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Energy Demand to 2015

by

John Fitz Gerald

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The Economic and Social Research Institute
4 Burlington Road
Dublin 4

Tel: (353-1) 667 1525
Fax: (353-1) 668 6231

Introduction

This working paper outlines a set of forecasts for the likely development of energy demand in Ireland over the next 15 years. The "Central Forecast", based on the ESRI *Medium-Term Review: 1999-2006*, published last year, represents the scenario that we consider to be the most likely. However, because of the wide range of uncertainty involved in such an exercise, we also describe two other scenarios – a high and a low growth scenario. In these two scenarios we have varied the assumptions concerning the likely rate of economic growth in the medium term. In addition, we have also varied some other assumptions relating specifically to the development of the energy sector. The requirement to reduce emissions of greenhouse gases will play a significant role in determining the future growth path of the energy sector. While the recently published government *National Climate Strategy* report does set out a range of measures to be taken to reduce Irish emissions, the uncertainty about the full implications of policy changes for the energy sector is reflected in the range of assumptions examined in this paper.

In undertaking this exercise we have used the ESRI's macro-economic model and a separate simple model of energy demand to consider the effect of varying assumptions about economic growth. We first describe the macro-economic scenarios underlying the forecast for energy demand. We then describe some assumptions relating to the energy sector that are imposed on our model of energy demand. The following sections describe the implications of these assumptions for electricity demand and for the demand for energy from each of the different sectors of the economy: households, commercial and public, industry, and the transport sector. The final section sets out ourconclusions.

Macro-Economic Assumptions

As outlined in the *Medium-Term Review: 1999-2006*, the Irish economy is performing strongly and the underlying factors driving that rapid growth will continue to affect performance for some time to come. This means that growth over the next decade is likely to exceed that in most other members of the EU. However, as the special demographic circumstances that underpin this outlook revert to a more normal European pattern, the rate of growth can be expected to gradually slow.

Underlying the set of forecasts for gas demand to the end of the decade and beyond are a series of macro-economic projections. The Central Forecast is based on the *Medium-Term Review* published in October 1999. While economic growth since the *Review* was published has proved more buoyant than expected, there seems no reason to change the medium-term forecasts for the average growth over the next decade. However, we have updated the macro-economic aggregates to take account of new historical data for the period to 1999. We have also incorporated the latest forecasts for 2000 and 2001 based on the September 2000 *Quarterly Economic Commentary*. Using these data as a basis, the macro-economic aggregates from 2002 onwards are assumed to grow at the same rate as in the *Medium-Term Review*.

Because of the uncertainty inherent in any such forecasts we have examined the sensitivity of the energy demand forecasts to two alternative economic scenarios:

- **High growth scenario** where the forecast growth rate for GNP is around one percentage point above that of the Central Forecast from 2001 to 2010. This corresponds to the high growth scenario worked out in Chapter 6 of the *Review*.
- **Low growth scenario** where the forecast growth rate for GNP is three-quarters of a percentage point below that of the Central Forecast. This is an even less favourable medium-term scenario than the "US equity price shock" in the *Medium-Term Review* because growth is assumed to be below the Central Forecast every year for the foreseeable future. This scenario is similar to the "loss of competitiveness scenario" in the *National Investment Priorities Report*, 1999, p.85, except that there the growth was assumed to be 1.5 percentage points below trend.

These three scenarios - High growth, Central forecast, and Low growth are then applied to the same basic energy sub-model to derive the demand for energy (and greenhouse gas emissions). The estimates of greenhouse gas emissions have not been calibrated to the latest EPA figures.

The key macro-economic assumptions for the period to 2015 under the three different scenarios are shown in Tables 1 to 3. Here we show the key variables that are used in the energy sub-model to generate forecasts of energy demand. The forecasts for the number of households under each scenario are derived from the ESRI's demographic sub-model and they are consistent with the other macro-economic aggregates shown in the Tables.

