Cambridge Econometrics
Connecting you to the future

REWARD: Overview of the REEIO Model Development Programme

15 August, 2003

Cambridge Econometrics
Covent Garden, Cambridge CB1 2HS, UK
Tel 01223 460760 Fax 01223 464378
From abroad Tel +44 1223 460760   Fax +44 1223 464378
Email info@camecon.com
Website http://www.camecon.com

CONTENTS

1 INTRODUCTION

Context of the REWARD project

The REWARD project ('Regional & Welsh Appraisal of Resource Productivity & Development') is a partnership project working to ensure that regional and Welsh strategies are fully coordinated between economic development, resource productivity and environmental protection. It has three objectives:

1 development of the REEIO computer model (Regional Economy-Environment Input-Output model) to analyse the effects of economic trends and policies on resources and the environment

2 a research programme and database on resource productivity of the regions of England & Wales, showing the implications for policy and for business

3 applications and capacity building programme in each of the regions of England & Wales, enhancing strategic intelligence through workshops, training, toolkits, information systems, analysis and communications

This document focuses on the first of these objectives: the development of the REEIO model.

A tool to promote sustainable development

The context within which the project is located is the duty that the RDAs have to contribute to sustainable development in their regions, with respect both to the framing of their own policies and also their broader role in working with other regional partners, stakeholders and responsible agencies. In the text that follows, we discuss the objectives of the project, but one overriding point with regard to objectives is worth emphasising: although REEIO is a modelling project, *the model is not an end in itself*. Clearly the model must be technically sound, make the best use of the available data, and be implemented efficiently in software that is easy to use and to update. However, the success of the project depends critically on the effectiveness of the model as a tool for policy-makers to promote sustainable development in the regions. Hence, the design of the model must take account not only of technical considerations, but also of the practical requirements of the intended users. For example:

- the model should be capable of addressing the key policy scenarios of interest to users, so that it is relevant to policy questions
- the model's rationale and methodology should be clear, so that users understand the way in which outputs have been derived, and understand what the model can and cannot do; it should not be a 'black box'
- the scope of the indicators and processes covered by the model should be clear, so that its relevance as a tool can be located within the broader sustainable development agenda
- the process of installation of the model, with associated documentation, training and support is as important as the process of model development, so that users take full ownership of the model

2 OBJECTIVES

The objectives of the REEIO modelling project are set out below.

To develop a regional environmental-economic input-output (REEIO) model that

- would allow different economic policy options, economic growth (level and sectoral make-up) and resource productivity policy scenarios (eg different technological or recycling change scenarios) to be linked to a limited set of key environmental pressures
- could be well understood by, have credibility with and involve key stakeholders in its use to enhance the ability of the Partner RDAs and the Environment Agency to fulfil their duties to contribute to these regions' achievement of sustainable development in particular through contributing to
  - the current stakeholder dialogue on and understanding of these regions' sustainable development challenges
  - the better understanding of resource productivity of the regions' economies and consumers, and to the prioritisation of the collection of further data on this environmental performance
  - improved sustainability assessments of their Economic Strategies
  - prioritisation of economic policies for the optimum benefit for environmental objectives
  - the development of objectives for reduction of the overall pressures on the environment from their country's/region's economic activity and consumption

3 DEVELOPING THE REGIONAL ENVIRONMENTAL-ECONOMIC INPUT-OUTPUT MODEL

3.1 Issues that cut across all the modules

An existing regional economic input-output model

The original brief referred to the need for an existing regional economic model within which the modelling developed under the present contract would provide additional modules. Although it is not explicit in the brief, it is clear that this existing model must be 'stand-alone' for each region, so that a separate REEIO model could be established for any given region. The existing model that is being used for this purpose is the Local Economy Forecasting Model (LEFM). Details are provided in Annex 1.

Baseline national and regional economic forecasts

Although the brief focuses on the use of the model by users to produce scenarios under various assumptions for regional development and policy actions, it is clearly essential that the model is provided with an existing, realistic, baseline forecast against which such scenarios can be developed. Ideally this baseline forecast should also be consistent with a national forecast, and forecasts for other regions, so that the projections for the region can be compared both with historical trends and with comparable forecasts for the rest of the national economy; the possibility of making these comparisons is important if the baseline is to be owned by users and have credibility with the wider audience.

However, this is a far from trivial exercise. In the first place, a model that has been designed for detailed scenarios will not, automatically, generate sensible baseline forecasts. This is because the simplest way to ensure a 'plausible' long-term forecast is to adopt some sort of extrapolative approach; but a model whose equations are dominated by extrapolation over time will be unresponsive to the kind of economic and policy drivers that users want to see have an impact in the scenarios. We have already invested heavily in establishing methods to calibrate a model suitable for scenario work to plausible baseline projections, and this is how LEFM is currently delivered.

Secondly, the task of producing national and regional context forecasts to provide the baseline projection is, itself, a major exercise. CE was established in the late 1970s to provide model-based, commercial forecasting services in considerable disaggregation. Hence, the baseline forecasts used in the present project can draw on the outputs of these services and benefit from the programme of model development, analysis of current trends and review of future developments (which may make the future different from the past) that is a continuing feature of these services.

