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# D4.1
# Report on Existing Data and Data Requirements

**30 November 2011**

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IER

# Analysis of data requirements for the proposed models

## ATEsT Report on Existing Data and Data Requirements

### Deliverable D4.1

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ATEsT

http://www.atest-project.eu/

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## Abstract

The objective of this work package is to analyse and evaluate the data and/or qualitative information that are currently in use in different models and tools. Furthermore, the objective is also to show the additional data or information needs to improve the existing models and tools or even to developed new ones.

To structure this data assessment, different model families are defined. Different types of models or model combinations are needed to answer different policy questions. Depending on the type of the model or tool, the currently used data sources and data as well as the additional data needs to improve or extend the model clearly differ. The model type determines the data which are used. In this report, both existing data and additional data needs are analysed in detail by model family.

For instance, Energy System Models cover in general a wide range of sectors and countries in detail. Therewith it is one key issue to get all data for all sectors and countries. Other model types face the challenge that they need very detailed data only for one explicit sector or market or in a very high time resolution like Sector Level or Disaggregated Models. In addition to quantitative models, also information used by Energy Behaviour Tools is highlighted. The main emphasis of Energy Behaviour Tools is in understanding and impacting the behaviour of various stakeholders including consumers and citizens, rather than modelling and analysing the energy system transitions. These types of tools need behavioural data on a specific-context which quality depends on the commitment of the stakeholders. A summary of the main characteristics of the data or other information currently in use, their weak points and the additional data needs by model or tool type are summarized in the following tables.

**Table 1:** Data characteristics by model family

| Model Family | Data characteristics |
|---|---|
| Energy System | • Detailed data for energy supply and demand sectors and different regions |
| Macroeconomic | • Highly aggregated macroeconomic information |
| Sector Level | • Detailed data on one specific issue/ sector |
| Disaggregated | • Detailed data on a specific part of the energy system |
| Energy Behaviour | • Mainly context-specific qualitative and semi-qualitative information |

**Table 2:** Weak points by model family

| Model Family | Weak points of existing data |
|---|---|
| Energy System | • Difficult to get data in the same quality for all regions<br>• Different accounting methods in different regions and inconsistencies<br>• Differentiation between conversion and industrial sector<br>• Interpretation of values for specific consumption |
| Macroeconomic | • Low frequency and significant time lags<br>• Poor representation of technologies and preferences in substitution elasticities |
| Sector Level | • Missing updates for some sectors of the reference data |
| Disaggregated | • Difficult to get all necessary data about existing power plants due to confidential reasons<br>• Data for renewables have to be more frequently updated and must refer to the actual technologies<br>• Due to the use of very detailed and specific data, the model can't be easily adopted for another country |
| Energy Behaviour | • Data quality strongly depends on involved stakeholders and their commitments and therewith the quality varies by context<br>• Data from different contexts usually not comparable |

**Table 3:** Additional data requirements by model family

| Model Family | Additional data requirements |
|---|---|
| Energy System | • Data about the stock of technologies which are currently in use<br>• Costs data for new technologies<br>• Data about buildings like number of floors, age structure or reconstruction information<br>• Load curve data for different commodities and sectors |
| Macroeconomic | • Worldwide consistent national Social-Accounting-Matrices with direct connection to Physical-Input-Output-Tables<br>• Inclusion of durable goods in National Accounts<br>• More profound behavioural and technology information |
| Sector Level | • Reference values for the single sectors to evaluate efficiency measures have to be updated<br>• Adding data for new technologies and measures |
| Disaggregated | • Information about the thermal vs. electric generating performance of thermal plants<br>• Forecasting of load duration curves and demand evolution<br>• Data for increasing RES integration and electricity storage<br>• Information about demand-price relationships and public acceptability |
| Energy Behaviour | • New and context-specific information sources are needed for specific energy projects<br>• Establish a "case library" (project documentation) to learn from previous projects<br>• In a new process always the relevant various stakeholders and their experiences, interests and expectations have to be considered |

# 1 Introduction

In order to achieve the goals of the European energy and climate change policy in terms of greenhouse gas emissions, security of energy supply and competitiveness, the development and deployment of a diverse portfolio of low carbon energy technologies play a pivotal role (An Energy Policy for Europe COM (2007)1).

The European Strategic Energy Technology Plan (SET-Plan), adopted by the Commission on 22 November 2007, is the European Union's response to the challenge of accelerating the development of a low carbon future, leading to the market take-up of low carbon energy technologies. This plan comprises measures relating to planning, implementation, resources and international cooperation in the field of energy technology.

## 1.1 The ATEsT Project

The implementation of the SET-Plan involves different pillars:

• Effective Implementation:
  - Creating European Industrial Initiatives (EII), focusing on technologies for which the barriers, scale of investments and risk can best be tackled collectively.
  - Creating a European Energy Research Alliance (EERA), to enable greater cooperation across Europe of the research work going on in universities, research institutes and specialized centres.
  - Planning the transition of European energy infrastructure networks and systems.

• Joint Strategic Planning:
  - Creating a European Community Steering Group on Strategic Energy Technologies, which allows Member States and the Commission to plan joint actions and coordinate policies and programmes.
  - Establishment of an information system on energy technologies and their innovation aspects, geared to supporting the decision-making of the SET-Plan (SETIS).
  - Annual SET Plan summits.

• Increase in resources, both financial and human, and enhance international cooperation.

In the framework of the SET-Plan implementation pillar, related to addressing future European energy infrastructure networks and systems transition planning, the European Commission has launched an FP7 Support Action named ATEsT (Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System).

The aim of the ATEsT project is to address the methodologies and modelling toolbox required to support the decision making of the SET-Plan Steering Group in the priority area of transition planning of the deployment of low carbon technologies and their supporting infrastructures. ATEsT is a joint effort between 6 European research institutes (CRES, ECN, ENEA, IER, VTT, PSI, CIEMAT, EIHP) and the JRC (the organization managing SETIS).
The "tools" that were evaluated in the framework of ATEsT are methodologies for the analysis of energy policies and mathematical models that can be used in order to simulate/optimize the development of the energy system or analyse the transition planning in the energy system. The scope of the ATEsT project includes models and tools from both inside and outside Europe.

