ELSEVIER

Energy Policy 36 (2008) 1858–1866

ENERGY POLICY

www.elsevier.com/locate/enpol

Effect of daylight saving time on lighting energy use: A literature review

Myriam B.C. Aries, Guy R. Newsham*

Institute for Research in Construction, National Research Council, 1200 Montreal Road, Building M24, Ottawa, Canada K1A 0R6

Received 9 March 2007; accepted 29 May 2007
Available online 19 March 2008

Abstract

The principal reason for introducing (and extending) daylight saving time (DST) was, and still is, projected energy savings, particularly for electric lighting. This paper presents a literature review concerning the effects of DST on energy use. Simple estimates suggest a reduction in national electricity use of around 0.5%, as a result of residential lighting reduction. Several studies have demonstrated effects of this size based on more complex simulations or on measured data. However, there are just as many studies that suggest no effect, and some studies suggest overall energy penalties, particularly if gasoline consumption is accounted for. There is general consensus that DST does contribute to an evening reduction in peak demand for electricity, though this may be offset by an increase in the morning. Nevertheless, the basic patterns of energy use, and the energy efficiency of buildings and equipment have changed since many of these studies were conducted. Therefore, we recommend that future energy policy decisions regarding changes to DST be preceded by high-quality research based on detailed analysis of prevailing energy use, and behaviours and systems that affect energy use. This would be timely, given the extension to DST underway in North America in 2007.

Keywords: Daylight saving time (summer time); Energy use; Lighting

1. Introduction

Lighting has a profound effect on the lives of humans. It facilitates vision, which is our most important source of information on the world, and it affects our basic biological functioning through its effect on our 'body clocks' (Webb, 2006); access to daylight and sunlight affects the form of our buildings and our cities, and provision of electric lighting is one of the world's biggest end uses of electricity. For industrialized countries, national electricity use for lighting ranges from 5% to 15% of total electrical energy use (Mills and Orlando, 2002). Because this energy is often supplied by fossil-fuel generation, provision of lighting results in the large-scale release of greenhouse gases (GHGs): 1775 Mt of carbon-dioxide emissions, according to a 2002 estimate (Mills and Orlando, 2002). Further, lighting is a major contributor to the peak demand for electrical power, which is often met by expensive, high-GHG generators.

Because of its high-energy burden, lighting has often been the target of energy efficiency initiatives. One such initiative is daylight saving time (DST). The principal reason for the introduction of DST was to shift human activity patterns to make better use of daylight, and thus reduce the amount of electric lighting necessary to support these activities. There are several other effects of DST, including changes to traffic fatalities, and commercial activities.

Abbreviations: BST, British Standard Time (equivalent to YRDST); DST, daylight saving time; DDST, double daylight saving time (LST + 2 h in summer); SDST, single/double summer time (LST + 1 h in summer); ST, standard time; YRDST, year-round daylight saving time; ACHE, Association contre l'Heure d'Eté double; ADAS, Agriculture Development Advisory Service; ADEME, Agence De l'Environnement et de la Maîtrise de l'Énergie; CEC, California Energy Commission; CFLs, compact fluorescent lamps; CSEM, Center for the Study of Energy Markets; DOT, Department of Transportation; EIA, Energy Information Administration; GHGs, greenhouse gases; HMG, Heschong Mahone Group; HMSO, Her Majesty's Stationery Office; IFPI, Indiana Fiscal Policy Institute; NBS, National Bureau of Standards; NRCan, Natural Resources Canada; OECD, Organization for Economic Co-operation and Development; RvB, Research voor Beleid International; RoSPA, Royal Society for the Prevention of Accidents; Sapa, South African Press Association.

*Corresponding author. Tel.: +1 613 998 6805; fax: +1 613 954 3733.
E-mail address: guy.newsham@nrc-cnrc.gc.ca (G.R. Newsham).

0301-4215/$ - see front matter
doi:10.1016/j.enpol.2007.05.021

Beginning in 2007, DST—or summer time in Europe[1]—was extended by 1 month in the US and Canada (with some exceptions). DST started on the second Sunday in March and will end on the first Sunday in November. The new begin and end dates are set in the 2005 US Energy Policy Act (Energy Policy Act, 2005). To investigate the influence of the extension, the Act included the commitment that "not later than nine months after the effective date of the 2007 DST, the Secretary will report to the US Congress on the impact of the extension on energy use in the US". Depending on the results, the Congress retains the right to revert DST back to the 2005 time schedules. Canada followed the US in extending DST; this decision may have been more about avoiding chaos in financial and commercial areas due to lack of clock synchronization, than about expectations of energy savings (Beauregard-Tellier, 2005). In Europe, agreements are signed until 2007 (Fontaine and Ringholm, 2001). The European Commission will submit a report in 2007 with suitable proposals for continuation or change (Fontaine and Ringholm, 2001; De Bruijn and Van Poppel, 2005; EurLex, 2000).