Baseline national energy use and environmental emissions forecasts

In some cases, the projections in the environmental modules will depend heavily on national policy initiatives. This is particularly the case with respect to greenhouse gas emissions, where the various central government policies (such as the climate change levy, negotiated agreements, and promotion of renewables) have important consequences for energy use and emissions by sector. Ideally, the influence of these policies should be capable of being represented in the baseline projections at regional level, so that regional policies are working within a realistic context. CE is a world leader in the modelling of energy use and greenhouse gas emissions and this project can draw on its regularly maintained long-term, disaggregated projections for energy consumption by user and fuel and the air emissions associated with energy consumption.

User requirements: inputs, outputs and scenarios

It is clearly essential to involve prospective users in the design of the model. In the course of the project the team is establishing the model's 'user requirements', expressed in the users' language. This covers the kind of inputs that users will want to enter, the kinds of outputs they expect to see, the kind of relationships they expect to be represented in the model, and the kind of scenarios that they can envisage wishing to undertake. Having gathered this information on user requirements, the project team will then specify the technical requirements, expressed in terms appropriate to guide software development, implied by these user requirements.

Consistency with the methodology used to construct data

A separate project undertaken by AEA Technology has developed data estimates which will support the modelling work. Close liaison is clearly important so that the model's requirements for environmental data are in fact met. But there is an additional reason for close liaison: it is important that where environmental data are not directly observable, the *methods* used to construct the data are consistent with the methods used in the model for forecasting. For example, the estimation of air emissions by SIC code at regional level need to be consistent with estimates of each (regional) sector's energy consumption by fuel which will be used in the model for projections.

Classifications

This is a technical point which we regard as key to the success of implementing the modelling, but about which the normal user need not be aware.

Our experience in undertaking disaggregated modelling (for example, by detailed industry, by type of waste, by type of air emission) has shown that there are very substantial benefits to organising the modelling around the fundamental concept of 'classifications'. A 'classification' represents a set of categories, typically mutually exclusive and exhaustive, which defines the level of disaggregation at which the model operates. For example, the definition of industries (by a suitable selection of SIC codes) represents the 'industry' classification in the model. Variables in the model are then defined on one or more classifications. For example, energy consumption might be defined on the classifications 'industry' and 'fuel', so that in any given year this variable would be represented by a 2-dimensional matrix of dimension 'number of industries' X 'number of fuels'.

The following examples illustrate some of the benefits of adopting classifications as a fundamental organising principle in the model. From a conceptual point of view, the use of classifications forces the modeller to consider systematically the relationships between variables: for example, emissions coefficients related to specific forms of energy consumption are sensibly applied to a variable defined on the ‘fuel’ classification, but not, say, to a variable representing aggregate energy use by industry (and so defined only on the ‘industry’ classification). From a model management point of view, the use of classifications reduces the risk of coding error and increases the flexibility of the model with regard to future changes. The model equations for a given variable are defined to operate over the whole classification. This represents a substantial simplification in coding. In the example given above for energy consumption by industry and fuel, a conventional modelling approach would require ‘number of industries’ X ‘number of fuels’ separately coded equations; in our approach just one equation is coded, and this is capable of applying separately estimated parameters for each of the ‘number of industries’ X ‘number of fuels’ equations that it represents. Similarly, this approach ensures that the model solution code is sufficiently general so as not to require any amendment if the classification (for example, the number and definition of industries) needs to be revised at a later date.

Sectoral disaggregation

The brief notes that specific sectors are of particular relevance to specific kinds of environmental pressures. We believe that the model’s industry classification should be sufficiently detailed to allow such sectors to be identified, but not so detailed as to make the model unmanageable or to make unrealistic demands on the economic data. Vaze (2001) recommends adoption of a 2-digit SIC disaggregation for manufacturing, and a 1-digit SIC disaggregation for services. However, we favour a somewhat greater level of disaggregation than this in services, partly because in the sustainable development agenda the nature of employment opportunities is important and these differ greatly from one service to another, and partly because the prospects for output and employment growth differ markedly across services, as reflected in the importance attached to particular services in the RDAs’ economic strategies.

The economic core of the model therefore uses the 49-sector classification that we currently use in LEFM (and also in our national and regional model, MDM). We believe that this has sufficient disaggregation to address the environmental themes currently of interest and that it offers sufficient flexibility to accommodate potential future modules. This approach should minimise the need for extensive pre-model calculations undertaken at a more detailed sectoral level than that maintained in the model. It makes considerable demands on the existing economic data (data are available for all sectors for employment, but the ONS’s regional accounts are somewhat less detailed), but our experience with LEFM has shown that implementation is feasible.

The definition of the sectors is shown in Annex 2.

Sectors and households

The brief emphasises the role of productive activity in generating environmental pressures, and so focuses on the sectors whose activity is responsible for these pressures. If the model was limited to these influences, it would not incorporate the impact that households have on environmental pressures, for example by using water, consuming energy, and generating waste. In our view the model should seek to represent all the areas of the economy that generate environmental pressures, and so we include households within the model.

'Constant coefficients', 'regional coefficients' and input-output modelling

There is some discussion in Vaze (2001) about the role of 'constant coefficients' in input-output modelling, and the limitations that this implies. It is worth clarifying this issue, since it is important for future scenarios in which resource productivity may be increased (implying a lower coefficient for inputs of the resource per unit of output).

