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The Energy and Resources Institute

Don't tinker with the clock to save energy

CONTENTS

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Introduction

On 23 March 2011, all clocks in the UK were turned forward by an hour marking the start of Daylight Saving Time (DST). The clocks will be turned back on 30 October 2011. The objective is to save energy by reducing the use of artificial light and maximizing the use of daylight over a period of seven months.

While this has been the practice for many years in countries situated in the upper part of the northern hemisphere and the lower part of the southern hemisphere, DST is hardly practised in countries situated closer to the equator.

Several studies have also been conducted in India, over the last three decades, to evaluate various time-based measures for energy conservation. These include introduction of Daylight Saving Time (DST), and shifting Indian Standard Time (IST)—currently GMT + 5½ hours. In 1988, TERI undertook a detailed study for the Government of India's Advisory Board on Energy to explore these options. The results revealed only nominal savings potential, both in terms of energy and reduction in peak load. However, it was also pointed out that the potential impacts of deploying these options need to be evaluated periodically, because as demand grows, prices change and consumption patterns vary. Therefore, TERI recently undertook a fresh study to re-examine the various issues in greater detail and came to similar conclusions, which are explained in this policy brief. However, knowledge of basic geography as regards the rotation of the earth around the sun and the impact it has on the seasons and on the varying lengths of days and nights is important for a proper understanding of the subject.

Change of seasons and daylight hours

Figure 1 shows a diagrammatic representation of the earth as it moves around the sun once a year (apart from rotating on its own axis once in 24 hours). A key factor in this cycle is that the north-