Table 1: Central Forecast - Macro-Economic Assumptions, Average Growth Rate %

	2000-2005	*2005-2010*	*2010-2015*
GNP	5.2	4.3	3.2
Consumption	5.1	4.4	3.4
Gross Output, Traditional manufacturing	2.5	2.5	1.8
Real personal disposable income	5.2	4.6	3.6
Households	2.6	2.4	1.3
Population over 15	1.2	1.1	0.8
	2005	*2010*	*2015*
Persons per household	2.8	2.6	2.5

Table 2: High Growth - Macro-Economic Assumptions, Average Growth Rate %

	2000-2005	*2005-2010*	*2010-2015*
GNP	6.4	5.6	4.5
Consumption	5.5	5.0	4.0
Gross Output, Traditional manufacturing	2.6	2.8	2.2
Real personal disposable income	5.8	5.3	4.2
Households	3.0	2.9	1.7
Population over 15	1.7	1.5	1.2
	2005	*2010*	*2015*
Persons per household	2.8	2.6	2.6

Table 3: Low Growth - Macro-Economic Assumptions, Average Growth Rate %

	2000-2005	*2005-2010*	*2010-2015*
GNP	4.2	3.6	3.1
Consumption	4.3	4.0	3.9
Gross Output, Traditional manufacturing	0.6	-0.2	-1.1
Real personal disposable income	4.3	4.3	4.5
Households	2.3	2.1	1.0
Population over 15	0.8	0.7	0.5
	2005	*2010*	*2015*
Persons per household	2.8	2.6	2.5

Assumptions on Energy Demand

The forecasts are built up from a series of sectoral models that determine the final energy demand. For each sector electricity demand is modelled separately from the "rest of energy" and then the "rest of energy" category is broken down between the different fuels. The electricity demand from all sectors is then aggregated to give total electricity demand and the behaviour of the electricity sector in responding to the demand is then modelled. The final sectoral energy demand for "rest of energy" is then added to the forecast fuel demand from the electricity transformation sector to arrive at an estimate of demand for total primary energy. In turn, this gives rise to a forecast for greenhouse gas emissions from the consumption of fossil fuels.

While the sensitivity of the forecasts to alternative macro-economic assumptions has been tested, there is probably more uncertainty concerning the likely public policy response to the problem of global warming and the related reaction of the energy sector to new policy initiatives. We have assumed that public policy changes the incentives for the electricity sector to effect some reduction in emissions but that public policy still insists on the continuation of the environmentally damaging generation of electricity from peat.

Specifically, we have also assumed that the Moneypoint electricity generating station is reduced to half power from 2008 onwards for environmental reasons. The Government's *National Climate Strategy*, published this autumn, suggests the possibility that Moneypoint could actually be closed altogether to help achieve a substantial cut in greenhouse gas emissions. In the high growth scenario we have also assumed that from 2003 onwards the electricity generation market has access to unlimited gas supplies and that, as a result, sufficient new firms enter the electricity market to displace all the existing high priced oil generation. These two assumptions serve to reduce greenhouse gas emissions and they could allow strong competition to develop in the electricity sector, while leaving Ireland more dependent on gas as an energy source.

For other sectors we have not assumed a major change in behaviour in response to the problem of global warming. However, depending on the measures taken, there could be some significant further reductions in energy demand compared to the scenarios shown here.

Electricity Generation

For purely environmental reasons, electricity output at Moneypoint is assumed to be halved in 2008. This results in a halving in coal consumption by the electricity sector. It is assumed that Moneypoint is kept operational for security of supply reasons. This could involve shutting one of the three units at Moneypoint and alternating between the other two units to keep them fully operational.[1] In case of gas supply problems, this would allow Moneypoint to increase its output to two-thirds of the current level.

Oil usage is assumed to be gradually phased out over the decade to 2010, by which stage consumption is assumed to be down to 100 KTOE a year. This reflects the fact that the existing oil fired plant is old and inefficient. Even in the absence of environmental considerations commercial forces would encourage its closure by the end of the decade. In the high growth scenario we assume that they are phased out by 2003.

With the first Europeat station coming on line in the near future, there is assumed to be some small increase in consumption of peat. However, 200 KTOE of peat is assumed to be used by the new station at a conversion rate of 37%. The conversion of the remaining fuel is assumed at 25.3% (historical figure for peat stations from the early 1990s). All existing plant is assumed to be closed in 2006 and replaced with new plant consuming the same amount of peat as the plant closed and generating electricity at an efficiency of 37%. This is a rather extreme assumption. Any serious commitment to reducing greenhouse gas emissions would see the old plant closed without replacement. If this were to happen the closed plant would be replaced by new plant burning gas.

Renewables are assumed to account for 10% of electricity demand by 2010. At the margin, the bulk of the new plant is expected to be onshore wind-farms. The availability of the wind-farms would be likely to be over 30 per cent.