The objectives of the project are to:

1. Review models/tools used in European Countries, bearing in mind what is used outside Europe and what are the requirements of the SET-Plan.
2. Identify and recommend combination of tools and/or methods to be used in the Member States, across the whole of the EU or specified EU regions, and in SETIS.
3. Identify and recommend existing sets of data (on technologies, energy resources, statistics, etc.), and provide a roadmap for the development of the data at European and regional levels.
4. Identify the roadmap for the improvement and development of the tools and methods in order to cover the needs of the SET-Plan implementation and finally create a framework for tools necessary to plan and deploy future energy systems and policies.

## 1.2 Contribution of Work package 4

The ATEsT project is split into seven work packages. The first three work packages deal with the definition of requirements of the models and tools output (specifications), the analysis of existing models based on these specifications and the ranking of models and model combinations. After the development of a tool for the model selection according to the policy question which should be answered (WP 3 output), in work package 4 (WP 4) the data and corresponding data sources used in the models are analysed.
The contribution of WP 4 to the ATEsT project is to assess the currently used data and to analyse additional data requirements. Therefore an overview and inventory of data sources used in the different types of model families and the information taken from this sources is provided in a first step. In the second step, all data which are used are evaluated according to their quality and availability and the weak points of the existing data are described. In the

third step of this work package, the additional data requirements to improve the models themselves and therewith the quality of their outcomes, are described.

The data analysis is based on the work done in previous work packages. To organize the evaluation of the data sources and the analysis of the additional requirements, the work is structured according to the different model families. This clustering is related to the model types described in WP 2 (see Amerighi, Ciorba and Tommasino 2010: Deliverable 2.1 ATEsT Models Characterization Report)[1]. The work of WP 4 helps to validate some of the tools which are characterized in this report by assessing the quality of their data sources. This work is connected to the work of WP 5 in which the tools using the existing data will be evaluated. Further on, the Work Package 6 will formulate suggestions for the future tools development based on the analysis of additional data needs issued from this report.

[1] http://www.cres.gr/atest/pdf/D_2_1_Models_Characterisation_Report.pdf

# 2 Methodology

The objective of this work package is to identify in a first step the existing data and/or information sources which are currently used in the different model and tool types. In the second step, the data and qualitative information taken from these sources are evaluated and their weak points are described. Finally, additional data and other information requirements are analysed. Identifying these needs could help improving models and tools by improving the quality of their outputs. The updated data based on the additional needs could generate information of a higher quality and reliability in replacement of, for example, some assumptions or calculations while keeping the existing model structure. Data needs could also suggest developing new tools or extending the structure of the existing tools, such as for example a more detailed geographical or time resolution.

For an evaluation of the data sources and data used by the different models, a very deep knowledge of the models or tools is needed. For this reason, only specialists deeply involved in the models generation could be asked to perform the data evaluation for their own model. For practical reasons (ATEsT now covers 85 models) not all models included in the Work Package 2 could be assessed individually. However this WP attempts to cover the data and information and also the additional data needs of the model or tool types described in WP2 by relating to model families, instead of single models. The model families are chosen the same as those used in WP2: Energy System Models, Macroeconomic Models, Sector Level Models, Disaggregated Models, Energy Behaviour Tools, Socio-Technical Scenarios and Horizon Scanning Methodologies. The models within the same family share a similar structure and use comparable data. Therefore the additional needs are connected to the same family type. Each model family is represented by one key model example which is analysed in detail. Other models within the same model family were also considered if data was available. Data issues found for the analysed models were assumed to hold for all models within that family. In addition to qualitative model, also the information used by different types of tools is highlighted. Typically the above mentioned Energy Behaviour, Socio-Technical and Horizon Scanning tools and methodologies use also qualitative information, which might be gathered by stakeholder interviews or different surveys, for example.

The work of collecting and evaluating the existing data sources and data itself as well as the analysis of the additional requirements is split among the ATEsT project partners to gain expertise for different model types. In addition to the work of the ATEsT project partners, an Open Call was launched in order to include the input of other modelling teams (called *external* modelling teams in this report).

To structure these three steps, i.e. data source collection, existing data evaluation and data needs analysis, a data collection list is developed within this WP. The results obtained from this list are presented in five appendixes attached to this report. The list provides predefined data categories in order to evaluate the data and to generate a standardized assessment. By using this approach the different sources should be comparable. The following paragraphs describe in detail the structure of this data list.

### 2.1 Data sources and information used in the model families

The first step in the existing data analysis is to define the name of the specific model analysed and the model family/group which this model belongs to. The second step is the description of the data sources and information using different parameter categories. Several questions in the inventory have answers predefined in drop down menus which are shown in Table 4. The remaining data categories are described by using free text.

The categories and sub-categories which have to be filled for the inventory are:

- Data Source:
  - Name of the data source [free text]
  - Classification of the data source [predefined]
- Category of data, split in main and additional (if needed) category of data [predefined]
- Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) [free text]
- Sector coverage of the data
  - Sector which is covered [predefined]
  - Additional comments on the sector coverage if needed [free text]
- Geographical resolution of data [predefined]

The objective of this part of the data list is to create an inventory of the various sources and describe the data taken from these sources. Therefore it is important to clearly point out which specific data were taken from which source. After establishing the model family, the specific model and the name of the data source, this source and the related data are sorted in classes. The classification of the data sources ranges from official statistical sources which are publicly available to interviews with experts or stakeholders (Table 4).

In addition, the data should be described more in detail in order to understand which part of a source is used in this specific case. An example is to use only information about primary

energy consumption by fuel issued of the Eurostat database and therewith only these data are analysed in the data collection list.

The data are further characterized by their function in the model. They could be used for example as model input data like energy quantity, costs or technical parameters. It is possible to name an additional category if the data from one source are used for different purposes.

