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Changing Time: Possible Effects on Peak Electricity Generation[1]

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Abstract: This article considers the possible effects on electricity costs of implementing The Brighter Evenings Bill, 2012, which would move Ireland to Central European Time (CET). The results suggest that such a change would produce very limited savings in peak demand for electricity and possibly some increase in off peak electricity costs. Moving time zone in the other direction would result in some limited savings on both counts. The effects of changing time zone on the cost of electricity would be likely to be small so that other considerations are likely to be more important in any such decision.

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Changing Time: Possible Effects on Peak Electricity Generation

1. Introduction

There was a proposal in the Dáil to change the Irish time zone: the Brighter Evenings Bill 2012 was a private members bill, introduced in July 2013 by Tommy Broughan TD, which proposed moving Ireland to Central European time for a three year trial period. If adopted the experiment would see time in Ireland being GMT+1 in winter and GMT+2 in summer.

The object of this paper is to consider how such a change in time zone for Ireland might impact on electricity generation requirements in the longer term. In an interconnected electricity system, if such a change in time zone in Ireland resulted in peak demand in Ireland being less correlated with that in Great Britain, it would reduce the peak generation needs of the integrated system. Such a change could, potentially, result in long-term savings in the required generating capacity needed to meet the set security standard.

In Ireland and Great Britain the peaks in daily electricity demand either coincide or occur close together. This is usually between 6pm and 8pm in the winter. If the peaks in both countries were to be displaced from each other, the maximum amount of electricity a fully integrated system would have to generate at any one point in time might be reduced, with a consequent saving in required generation capacity needed to cover peak load. This paper initially concentrates on the potential savings in peak generation capacity. However, there could also be savings over the rest of the day through more efficient utilisation of lower cost generation capacity; this is also estimated in this paper.

Section 2 of this paper briefly discusses the history of time zones, especially, the history of time zones in Ireland. The literature on the effects of changes in time zones on energy demand is considered in Section 3. The methodology used is set out in Section 4 and the data are described in Section 5. The results are set out in Section 6 and Section 7 concludes.

2. Changing Time Zones

In the past changes in Time Zone, including Daylight Savings Time (DST),were introduced to save energy. Great Britain and Ireland observed local mean time up until 1880. Local mean time was determined by solar time or sundials in various regions across both countries. In 1880, Dublin Mean Time was established as the legal time for Ireland following The Statutes (Definition of Time) Act, 1880.

There was a difference of 28 minutes and 21 seconds between Dublin Mean Time and Greenwich Mean Time (GMT), which had been adopted as the legal time for Britain. This difference proved inconvenient for telegraph communication following the 1916 Easter Rising; the Time (Ireland) Act, 1916 altered this and set Irish time to be the same as British time. Irish and British time have been similar since then.

Daylight Savings Time (DST) is defined by turning the clocks forward by one hour in spring and turning them back an hour in autumn. It was introduced as an energy saving policy. Benjamin Franklin (1784) is credited with the original idea of DST as he noticed that people were sleeping during morning when it was bright and lighting candles in the evenings while it was dark. It was William Willet (1907) who first proposed the simple adjustment of time by an hour during the summer months to avoid “The Waste of Daylight”.

During World War I Germany was the first country to adopt DST, with the aim of reducing electricity consumption; this was anticipated to free up coal for use in the war-time economy. Many countries, including the US, followed suit. However, following the war this practice was discarded. Similar actions were taken during World War II and also repealed in its aftermath.

Both Ireland and Britain adopted Daylight Savings Time on a one off basis in 1923 and 1924. It was soon accepted permanently following the Summer Time Act, 1925.

In 1968, Daylight Savings Time was put in place all year round. It was an experiment in anticipation of Ireland’s membership to the EEC in 1973, as it put Ireland (and the UK) in the same time zone as the then six EEC countries. The experiment was ended in 1971 with the Standard Time (Amendment) Act, 1971; at the time it was suggested that road fatalities among children walking to school had increased due to poor visibility in the early hours of the day.

The dates for switching between summer time and winter time have been synchronized across the European Union since the 1980’s. Possible changes to the Irish practice have been discussed over the years; they were discussed by the Oireachtas Joint Committee on Justice, Defence and Equality in November 2011, and again in November 2012 when Tommy Broughan TD introduced the Private Member’s Bill to permit a three year trial of advancing time in Ireland by one hour.

3. Literature Review

In 1973 the Emergency Daylight Savings Energy Conservation Act was introduced in the United States. It was a response to the oil crisis that had erupted that year; this Act imposed year round DST for fifteen months. The US Department of Transportation were required to do a report in 1975 on the energy savings achieved during the fifteen month period. The report found that there was an average 1% load reduction during the spring and fall transition periods. However The National Bureau of Standards (Filliben, 1976) conducted a review on the report and concluded that results were questionable and statistically insignificant.

The California Energy Commission (CEC) presented a simulation-based study on the introduction of DST on a year round basis. This study estimated the reduction of electricity consumption within the state of California with regard to variables such as employment, temperature, and sunlight. It was found that electricity consumption would be left almost unchanged from May to September, however a reduction of between 0.15% and 0.3% would be experienced from October to April.

The model, used in CEC (2001), was applied to the actual extension of DST in 2007 (CEC, 2007). In some special cases over the years, DST has begun earlier in the spring or continued on later in the autumn; this is known as extended DST. The results predicted a 0.56% reduction in electricity consumption, however the 95% confidence interval included 0; it ranged from a decrease of 2.2% to an increase of 1.1%.

The US Department of Energy (2008) published a report on the actual extension of DST in the US in 2007, as was required by the Energy Policy Act of 2005. This report concluded that there were electricity savings of 0.5% for each day of extended DST. It was found that extended DST caused an increase in electricity consumption in the mornings, but this was outweighed by the decrease in electricity consumption in the evenings.

