ESRI
www.esri.ie

Working Paper No. 214

October 2007

The Value of Lost Load

Richard S.J. Tol*

Corresponding Author: Richard.Tol@esri.ie

*The Economic and Social Research Institute, Dublin; Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands; Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA, USA

The Value of Lost Load

1. Introduction

The value of lost load is the average willingness to pay of electricity consumers to avoid an additional period without power. The value of lost load is a useful yardstick for decisions on the total capacity of the power supply (e.g., Sanghvi, 1983). In the efficient solution, the marginal cost of additional capacity, which is roughly equal to the wholesale peak price, is equal to the value of lost load. In a regulated market like the Irish, customers cannot express their willingness to pay, and suppliers cannot reveal their marginal costs. Therefore, the value of lost load has to be inferred. This is particularly relevant for Ireland as the electricity supply is rapidly expanding and being restructured, and the prospect of supply shortages is real (Bazilian *et al.*, 2006; Lyons *et al.*, 2007; Malaguzzi Valeri and Tol, 2006).

There are three groups of methods for doing so, if the preferred method (based on preferences revealed in market behaviour) fails. The first alternative is based on stated preferences (e.g., Beenstock *et al.*, 1998). It relies on surveys of customers, who answer hypothetical questions. This method is the most common one, but this may be because it is academically the most challenging method. Stated preference methods suffer from substantial biases. No Irish data are available. There is substantial empirical evidence that using estimates from other countries is inappropriate. The second alternative is to use cost estimates from black-outs or brown-outs in the past (e.g., Corwin and Miles, 1978). This avoids the biases of the survey methods, but one needs to assume that the future and the past are similar. Ireland has changed rapidly.

The third alternative is based on estimates of the production function, which relates electricity use to output. This is the method used here. See Section 2 for an elaboration.

CER & NIAUR (2007a) use a tautological method for estimating the value of lost load. They use the estimated peak price of electricity for the planned capacity. In this circular reasoning, planned capacity automatically equals desired capacity, and future decisions are justified by reference to past decisions.

2. Data and methods

If there are no disaggregated data on the demand for electricity at peak hours, as is the case for Ireland, one can instead use a production function. Production functions imply demand functions. However, this method is one step removed from the variable of interest, and additional assumptions (e.g., rationality of economic agents, divisibility of goods and services) are required. Furthermore, typical production functions are estimated for a year as a whole, and may not be appropriate for an assessment of the impact of an event such as electricity interruptions for a few hours. Nonetheless, the production function approach is adopted here as the only viable option given data availability.

The method used here is identical to that used in de Nooij *et al*. (2007). Specifically, the production function is assumed to be linear. That is, the value of electricity to a particular industry equals annual electricity use over annual value added. The crucial assumption is that companies are able to shift production in the year, so that the exact time of the black-out does not matter. This assumption is a reasonable one for most activities. Another assumption is that the duration of a black-out does not matter, which is again reasonable for a relatively short brown-outs that could occur in Ireland.

Electricity use by sector can be found in the Energy Balances of the SEI for the years 1990-2005 (SEI, 2006). Operating hours are as in de Nooij *et al*. (2007). Production data for the same period are taken from the ESRI Databank (Bergin and Fitz Gerald, 2006). The time series gives some idea of the evolution over time.

For residential electricity use, de Nooij *et al*. (2007) similarly assume that all activity stops when there is no electricity – essentially, an hour of time is lost for every hour without electricity. This seems large, but risk and annoyance are not counted. The opportunity cost of leisure time is assumed to be equals to average wage, here assumed to equal the average GDP per working hour, after tax. For those who do not work, the opportunity costs are half the average wage. The cost per KWh follows from dividing the total value of leisure production by total residential electricity consumption, both by time of day and week.

Data on GDP, size of the population and labour force, and number of working hours are taken from GDDC (2007). The average labour tax rate is taken from OECD

(2007); it falls from 40% in 1990 to 26% in 2005. As an alternative, we use the average income tax rate from Bergin and Fitz Gerald (2006), which is roughly constant around 20% -- the two tax numbers are consistent if one considers the increase in the labour participation rate. Exelon (2007) shows that 44% of domestic electricity is used during the day, 35% in the evening, and 20% at night. These numbers are for Great Britain, but used here as such data are not available for Ireland.

3. Results

Figure 1 shows the value of lost load for the different sectors in 2005. There are substantial differences. In "traditional" manufacturing sectors, the VoLL is only a few euro per KWh, but this goes up to some €20/KWh in the manufacturing of electronic and chemical products. Transport is exceptional, as it uses little electricity. The average value is €8/KWh. Residential electricity use is by far the most valuable among the large users.