In the next steps, the data is characterized by their sectoral and geographical coverage. The predefined sectors are Gas, Electricity, Transport, Industry and Buildings. Also the categories for the geographical description are predefined and consist of: group of countries, country, part of a country, location within a country, project location, actor location/residence and, at a more detailed level, geographical coordinates. This last category includes data issued from a geographic information system (GIS).

**Table 4:** Drop down menu for the possible answers to the categories for the inventory of the existing data

| **Model group/ model family** | **Classification of data source** | **Category of data (amd additional category if needed)** | **Sectors covered by data source** | **Geographical resolution of data** |
|---|---|---|---|---|
| Energy system | Official statistic source (public source) | Model Input Energy | Gas | Group of Countries |
| Macroeconomic | Private statistic services | Model Input Costs | Electricity | Country |
| Sector level | Company data | Model Input Technology | Transport | Part of a country |
| Disaggregated models | Associations (e.g. industrial associations) | Model Input demand | Industry | Location within a country |
| Energy behaviour tools | Literature (articles, books, newspaper) | Other model input | Buildings | Project location |
| Socio-technical scenarios | Stock exchange or market data | Data used for internal additional calculation | All sectors mentioned above in the drop down menu | Actor location/residence |
| Horizon scanning methodologies | Query, survey | Qualitative information on context | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Geographical coordinates |
| | Interviews (experts, stakeholders) | Qualitative information on interests, values and/or expectations | Others | |
| | Focus groups, workshops | Behavioural information | | |
| | Public database incl. other than statistic data | Information on carbon footprint | | |
| | Web server | Macroeconomic data | | |
| | Personal information account | | | |
| | Soft link with another model's output | | | |
| | Database built for specific purposes | | | |

## 2.2 Assessment of existing data and weak points

This section evaluates the data based on the description of the sources and data presented above. The data assessment is performed using different indicators which measure the quality and the availability of the data, and identify the weak points of the existing data. The evaluation should be the basis to point out the weak points of the current data. Based on these shortcomings, in the next step additional data requirements are described to close these data gaps (section 2.3).

The categories and sub-categories to assess the existing data are as follows:

- Quality of data:
  - Time resolution of the provided data [predefined]
  - Time lag (between date of publication and reference date) [predefined]
  - Frequency of data publishing [predefined]
  - Level of completeness and consistency [predefined]
  - Level of detail [predefined]
  - File format [predefined]
  - Data documentation [predefined]
- Availability:
  - Status of availability [predefined]
  - Price [free text]
- Description of weak points of existing data [free text]

The evaluation is performed by model experts. The details on the predefined answers and the structure of the data assessment are shown in Table 5 and Table 6. Concerning the evaluation of the data according to their completeness/consistency and the level of detail, additional guidelines were worked out. These guidelines[2] were provided to the experts from modelling teams among the ATEsT project partners and to the external modelling teams within the framework of the Open Call.

[2] These guidelines were included in the data list which was filled by ATEsT project partners and external modeling teams. In these guidelines additional information how to fill the data list were given. For example, it is explained that the ranking for the level of detail and the completeness/consistency should be based on personal expectations. The guidelines are included in the Appendix.

**Table 5:** Drop down menu for the possible answers for the assessment of existing data (part I)

| Time Resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency |
|---|---|---|---|
| Annual | < 1 year | Continuously Updated | 1 (very low) |
| Seasonal | 1-2 years | < 1 year | 2 (low) |
| Monthly | 2-4 Years | Yearly | 3 (medium) |
| Daily | > 4 years | Every two years | 4 (high) |
| Hourly | Future-oriented projections | More than two years | 5 (very high) |
| Less than 15 min | | Not periodically | |
| Depends on issue in focus | | Not published | |

**Table 6:** Drop down menu for the possible answers for the assessment of existing data (continued)

| Level of detail | File format | Data documentation | Status of availability |
|---|---|---|---|
| 1 (very low) | GIS data | Available | Public + free |
| 2 (low) | Excel download | Not available | Public + charge fee |
| 3 (medium) | PDF | Available, but not up to date | Private |
| 4 (high) | Paper Report | | Personal contact required |
| 5 (very high) | Web account/webpage | | |
| | Qualitative+quantitative audio-visual information | | |
| | Access database | | |
| | Other database system | | |

The assessment of the data according to these categories depends on the personal expectations and data needs of the modeller who evaluates these data. Therefore the expressed ratings do not necessarily reflect the needs and expectations of each modelling team within a model family. For instance, if a specific model requires data on an annual level and the specific data

source provides annual data, expectations and needs are completely fulfilled. In this case the rating should be “5” (very high). But the same data might not fulfil the needs for other models and would be ranked lower if another model had been chosen to reflect data needs for the model family.

Concerning the rating of the completeness, depending on the number of expected elements missing (like years, countries, fuel types, technologies) the ranking of the data source could decrease. As each model expert may have different needs and expectations, the results of the ranking could hardly be used for comparing different sources in different models directly. The ranking might help identifying weak points and additional needs for specific models and model families.

The data assessment should provide a basis to point out the weak points in existing data. In the next step additional data requirements are described to close these data gaps (section 2.3).

## 2.3 Further data needs

In the third step of this methodology, the additional data requirements are identified based on the previous steps where the weak points of the data currently in use are analysed. The categories and the predefined answers are comparable to the previous sections, however now the focus is not on the current status of data, but on what data are missing and what quality should be achieved. Additional data requirements are considered from two different perspectives: data required to improve the models within their current structure and data needed to improve the model structure itself. The first perspective provides insight in additional requirements which could help improving the quality and reliability of the output of existing models. The second perspective covers the additional requirements that could help to extend existing models (like additional regions or a higher time resolution), or indicate the need for the development of new models.

