conclusion has been that the savings for a 1 h bi-annual shift do not justify the risks[3]. We concur with the arguments that having two time zones and/or having biannual time changes pose

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unacceptable risks in our country. However, we make a different proposal that captures the benefits of these proposals without their disadvantages.

The proposal

We propose that we advance, once and for, all IST from being the time at the 82.5°E long. (Mirzapur District, Uttar Pradesh) to 90°E (Bengal–Assam border), i.e. from being 5 h 30 min ahead of UTC to being 6 h ahead of UTC and that we do not cycle the clocks annually. The consequence will be that we would advance the day by half an hour and hence have available an extra half-hour of daylight in the evenings, when it is more useful, for the entire country. The major quantifiable benefit will be the savings in peak load electricity, which we discuss below.

Energy savings

Data on electrical loads in India are divided into five major sectors – domestic, commercial, industrial, agricultural and others. Table 1 gives the forecasts of the relative sectoral loads for 2004–05 made by the Central Electricity Authority in 2000. India is divided into five regional grids. Table 2 shows the peak loads and annual energy consumption in these regions. Electricity consumption is significantly lower in the eastern and northeastern regions compared to other regions reflecting levels of economic activity. An extra half hour of daylight will yield larger savings in electrical energy in regions with larger evening domestic lighting loads.

Natarajan *et al.*[3] calculated energy savings by statistically extrapolating to the whole country from limited sample surveys carried out in South Bombay. They correlated electrical energy consumption for domestic lighting to various income groups and populations in different areas. This consumption at a micro-level is highly stochastic and any attempt to develop a model with multiple random variables and extrapolating the results to the entire country have inherent limitations in reliability.

Our estimates of savings are based on actual regional seasonal load curves that indicate loads every minute or half a minute. A typical load curve has a double-hump shape. The morning peaks, caused mainly by water-heating (in winters, also some amount of space heating), are generally lower than the evening peaks, caused mainly by domestic, commercial and streetlighting loads. Since most states in the country fail to supply peak loads, the load curve does not represent the actual demand, because some of the loads have been ‘shed’ from the system.

Regional load curves smoothen out local perturbations and help identify the effect of daylight on electrical energy consumption. Therefore, we decided to base our study on the regional load curves for a working day in each of the four seasons. Since the load in the northeastern region is less than 2% of the national load, the analysis is based on the other four regions. Figure 1 shows the regional load curves for 1 December 2005. Figure 2 shows the load curve for the northern grid for 1 June 2005 and 1 December 2005 normalized to the load at midnight on 1 December 2005.

Table 1. Forecasts of sectoral electrical demand

Sector	Demand (%)
Industrial	37
Agricultural	27
Domestic	23
Commercial	7
Other	6
Total	100

Source: Central Electricity Authority[7].

Table 2. Regional peak demand

Region	Peak demand (MW)	Peak energy demand (MU/day)
Eastern	9700	212
Northern	25,362	522
Northeastern	1200	25
Southern	23,500	520
Western	26,575	620

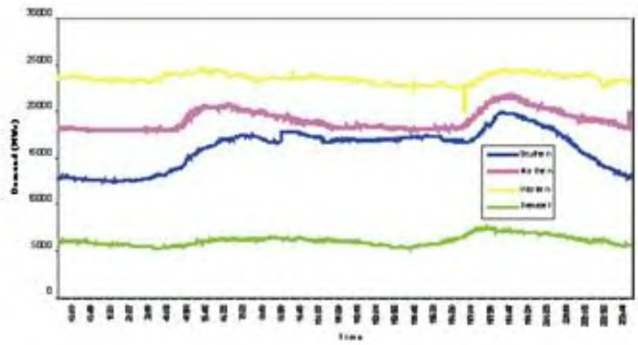

Figure 1. Zonal load curves for 1 December 2005.