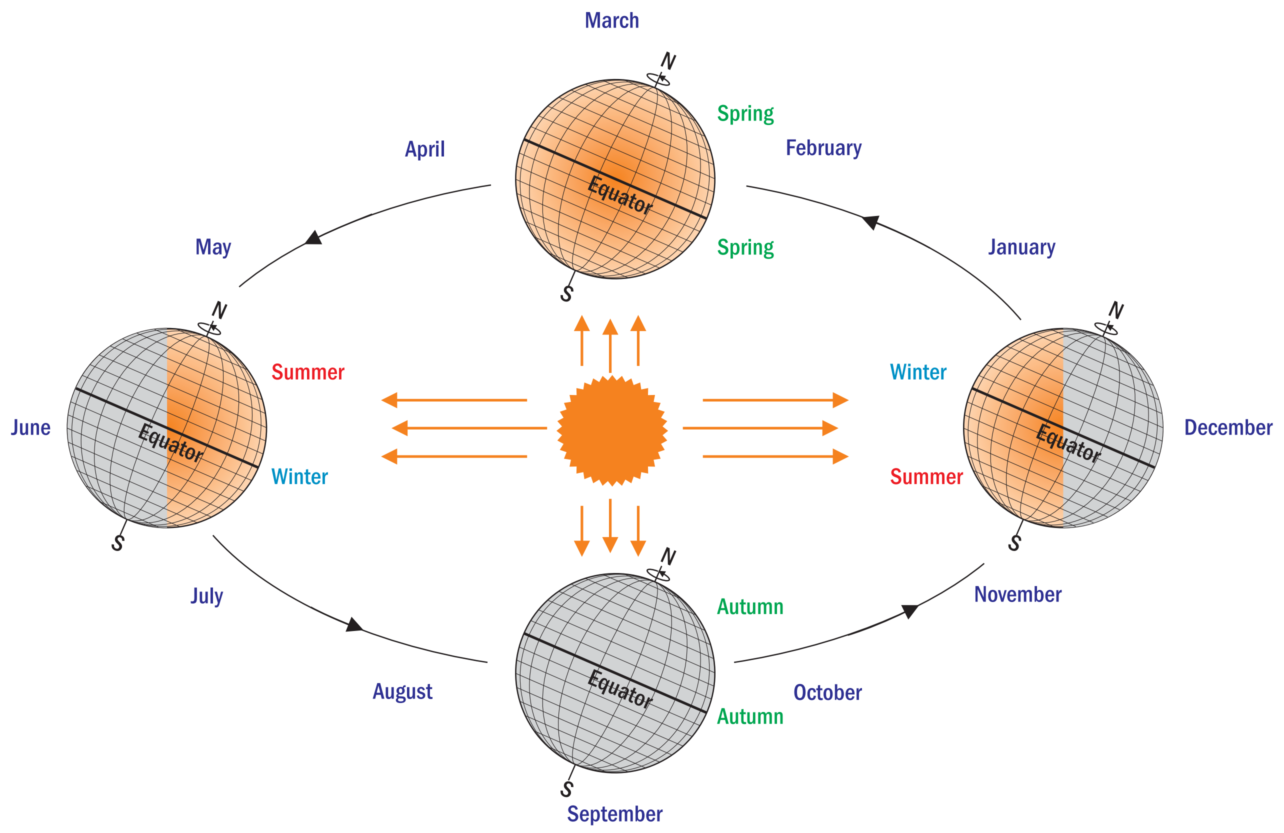

Figure 1 Change of seasons and daylight hours

south axis of the earth is not vertical, but tilted at an angle of 23.5°. It is this tilt, which gives rise to seasons and also to varying lengths of days and nights.

In December, the axis is tilted away from the sun. The rays shine on a greater part of the southern hemisphere giving rise to a summer season with longer days, compared to the northern hemisphere, which has a corresponding winter season and shorter days. As the earth moves in its orbit, around 21 March the sun's rays impact all parts of the earth equally and every place on earth has a 12-hour day and a 12-hour night. Continuing in its orbit, in June the axis of the earth is tilted towards the sun causing summer (and longer days) in the northern hemisphere and vice-versa in the southern hemisphere. Around 22 September the situation is similar as in March and all places on earth have 12 hours of daylight and 12 hours of night.

Figure 2 represents an enlarged view of the earth on 21 June, showing the number of daylight hours in four selected cities, of which London and New Delhi are in the northern hemisphere; Singapore, almost on the Equator; and Cape Town in the southern hemisphere. The maximum amount of daylight is in London followed by New Delhi, Singapore, and Cape Town. In December, the situation is reversed. Due to its location, Singapore has approximately 12 hours of daylight throughout the year.

The variation in daylight hours during the year will be least in countries on or close to the equator and will gradually increase according to the distance (latitude) of countries from the equator. The day on which the sun shines longest on the northern hemisphere (around 21 June) is known as the summer solstice and least (around 22 December) as the winter solstice. When the days and nights are of equal length, that is, around 21 March and 22 September, they are known as the spring and autumn equinox, respectively.