The profile on gas demand from CHP plant assumes a steady increase in usage, with a somewhat more rapid increase after 2005. There is one major exception to this: it is assumed that a 250 MW plant is installed at a site in the mid-west to operate from the beginning of 2005. By 2010 the installed electricity capacity in the CHP sector (including the 250 MW plant) is assumed to be 650 MW.

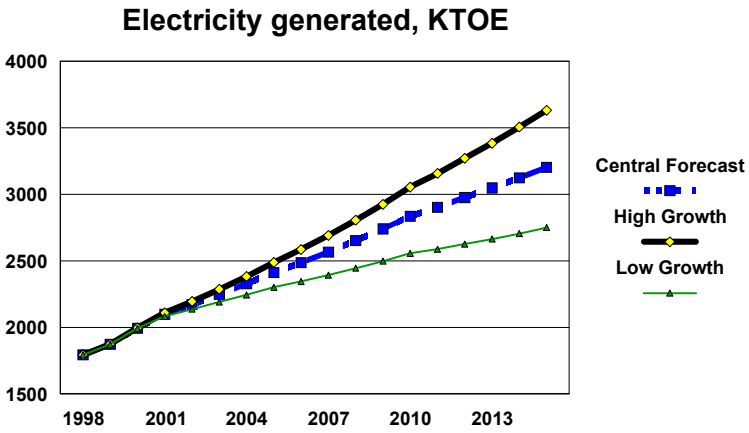
It is assumed that the combined heat and power produced from the plant effects an 80% conversion rate of energy input to useful energy. Of this, 40% of the total energy input is assumed to be converted to heat (at 100% efficiency), and the rest of the output (from 60% of the fuel) is used to generate electricity at an efficiency of 66%. The electricity is all assigned to the electricity generation sector and all the heat from the plant in the mid-west, and three quarters of the rest of the heat, is assigned to the industrial sector. The residual heat is assigned to the commercial sector. In the case of the plant in the mid-west

[1] It would also be possible to keep the three units operational while maintaining the same overall electricity output.

the heat displaces heat from oil, while the rest of the heat directly displaces gas use in the sectors where the investment takes place.

The rest of electricity demand is assumed to be met by gas-fired CCGT, at 55% efficiency at the margin. It is assumed that existing plant, operating at efficiency levels below new plant, is not replaced before 2010. However, commercial pressures in a deregulated environment from 2005 onwards could see the early replacement of this plant by new CCGT plant.

Figure 1: Electricity Generation



The ratio of electricity demand to electricity generated is assumed to be 87%. In addition, because conversion factors for different fuels into electricity are not fully up to date[2], an adjustment is necessary in the spreadsheets to bring the estimated electricity generated in 1999 into line with actual generation.

Figure 1 shows the resulting forecast for electricity generation to 2015. In the Central Forecast the average annual growth rate from 2000 to 2005 is 3.9 per cent, falling to 3.3 per cent between 2005 and 2010 and to 2.5 per cent a year from 2010 to 2015. By 2010, the share of electricity generated using gas is forecast to rise to 71 per cent (including CHP), while the share from coal is forecast to fall to less than 10 per cent. Figure 1 also shows the forecasts for electricity demand on the base of the alternative "high-growth" and "low-growth" sets of macro-economic assumptions.

Residential Demand

The forecast demand for energy from the household sector is based on recent research work by Conniffe, 2000. Using detailed data for the consumption patterns of a few thousand households in 1994/5, he has estimated the sensitivity of energy demand to changes in income and household size. These results have been embedded in our energy sub-model. In addition, a number of other methods were examined which gave rather

[2] It is some years since the ESB's annual report gave the relevant information.

similar results. The overall results are compared to the current consumption patterns in some of our EU neighbours. Full details of the derivation of the forecast for electricity are given in Appendix 1.

In the Central Forecast household numbers are forecast to rise by an average of 2.5 per cent a year between 2000 and 2010. However, average household size is likely to fall over the period. When the rise in household numbers is combined with the forecast rise in personal disposable income over the period, the model suggests a rise in residential electricity consumption of an average of 3.2 per cent a year.