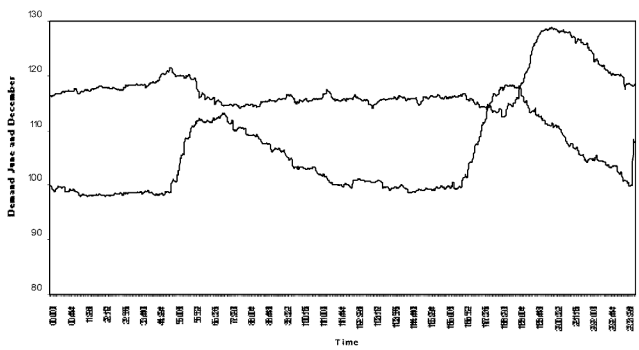

Figure 2. Northern region load curves normalized to December.

Loads during late night hours and during early morning in India are larger than one would normally expect. This is due to a combination of factors – factories working all three shifts, agricultural loads being supplied during nights as well as operating of air-conditioners (note higher base loads during summer in Figure 2), and some commercial loads being connected in the business process outsourcing (BPO) sector.

The morning peaks in June are hardly perceptible in the northern zone since both domestic water heating and lighting are negligible. Morning peaks in December are larger, primarily due to water and space heating and also due to a certain amount of lighting because of the late sunrise during winter. Since many stores and offices keep lights on throughout the day, the steep rise in the load after sunset appears primarily due to domestic lights, streetlights and some commercial lights. Figure 2 shows that the increase in load that follows sunset (2 h earlier in December than in June) is nearly the same during June (~3000 MW) and December (~3200 MW). This may be attributed to lighting load since air-conditioners and fans are seldom used during winter months in the north, and the space heating loads shift from offices to homes. The actual rise may be much higher, because at the same time load cuts are also applied; the 3000–3200 MW values are the net results.

These assumptions make it fairly straightforward to calculate (or estimate graphically) the electrical energy savings following the advancement of IST. Figure 3 *a* is a typical zonal load curve (for the northern zone). We assume that all loads except the domestic lighting load remain unaffected by the shift in IST and therefore may be shifted

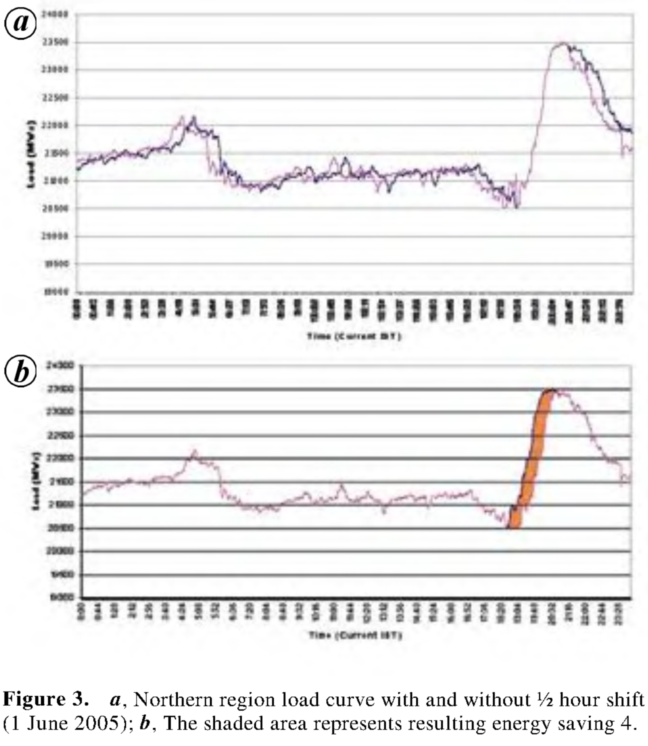

Figure 3. ***a***, Northern region load curve with and without ½ hour shift (1 June 2005); ***b***, The shaded area represents resulting energy saving 4.

to the left (earlier) by half an hour without any change, except the section of the graph that follows the sunset. This section remains in the same position independent of how the clocks are set. This leads to the graph shown in Figure 3 *b*. Since the area under the load curve gives the energy consumed, the easiest way of computing the change in area, i.e. a change in energy is to shift the graph forward by half an hour. All sections in Figure 3 *b*, except the one following the sun coincide (because other loads have not been changed with time advancement). The energy saving is estimated from the shaded area. These savings can be computed and are summarized in Table 3. In the western region, the reason for low value for change in load during peak is that due to high demand and shortage, the load curve has been flattened.