The pattern shown in Figure 1 was very different in 1990. The largest differences are for mining, where the VoLL has fallen by 7% per year on average between 1990 and 2005; and other manufacturing, where the VoLL has increased by an annual 14%. The average has grown by 2% per year. The VoLL for households has increased by almost 3% per year. Although wage growth has only slightly exceeded the increase in residential electricity use, the value of leisure time was substantially increased by the fall in labour taxes.

Figure 2 shows the value of lost load for 1990-2005, split by time of week. The VoLL grew by some 3.5% per year over this period, but growth was more rapid for 1997-2004. The recent deceleration is largely due to the household VoLL, which is driven by a deceleration in labour productivity growth and a saturation of the employment ratio. The stabilisation of wage taxes is also important. If the average income tax is used rather than the average wage tax, the VoLL increased by only 1% per year.

The VoLL differs substantially between week days and the weekend, and between times of day. For production, electricity is most valuable in week nights, and least valuable in weekend nights. This is because industries with the lowest VoLL tend to work either on Monday to Friday from 9 till 5, or 24-7. For households, electricity is more valuable in the weekend than during the week. During the week, electricity is more valuable in the evening than during the day; the opposite is true for the weekend. As the value of electricity is so much greater to households than to companies, the household VoLL dominates the average VoLL.

The average VoLL is around €40-43/KWh, which is considerably higher than the €10/KWh set by CER & NIAUR (2007b). The lower number uses the wage tax, the higher number the income tax. At week days during the evening, when brown-outs are most likely, the value goes up to €68-74/KWh. This suggests that the regulators aim for less power generation capacity than is socially desirable, and that the probability of a brown-out is too large. At present, during a brown-out, it is policy to shut off electricity in residential areas first, and in industrial estates later. As the household VoLL is much larger than the company VoLL, this policy may be reconsidered.

4. Conclusions

In this paper, I use a simple version of the production function approach to estimate the value of lost load in the Republic of Ireland for the period 1990-2005. The estimate suffers from lack of detailed data on residential electricity use. The value of lost load has grown considerably over the last 15 years, as wage growth outstripped electricity demand, and the Irish economy shifted towards production that has a higher value added per amount of electricity used. In 2005, the VoLL is about €40/KWh, which is considerably higher than the regulator assumes it to be.

Acknowledgements

John Fitz Gerald, Laura Malaguzzi Valeri and Edgar Morgenroth had useful comments on an earlier version of the paper. Financial support by the ESRI Energy Policy Research Centre is gratefully acknowledged.

References

Bazilian, M., F.O'Leary, B.O Gallachoir, and M.Howley (2006), *Security of Supply in Ireland 2006*, Sustainable Energy Ireland, Cork.

Beenstock, M., E.Goldin, and Y.Haitovsky (1998), 'Response Bias in a Conjoint Analysis of Power Outages', *Energy Economics*, 20, 135-156.

Bergin, A. and J.D. Fitz Gerald (2006), *The ESRI Data Bank*, Economic and Social Research Institute, Dublin.

CER and NIAUR (2007a), *The Value of Lost Load, the Market Price Cap and the Market Price Floor*, Commission for Energy Regulation and Northern Ireland Authority for Utility Regulation, Dublin and Belfast, **AIP-SEM-07-381**.

CER and NIAUR (2007b), *The Value of Lost Load, the Market Price Cap and the Market Price Floor -- A Response and Decision Paper*, Commission for Electricity Regulation and Northern Ireland Authority for Utility Regulation, Dublin and Belfast, **AIP-SEM-07-484**.

Corwin, J. and W. Miles (1978), *Impact Assessment of the 1977 New York City Blackout*. US Department of Energy, Washington, DC.

de Nooij, M., C.Koopmans, and C.Bijvoet (2007), 'The value of supply security: The costs of power interruptions: Economic input for damage reduction and investment in networks', *Energy Economics*, 29, 277-295.

Elexon (2007), *Load Profiles and their Use in Electricity Settlement*, Elexon, http://www.elexon.co.uk/documents/Participating_in_the_Market/Market_Guidance_-_Industry_Helpdesk_faqs/Load_Profiles.pdf.

GDCC (2007), *Total Economy Database*, Groningen Growth and Development Centre, http://www.ggdc.net.