Table 4: Household Electricity Consumption per head, Mwh

UK	Netherlands	Ireland		Denmark	Germany
1998	1998	1998	2010	1998	1998
1855	1329	1494	1973	1934	1594

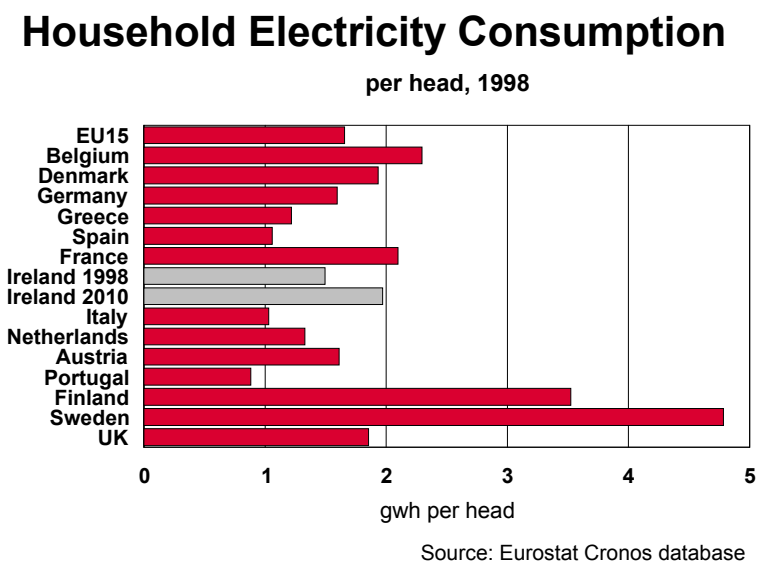
Source: Eurostat Cronos database

By 2010 this would result in household electricity consumption per head of population of 1973 Mwh. As shown in Table 3 and Figure 2, this is higher than in a range of neighbouring countries today but it does not seem unreasonable in the context of the likely rise in living standards over the decade.

In forecasting demand for "other energy" in the residential sector, it is assumed that it is driven primarily by the demand for space heating. It is estimated that in 2000 just over 80 per cent of households have central heating. It is further assumed that 95 per cent of all new dwellings have central heating while the proportion of existing houses with central heating will rise to 90 per cent by 2010. This would result in somewhat over 90 per cent of all houses having central heating by 2010. It is assumed that the consumption of gas and oil by central heating boilers remains unchanged over the next decade so that total demand is driven purely by the rise in the number of boilers.

The proportion of households in the gas region (with gas supplies potentially available to them) is derived from BGE forecasts. As a result of the extension of the gas network to the Galway region and intervening areas, the proportion of households in the gas region begins to rise more rapidly from 2003 onwards. In 2003 there is an initial significant increase, with the pipeline to Galway opening. This is assumed to raise the share of households in the gas region (with potential access to gas) by 5 percentage points. However, because of the time it will take to connect up all areas within the gas region, we have assumed that the proportion of all households in the state with ready access to gas rises by 1.5 percentage points in 2003, and by 0.5 percentage points a year thereafter. It should reach a plateau at 50% of all households by 2009.Of these households, 94% will have access to a gas pipe. Gas penetration among these households is assumed to rise to 85% by 2010.

Figure 2: Electricity Consumption per head



Gas demand is then forecast to rise in line with the number of customers. This suggests an annual rise in consumption of 6.1% a year over the period to 2010. This is substantially more rapid than would be implied by Conniffe's elasticities (4.2%). However, it is all driven by the forecast rise in the number of connections.

By 2010, 91% of households are assumed to have central heating. All gas customers are assumed to have it and the residual is assumed use oil. Assuming oil use per boiler is constant, then the consumption of oil is assumed to rise in line with the rise in the number of oil boilers. In addition, 20% of the reduction in coal use (in KTOEs) is added to oil each year to allow for conversion from coal to oil-fired central heating. This involves a very much slower rise in oil consumption than would be implied by Conniffe's elasticities, which substantially counterbalances the more rapid rise in gas. The reallocation to gas demand arises from the assumption of increased gas penetration.

Coal and peat usage is assumed to fall to around half current levels by 2010.

Table 5: Residential Sector Energy Consumption per Household, TOE

UK	Netherlands	Ireland		Denmark	Germany
1997	1997	1997	2010	1997	1997
1.65	1.61	1.84	1.98	1.99	1.88

Table 5 gives details of current energy consumption by households in Ireland and in neighbouring EU countries. When the forecast energy consumption by Irish households in 2010 is compared with these data for other countries today, we see Irish consumption

levels remaining quite high at around German and Danish levels, significantly above current consumption levels in the UK and the Netherlands.

Commercial and Public

Because of the rather uncertain data quality, and the poor fit obtained by estimated models for this sector, the forecasting methodology used for this sector is subject to quite wide margins of error.