The categories and sub-categories of data needed are as follows:

- Lack of data:
    - Sector covered by required data [predefined]
    - Additional comments on the sectoral coverage (if needed) [free text]
    - Geographical resolution of the required data [predefined]
    - Description of the lack of data/ additional data needs [free text]

# 3 Existing Data and their weak points

## 3.1 Energy System Models

### 3.1.1 Existing data used in the model family *"Energy System Models"* and model example *"TIMES PanEU"*

#### 3.1.1.1 Characterisation of model family/ model example

The analysis of the existing data in this paragraph relates to the model family Energy System Models. The example used for this model family is the TIMES PanEU model. Energy System Models are bottom-up models which have a large coverage of the sectors of the energy system. In general, these models are technology rich and different technologies for the energy supply and/ or the demand side are modelled in detail.

This modelling approach has an impact on the existing data. Detailed data on different technologies for one or both the supply and demand side sectors are necessary. Depending on the focus of the specific model, there could be other key data issues, such as the requirement for a very detailed time resolution. If the Energy System Model has a high number of time slices, very detailed data with a high time resolution are needed for all sectors and commodities. Moreover, when Energy System Models cover different regions, these regions could be single countries or in case of global models a group of countries and all data are needed for all regions. This issue could raise a challenge in terms of availability of reliable data.

The main model example presented in this section is the Energy System Model TIMES PanEU (for detailed model descriptions see for example Blesl et al. 2010; Kuder, Blesl 2010; Blesl et al. 2008). This model covers the countries of the EU-27 plus Norway, Switzerland and Iceland. The model is technology rich with detailed modelling of the public electricity and heat supply, and of the demand sectors such as residential, commercial, agriculture, transport and industry. An endogenous modelling of trade of electricity as well as of biofuels between the countries is implemented in the model.

Concerning data issues, one major challenge is the need for detailed data for all 30 countries included in the model. The data are needed for each country in order to evaluate the different emission reduction potentials by country due to their different abatement costs. Specific and technology oriented data are needed for all demand sectors, like for example the use of different technologies with different efficiencies for steel production.

After depicting the data used in TIMES PanEU model, the section assess the data used in other models within the family of Energy System Models. These models are the German TIMES version TIMES-D (see for a model description amongst others Blesl et al. 2007; Götz

et al. 2011a; Götz et al. 2011b) the TIMES model for South Africa TIMES-GEECO (Tomaschek, Dobbins, Fahl 2011), the global TIMES Integrated Assessment Model TIAM-World (Kanudia 2010[3]) and TIAM-IER (Kesicki et al. 2009; Blesl 2010). Due to their different geographical resolution, these different models rely on different data sources.

#### 3.1.1.2 Analysis and characterisation of existing data

The starting point for this report on existing data in Energy System Models is the data list described above which was filled by the modelling teams involved in the developing and the use of this model family. The objective of this list is to create an inventory of data sources which are used in Energy System Models, to evaluate these data according to their quality and availability and to describe in a next step the additional data needs. The data collection list for this model family is based on the data used in the models mentioned previously. Due to the key role of TIMES PanEU in filling this list, the focus of the analysis is on the TIMES PanEU model, while the results of the other models are aggregated. In this step of the data analysis, the currently used data and data sources are listed as an inventory and analysed by category. Therefore, the data sources are firstly classified, then the data from these sources are categorized and finally their sectoral and geographical coverage is analysed.

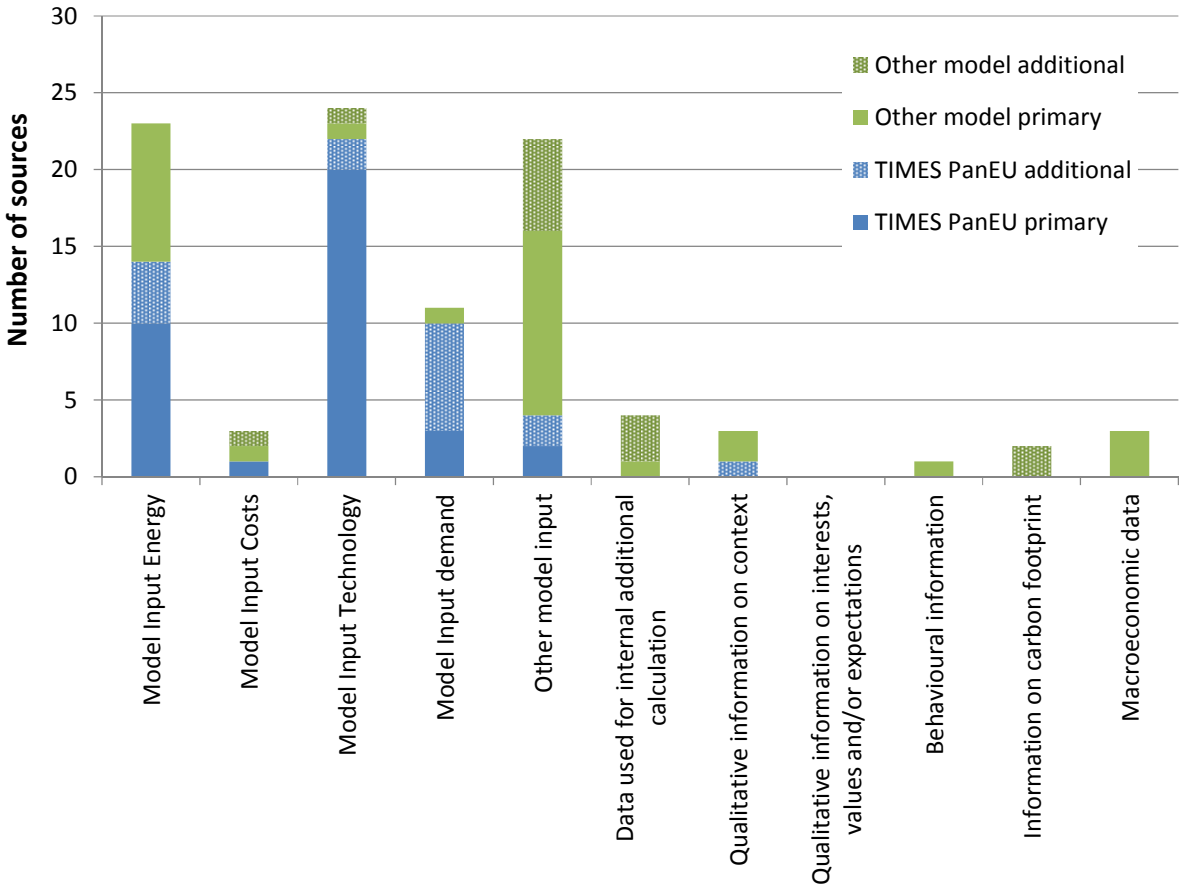


**Figure 1:** Number of sources by category of data

[3] Additional information could be found at http://www.kanors.com/WebSite/Mod_TIAM.asp.