Lijesen, M.G. (2007), 'The Real-Time Price Elasticity of Electricity', *Energy Economics*, 29, 249-258.

Lyons, S., J.Fitz Gerald, N.McCarthy, L.Malaguzzi Valeri, and R.S.J.Tol (2007), 'Preserving Electricity Market Efficiency while Closing Ireland's Capacity Gap', *Quarterly Economic Commentary*, 2007, (Autumn), 62-82.

Malaguzzi Valeri, L. and R.S.J.Tol (2006), 'Electricity Shortages in Ireland: Probability and Consequences', *Quarterly Economic Review* (winter), 1-7.

OECD (2007), *Taxing Wages 2005/2006*, Organization for Economic Cooperation and Development, Paris.

Sanghvi, A.P. (1983), 'Optimal Electricity Supply Reliability using Customer Shortage Costs', *Energy Economics*, 129-136.

SEI (2006), *Energy in Ireland 1990-2005*, Sustainable Energy Ireland, Dublin.

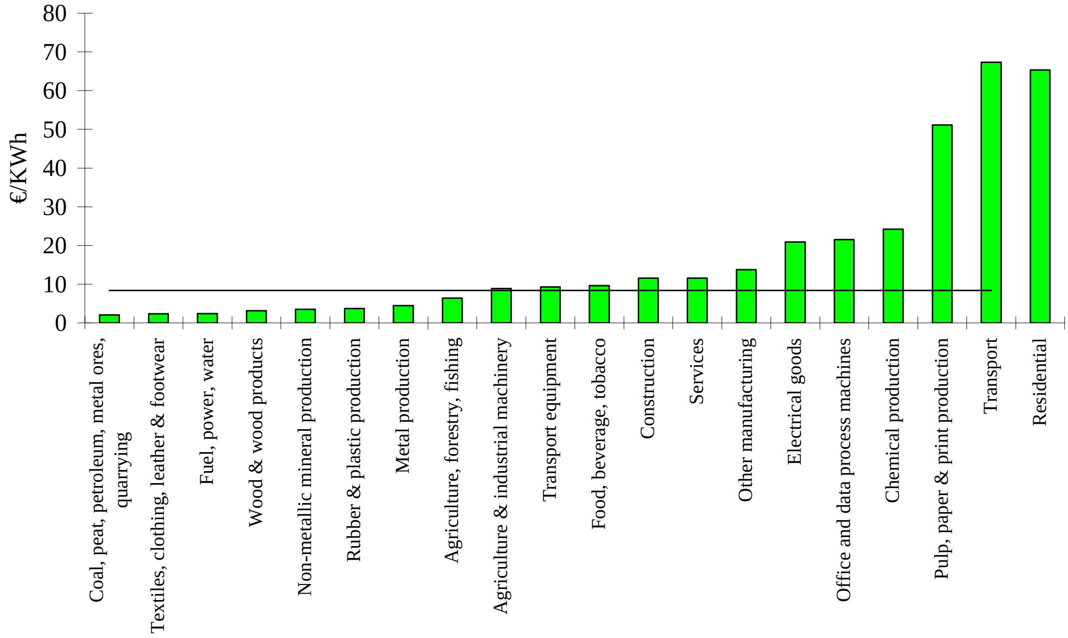

Figure 1. The value of lost load per sector in 2005. The average value (except residential) is also shown.