The elasticity of demand for electricity in this sector with respect to personal consumption is estimated be1.1. Thus electricity demand is forecast to rise slightly more rapidly than the forecast rise in consumption over the period.

Non-electricity energy consumption in the sector is assumed to grow in line with employment in the services sector. This is based on the assumption that the bulk of such energy is used for space heating and that the space to be heated is a function of employment.

The gas share of non-electrical energy demand from this sector is assumed to grow by a half of one percentage point (.005) a year to 2010. This would take its share from around 20% to around 25%. The share rose much more rapidly between 1990 and 1998 from 10% to 18%.

Oil accounts for the residual energy demand

Agriculture

Energy consumption of electricity and oil is indexed to the volume of gross agricultural output – an elasticity of one.

Feedstock

Demand for gas for feedstock is held constant from 1999 till 2010.

Industry

Electricity demand in the industrial sector is related to the change in the volume of GDP arising in industry. The elasticity assumed is 0.57 – for every one per cent rise in output, electricity demand is assumed to rise by 0.57 per cent.

Non-Electricity energy demand from the industrial sector is assumed to be a function of employment in manufacturing and time. The elasticity with respect to employment growth is 0.5298. The time trend has a negative coefficient of 0.01 i.e. one percentage point is deducted from the annual percentage increase based on the relationship with employment. The result of this relationship is a forecast that non-electricity demand for energy in industry will not change over the period to 2010.

Coal usage is related to gross output in the traditional manufacturing sector with an elasticity of –5.0 i.e. it is declining very rapidly.

Use of renewables and LPG is assumed to be constant over the forecast period. Gas CHP relates to the heat output from CHP plant. The derivation of this figure is discussed under electricity above. Non-CHP gas use is indexed to total non-electricity energy use. Oil is the residual fuel. Overall, because of the slow growth forecast in industrial employment, there is little growth forecast for non-electrical energy demand in this sector.

An additional 70 ktoe of demand for gas has been added in 2001 and 2002 to allow for growth in web farms, assuming that they generate their own energy needs.

It seems likely that the rise in investment in the immediate future will see some increase in demand for, and production of cement. However, growth in demand is likely to slow or stabilise after 2005, once the programme of planned infrastructural investment is well under way. The production of this cement will require some increase in energy input. However, the changing structure of the industrial sector will see significant numbers of closures in more traditional types of industry. This structural change in the sector will also involve a shift from solid fuel to gas as an energy source. Because gas is converted into useful energy more efficiently than is solid fuel, this change will allow for some economising in aggregate energy input, as implied in our forecast.

Transport

The main component of the demand for energy in the transport sector is the oil used in motor vehicles. Here we assume that energy consumption rises directly in line with the rise in the number of cars (an elasticity of one). The number of cars in 2010 is taken from an ESBI report, which suggested that there would be 1.856 million cars by that date. That forecast is, in turn, taken from DKM. An alternative model suggested a significantly smaller number of cars at that date. However, as shown in Table 6, the higher figure would seem more appropriate in the light of current ownership levels in neighbouring countries.

Table 6: Cars per Adult Aged 15 to 64

UK	Netherlands	Ireland			Denmark	Germany
1997	1997	1997	ESBI/DKM	Model	1997	1997
.61	.56	.47	.66	.62	.50	.74

On this basis, the demand for oil for private motor vehicles is forecast to grow by 4 per cent per annum from 2000 to 2005 and by 3.3 per cent per annum for the following five years to 2010.

Conclusions

Tables 7, 8, 9 and 10 set out the forecast growth in demand for electricity, gas, oil and total primary energy for the next 15 years, based on the three different scenarios. While there are significant differences between the three scenarios, it would appear that greater uncertainty lies in areas other than the macro-economic forecast. The assumptions made on the manner and timing of implementation of measures to achieve the Kyoto limits will probably have a significantly larger impact on future growth in gas and oil demand than will alternative outcomes in terms of economic growth.

Table 7: Forecast Growth in Electricity Demand, annual average, per cent

	2000-2005	2005-2010	2010-2015
Central Forecast	3.9	3.3	2.5
High Growth	4.5	4.2	3.5
Low Growth	2.9	2.1	1.5

Table 8: Forecast Growth in Gas Demand, annual average, per cent

	2000-2005	2005-2010	2010-2015
Central Forecast	7.5	6.0	2.2
High Growth	9.9	5.3	3.2
Low Growth	6.4	5.2	1.6

In the central forecast, gas consumption is forecast to grow by 6.7% a year over the current decade. This compares with a compound growth rate of 5.6% over the last decade. This rapid increase occurs in spite of the forecast slow growth in primary energy demand over the current decade of only 2.1 per cent a year.