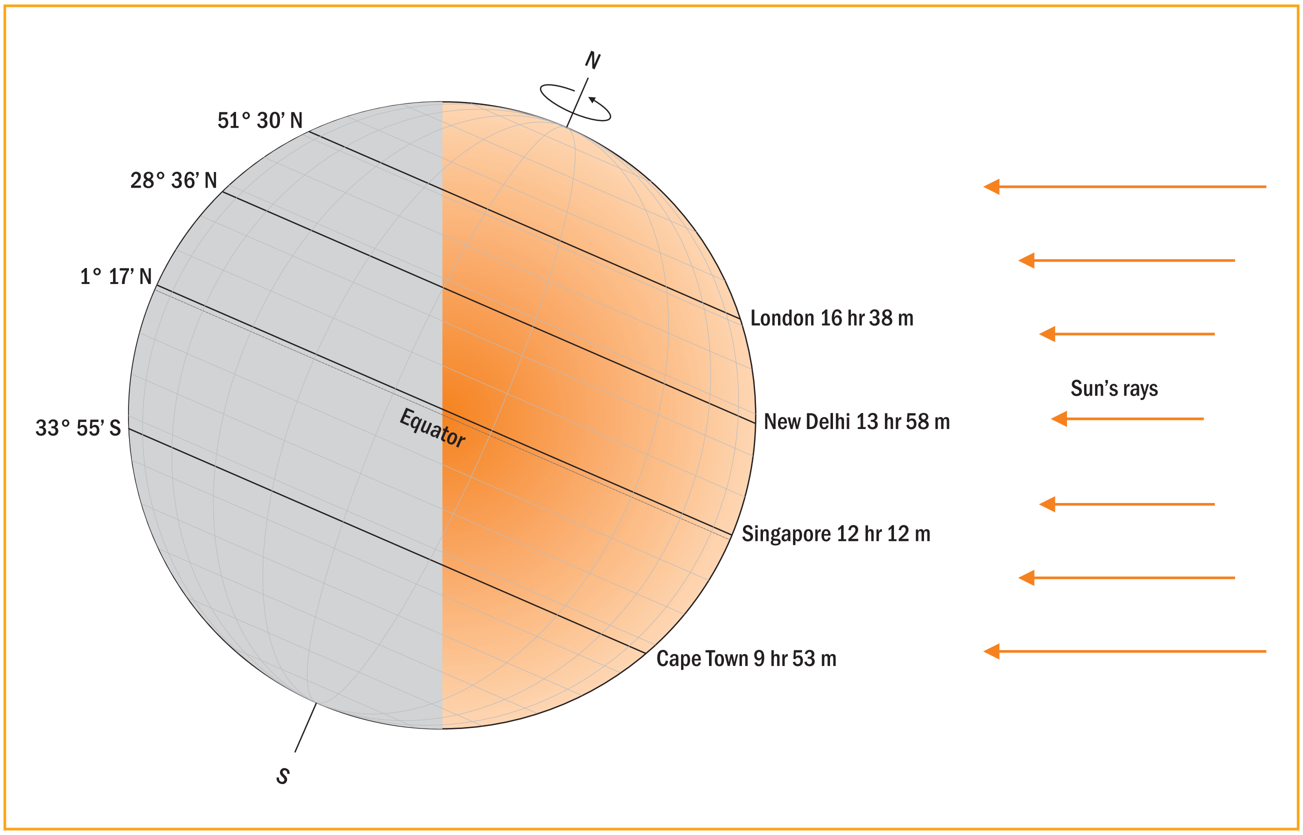

Figure 2 Summer solstice—daylight hours in four cities

Variations in daylight hours and time of sunrise across India

The longitude of a place normally dictates the time of sunrise. Places in the east will have an early sunrise and those of which are located in the west will witness a late sunrise according to the clock. However, this is not always the case as it also depends on the time of the year. For example, Figure 3(a) shows sunrise during the winter solstice at Nagpur. The sun has already risen in Shillong, Kolkata, and Varanasi. It has also risen in Bengaluru, which is almost on the same longitude as Delhi where the sun is yet to rise. Figure 3(b) shows the position of sunrise at Nagpur during the summer solstice, and herein, the sun in Delhi has risen earlier than that in Bengaluru. It is only during the spring and autumn equinox that Delhi and Bengaluru have sunrise at the same time—Figure 3(c). As regards the duration of the day, the higher the latitude, the longer the day in summer and shorter the day in winter. For example, on the day of the summer