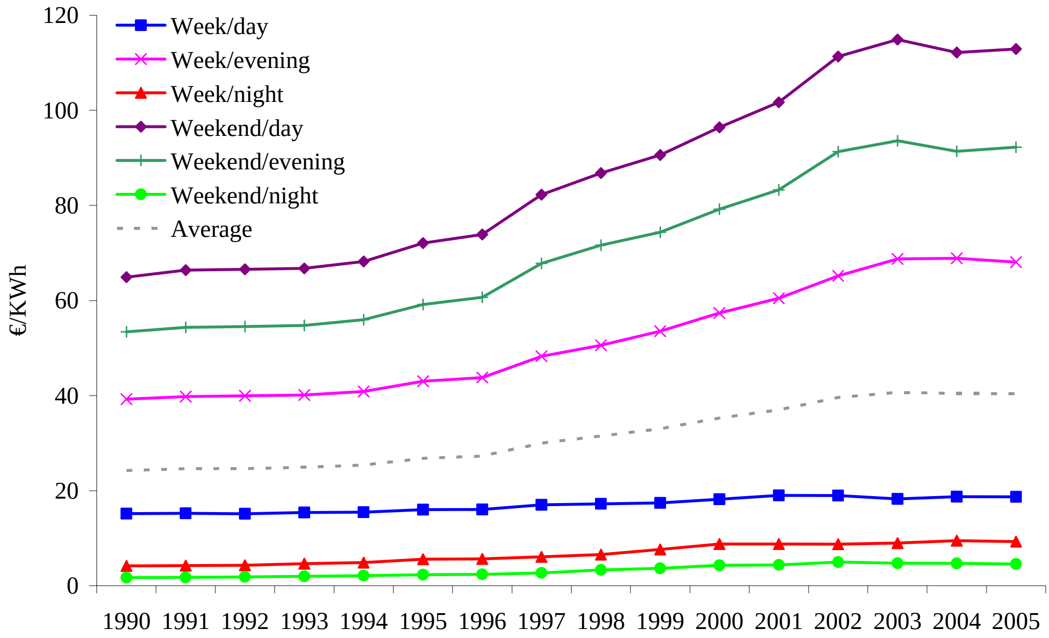

Figure 2. Value of lost load by time of week and year.

Year	Number	Title / Author(s) ESRI Authors / Co-authors Italicised
2007	213	Adolescents' Educational Attainment and School Experiences in Contemporary Ireland *Merike Darmody, Selina McCoy, Emer Smyth*
	212	Acting Up or Opting Out? Truancy in Irish Secondary Schools *Merike Darmody, Emer Smyth* and *Selina McCoy*
	211	Where do MNEs Expand Production: Location Choices of the Pharmaceutical Industry in Europe after 1992 *Frances P. Ruane*, Xiaoheng Zhang
	210	Holiday Destinations: Understanding the Travel Choices of Irish Tourists *Seán Lyons, Karen Mayor* and *Richard S.J. Tol*
	209	The Effectiveness of Competition Policy and the Price-Cost Margin: Evidence from Panel Data Patrick McCloughan, *Seán Lyons* and William Batt
	208	Tax Structure and Female Labour Market Participation: Evidence from Ireland *Tim Callan,* A. Van Soest, *J.R. Walsh*
	207	Distributional Effects of Public Education Transfers in Seven European Countries *Tim Callan,* Tim Smeeding and Panos Tsakloglou
	206	The Earnings of Immigrants in Ireland: Results from the 2005 EU Survey of Income and Living Conditions *Alan Barrett* and *Yvonne McCarthy*
	205	Convergence of Consumption Patterns During Macroeconomic Transition: A Model of Demand in Ireland and the OECD *Seán Lyons, Karen Mayor* and *Richard S.J. Tol*
	204	The Adoption of ICT: Firm-Level Evidence from Irish Manufacturing Industries *Stefanie Haller* and *Iulia Traistaru-Siedschlag*
	203	EU Enlargement and Migration: Assessing the Macroeconomic Impacts Ray Barrell, *John Fitz Gerald* and Rebecca Riley

202	The Dynamics of Economic Vulnerability: A Comparative European Analysis *Christopher T. Whelan* and *Bertrand Maître*
201	Validating the European Socio-economic Classification: Cross-Sectional and Dynamic Analysis of Income Poverty and Lifestyle Deprivation *Dorothy Watson, Christopher T. Whelan* and *Bertrand Maître*
200	The 'Europeanisation' of Reference Groups: A Reconsideration Using EU-SILC *Christopher T. Whelan* and *Bertrand Maître*
199	Are Ireland's Immigrants Integrating into its Labour Market? *Alan Barrett* and *David Duffy*
198	"Man Enough To Do It"? Girls and Non-Traditional Subjects in Lower Secondary Education *Emer Smyth* and *Merike Darmody*
197	Analysing the Effects of Tax-benefit Reforms on Income Distribution: A Decomposition Approach Olivier Bargain and *Tim Callan*
196	Heterogeneous Exporter Behaviour: Exploring the Evidence for Sunk-Costs and Hysteresis *Frances Ruane*
195	The Regional Dimension of Taxes and Public Expenditure in Ireland *Edgar Morgenroth*
194	Do Consultation Charges Deter General Practitioner Use Among Older People? A Natural Experiment *Richard Layte*, Hannah McGee and Ann O'Hanlon
193	An Analysis of the Impact of Age and Proximity of Death on Health Care Costs in Ireland *Richard Layte*
192	Measuring Hospital Case Mix: Evaluation of Alternative Approaches for the Irish Hospital System Chris Aisbett, *Miriam Wiley, Brian McCarthy, Aisling Mulligan*