Within the Energy System Models family, a total of 67 data sources are analysed, out of which 36 sources (54 %) are used in the example of the TIMES PanEU model[4]. Many sources are used for different purposes and are therefore split into different categories such as presented in Figure 1 where they are split into primary and additional categories and in addition if they were used in the model example TIMES PanEU or in other Energy System Models. Examples for these sources are the ETP report from the IEA (IEA 2010) which is used for technological and cost input data or publications from associations which are used in the industrial sector both to calibrate the demand and as technology input data (World Steel Association 2009).

These data in Energy System Models were mainly used as technology model input data (20 data sets as primary category in TIMES PanEU, 2 sets additional category[5] used in TIMES PanEU, 1 primary category in other Energy System Models, 1 additional category used in other Energy System Models), energy input data (mainly as primary category for TIMES PanEU with 10 sets and primary category used in other Energy System Models at an amount of 9), model demand (mainly primary in TIMES PanEU) and other model input (Figure 1).

This data split among the different categories represents the modelling approach of Energy System Models. Models within this category are technology rich models where the information about technologies plays a key role, e.g. efficiencies, availabilities, input and output commodities, temperature level etc. Furthermore, the sources about model input of energy are very important since energy flows of all demand and supply sectors are covered. The data summarized as "other model data" are mainly data on emissions. Other categories like behavioural information or qualitative information are not used in the Energy System Models analysed in this study.

Concerning the sectoral coverage, most data used for Energy System Models (Figure 2) cover all sectors (21 sources of this type) which are selected for this study (gas, electricity, transport, industry and buildings). Because the demand sectors are also modelled in detail in Energy System Models and mostly they are not covered in total in one single data source, a lot of sources are used for the demand sectors with a specific focus on the industrial (14 sources) and the transport sector (13). With regard to the data on the electricity sector, these

[4] An extended data evaluation of additional model examples was the result of the Open Call. Next to the examples discussed in this section, the Energy System Models family depicts also models such as EnergyPlan and, more in detail as already mentioned, the TIAM-World model. The results of this Open Call are included in the summary.

[5] Different kind of data could be taken from one single data source and used for different purposes. In this case, it is just counted as one source but having a primary and additional category of the used data from this source.

are often included in general sources covering all sectors. Furthermore, often all kind of data needed for the electricity sector (like electricity production by fuel, capacities by fuel) could be found in one source. This reduces the number of different sources used in the electricity sector (5 sources are specifically used for the electricity sector in Figure 2). By contrast, the data required in the industrial sector have to be provided by different sources for each subsector, like specific sources for the iron/steel and the cement industry (for example International Copper Study Group 2010 for the copper industry; Cembureau 2009 for the cement industry).

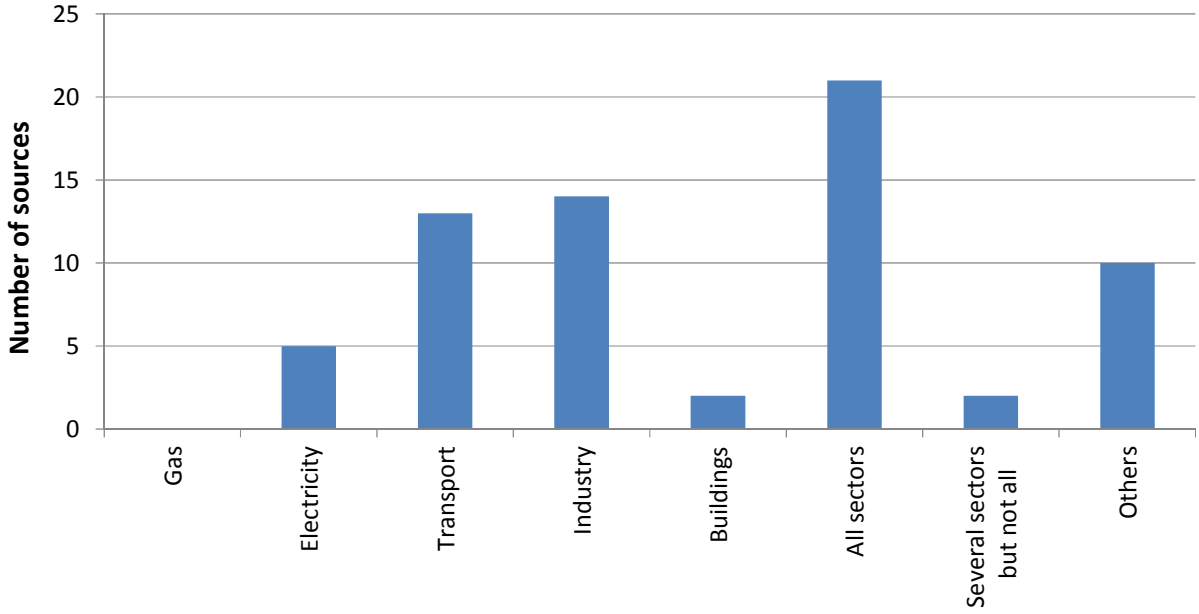


**Figure 2:** Number of sources by sector

The assessment of data regarding the geographical resolution shows that most of the data used are at a country level (71 %) and at the level of a group of countries (21 %). This shows that the data needed in Energy System Models are on a highly aggregated level from a geographical point of view due to the wide coverage of the whole energy system. More disaggregated data are rarely used (e.g. project location data 5 %, location within a country 3 % and no data on the level of "geographical coordinates").