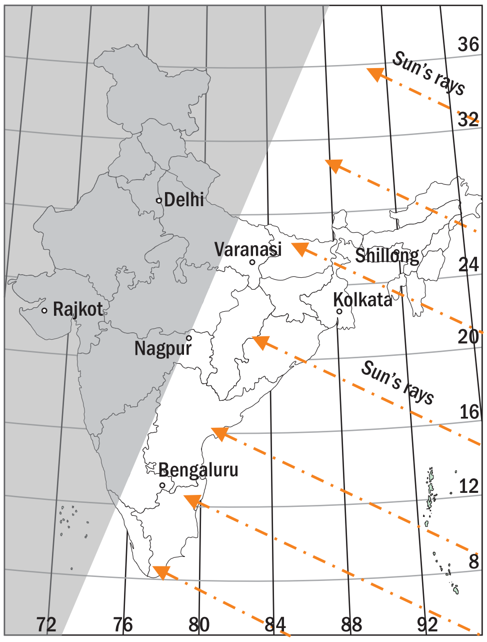

Figure 3(a) Winter solstice—variations in daylight hours/sunrise

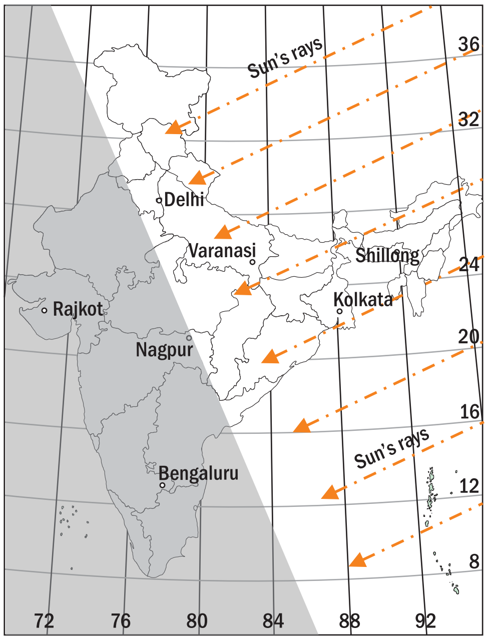

Figure 3 (b) Summer solstice—variations in daylight hours/sunrise

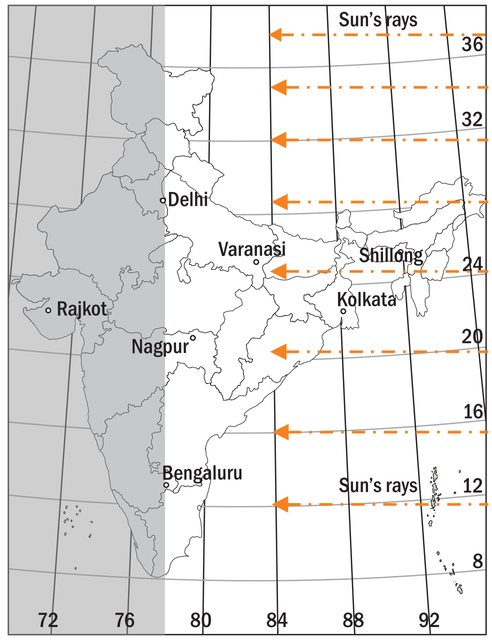

Figure 3 (c) Spring/autumnal equinox—variations in daylight hours/sunrise

solstice the locations with the longest day are Delhi, followed by Shillong, Varanasi, Kolkata, Rajkot, Nagpur, and Bengaluru. The sequence also holds true for the shortest day, which is the winter solstice on 22 December.

How DST works

The Figure 4 is a very basic illustration of the application of DST in India where the Indian Standard Time (IST) is 5½ hours ahead of GMT. On the first horizontal line, it is assumed that at