Three states in Australia observe DST; South Australia, New South Wales and Victoria. In 2000, DST in New South Wales and Victoria was extended by two months, to accommodate the Sydney Olympic Games. Kellogg and Wolff (2008) carried out analysis, contrasting South Australia, which remained unchanged, and Victoria, which observed extended DST. The findings challenged previous research on energy savings due to DST. Similar to US Department of Energy (2008), it was found that electricity consumption increased in the morning and decreased in the evenings, however, the overall combined results were not significantly different from 0. In some cases it resulted in a net increase in demand. Kellogg and Wolff (2008) also went on to test the CEC (2001) simulation model; it was found that the model underestimated the demand increase in the mornings and overestimated the demand decrease in the evenings.

Rock (1997) conducted research on energy savings due to DST in 224 different locations within the US. The model measured the energy consumption for a typical residence with regard to parameters such as construction type, residential appliances, heating and cooling systems, lighting requirements, and number of occupants. The model indicated that DST increased electricity consumption by 0.244% when averaged over all locations.

Indiana's 2006 change to DST policy provided a natural experiment for identifying the effect of DST on residential electricity demand. Kotchen and Grant (2008) carried out research on the change in electricity demand during this period. The findings concluded that DST resulted approximately in a 1% overall increase in residential electricity demand; the results were statistically significant. It was found that although demand for lighting was decreased, it was outweighed by the increase in demand for heating and cooling.

A more recent study was conducted by Krarti and Hajiah (2011) on Kuwait. Similarly to Kotchen and Grant (2008), the study shifted the emphasis from savings due to decreased necessity for lighting to costs due to increased necessity for heating and cooling. However, it was found that the adoption of DST resulted in a 0.07% decrease in annual electricity energy demand and a reduction of 0.14% in electrical peak demand.

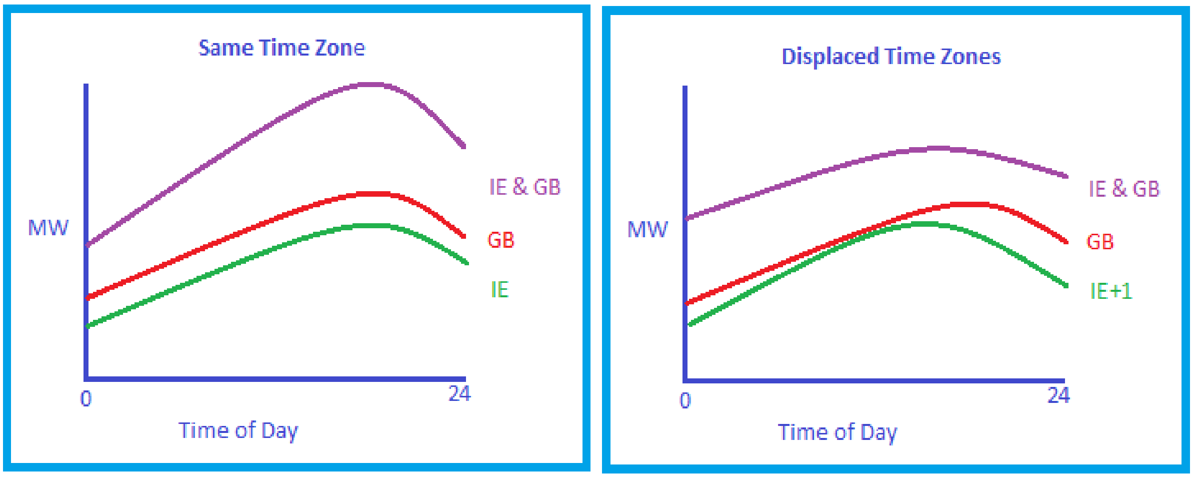
In summary, these studies found, at most, small savings from changing time zone. Many of them considered behavioural changes in response to the change in time zone. The results also showed that the effects are likely to differ across locations and economies. An important issue in some places, which is not likely to be relevant in Ireland, is how time changes may affect demand for air-conditioning.

4. Methodology

The approach adopted in this paper is to first consider the peak daily demand for the two electricity systems, GB and Ireland, treated separately. This establishes for each day the generating capacity needed on each island to meet demand where there is no interconnection. Even if the peak demands are not coincident time-wise, each system must have this minimum level of generating capacity to ensure no shortages. However, in an integrated system the generating capacity needed each day would be the peak of the combined demands of the two systems. To the extent that the peak demands of the two systems are not synchronised there would be potential savings in generating capacity from an integrated system. This concept can be observed in Figure 1.

Thus an estimate of the potential savings in generating capacity from an integrated system is derived by taking the difference between the total for the peak daily demand on the two systems treated separately and comparing this to the peak of the combined demand of the two systems. Then the effects of a time change are estimated by shifting the time zone forwards and backwards by one hour to reflect the effects of a change in time zone. In each case the same measure of savings in generation capacity required on a combined system is calculated. This measure does not take account of any possible behavioural change.

Figure 1. Demand is Smoother in an Integrated Electricity System when Ireland changes time zone



In addition to the saving in the capital cost of generating capacity needed to cover peak electricity demand, there could also be potential savings in energy costs over the course of the day. These energy savings could arise if the effects of a change in time zone in an integrated Irish-British market allowed lower cost generation to replace higher cost generation over a significant part of the day. In this analysis it is assumed that Britain and Ireland are part of a fully integrated electricity network.

To undertake this analysis the hourly electricity demand for Ireland and Britain in 2011 is aggregated to get the total demand of a British Isles system. The Irish data is then displaced by an hour and aggregated with the British demand again. The difference between the two totals is the amount of electricity saved (or increased) in each time period as a result of a change in time zone. A monetary figure can be put on this saving/ loss using the Irish System Marginal Price values for 2011; this gives us the price of a MW of electricity for each hour over the whole of 2011. These savings or cost increases can then be summed over the year to arrive at the annual savings (or costs) arising from the use of generating capacity with different energy cost characteristics.