The methodology that we adopt in modelling requires the completion of a full 'use matrix' (the input-output matrix of purchases by industry of inputs to production). It does not require that the elements of this matrix be filled in any particular way. One way of determining these values is to multiply constant input-output coefficients by industry gross output, but it is not the only way. In our modelling at the national level currently, the purchases of energy products by industries are, in fact, determined by econometric equations in which energy use responds to relative energy prices. Hence, the input-output coefficients for these purchases are endogenous, not constant. As another example, it is clear from analysis of long-term trends that some coefficients are subject to continual changes over time. For example, all industries are purchasing larger amounts of computing services than they used to. We represent this in our modelling by making assumptions for trend changes in selected input-output coefficients over time. These coefficients are therefore not 'constant' in the sense of unchanging over time, but they are exogenous (in any given year they will not differ among different scenarios).

Hence, the modelling framework that we are proposing is not limited in the way that the input-output coefficients are determined. We use assumptions for coefficients when we have no better method of determining their values. These assumptions can be made available to the user to change (for example, to implement off-model adjustments to reflect greater resource productivity), or they may be replaced by a method which determines their value within the model (for example, if equations were introduced to model water demand by industries).

Vaze (2001) also discusses the question of the work required to estimate regional input-output coefficients, and the literature that has developed on this subject. There are two issues here that should be distinguished:

1 the extent to which an industry in a given region has a different input structure (ie a different technology) from the national average, regardless of whether or not the inputs are sourced from within the region

2 the extent to which inputs are sourced from within the region

The first issue is the key one with regard to the use of resources by the region's industries. Much of the literature, including the discussion of the use of location quotients referred to in Vaze (2001), actually addresses the second issue.

Where there is information about the input structure of the region's industry, this can readily be incorporated in the input-output coefficients assumed in the modelling. Where no such information is available, we regard it as acceptable to use national input-output coefficients as a best guess for the technology adopted by the industry in the region. The question of sourcing is addressed below, where we discuss the concept of supply and demand balances for selected products.

The production/ consumption distinction, and boundary issues

This issue, which becomes more acute for smaller geographical areas, can be expressed as follows: should the environmental pressures to be estimated be defined as those that are produced in the region, or those that arise from the 'activities of residents' (including firms) of the region? The presence of coal-fired power generation in the region would boost average per capita emissions, but these emissions might be regarded as more properly the responsibility of those consuming the electricity, who may reside outside of the region. Similarly, should we count electricity consumption by households in the region as a source of emissions, given that there are no emissions at the point of consumption? Although the issue is stark in the case of electricity, the same argument could in principle be applied to any product: the emissions associated with steel production could be regarded as ultimately driven by, say, the demand for the cars in which the steel is used.

We adopt the following treatment.

1 Implications of demand

The model identifies the products, and hence the resources, consumed in the region, either as inputs to production or for final consumption (largely by households). It identifies the impact of this consumption/productive activity on the environmental indicators which are being modelled. For example, it will identify the air emissions directly associated with energy consumption in the region, the water consumed and the waste produced.

The indirect consequences of demand, in the form of the implied environmental impact embodied in imports, could in principle be calculated, on the basis of national averages. For example, the air emissions associated with imported electricity could be calculated on the assumption that the fuel mix required to produce the electricity was the national average. The question of how far to go with such indirect impacts is more a matter of intelligibility to the user than complexity in the modelling. Should the embodied energy content of steel imports be calculated? Or the embodied energy content of the steel contained in car imports? Currently we limit such calculations to the most high-profile case, ie the contribution of electricity consumption to primary fuel consumption and air emissions. This case is presented in a demand implications table as a 'memo item', clearly distinguished from the implications that are directly associated with consumption in the region.

2 Implications of supply

In the present project, there are a small number of cases where the scale of supply within the region is itself an environmental indicator of interest. For example, while we are interested in the consumption of water in the region, regardless of the source of that water, as an indicator of the extent to which efficiency measures have been introduced, we are also interested in the scale of water abstraction in the region, regardless of the destination of the water, because of its impact on amenity, river flow and groundwater stocks. In the same way, we treat the presence of landfill sites in the region as a supply of the service of waste disposal to landfill, the scale of which may or may not depend on the generation of waste within the region.

For these selected cases, and subject to the availability of data, model incorporates 'balances' which show the relationship between supply from within the region, demand from within the region, and imports and exports. In this way the extent to which the region is a net exporter or importer of these environmentally-sensitive products would be clear, as would the scale of such exports or imports relative to the region's own consumption.

Sub-regional spatial detail

Vaze (2001) rightly highlights the difficulties faced in developing regional estimates for environmental pressure indicators and then allocating these to particular locations within the region. This issue is of particular importance in cases where the importance attached to a given pressure depends critically on its location. For example, the impact on health of certain air emissions depends upon concentrations, rather than the region-wide volume of emissions. The impact of water abstraction may be similarly location-dependent. The impact of waste disposal (or other land-use issues that go beyond the scope of the present project, such as the commercial development of land) is related to location. The impact of transport use on congestion and the effectiveness of strategies to discourage private car use are clearly highly location-dependent.

The question therefore arises as to whether and how the results from a model defined at the regional level can be made relevant to specific locations. The principal difficulty is that of allocating the regional economic development indicators to sub-regions. One option is to produce a projection for sub-regional areas, consistent with the regional total, in which the geographical pattern of economic development is similar to that seen over the past. However, it may be an objective of policy to alter this pattern. An alternative is to allow the user to enter assumptions that would determine the allocation of the regional total among sub-areas. Once economic development has been allocated, there is then a basis for drawing out the implications for environmental indicators at the sub-regional level.