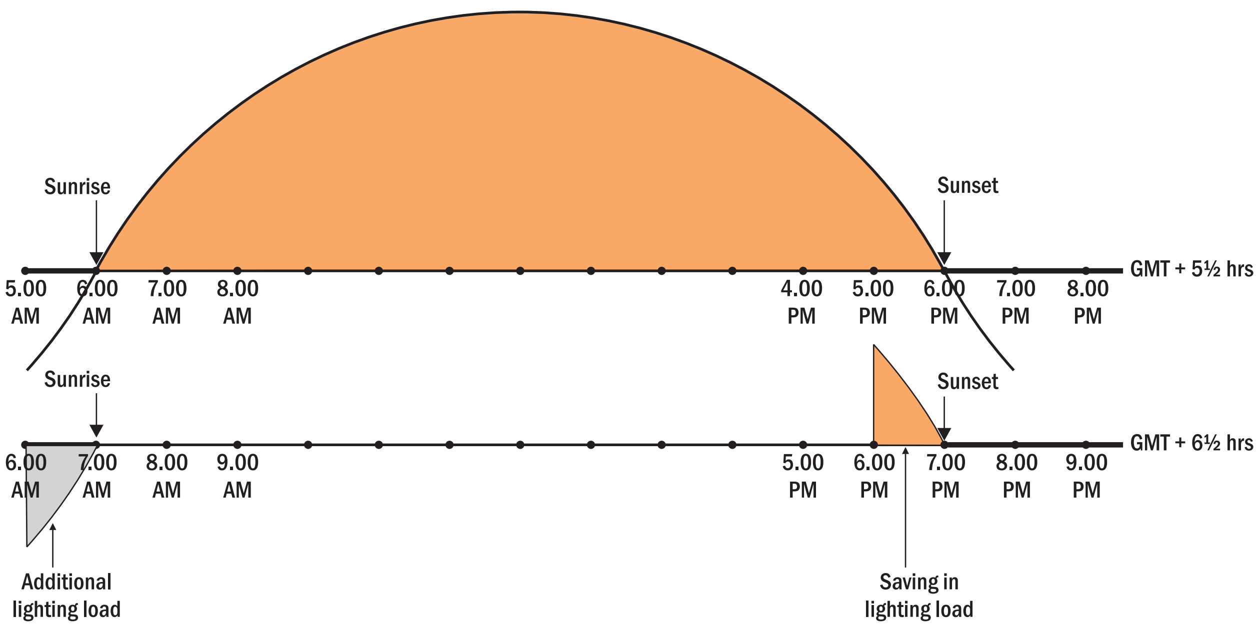

Figure 4 Setting the clock ahead by one hour

a particular location in India sunrise, on a specific day, is at 6 a.m. and sunset is at 6 p.m. A family has to wake up at 6 a.m. so that the child can get ready and reach school by 8 a.m. In the evening, the husband finishes work and reaches home at 6 p.m., that is, sunset. The second line shows an identical situation except that DST has been introduced and clocks have been brought forward by 1 hour (GMT+6½ hrs). Now for the child to reach school by 8 a.m., lights have to be put on between 6 a.m. and 7 a.m., which means an increase in domestic electricity consumption. However, in the evening, the husband reaches home at 6 p.m. and household and other activity can continue till 7 p.m. before lights are switched on. Therefore, there should be a saving in electricity in the evening. If both situations can be balanced, then obviously there is no loss or gain of energy. However, intuitively more people are active and busy towards sunset than at sunrise. Therefore, there should be a greater net saving overall in the electricity consumption.

In practice, there could be a wide variation in the above situation due to sunrise and sunset times varying from place to place in India (as illustrated earlier), and habits of the people in various regions. It is primarily for this reason that the study undertaken in TERI captures the variations in domestic electricity consumption at sunrise and sunset for India as a whole.

The TERI study

The following three scenarios were examined for the study:

- *Scenario 1*: Advancing IST by half an hour across the whole of India and for the full 12 months of the year.
- *Scenario 2*: Introducing DST by advancing IST by half an hour during summer months from April to September (similar to what is done in Europe).
- *Scenario 3*: Creating two time zones comprising:
  - the northern, western, and southern electricity grids with IST set at GMT+5 hrs and
  - the eastern and north-eastern grids set at GMT+6 hrs. These are illustrated in Figure 5, which also gives the population profile over every 2.5° difference in longitude.