If demand is shifted to an hour when electricity is more expensive to generate, then costs to the system will increase, whereas a shift in demand to a period when generation costs are lower would result in savings. An example of the method used can be observed in Table 1. In this case there are savings in energy costs for the periods 16.00 to 18.00, with a small increase for the 19.00 period. These savings arise because the plant used to cover higher loads in the evening peak tends to have much higher energy costs than is the case of base-load plant.[2]

Table 1. Illustration of Methodology for All Day Analysis

Time	Current Demand (MW)	Demand with time change (MW)	Difference (MW)	SMP (€/MW)	Savings from Time Change (€)
16:00	42572	42583	11	53.37	587.07
17:00	43149	43536	387	65.505	25350.44
18:00	46502	46892	390	207.255	80829.45
19:00	48743	48588	-155	77.34	-11987.7

Four different scenarios were taken into consideration using this methodology. One dimension considered in the scenarios is where the Irish time zone is moved to either continental European time or where it is moved in the other direction to UTC+1. The other set of alternatives considered are the case where Northern Ireland continues to follow the same time zone as in Great Britain or where it moves time zone with the Republic. These two dimensions give rise to four different scenarios to be considered.

The electricity system is assumed to operate as a fully integrated British Isles market. The current limited interconnection between Great Britain and Ireland would reduce the possible benefits of any change. However, in the longer term, it is likely that there will be increased interconnection which could make such an approach relevant.

This exercise does not take possible behavioural change into consideration. To the extent that people change their routine in the face of a change in time zone this approach may overestimate the effects of a time change. A separate exercise to deal with this issue would involve modelling how behaviour would change as a result of a time change and how that behaviour would impact on electricity demand.

While suffering from the limitations described above, this approach still provides a guide to whether significant savings might be possible in the long run from changing time zones for Ireland.

[2] These higher costs may be because the plant used is less efficient at converting energy into electricity than the plant used when demand is low or it may also be because it uses more expensive fuel than used in base-load plant used in valley periods e.g. gas rather than coal.

5. Data

Data on hourly electricity demand in Ireland and Great Britain for 2011 and 2012 are used in this study.[3]

Here we consider some examples of the pattern of daily demand on the two systems. In the Graphs, as we are particularly interested in the changes in the pattern of demand over the day, we scale the demand in Ireland by multiplying it by ten[4] and show the demand for Ireland and Great Britain on the same graph. This illustrates the extent to which peak demand is synchronised.

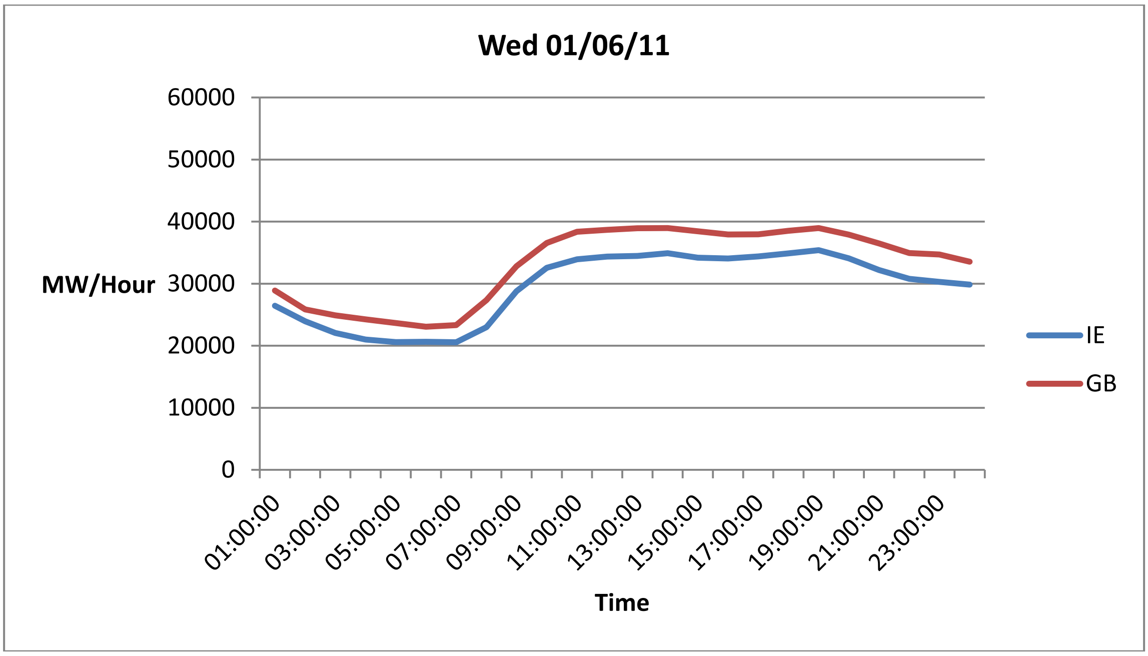
As can be seen from these examples (Figures 2 and 3), the pattern of daily demand in Ireland and Great Britain is quite similar. During the DST months, April to September, both systems observe quite a constant path of electricity consumption during working hours. Taking a weekday from June, a typical DST daily electricity trend can be seen in Figure 2. The two systems experience a trough in electricity consumption between the hours of midnight and 8am, with the day's minimum usually occurring between 6am and 8am. The consumption then rises until roughly 11am and holds around that level until 8pm; peaks in the day are limited.

However, in winter pronounced peaks are experienced in both countries; the two countries experience a high degree of correlation over the day. The winter daily pattern of demand is similar to the pattern of DST daily demand up until around 2pm. However, the electricity consumption then tends to increase until it peaks between 6 and 8pm. This can be seen from Figure 3, which depicts the daily electricity consumption for a weekday in November. It can also be observed that the peak in Ireland occurs up to an hour before the peak in Great Britain.

[3] Data provided by ENTSO-E.