Since it is outside the scope of the brief, we have not pursued this issue further in the present project. However, in the future we may develop these ideas further into a formal specification of how sub-regional disaggregation might usefully be developed.

Software

The useability of the model is greatly affected by the software in which it is implemented. In choosing software we face the alternatives of

- general office software with which users are likely already to be experienced but which is not adapted to the specific task
- bespoke software which is tailored to the task but which users need to learn

In our view the complexity of a model with the disaggregation required to be useful for the present purpose rules out the use of spreadsheet software. Implementation in spreadsheets would be very cumbersome and the risk of programming mistakes would be high. LEFM's front-end is presently implemented in friendly Windows-based software, and we are extending this software to incorporate the additional modules.

The framework/platform for user development of 'off-model' calculations is particularly important. No modelling software can anticipate all the uses to which users might wish to put the model data and results, and users need to be able to manipulate these data in a software environment in which they are experienced, so that they can produce additional tables and charts to aid analysis, or combine the data from the model with other data to produce an analysis that addresses a fuller agenda than the model's scope permits. LEFM has been explicitly designed to accommodate this need: users can easily export data to spreadsheets, for example.

In considering the model design we considered the possibility of a web-based delivery of the model. There are clear advantages in this approach. There would be no installation requirements for users and anyone with access to the relevant web pages would have immediate access to the resource. Any model upgrades would not require distribution. However, there are certain issues to be overcome before web-based delivery could be implemented. To our knowledge, the only existing applications of this kind of approach consist of a set of very tightly delimited options for a relatively simple task. Many such web-based applications require the user to complete a form and then a process is run to extract information from a database. The scope of both the inputs required from the user and the outputs supplied are usually small: typically capable of being presented on a single page. In the case of most economic models, the number of input assumptions that the user might want to change is large enough to require a separate input screen (say, a separate web-page) for each assumption, and this poses important questions about whether such inputs would be stored with the client or the server. Similarly, the model results are typically large in number, and the normal method of handling this is to store the model results somewhere and allow the user to interrogate these. But in a conventional web application, the results of a user query are simply returned to the screen, not stored in a database unique to the user. Finally, users of economic models typically want to undertake various scenarios and compare the results, then modify assumptions and repeat the runs, and so on. Again, this raises important questions about the extent to which results are held on the server or transferred to be stored on the client's desktop. The present model is therefore being implemented as an extension to our existing LEFM software rather than delivered over the Web.

3.2 Waste arisings

We have considerable experience in modelling waste arisings at the national level, having developed a waste module for our national model, MDM, which established balances for the production of waste, of different types, and its management by different routes, in order to model the impact of the landfill tax[1]. The production of industrial and commercial waste was projected on the basis of each industry's purchases of input products, weighted by a coefficient representing the weight per £1 purchase of each product.

The same kind of approach is being implemented at the regional level. We allow for assumptions for imported waste (disaggregated by stream) and for a disposal route that represents exported waste. The classifications for waste arisings and waste management routes are shown in Annex 2.

As noted earlier, waste management services represent a case where we are interested not only in the demand in a region (ie the waste produced) but also in the supply (ie the

1 See Cambridge Econometrics (1996).

presence of waste management sites), because of the consequences that management sites have for various environmental pressures. We establish a simple supply and demand balance, which includes net exports of waste and shows the projected waste to be disposed of within the region.

3.3 Water use

We have extensive experience in modelling water demand, having undertaken numerous studies for water companies and having prepared the industry standard manual[2] recommending best-practice methods for water demand forecasting.

The approach that should be taken in modelling depends to some extent on data availability. The conventional approach adopted in the industry is to distinguish the following 'components' (categories) of demand:

- unmeasured household demand
- measured household demand
- measured non-household demand
- other (leakage, unmeasured non-household demand, meter underrecording etc)

For each of these components, an appropriate methodology is then applied.

With regard to household demand (whether measured or not), methods vary from the simple (multiply projected per capita consumption by projected population) to the more sophisticated (the 'microcomponents approach', in which per capita consumption is itself determined by assumptions for the penetration, use and water efficiency of water-using appliances). The advantage of the latter approach is that it makes explicit the relationship between changes in technology/behaviour and per capita consumption; its disadvantage is that it is very data-intensive and unlikely to be feasible.

With regard to measured non-household demand, the recommended approach for long-term forecasting is to link this to economic activity in the region. Since the water companies typically do not have long time series for water consumption by detailed SIC code, the usual approach is to aggregate industries into two groups, broadly 'industrial' and 'commercial' (approximately manufacturing and services). The activity indicator used for 'industrial' is usually a measure of output (typically value added in constant prices); the activity indicator for 'commercial' is often employment, since water use in this sector is often people-related.

The water industry's own experience in modelling has typically focused on the demands on the public water supply. Clearly, from the point of view of environmental sustainability we are interested also in own abstraction, which is important in agriculture and also in certain sectors where heavy use of water at specific large locations makes it economic to invest in abstraction from boreholes. However, data on such abstractions are typically poor. Users will have a licence that sets a limit as to the maximum amount

2 UKWIR and Environment Agency (1997).

that may be abstracted, but this may exceed by a considerable margin the amount that they are actually abstracting. However, in the absence of anything better it may be necessary to use these data as a guide.