We readily acknowledge that some lights may have to be switched on in the mornings, especially in the northern and western parts of the country for a few weeks in winter following the time advancement. This increase could be considerably reduced by having separate timings for schools during winter, thereby also reducing the inconvenience of sending children to school in the dark.

The morning peak energy consumption caused mainly by water and space heating during winter will not change by advancing IST. Streetlights that will now be switched on half an hour later in the evening following the proposed advancement in IST, will also be switched off half an hour later in the mornings. Since their usage is coupled to luminosity, there will not be any net savings in electric energy from streetlights. Since evening energy is costlier to obtain, there will still be a net benefit from switching on streetlights later.

Although as shown in Figure 3 *b*, about one-sixth of the evening peak energy is saved by advancing the IST by half an hour, saving in the evening peak load is not immediately evident and no attempt is made to estimate this reduction.

Estimates of electrical energy saved on four typical working days during four seasons are presented in Table 3. The total saving[1] extrapolated for the year (but still excluding the northeast) comes to approximately 1.82 TWh, out of a total nation-wide consumption of 592 TWh during 2003–04. The percentage savings are about 0.3% for a half-hour advancement, which might not seem large[4]. The percentage savings in the evening peak energy, however, are about 16%, which is substantial. It is recognized that evening energy demand is the most difficult to meet. Rural load-shedding is common, but since outages cause considerable public ire in the cities, electricity is purchased at high costs (~Rs 6/kWh), often generated using gas turbines and diesel generators. Average tariff charged is usually less than the average cost of generating evening energy. The money value of the saving is likely to be in the range of Rs 1000 crores per annum and will alleviate partially the current problem of meeting the evening energy demand.

Table 3. Estimates of million kWh saved per day in different zones

	1 June 2005	1 September 2005	1 December 2005	1 March 2006
Eastern	1.01	1.19	1.05	0.87
Northern	1.49	1.03	1.69	1.55
Southern	1.49	1.44	1.53	1.68
Western	(0.98)*	(0.98)*	0.82	1.14
Total	4.97	4.64	5.09	5.24

*Load curves show repeated interruptions and therefore are estimated to be the average of savings on 1 December 2005 and 1 March 2006.

Table 4. Earliest and latest times for sunrise and sunset in four Indian capitals in 2005 (the figures in brackets represent the same after the proposed shifts)

State capitals	Earliest sunrise	Latest sunrise	Earliest sunset	Latest sunset
Imphal	0424 (0454)	0601 (0631)	1625 (1655)	1808 (1838)
Bangalore	0552 (0622)	0646 (0716)	1750 (1820)	1850 (1920)
New Delhi	0522 (0552)	0715 (0745)	1724 (1754)	1923 (1953)
Ahmedabad	0553 (0623)	0722 (0752)	1753 (1823)	1929 (1959)

As a comparison[1], the total energy obtained from all renewable sources is about 3 TWh and from nuclear sources 17 TWh. We get savings within an order of magnitude from advancing IST with none of the capital expenses associated with nuclear energy. Advancing IST will continue to save expensive evening energy, increasing year after year with increasing domestic consumption. The only investments that will be required are for planning for the first year of implementation and for subsequent monitoring and evaluation.

Other benefits

There are several other classes of benefits from advancing IST, each of them possibly modest and difficult to quantify, but collectively quite significant. We believe that this shift will: (i) help mainstream the northeast; (ii) make the country in conformity with most regions of the world; (iii) reduce traffic fatalities and injuries; (iv) reduce street crime; (v) result in stoppage of fewer sporting events due to poor lighting conditions; (vi) increase outdoor activities and shopping, and (vii) increase professional productivity. We discuss the first three of these in some detail.

Mainstreaming the Northeast

Currently, the Northeast gets bright before 4 am in June in eastern India. Civil twilight is 25 min before sunrise, which occurs at 0424 in June in Imphal, for example. Similarly, the earliest sunsets in Imphal occur at 1625 (Table 4) in November and December. Advancing IST by half an hour would make available to the Northeast almost an hour more of usable daylight (half hour in the morning and half hour in the evenings). Because office timings would be more in line with the rest of the country, this shift would help mainstream the Northeast.