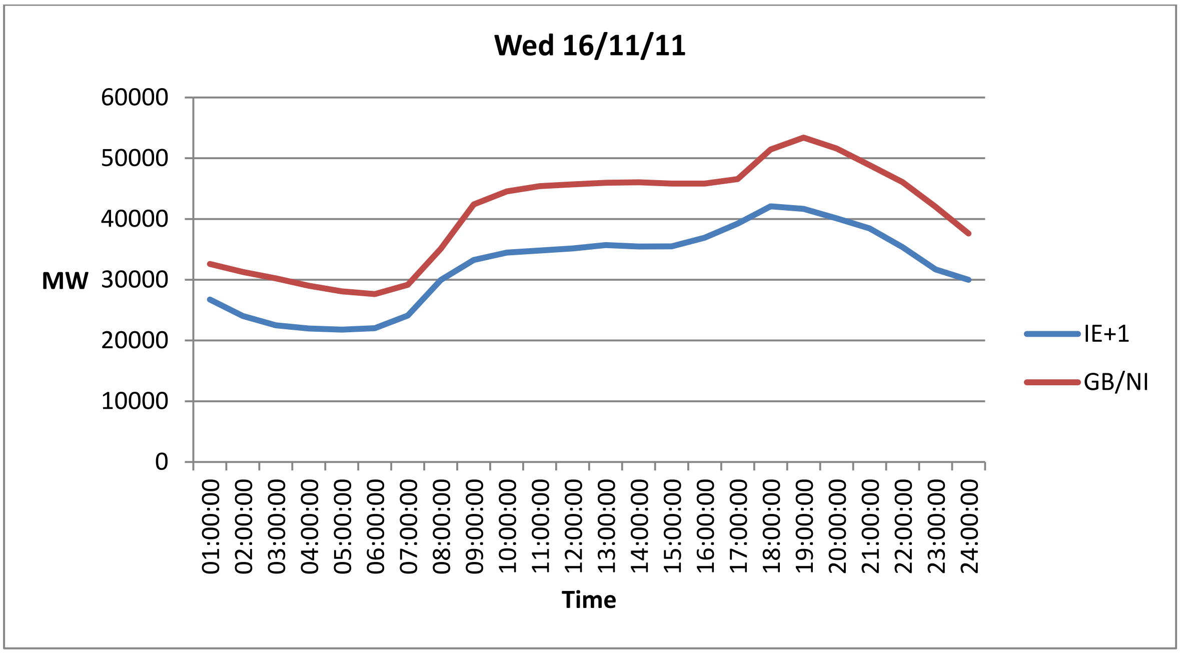
[4] Empirically, this shifts the scale of the Irish data so that it matches the UK data facilitating graphical presentation.

Figure 2.-Daily Electricity Consumption for Sample Day in June



For the purpose of observing the trend, the Irish data have been scaled up by a multiple of 10 to put it on a similar scale to Great Britain.

Figure 3. Electricity Consumption for Sample Day in November



For the purpose of observing the trend, the Irish data have been scaled up by a multiple of 10 to put it on a similar scale to Great Britain.

It is also interesting to compare the situation in Ireland to a case with similar characteristics: Finland and Sweden currently experience a time zone difference similar to the case being investigated in this paper. Unlike Ireland and Great Britain, Finland and Sweden have a highly interconnected electricity system that links them to each other and to the other Nordic countries. These two countries are also in two different time zones; Sweden adheres to Central European Time and Finland to Eastern European Time. Demand is much flatter in these two markets. In turn, this leaves more limited opportunities to achieve savings in peak generation through changing time zones. Taking a weekday from June, a typical DST daily electricity trend for Finland and Sweden can be seen in Figure 4. This is very similar to the winter trend which is represented by a typical day in November in Figure 5.