We suggested earlier that water represents a case where we are interested not only in the demand for water in a region but also in the supply, because of the consequences that increased water gathering and abstraction have for various environmental pressures. We propose to establish a simple supply and demand balance, which includes net exports of water and shows the projected use of the region's water resources. For long-term purposes it may be necessary to include assumptions about the development of future resources, for which planning permission may not yet have been sought or obtained. It is not envisaged, however, that detailed supply characteristics (such as current limits on pipeline capacity) would be included: the aim is simply to reveal the broad features of the region's supply and demand balance.

3.4 Energy use

We have extensive experience in modelling energy use disaggregated by user industry and fuel, going back to the founding of CE in the late 1970s. Since the 1980s much of this modelling has been driven by the information requirements of the environmental policy agenda, and so our model development has been designed to produce results that are relevant to these requirements. Our *UK Energy-Environment-Economy service* provides regular forecasts, updated twice a year, for energy consumption by user industry and fuel, following the detailed energy classifications available in the *Digest of UK Energy Statistics*; to our knowledge these are the only such comprehensive forecasts produced regularly outside of government. We undertake energy modelling projects for the DTI and DEFRA. We have undertaken for one RDA what to our knowledge is the first project in this country to model energy use and greenhouse gas emissions for a UK region.

In brief, we propose to adapt to the regional level the modelling that we have already developed at the national level. The classifications for fuel users and fuels are noted in Annex 2.

The modelling would determine fuel use by user on the basis of the scale of activity (level of output, for industry sectors) of the fuel user and the relative prices of fuels, with econometric evidence from the national level to calibrate the parameters. Power generation may deserve special treatment because the region's power stations will have particular characteristics: in our national model we identify all the UK power stations and their energy-use characteristics. Similarly, the implementation of CHP plants by sector will deserve special treatment: probably it will be appropriate to allow users to enter specific assumptions for the diffusion of this technology among the different sectors, which would require some pre-model calculations.

The treatment of road transport requires particular consideration. While it is feasible to model the demand for road transport on the basis of broad economic indicators (for example, incomes and fuel prices), this may not represent sufficient detail to represent the kind of policies that are of interest at the regional level. A more detailed approach, which we are implementing, involves explicitly modelling passenger and freight kilometres, vehicle kilometres and fuel consumption by type of vehicle. A policy which succeeded in encouraging greater use of public transport would then be reflected in fewer car vehicle kilometres and more bus vehicle kilometres, with a net reduction in fuel use, and possibly in less congestion and hence lower fuel use per vehicle kilometre. This framework therefore makes explicit the indicators which should be affected by policy. However, the costs of this approach are clearly the demands that it makes on data (including data construction) and the greater complexity both with regard to modelling and with regard to the user's understanding of the model.

3.5 Air emissions

As noted under Section 3.4, we have extensive experience in the modelling of air emissions associated with energy use, and we are currently undertaking a project for one RDA to implement a model explaining and projecting greenhouse gas emissions in its region. CE's chairman, Dr Terry Barker, is a world expert in the economy-energy-environment modelling of greenhouse gas emissions, and served as a coordinating lead author and member of the report synthesis team for last year's report of the Intergovernmental Panel on Climate Change.

The method that we are adopting for air emissions is as follows:

- establish a classification of air emissions types
- establish a classification of air emissions sources; for energy-related emissions this would include the fuel user classification noted in Section 3.4; it would also include sources that are not related to current energy consumption such as methane emissions from agriculture; it would also include carbon sequestration (as a 'negative source')
- for each emissions source, identify what are conceptually the most relevant 'activity' indicators which drive each type of air emission; for GHG emissions this will often be consumption by specific fuel
- develop equations in which air emissions (by type) are driven by the activity indicators, taking account of the technological possibilities of mitigation

Hence, the aim would be to determine air emissions in the model by

- the sectoral composition of the region's GDP
- for energy-related emissions, the energy-efficiency of production technologies and the fuel mix, together with the analogous factors in transport and household energy use
- for non-energy emissions, the scale of the relevant 'activity' indicator
- the diffusion of mitigation technologies

The classifications are shown in Annex 2.

4 TIMETABLE

Delivery of the modules of REEIO is currently scheduled as follows:

Waste	April 2003
Energy and transport	October 2003
Air emissions	October 2003
Water	January 2004

ANNEX 1 THE LOCAL ECONOMY FORECASTING MODEL (LEFM)

LEFM has been developed by CE in collaboration with the Institute for Employment Research at the University of Warwick. It is, to our knowledge, the only software package in Europe tailored to model regional and local economies and designed to conventional commercial software standards. It has been commercially available since the early 1990s (since when it has been continually developed) and is designed to empower organisations to undertake detailed economic analysis in-house. It is used extensively by local agencies, including local authorities, and by CE for more specialised analysis often commissioned by development agencies.

LEFM has been designed to project economic indicators for a local area by explaining the output of local industries through an explicit representation of expenditure flows in the area and their links with the world outside the local area. In this it differs from other methods of local economy modelling which typically link local output or employment (by sector) directly to national or regional output or employment. While these other methods allow a user to derive projections for local output or employment growth from national or regional projections, they offer little scope for introducing an explanation of local performance relative to these higher levels, and they are typically not suitable for analysing the indirect effects on the local economy arising from the opening of a new enterprise or the closure of an existing one.