A detailed market survey was carried out in the seven cities including the surrounding districts, as shown in Figure 5, and taken to represent the five grid areas/country as a whole. A total of 6,600 questionnaires were distributed to determine urban domestic, rural domestic, and commercial lighting demand, which is sun dependent. Industrial demand and other demands were not included as these are predominantly not sun dependent. The timing and use of electricity for each room in each house/commercial building/

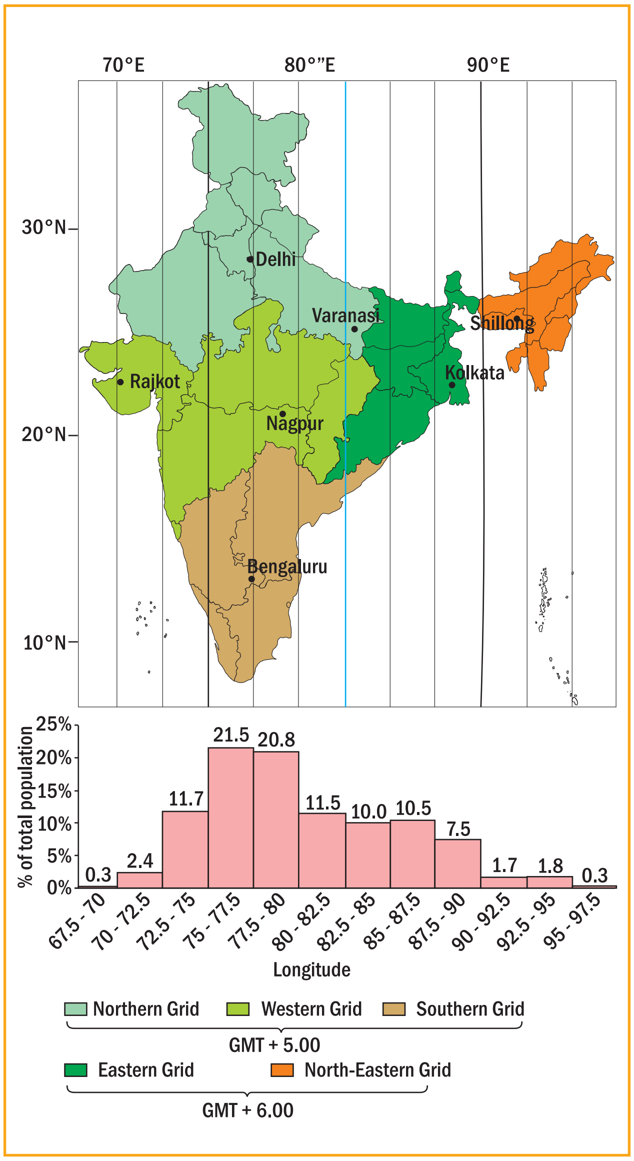

Figure 5 Scenario 3 – Two time zones

shop, impact on shifting the clock by half an hour, waking up time, sleeping time, attending school, office, and so on were recorded. For each of the three scenarios, the lighting consumption and load factors were calculated based on the data obtained through the questionnaires.

The findings under the three scenarios are given in Table 1.

In Scenario 1, the quantum of energy saved during evenings is higher than the energy required in the mornings, resulting in a net energy gain. However, as a percentage of total availability of electricity, the savings are very low. In Scenario 2, the situation is very similar. In Scenario 3, since there is a backward shift in the time of the northern, western, and southern grid areas, there will be half an hour of extra sunlight during the morning, and half an hour of extra darkness in the evening, resulting in a net increase in energy consumption.

An analysis was also carried out on the impact of the three scenarios on the overall load curves for each region. This showed that while there was a small increase in the morning peak, the evening peak (which is also the day's peak in most cases) generally takes the form of a plateau occurring well after the sunset. Therefore, shifting the clock by half an hour would not affect the capacity requirement to cater to the peak demand.

International perspective: time zones and DST

a) Time zones

As the earth completes one revolution (360° longitude) in 24 hours, internationally there are 24 standard time zones of 15° longitude. Each country sets its own local time, which is expressed in the number of hours in advance of GMT.

In countries where the territory covers many degrees of longitude, it is not feasible to set a single time zone. Russia, for example has nine time zones ranging from GMT+3 hours to GMT+12 hours. Continental USA has four time zones. Although China covers five standard time zones (GMT+5 hrs to GMT+9 hrs), it standardized on only one time zone (GMT+8 hrs) in 1949.