Figure 4.-Daily Electricity Consumption for Sample Day in June

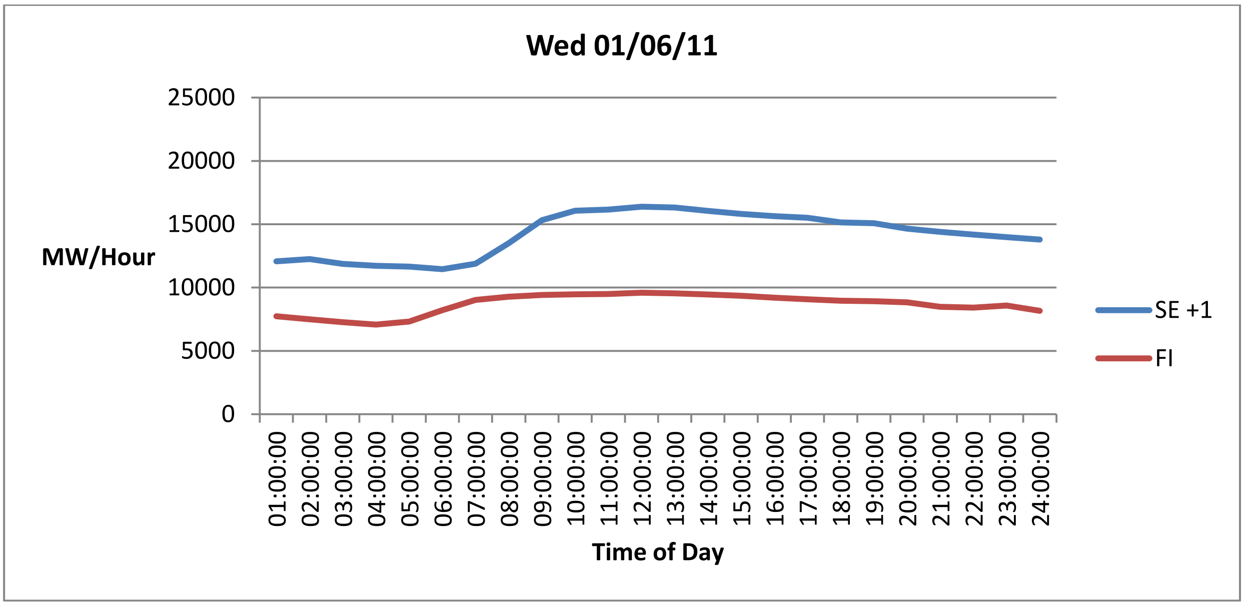
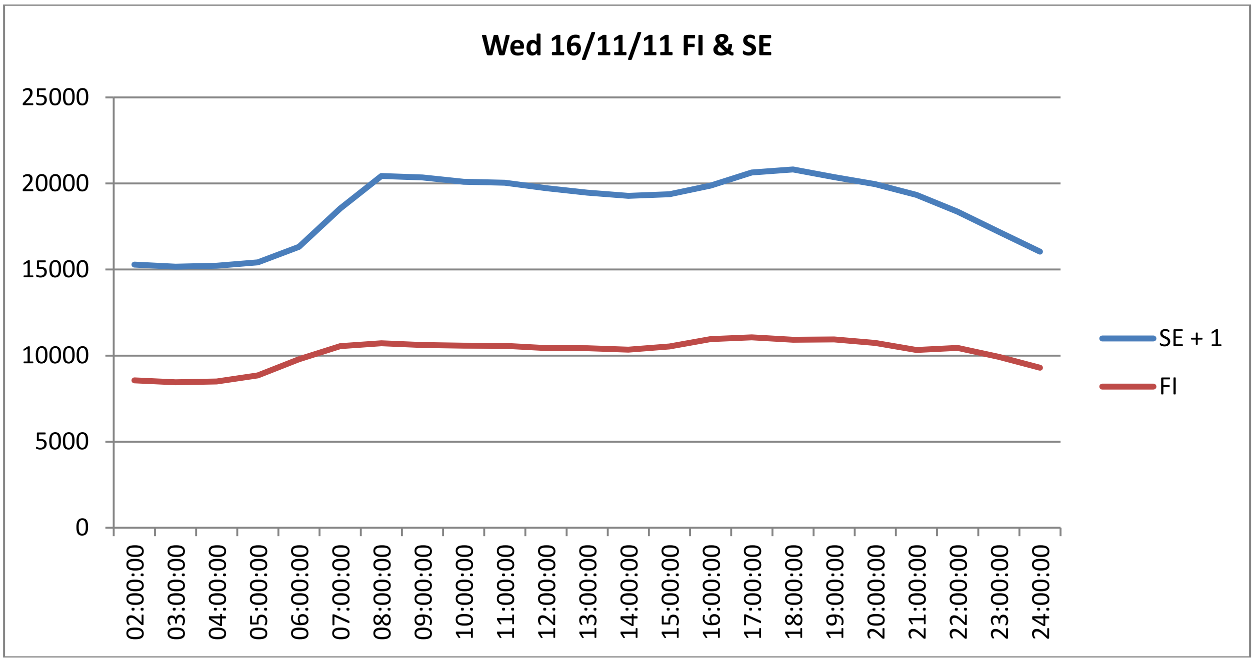


Figure 5 . Daily Electricity Consumption for Sample Day in November



6. Results

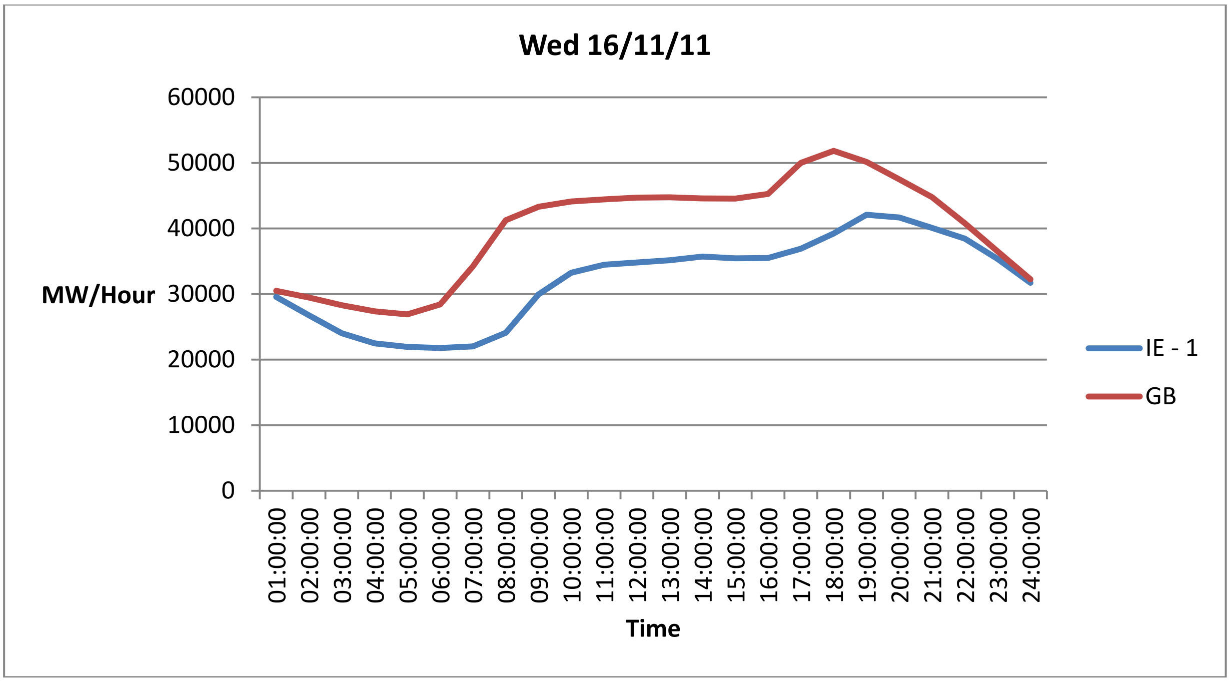
Peak Analysis

Option 1 Central European time

The first option to be explored is the proposition in The Brighter Evenings Bill 2012 that Ireland would change to the same time zone as France and Germany (while the UK does not change). The electricity generation savings at the peak are measured when Ireland's time zone is an hour behind Britain; putting it on Central European Time. Consistent with this assumption, there are two additional scenarios; the first is for Northern Ireland to remain unchanged in the GB time zone. The second is to assume Northern Ireland moves time zone with the Republic of Ireland.