Table 5. Advancing IST by half hour would place India ahead of UTC by integral hours, conforming with 95% of the regions of the world (expressed as percentage of the total of 311)

Region	Differing from UTC by integral hours	Differing from UTC by non-integral hours	Total
With DST	109 (35%)	05 (2%)	114 (37%)
Without DST	187 (60%)	10 (3%)	197 (63%)
Total	296 (95%)	15 (5%)	311 (100%)

Conformity with most regions of the world

A majority of countries, generally those that are closer to the equator, do not observe DST. Only about 70 countries observe DST[4], but 114 regions (because some countries have multiple time zones) do so. As shown in Table 4, 63% of the regions, mostly in the tropics, is without annual DST cycles. However, only 5% of the regions has non-integral time shifts from UTC – shifts of one-, two-, or three-quarters of an hour. Advancing IST by half an hour will bring us in conformity with the choices made by 95% of the regions in the world.

Reduction in traffic accidents

According to WHO, in 1998, India had the distinction of having the highest traffic fatalities (~217,000) and the highest number of injuries (~7.2 million) in the world, more than entire continents. Accident rates in India are ten times those in the developed countries on the basis of the number of vehicles (and twice on the basis of population). There is little information in India on accident rates by time of day. Data merely record whether the accident occurred in daylight or in darkness[5]. A study from Pondicherry[6] reported that the highest number of road traffic accidents took place in January and the peak time for accidents was from 4 to 5 pm and a second peak was from 6 and 7 pm. Even if fatality rates could be brought down by one-third of 1%, it would result in the savings of hundred of lives every year and prevent injuries to thousands. Reduction of 0.7–1% in fatal motor vehicle accidents has been recorded in other countries observing DST. These are net declines after the increase in accidents in the mornings have been subtracted.

Discussion

The other benefits stated earlier from an increase in daylight are even more difficult to quantify. Indian statistics on crime by time of day is difficult to find; anecdotal evidence indicates purse and chain snatchings from women increase during dusk. As more people will be able to get home before dark, *ceteris paribus*, we should expect a reduction in street crime. Sometimes cricket matches are stopped early because of poor lighting conditions. Advancing DST will not prevent this, but would make it less likely. Modest increases in outdoor activities; shopping and professional productivity can all be reasonably expected.

We have identified two possible objections to our proposal. The first concerns later winter sunrises. As shown in Table 4, the latest sunrises in New Delhi and Ahmedabad under current IST (in mid-January) occur at 7:15 and 7:22 am respectively. With the proposed shift, this would happen at 7:45 and 7:52 am. The civil twilight, however, would occur 26 min earlier at 7:19 and 7:26 am. This would inconvenience those who have to send children to school in the fog and the dark. However, many schools even now have separate timings for winter and these timings could be further adjusted by half an hour. This is one reason why an hour's shift, as considered by Natarajan *et al.*[3], would face more opposition.

A second possible objection might come from the IT and BPO industries that link their operations to business timings in the US. When it would be 8 am in Silicon Valley, it will be 21:00 or 22:00 in India, instead of 20:30 and 21:30 now. The duality arises from the observance of DST in the US. By the same token, there will be more overlap with eastern countries like China and Japan.

As against these possible disadvantages, which we believe can either be circumvented or traded-off with other advantages, is the almost certain saving of peak energy in the evening. Several electric utilities are hard-pressed to meet evening loads and have to resort to costly and polluting energy production using diesel and/or natural gas, adding to the emission of greenhouse gases. The savings of about 16% will be greater in later years as domestic loads tend to increase with GDP growth[3]. Other benefits are more difficult to quantify, but there are expectations that accidents and street crimes will decrease following the advancing of IST.

Weighing the potential benefits from this proposal against the possible demerits, the proposal needs to be examined by the Government of India and various stakeholders such as educational institutions, transport authorities, broadcasting corporations, and the IT industry, need to be consulted. If this proposal of advancing IST is found acceptable, we believe that 1–2 years would suffice to plan for a smooth transition.

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Received 5 February 2007; revised accepted 27 June 2007