The whole of India covers two standard time zones (2 hours). But, India has just one time zone, which is GMT+5½ hours and corresponds to the longitude of the 82.5° E passing very close to Allahabad. We can notice from Figure 5 that over 40% of the population is located between 75° E and 80° E representing just 20 minutes of time difference, and 86% of the population is located between 72.5° E and 87.5° E representing one hour. This heavy concentration of the population in middle India is another factor against any change in the current status.

Table 1 Savings/losses

	Total availability of electricity (BU)	Net saving (BU)	Net loss (BU)	%age of total electricity availability	Value of saving/ loss in Rs crores
Scenario 1—IST+ ½ hour	746.50	1.02 – 1.10		0.14 – 0.15	306 – 330
Scenario 2—DST, that is, IST + ½ hour April to September	746.50	0.69 – 0.84		0.09 – 0.11	207 – 252
Scenario 3—Two timezones—GMT+5 hrs and GMT + 6 hrs	746.50		0.54 – 0.64	0.07 – 0.09	162 – 192

Note: a) BU = Billion Units = 10^9 Kilowatt hours
b) Value of savings/losses calculated at Rs 3 per kWh

b) DST

Those countries that are close to the equator, where the variation/difference in the length of days during the year is not significant, do not benefit from introducing DST (in terms of energy savings). The impact of introducing DST in India is observed to be insignificant in the TERI study. The further away from the equator, the greater the number of countries, which have introduced DST.

The USA, Canada, and Europe and the southern part of South America, Africa, and Australia have DST. A number of other countries have experimented with DST, but abolished it at some point of time. India once implemented DST, briefly during World War II. Some of the countries in the region (Pakistan, Bangladesh, among others) in recent years have discontinued the use of DST. Interestingly, Russia, which had DST, abolished it as recently as February 2011.

According to Wikipedia, "The practice of DST has been both praised and criticized. Adding daylight to afternoons benefit retailing, sports, and other activities that exploit sunlight after working hours, but causes problems for farming, evening entertainment, and other occupations tied to the sun. Its effect on health and crime is, however, less clear. Although an early goal of DST was to reduce evening usage of incandescent lighting, formerly a primary use of electricity, modern heating and cooling usage patterns differ greatly, and research about how DST currently affects energy use is limited or contradictory. The DST clock shifts present many other challenges. They complicate timekeeping, and can disrupt meetings, travel, billing, recordkeeping, medical devices, heavy equipment, and sleep patterns. Software can often adjust computer clocks automatically, but this can be limited and error-prone, particularly when DST protocols are changed." (http://en.wikipedia.org/wiki/Daylight_saving_time)

Conclusions and recommendations

Given the findings, TERI does not find any value in investing in any of the identified options—DST, IST or in demarcating the country in two time zones. *Prima facie* it appears that given the small saving potential in Scenario 1 and 2, financial and social costs (some of those listed in the previous section may apply) will offset or even negate the savings.

It is also observed in the TERI study that the majority of the households in urban areas align their daily activities with their office or school timings; therefore, a change in these will have the same impact as changing the clock twice a year and would be far more simpler to implement. In addition, various studies have shown promising results in terms of energy savings and load management by influencing consumption pattern through appropriate price signals (Time of Day metering). The government needs to focus its efforts on these simple measures that would yield greater benefits rather than any tinkering with the clock.

This is part of a series of policy briefs by TERI based on its research work in specific areas. These briefs are made available to members of parliament, policy-makers, regulators, sectoral experts, civil society, and the media. The briefs are also accessible at http://www.teriin.org/policybrief/. The purpose is to focus on key issues and list our policy recommendations to encourage wider discussion and debate. We would very much value your comments and suggestions.

Previous policy briefs

Title	Date
1. Strengthening agricultural biotechnology regulation in India	September 2010
2. Critical non-fuel minerals security: why India urgently needs to have a policy in place	December 2010
3. India's coal reserves are vastly overstated: is anyone listening?	March 2011

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