LEFM is also distinguished from other approaches by its sectoral detail. It identifies 49 sectors (defined on SIC92), allowing (for example) electronics to be distinguished from electrical engineering, and computing from other business services. Detailed disaggregation by sector is usually valuable because different sectors have different prospects (eg technological change is driving much faster growth in electronics and computing than in the other sectors with which they are commonly combined), because they have different employment characteristics, and also because it allows local knowledge about specific firms to be more easily incorporated in the forecast. There is, however, a cost to working in such detail: most variables in the model have to be disaggregated by sector (or a similar classification: see below for more details).

LEFM's structure draws heavily on that of MDM, Cambridge Econometrics' multisectoral model of the UK economy and its regions, and it shares the same model solution software.

The main input assumptions used in LEFM are:

- forecasts for the UK and, where appropriate, the region in which the local economy lies for selected variables, including
  - the components of domestic final expenditure, disaggregated into spending by function as published in the UK National Accounts
  - components of personal incomes

  - gross output, value-added and employment by 49 sectors (essentially the two-digit sectors that Vaze (2001) recommends)
  - matrices to convert the components of domestic final expenditure into commodity demand for 49 sectors
  - input-output coefficients and projected changes
  - projected changes in occupational structure and gender

- forecasts for the region/local economy
  - population by 5-year age band and gender
  - participation rate by gender for a constant level of unemployment (these are then adjusted by the model in response to actual changes in unemployment)

Outputs for the region/local economy currently include:

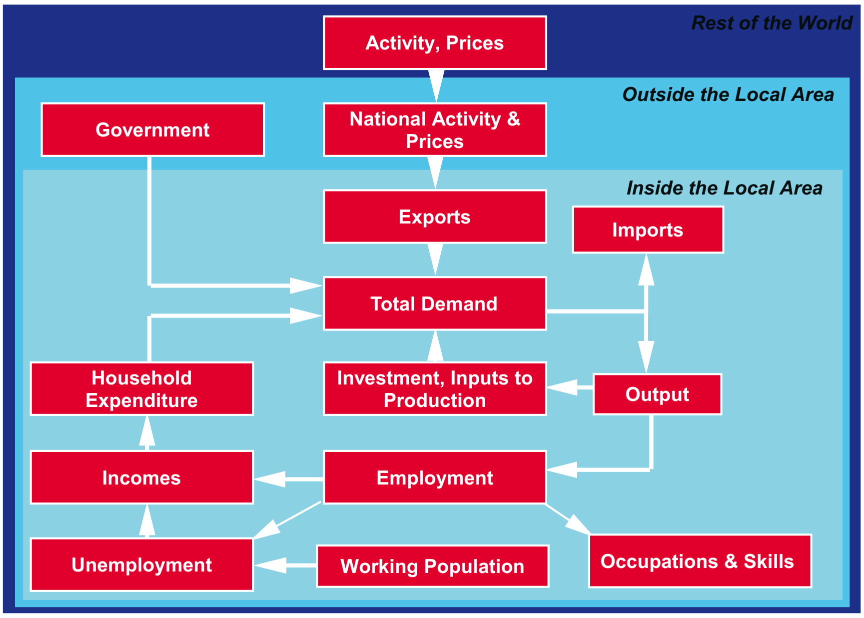
- gross output, value-added and employment by sector
- employment by gender and status
- employment by occupation
- components of final expenditure (exports and imports are treated as to/from the local economy)
- personal incomes (currently in total only, but a breakdown by income group could be developed)
- demographic indicators, including unemployment

Figure A1.1 summarises the model's accounting structure, which follows the social accounting matrix approach adopted in MDM. In most cases, the variables shown in the diagram are disaggregated (eg by sector for output and employment).

Each industry's gross output is determined as the difference between commodity demand (the sum of demand coming from the final expenditure components together with intermediate demand coming from production in the local economy) and imports to the local area. Each industry's value-added is assumed to be in the same proportion to its gross output as is the case for the region as a whole.

Employment in the region/local area generates incomes. Assumptions are made for net commuting, which determines the extent to which incomes from local employment accrue to non-residents. Similarly, some incomes in the local area are derived from employment outside the area, or from non-employment sources (eg unemployment benefit). Aggregate household expenditure by residents in the local area is determined by real household disposable incomes (deflated by the national household expenditure deflator) and projections for the household saving ratio (derived from changes in the regional household saving ratio). Household expenditure is then disaggregated into spending by function according to the proportions forecast for the region.

FIGURE A1.1: PRINCIPAL RELATIONSHIPS IN THE LOCAL ECONOMY FORECASTING MODEL



Government final expenditure (disaggregated by type) in the regional/local economy is projected on the basis of changes in the region/local area's share of the region's population.

Investment by sector is determined by a simple relationship with output. Projections for social investment (eg education, health) and investment in social services (eg roads), which are treated as assumptions at the UK level in MDM, are currently allocated to the local area according to population changes.

Intermediate expenditure by sector and commodity is determined by applying the national input-output coefficients to local economy gross output by sector.

Exports by sector from the local economy are linked to national gross commodity output in each sector. In effect, local firms are treated as competing in the national pool. Export projections then depend upon UK gross commodity output in each sector, and on assumptions for trends in the local economy's share of this output. In some cases, simple methods have been tried to model these export shares (eg to represent the effects of policies to promote inward investment). Imports by sector to the local economy depend on the demand for commodities in the local economy and on assumptions for import shares.