The sources which are used in the Energy System Models included in this analysis are mainly official statistics and therefore public sources (Figure 3 shows the number of sources by type and sector). In total, 36 sources (54 %) are official statistic sources. In addition, data from international or European industrial associations (18 %) and from the literature (16 %; refers to articles, books, newspaper etc.) play a key role. Figure 3 shows the type of sources and also which source type dominates in the different sectors of the energy system. Official statistic sources are used by every sector. Most of the official statistic sources cover all sectors. From

a sector perspective, this source type clearly dominates the sources used for the electricity sector. This shows that official statistic sources mostly provide data for the electricity sector in a satisfying way, but often do not provide information for the demand sectors in the level of detail which is needed for this kind of models. Therefore more than half of the sources used in the industrial sectors are from associations (like the world steel association for the steel industry).

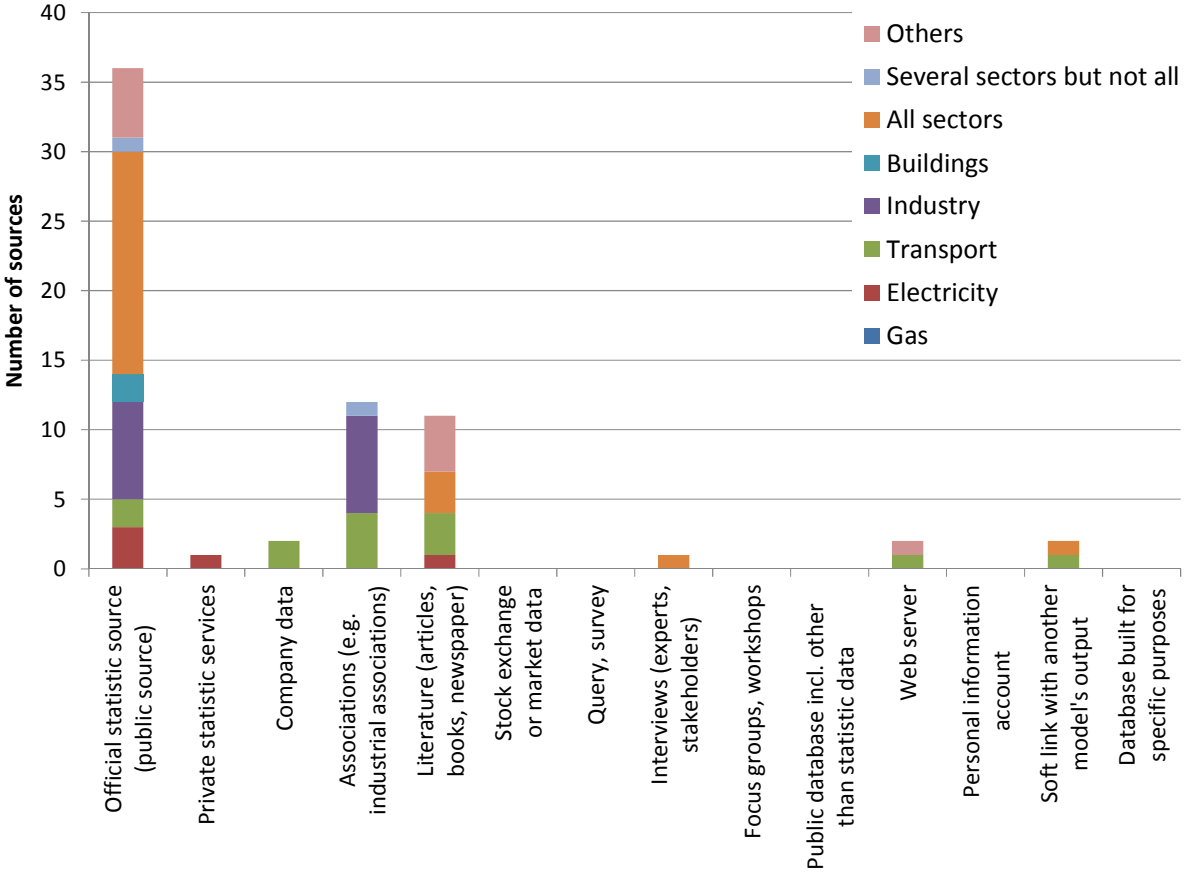


**Figure 3:** Number of sources by sector and classification

3.1.1.3 Assessment of the data quality and availability of existing data

After capturing the sources and the data which are used, their quality and availability should be evaluated. The assessment of the quality of the data builds on ranking of time indicators, such as time resolution, time lag, frequency of publishing, and also indicators like completeness, level of detail and the documentation.

Most of the data (47 %) used in the Energy System Models which are evaluated in this study provide information on an annual level (Figure 4). This is another feature of the approach and structure of Energy System Models. These models cover a wide range of sectors, technologies and countries and therefore they don't have a highly detailed time resolution. That is why no data are in use within this family with a time resolution of a day or less.

Another issue is the availability of data on a more detailed level. Often detailed load curve data for different commodities and user groups for all regions are not available (see 3.1.1.4 for the discussion of weak points and 4.1 for additional data needs).