Without the assumption of an environmental preference for gas, especially in electricity generation, the rise would be significantly lower. The rapid growth in gas demand in the 2000-2010 is due to the assumption of fuel switching in the electricity sector.

These assumptions would mean, in the case of the Central Forecast, 71% of electricity generated in 2010 would come from gas. This is a very high degree of dependence and it would give cause for concern in terms of security of supply. If Moneypoint were kept fully operational and used in case of emergency this would reduce gas dependence in electricity to 62% in 2010.

Table 9: Forecast Growth in Oil Demand, annual average, per cent

	2000-2005	2005-2010	2010-2015
Central Forecast	1.1	1.2	1.6
High Growth	-0.2	2.6	2.2
Low Growth	0.8	1.1	1.6

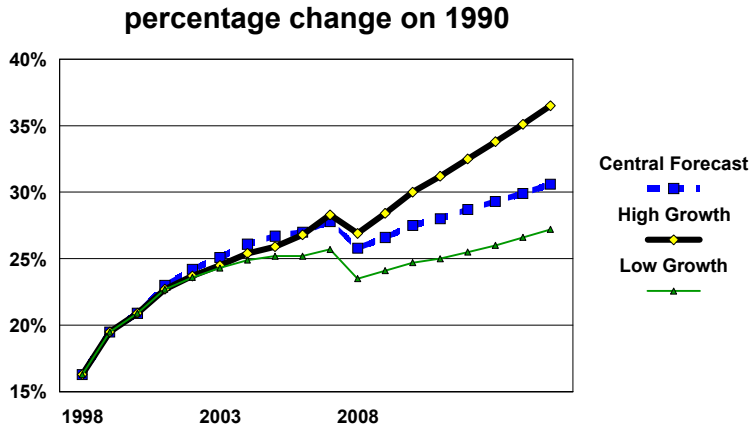
As shown in Table 9, in the case of oil in the "High Growth" scenario demand is actually projected to fall in the period to 2005. This reflects the assumption of a more rapid penetration of the electricity market by gas over the relevant period. The fall in demand for oil for the purpose of generating electricity and for space heating masks a substantial

rise in demand over the same period from the transport sector. As the process of fuel switching nears completion in the period after 2005, the projected increase in oil demand arising from the transport sector dominates and the overall increase in oil demand is significantly positive under all scenarios.

Table 10: Forecast Growth in Demand for Primary Energy, annual average, per cent

	2000-2005	2005-2010	2010-2015
Central Forecast	2.5	1.6	1.4
High Growth	2.6	2.2	2.1
Low Growth	2.1	1.3	1.3

Figure 3: Total Greenhouse Gas Emissions



On the basis of these forecasts for the growth in demand for different fuels to 2010, in the Central Forecast scenario greenhouse gas emissions, which are currently over 20 per cent above 1990 levels, would rise to over 27 per cent above 1990 by 2010 (Figure 3). This is a downward revision in our forecast compared to that published in the *Medium-Term Review*. This revision reflects a combination of more aggressive assumptions on the replacement of other fuels by gas, principally in electricity generation, and a somewhat lower elasticity of demand for energy with respect to rising economic activity. This latter change arises from a more detailed study of the effects of "maturing" on energy demand in a modern economy.

Finally, we have not prepared any macro-economic forecasts for the period after 2015 – there is no real basis for doing so. A reasonable assumption would probably be that Ireland would grow at what has been the recent capacity growth rate for the rest of Europe – 2.5% a year. Consumption of energy could rise at between 1.0 and 1.5 per cent per year. However, these are very crude guesses and significant further work on patterns of growth in other developed economies could help produce a more refined measure of the long-term relationship between GDP/GNP and energy demand.

Appendix 1

Household Demand for Electricity

The following detailed assumptions about household electricity demand are based on elasticities in Conniffe, 2000:

Household income elasticity with respect to personal disposable income is 0.35, and with respect to size is 0.07.

Change in number of households between 2000 and 2010	=	2.5% a year
Rise in nominal personal disposable income a year	=	7.6%
Rise in consumer prices a year	=	2.75%
Real personal income per household	=	2.2%
Household size	=	-1.4%
Electricity demand		
1.025*(1+(2.2*.35)/100)*(1+(-1.4*.07)/100)	=	3.2%