Employment by sector is determined by gross output and trends in productivity per person employed derived from regional projections (which in turn are derived from econometric estimates). Employment by gender and type is determined by the sectoral composition of employment and local information on the representation of genders and types of employment in each industry The default projections for trends in this representation are based on historical data for the local area, with the user given the option to change these default values. A similar procedure is followed for employment by occupation.

Projections for the resident workforce are derived from assumptions for the population for working age (by gender) and projected participation rates which vary with the unemployment rate. Unemployment is the difference between the workforce, local employment and ‘net commuting’.

Scenarios can be determined, driven by alternative assumptions for

- the UK economy (LEFM has ‘high’ and ‘low’ growth scenarios for the UK and the regions)
- demand for individual industries (structural change)
- population (by age and gender)
- activity rates (by age and gender)
- labour market dynamics
- future change in structure of occupations

LEFM allows users to examine the impact of alternative national scenarios on the local economy. For example, a ‘strong-sterling’ scenario can be prepared using MDM to assess the sensitivity of different industries to a high exchange rate. To the extent that the local economy has a high representation of vulnerable industries, output and employment in these industries will be affected in LEFM. The explicit social accounting matrix structure then allows the local multiplier effects to be fully represented, with the greatest effects on those industries that appear to depend mainly on local area demand.

ANNEX 2 SELECTED CLASSIFICATIONS PROPOSED FOR THE MODELLING

Waste arisings	1	Industrial - inert
	2	Industrial - non-inert biodegradable
	3	Industrial - non-inert non-biodegradable
	4	Industrial - hazardous
	5	Commercial - inert
	6	Commercial - non-inert biodegradable
	7	Commercial - non-inert non-biodegradable
	8	Commercial - hazardous
	9	Municipal - household - inert
	10	Municipal - household - non-inert biodegradable
	11	Municipal - household - non-inert non-biodegradable
	12	Municipal - household - hazardous
	13	Municipal - other waste - inert
	14	Municipal - other waste - non-inert biodegradable
	15	Municipal - other waste - non-inert non-biodegradable
	16	Municipal - other waste - hazardous
	17	Construction & demolition - inert
	18	Construction & demolition - non-inert biodegradable
	19	Construction & demolition - non-inert non-biodegradable
	20	Construction & demolition - hazardous
	21	Agricultural - inert
	22	Agricultural - non-inert biodegradable
	23	Agricultural - non-inert non-biodegradable
	24	Agricultural - hazardous
	25	Mining
	26	Sewage sludge
	27	Power station ash
Waste management routes	1	Landfill - active
	2	Landfill - inert
	3	Landfill - hazardous
	4	Recycling (excl composting)
	5	Composting

	6	Thermal
	7	Other recovery processes
Fuel users	1	Power generation
	2	Other energy transformation
	3	Energy industries’ own use: electricity generation
	4	Energy industries’ own use: other
	5	Basic metals
	6	Mineral products
	7	Chemicals
	8	Pharmaceuticals
	9	Mechanical engineering
	10	Metal goods
	11	Electronics
	12	Electrical engineering
	13	Instruments
	14	Motor vehicles
	15	Aerospace
	16	Other transport equipment
	17	Food
	18	Drink
	19	Tobacco
	20	Textiles
	21	Clothing & leather
	22	Paper, printing & publishing
	23	Other mining
	24	Wood & wood products
	25	Rubber & plastics
	26	Manufacturing nes & recycling
	27	Water supply
	28	Construction
	29	Air transport
	30	Rail transport
	31	Road transport
	32	National navigation and pipelines
	33	Domestic use (households)
	34	Public administration & defence

	35	Education
	36	Health & social work
	37	Retailing
	38	Distribution nes
	39	Hotels & catering
	40	Other transport services
	41	Communications
	42	Banking & finance
	43	Insurance
	44	Professional services
	45	Computing services
	46	Other business services
	47	Agriculture
	48	Waste treatment
	49	Miscellaneous services
	50	Miscellaneous
Air emissions	1	Carbon dioxide (CO2)
	2	Sulphur dioxide (SO2)
	3	Nitrogen oxides (NOx)
	4	Carbon monoxide (CO)
	5	Methane, (CH4)
	6	PM10 (black smoke)
	7	Volatile organic compounds (VOCs)
	8	Nuclear emissions to air
	9	Lead emissions to air
	10	Nitrous Oxide (N2O)
	11	Hydrofluorocarbons (HFCs)
	12	Perfluorocarbons (PFCs)
	13	Sulphur Hexafluoride (SF6)
Direct (non-energy) sources of air emissions	1	Emissions directly from agriculture
	2	Emissions directly from coal mines
	3	Emissions directly from landfill
	4	Carbon sequestration (negative)
Fuels	1	Coal and coke
	2	Motor spirit

	3	Derv
	4	Gas oil
	5	Fuel oil
	6	Other refined oil
	7	Gas (natural gas, coke oven gas and town gas)
	8	Electricity
	9	Nuclear electricity
	10	Landfill gas (renewable-obligation)
	11	Waste (Renewable-obligation)
	12	Other Renewable-obligation renewables
	13	Other renewables
	14	Heat sold
Greenhouse gas types	1	Carbon dioxide (CO2)
	2	Methane, (CH4)
	3	Nitrous Oxide (N2O)
	4	Hydrofluorocarbons (HFCs)
	5	Perfluorocarbons (PFCs)
	6	Sulphur Hexafluoride (SF6)
	7	Emissions implied by electricity consumption