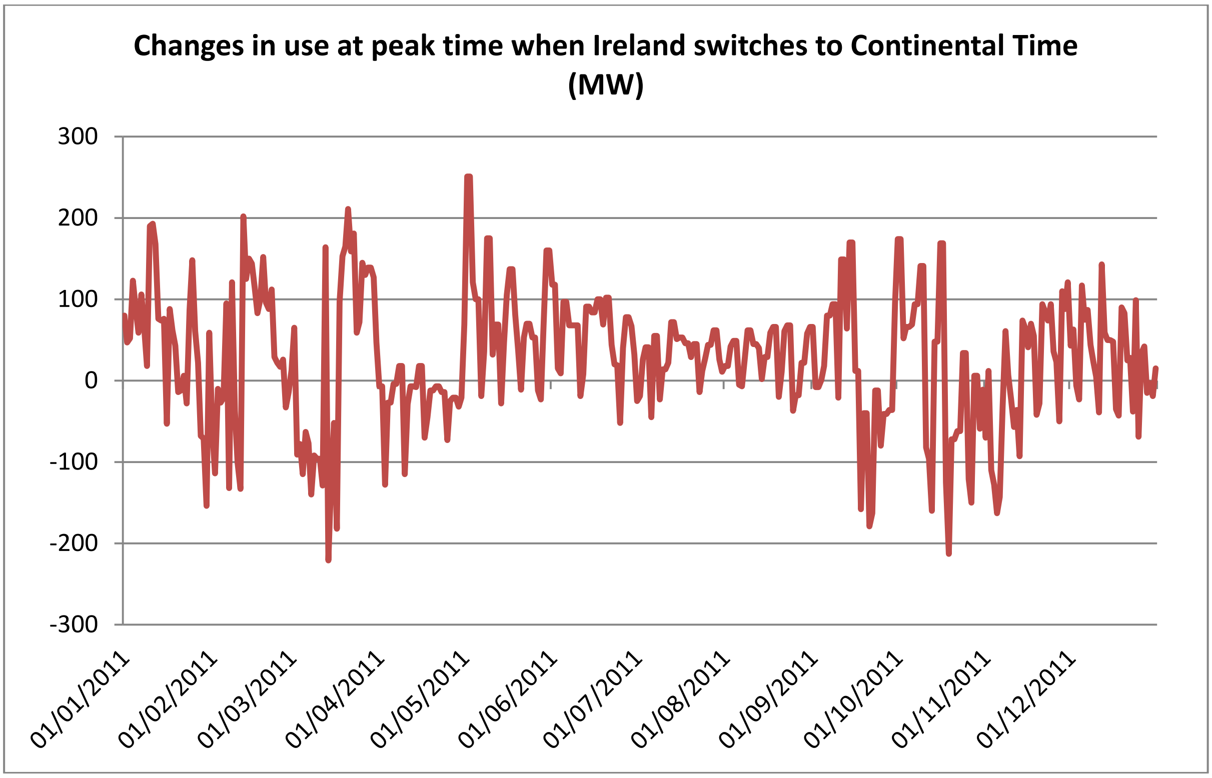
As was observed above in Figure 3, Ireland's daily peak occurs up to an hour before the peak in Britain. Therefore by slipping Ireland's time zone one hour behind Britain's, the peak in both countries would, in fact, be aligned even more closely. This can be observed in Figure 6.

Figure 6. Daily Electricity Consumption for Sample Day in November.



The implied savings are minimal for this option. The exact savings when Northern Ireland remains in the current time zone with Britain, for 2011, can be observed in Figure 7. The Figure shows the difference between an integrated British-Irish system, and a separate system under the current common time zone. As can be seen from the Figure there are many periods when there would actually be a cost from the time shift so that overall savings would be minimal, averaging around 15 MW per day over the year.

Figure 7: Savings at peak if Ireland adopted Continental Time & Northern Ireland remains unchanged.



Note: above 0 indicates savings, below 0 indicates additional demand

The alternative scenario, in which Northern Ireland changes time with the Republic of Ireland, shows similar results. A reduction in peak generation capacity is possible during Winter Time; this reduction is valued at 80 MW. However this would be offset by the increase of 31 MW in peak generation capacity necessary to sustain the electricity network during Day Light Savings Months.