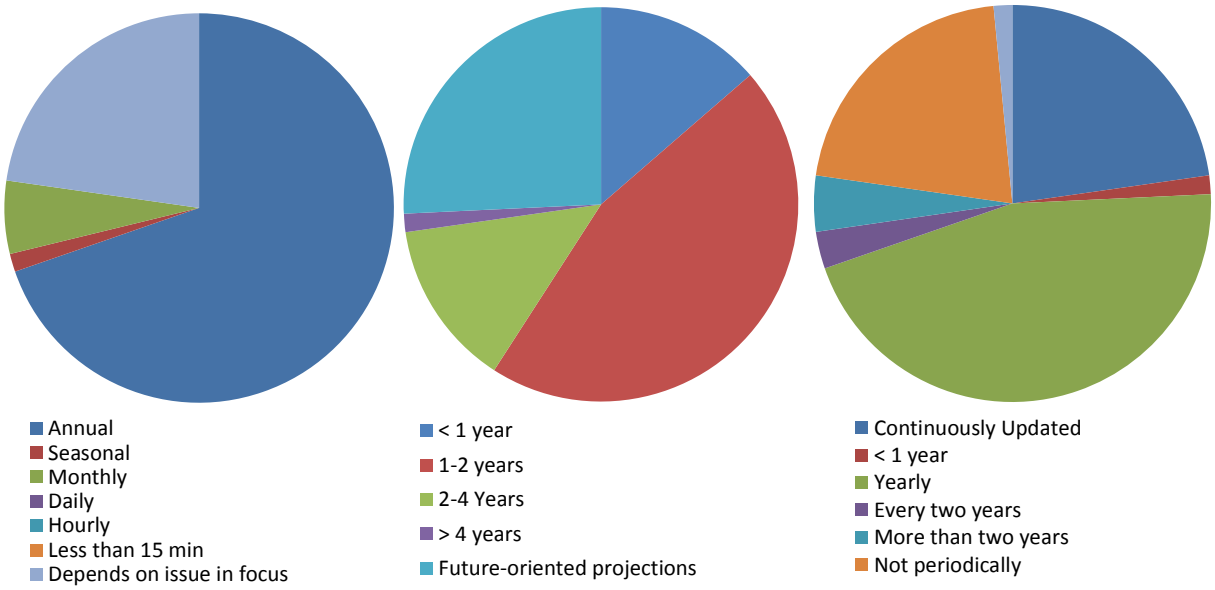


**Figure 4:** Time resolution (left), time lag (middle) and frequency of publishing (right)

Most data (30 %) have a time lag between the date of publication and the reference date of 1-2 years (see Figure 4, pie chart in the middle). It is found a 2 year time-lag between the calibration year and the current year, e.g. for the current year 2011 the last model year calibrated to the statistics is 2009. More recent information is often not available due to the procedure of the official statistic reporting mechanism.

As for data projection, about 17 % of the data used in the models are future orientated projections. This information is used for comparing the model results to other outcomes/ forecasts but also in order to create demand projections, which are usually external input to Energy System Models (for example the forecast of air traffic volumes and airplane demand). Projections are also used for the estimation of future potentials for renewable energy sources (calculations based for example on assumptions about potentials of useful areas and supporting schemes) or the development of specific energy consumption of technologies (like projections about the future fuel consumption of cement kilns).

The frequency of the data updating is presented in the Figure 4, the pie chart on the right. Main findings are that most of the data used (30 %) are updated annually; while about 15 % are continuously updated, which might raise problems when numbers could change without being noticed by the modelling team and consequently the model could in practice not to be up to date. Finally, 14 % are not periodically updated. This refers mostly to data issued from the publication of specific studies, as for example from technology associations.

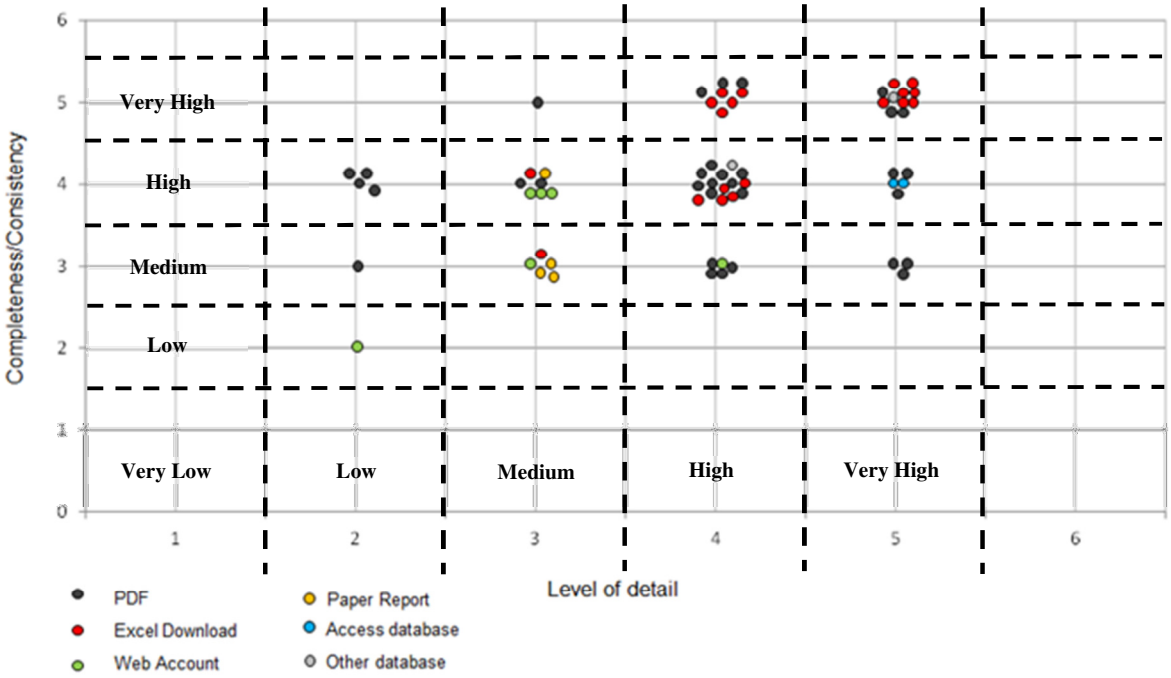


**Figure 5:** Completeness/Consistency, Level of Detail and file format

To evaluate the quality of the data, the information is furthermore ranked according to the completeness/ consistency and the level of detail (Figure 5). This assessment is done by the model users and relates to their personal expectations and data needs. The quality of data is further analysed according to the file format of their presentation.