North America and Europe are not the only areas in the world to observe DST. For example, on the African continent, Egypt, Tunisia, and Namibia have DST. Israel, Palestine, and Jordan observe DST, and both Australia and New Zealand introduced DST to save energy. Mexico has observed DST since 1996, and Cuba, Honduras, and Guatemala introduced DST in 2006.

The purpose of this paper is to review the literature concerning the effects of DST on energy use, particularly with regard to lighting, and to derive implications for energy policy. First, a short overview of the historical background of DST is given. Second, we give some simplified estimates of effect size, with a focus on residential lighting. Third, research conducted between 1968 and 2007 is discussed (mainly in chronological order). This research was conducted to better estimate likely effects, or to demonstrate effects from measured energy use data. We also briefly describe some of the research into the non-energy effects of DST. Finally, a general discussion with regard to the available knowledge, better effect estimates, and design possibilities is presented.

2. Historical background

In 1784, Benjamin Franklin, the American Minister to France, wrote a letter to the editors of the *Journal of Paris* about "the waste of both candlelight and daylight". Franklin was not proposing DST, but rather suggested that people get up and go to bed earlier, thus saving money on the purchase of candles (Franklin, 1784).

In 1907, the Briton William Willett published a pamphlet entitled "The Waste of Daylight". In this document he proposed advancing clocks by 80 min in the summer. On successive Sundays in April, the clocks should be advanced by 20 min at 2 a.m., and be retarded by the same amount on Sundays in September. He suggested that this would increase daylight recreation time, and save £2.5million on energy for lighting. A parliament committee examined the idea in 1909, but the idea was not adopted (Willett, 1907; Churchill, 1934).

During World War I, Germany began observing DST (1916), and as the war continued the rest of Europe adopted DST. The US followed 2 years later, in 1918. After the war, all countries went back to standard time (ST) until the outbreak of World War II. In that war, year-round DST (abbreviated as YRDST) was instituted, and after the war many countries adopted summer DST. This lasted until 1973 when the American Congress enacted a trial period (1974–1975) of YRDST to save fuel during the oil embargo. After the trial, the US returned to DST. Since then, DST in the US has started on the first Sunday in April (or the last Sunday in March), and ended on the last Sunday in October (Gurevitz, 2005). As stated in Section 1, DST in most of the US and Canada will be extended in 2007.

3. Simple estimate of potential lighting energy savings

The potential of DST to save energy rests primarily on projected effects on residential lighting use. The assumption is that with more daylight in the evening, residents will delay switching on electric lighting in their home. Advancing the clocks 1 h implies that lights will be switched on an hour later in the evening. Assuming the bedtime of residents does not change, this suggests that the "on time" of lighting with DST will be 1 h less than without DST. Combining this basic assumption with knowledge of overall lighting energy use allows a simple estimate of the savings that may accrue with the adoption of DST.

Electricity use in residences comprised around 36% of total electricity use in the US in 2005 (Energy Information Administration (EIA), 2005). Lighting makes up around 9% of all electricity use in US residences (EIA, 2001). Therefore, residential lighting is responsible for 3.5% of all electricity use in the US; the data for Canada are very similar (Natural Resources Canada (NRCan), 2006). Metering and survey studies show that lights are switched on for an average of 2–3 h per day in houses (Vine and Fielding, 2006), and that most of this use occurs in the evening (Enertech, 2002). Therefore, if DST reduces this use by 1 h for approximately half the year, total annual electricity use would be reduced by approximately 0.7%. Of course, not all lighting is used at night, and DST may increase the use of lighting during darker mornings, so a final rough estimate of the total annual electricity reduction may be closer to 0.5%.

This might seem like a very small number, especially to those used to studying energy savings associated with specific technologies at the single building level. Nevertheless, at the national scale, it is a saving worthy of

[1]This paper will use the term 'DST' for both of these time changes from this onwards.