TABLE A2.1: MDM95 AND LEFM INDUSTRIES DEFINED IN TERMS OF THE 1992 AND 1980 STANDARD INDUSTRIAL CLASSIFICATIONS

	MDM9	SIC92	SIC80
1	Agriculture	01, 02, 05	0
2	Coal	10	11
3	Oil & Gas etc	11, 12	13
4	Other Mining	13, 14	21, 23
5	Food	15.1-15.8	41-423
6	Drink	15.9	424-428
7	Tobacco	16	429
8	Textiles	17	43
9	Clothing & Leather	18, 19	44, 45
10	Wood & Wood Products	20	461-466
11	Paper, Printing & Publishing	21, 22	471-475
12	Manufactured Fuels	23	12, 14, 152
13	Pharmaceuticals	24.4	257
14	Chemicals nes	24 (ex 24.4)	25 (ex 257), 26
15	Rubber & Plastics	25	48
16	Non-Metallic Mineral Products	26	24
17	Basic Metals	27	221-224, 311
18	Metal Goods	28	312-319, 320
19	Mechanical Engineering	29	321-329, 346
20	Electronics	30, 32	33, 344, 345
21	Electrical Engineering	31	341-343, 347, 348
22	Instruments	33	37
23	Motor Vehicles	34	35
24	Aerospace	35.3	364
25	Other Transport Equipment	35 (ex 35.3)	36 (ex 364)
26	Manufacturing nes & Recycling	36, 37	467, 49
27	Electricity	40.1	161
28	Gas Supply	40.2, 40.3	162, 163
29	Water Supply	41	17
30	Construction	45	5
31	Retailing	52	64/65 (ex 651/652)
32	Distribution nes	50, 51	61-63, 651/652, 67
33	Hotels & Catering	55	66
34	Rail Transport	60.1	71
35	Other Land Transport	60.2, 60.3	72
36	Water Transport	61	74
37	Air Transport	62	75
38	Other Transport Services	63	76, 77
39	Communications	64	79
40	Banking & Finance	65	81
41	Insurance	66	82
42	Professional Services	67, 73, 74.1-74.4	831, 832, 835-838, 94
43	Computing Services	72	8394
44	Other Business Services	70, 71, 74.5-74.8	834, 8395-6, 84-5, 923
45	Public Administration & Defence	75	91
46	Education	80	93
47	Health & Social Work	85	95, 961
48	Waste Treatment	90	921
49	Miscellaneous Services	91-99	9 (rest of)
50	Unallocated		

ANNEX 3 BIBLIOGRAPHY

Cambridge Econometrics (1996) *UK Landfill Tax Study, Part 1*, A report for the European Foundation for the Improvement of Living and Working Conditions.

Collison, P. & Kennedy, J. 1989 'Residence and Place Image', *Planning Outlook*, Vol.32 No.2, pp.128-133.

DETR (Department for the Environment, Transport and the Regions) 1999a *A Better Quality of Life: a Strategy for Sustainable Development for the United Kingdom,* Cm 4345, The Stationery Office, London.

DETR (Department for the Environment, Transport and the Regions) 1999b *Quality of Life Counts*, DETR, London.

DETR (Department for the Environment, Transport and the Regions) 2000a *Regional Quality of Life Counts*, December, DETR, London.

DETR (Department for the Environment, Transport and the Regions) 2000b *Local quality of Life Counts*, July, DETR, London.

Ekins, P. & Simon, S. 1998 'Determining the Sustainability Gap: National Accounting for Environmental Sustainability' in Vaze, P. Ed. 1998 *UK Environmental Accounts: Theory, Data and Application*, Office for National Statistics, London, pp.147-167.

Ekins, P. 2001 'From Green GNP to the Sustainability Gap: Recent Developments in National Environmental Economic Accounting', *Journal of Environmental Assessment, Policy and Management,* Vol.3 No.1 (March), pp.61-93.

Findlay, A.M. et al. 1988 'Where to Live in Britain in 1988: Quality of Life in British Cities', *Cities*, Vol.5 No.3, pp.268-276.

Grayson, L. & Young, K. 1994 *Quality of Life in Cities: an Overview and Guide to the Literature*, The British Library, London.

Jesinghaus, J. 1999 'Indicators for Decision-Making', mimeo, European Commission Joint Research Centre, Ispra

PIU (Performance and Innovation Unit) 2001 *Resource Productivity: Making More with Less*, November, PIU, Cabinet Office, London.

Rogerson, R.J. et al. 1989 'Indicators of Quality of Life: Some Methodological Issues', *Environment and Planning A*, Vol.21 No.12, pp.1655-1666.

UKWIR and Environment Agency (1997) *Forecasting Water Demand Components - A Best Practice Manual,* Report Ref. No. 97/WR/07/1, prepared by Cambridge Econometrics.

Vaze, P. 2001 *Welsh and Regional Economies' Resource Productivity*, R&D Technical Report E2-053/TR, ECOTEC Research and Consulting, Environment Agency, Bristol.