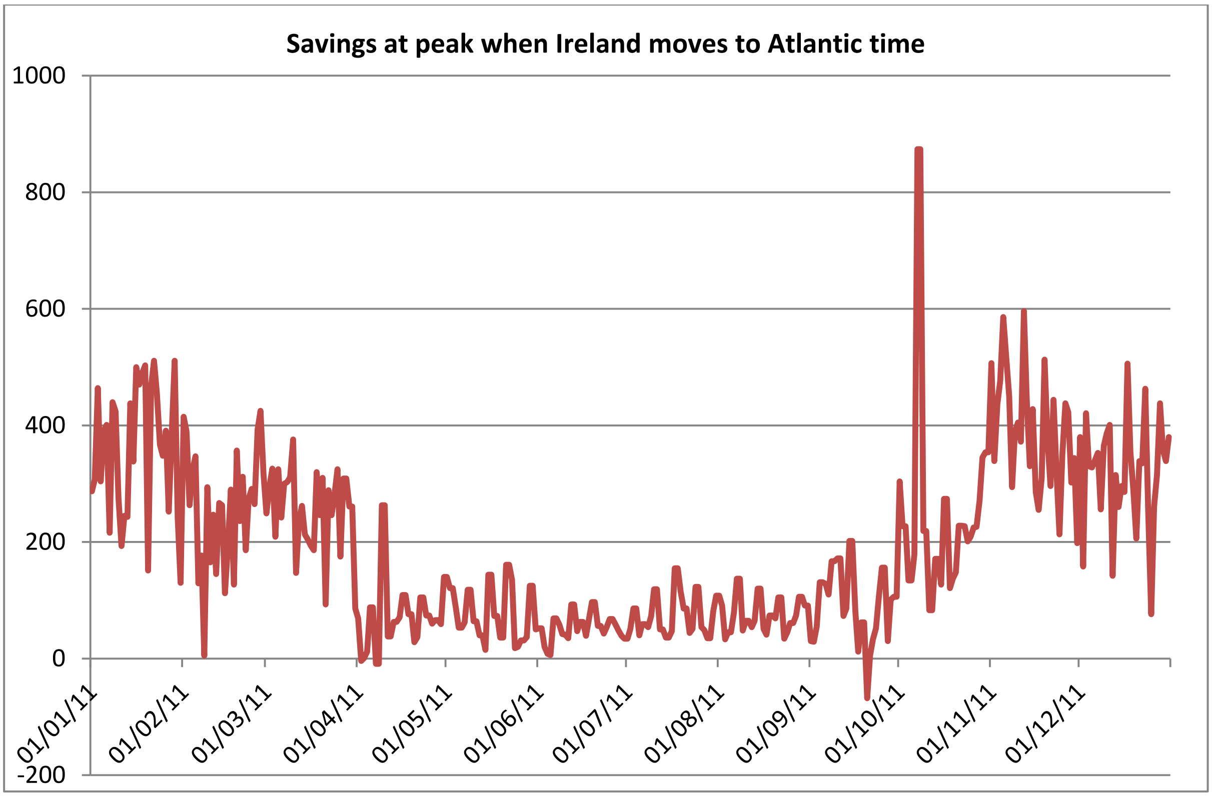
Option 2 Coordinated Universal Time

The other option explored involved shifting the time zone in Ireland to Coordinated Universal Time -1 (UTC-1), putting it an hour closer to time in the USA. Ireland would share a time zone with The Cape Verde Islands, The Azores Islands and a small part of Greenland. This move would move the peak in Ireland and Britain further apart; smoothing generation in an integrated system.

In this case the Republic of Ireland is shifted by an hour towards the Atlantic and Britain and Northern Ireland remain in the current time zone. Figure 8 shows the difference between an integrated British-Irish system, and a separate system if Ireland adopted UTC-1. Significantly higher savings of between 300 MW and 400 MW in peak generation capacity can be observed during the Winter Time months of 2011 under this arrangement.

This Figure shows, in mega watts (MW), the reduction in generation capacity needed to sustain electricity demand at the peak each day of the year. As can be seen, there are only a handful of instances when the savings are replaced by costs. The savings far outweigh the losses in this scenario. During the Winter Time months, an average of 314.5 MW could be saved at the peak each day. This is quite significant compared to the average daily saving of 72.5 MW during DST months.

Figure 8: Savings at peak when Ireland adopts UTC and Northern Ireland remains unchanged (MW).

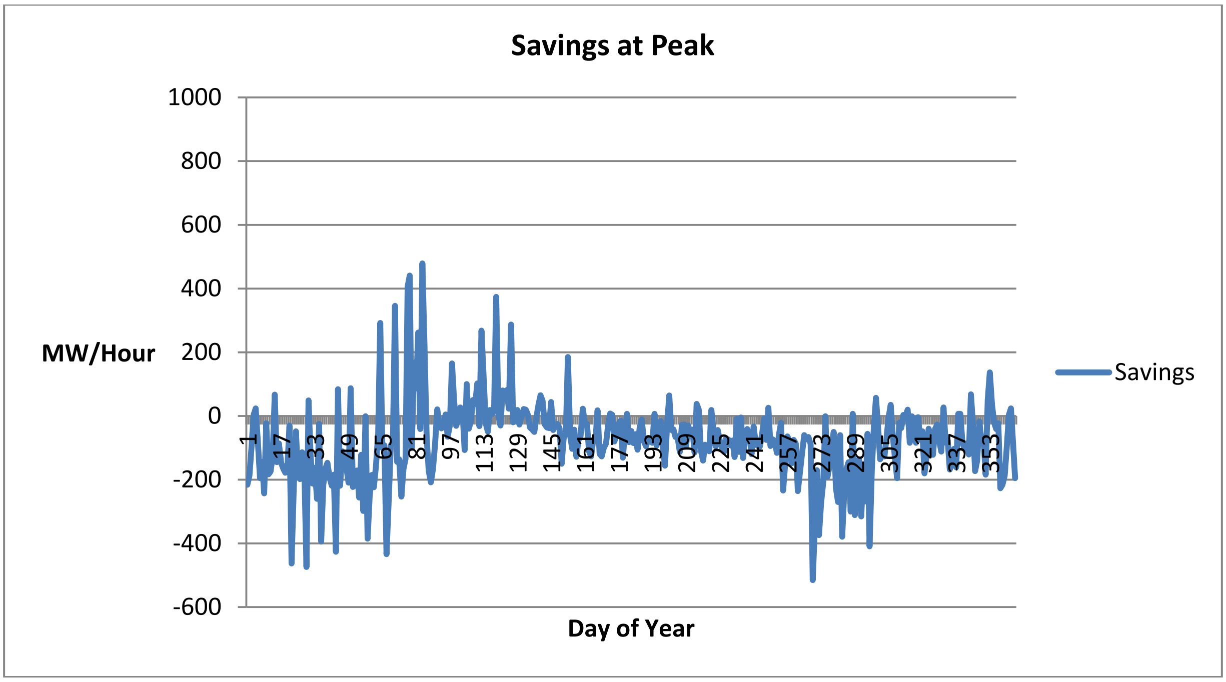


Note: Values above 0 indicate lower demand, values below indicate larger demand.

The savings in electricity generation capacity are even greater when Northern Ireland changes time with the Republic of Ireland. The generation capacity of the integrated electricity system can be reduced by 99 MW during the DST months and by 418 MW during Winter Time months.

As Finland and Sweden are currently in different time zones they were also looked at using a similar approach. This was done to observe if there is a major difference in the amount of electricity generation necessary at the peak if the two countries were put into the same time zone. As Figure 9 depicts, there would be little or no savings to be had from shifting time zones in Finland and Sweden. This reflects the fact that these electricity systems are already highly integrated. When the average annual effects of the shifting of time zone were measured it was found that Finland and Sweden would actually lose from being in the same time zone with an average loss of 94 MW in Winter Time months and a 65 MW loss in DST months.

Figure 9: Sweden and Finland, Savings at Peak Achieved from being in Different Time Zones.



Analysis of Energy Cost Savings over the Day

While changing time zone to ensure that demand peaks don't coincide can obviously save on peak generating capacity, there is also the possibility of making significant savings over the rest of the day by allowing lower cost generation in one jurisdiction to replace higher cost generation in the other jurisdiction. Here we provide an estimate of the possible magnitude of such savings if there were a fully integrated British Isles market.

To estimate the financial value of possible savings over the course of the day as a result of changing time zone we need to estimate the cost of the electricity each period of the day, each day of the year, before changing time zone and then estimate the cost after the change. The difference between these two measures is the saving or cost of the change in time zone.

If there were a single integrated Irish-British market, the effect of changes in Irish demand on total system prices would be very small because of the relative size of the markets. Thus assuming that prices don't change as a result of changes in time zone in Ireland is not an unrealistic assumption.

The GB price per time period would be the best price to use if it were available. However, the GB market is not very liquid as most sales are on the basis of bilateral contracts between generators and suppliers. By contrast, the Irish wholesale price reflects the true short run marginal cost of producing each period in the Irish market; it is liquid and transparent with all electricity sold on that market. Thus we use the current Irish System Marginal Price (SMP) as a proxy for the price of electricity each time period in an integrated market to estimate savings or costs from a time zone change.

The estimates of savings or costs made using this price should be interpreted as an upper bound of the true savings or costs for several reasons. First of all, as Irish demand decreases the SMP will also decrease, although, as argued, the change would be small in an integrated British Isles market; if Irish demand increases the SMP should also increase. Thus by using the initial SMP we may overestimate or underestimate costs by a small amount. Second, we assume no behavioural change by consumers – they consume an identical amount of electricity at 5 PM whatever time zone they are in.

However, even allowing for these caveats, the use of this price provides a mechanism for estimating the magnitude of possible costs or savings from changing time zone. Using this measure we obtain the results presented in Table 2 for the potential savings or costs over the full day, measured in millions of Euro.

Table 2: Potential Changes in Cost from changing Time Zone, € million

	IRL moves to Atlantic Time	IRL moves to CET	IRL and NI move to Atlantic Time	IRL and NI move to CET
Net annual gains	-12.736	11.656	-16.261	17.959

Note: negative values indicate overall savings. Positive values indicate additional costs.

These results 2 suggest that if the Republic of Ireland moved to Central European Time, the cost over a full year of supplying the electricity demanded would be higher than before the time zone change by €11.656 million. If Northern Ireland moved time zone with the Republic the additional cost would be €17.959 million.

By contrast, if the Republic of Ireland moved time zone in the other direction to Atlantic Time (as in the Azores) there would be a reduction in cost (saving) of €12.736 million. The saving if Northern Ireland changed time zone too would be €16.261 million. This change in energy costs would have to be added to the cost or saving in generating capacity from a change in time zone, set out in the previous section, to arrive at the overall savings or costs from a change in time zone.

If Ireland moved to Central European Time there would probably be potential benefits in other areas of business and social life as a result of a closer alignment of time with the bulk of our EU partners. This was the logic of the experiment carried out in the late 1960s. However, as shown here, rather than savings arising in the electricity system, it would probably see an increase in the cost of generation in an integrated Irish-British electricity market. It would only be if there were a change in time zone in the other direction - to Atlantic Time - that significant savings in electricity costs might arise. However, these savings would still be relatively small relative to possible other costs from moving Ireland into an isolated time zone two hours different from the bulk of our EU neighbours.

7. Conclusion

The analysis presented here suggests that there would be minimal savings in peak electricity generation capacity, and possibly higher costs of generating over the rest of the day, as a result of shifting Ireland to Continental Time. While the magnitudes of the costs and savings are slightly greater if Northern Ireland changed time zone as well as the Republic, it would not greatly alter the conclusions. On average, between 20 and 80 MW in generating capacity could be saved at each peak during winter time but the effect of this would be reduced by the increase of between 3 and 31 MW increase during DST months. Also when taking the effect of a change in time zone on energy costs over the course of the day into consideration, it was found that there would a significant increase in the cost of generation, with greater use of higher cost / lower merit order plant.

It was found that shifting the Irish time zone to Atlantic time (UTC-1), an hour further out into the Atlantic, would make a bigger difference to the amount of electricity generation capacity saved during peak periods within an integrated British Isles electricity system. The analysis suggested that an average of 317 MW in generation capacity could be saved at peak during Winter Time; this is the equivalent of three quarters of a standard base load station generation station. There would also be savings in the cost of electricity generated over the rest of the day amounting to between €12.7 million and €16.3 million. The combined savings would be small relative to the overall cost of generating electricity over the course of the year.

Thus this analysis suggests that there would be relatively little to be gained by shifting Ireland unilaterally to continental time or to UTC-1. This result is consistent with the studies undertaken on the possible effects of changes in time zone in the US and Australia discussed earlier. While shifting Ireland into a time zone one hour in the direction of the Atlantic would result in some reduction in electricity costs it would be likely to have many other costs; increasing the difference between time in Ireland and time in the bulk of the other EU members would be likely to have a range of negative effects on business and social life.

Possible behavioural changes from changing time zone have not been examined here. However if behavioural changes were taken into account they would be more likely to reduce the benefits of a time change than increase them, with people adjusting their behaviour to partially offset the effects of a time change. Thus a more detailed study would appear unlikely to alter the conclusions set out above: a unilateral change in time zone by Ireland would be unlikely to bring significant benefits in terms of saving in electricity consumption.

A further extension to this research would be to look at the savings to be made if both Ireland and Britain moved to Continental Time under a more interconnected electricity system.

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