Since Energy System Models are very detailed and technology oriented, most of the data have a level of detail of at least "4" (4 on a scale of 5 which refers to high)[6]. In multiregional models like TIMES PanEU or TIAM, all data are needed for all regions to analyse for example different emission reduction potentials and costs. Therefore the completeness and consistency of the used data ranks as high. Compared to the ranking of the "level of detail", more information is required on a level of high ("4") or very high ("5") at the ranking of "completeness/ consistency". While 71 % of the data are at high or very high "level of detail", 77 % of them are at this stage ("4" or "5") concerning the "completeness/consistency". This comparison shows that the "completeness" is a more important factor than "the level of detail".

Taking a look at the file format, the analysis of the data shows that the most common format are PDF documents (50 %), followed by excel files (29 %). Admitting that PDF documents are more difficult to use compared to excel files implies that there are no many alternatives to

[6] A description of the methodology which is used to rank the completeness and level of detail is part of the chapter on the methodological approach.

some data formats, and modelling teams might even be strained to use data which are available only from paper reports.

Additional indicators which measure the quality and availability of data are the existence of additional data documentation, the availability status and the price of the data. Almost all sources which were used offer additional information about the data and the way they are collected and on the balancing methods they was are based on. Concerning the availability of data, 77 % of the sources used are public and free. The remaining share is mostly covered by public sources for which a charge fee has to be paid. These are mostly official statistic sources like IEA statistics, which are not free of charge.

#### 3.1.1.4 Weak points of existing data

The analysis and description of the weak points of the existing data is based on the analysis presented in the previous section and on further comments which were made in the data list.

A first weak point regards **incomplete or inconsistent data**. As showed by the evaluation of the completeness/consistency, the level of detail and the file format in Figure 5, some data are only available in paper reports. This refers to data used in the South African Energy System Model TIMES-GEECO. The data for the energy system of South Africa are in addition not very detailed or complete and consistent. In case of global modelling aiming the comparison of emission abatement costs among regions, it is necessary to model all regions accurately.

Secondly, the **revision of data and databases** is challenging, when data concerning the past are modified, making it hard to keep the model calibration up to date with the official values.

Thirdly, some data currently in use, issued for example from reports, might **not cover all relevant technologies or countries**. This adds to another main problem which relates to the use of **different accounting methods** of the energy consumption and therewith to a different allocation[7] of the energy consumption to the sectors of the energy system. Even in one source covering different countries, different balancing methods among countries could be used. One key example is the classification and balancing of district heat and steam. In addition, the values of the European statistics do not always fit to the national statistics. Even between different publications from the European statistical office the numbers might not fit to each other. This is quite often related to CHP and the generation of district or industrial heat.

Additional to these general issues, some more **sector specific weak points** could be stated in particular in the industry and transport sector.

[7] "Allocation" in this context refers to the balancing of the energy consumption for example either in the production/ conversion sector or as final energy in the end use sectors.

- One challenge is the differentiation between industrial and public power plants, and therewith between industrial and public heat, e.g. the representation of either heat or the fuel used to produce this heat in the energy balance.
- The way of evaluating the specific energy consumption could be also challenging. The energy consumption could be primary energy, final energy, heat, steam, use of fuels and electricity of which a part is final energy consumption and another part has to be balanced as energy consumption of the transformation sector (like the use of coke in blast furnaces).
- Furthermore, the electricity input to some technologies is sometimes valued differently, e.g. with or without different conversion losses factors.
- Another issue is the balancing of by-products, for instance blast furnace gas in the iron and steel industry or black liquor in the paper and pulp industry. It is not always clear whether the specific energy consumption of a technology includes these values of by-products or not, which means that it is not clear if the values reported are gross or net values. The example of the coke use in blast furnaces goes along with the weak point of differentiation between final energy consumption of the industrial sector and consumption of the transformation sector.
- Another issue of the industrial sector is the consideration of import/export flows of intermediate goods. This could influence the evaluation of a specific energy consumption of a whole sub-sector. One example is the production and export of pulp, in the paper and pulp industry in Finland or Sweden. The value of specific energy consumption as PJ/Mt of paper could lead to the interpretation of a low level of efficiency of the production process in these countries.

Weak points are also raised in the transport sector, where some reports might cover only specific countries, they could be available in only one language or the price might be very high. For some technologies, like alternative fuels and power trains, data is missing or is available only in aggregated values for regions instead of single countries, or they could be based on average growth rates only. Other issues are that information is missing on details such as the date when the forecasted indicators - cost, efficiency and emission levels - are reached. Additionally, there is no regional data differentiation. Furthermore specific statistic values in the transport sector might not fit the values of other more general statistic sources.

**Key issues about existing data in Energy System Models**

- Technology rich bottom-up models with a large coverage of sectors in the energy system
- They require detailed data for energy supply and demand sectors and oftentimes for a high number of different regions
- Existing data:
  - Mainly technology model input data, energy input data and demand data
  - Most data cover all sectors + additional sources especially for the demand sectors (different sources for each industrial subsector)
  - Data mostly on country level or group of countries
  - Most common sources are official public statistics but also a lot of data from industrial associations (Industry sector)
- Data quality and availability of existing data:
  - Data used are mostly on annual level with a time lag of two years and continuously updated
  - High or even very high level of detail and completeness/ consistency of the used data
  - Most sources are public and free
- Weak points of existing data
  - Difficult to get data of the same quality for all regions of the models
  - Reports do not cover all relevant technologies (like alternative fuels…), are just aggregated, not precise enough (like reference dates for projections) or with average numbers or are only available in one language
  - Different accounting methods in different regions and inconsistency between publications (like classification of district heat and CHP)
  - Differentiation between conversion and industrial sector (CHP, autoproducer, coke ovens, blast furnaces)
  - Interpretation of values for specific consumption (final vs. primary energy, treatment of heat, steam, electricity, by-products like black-liquor or blast furnace

## 3.2 Macroeconomic Models

### 3.2.1 Existing data used in the model family *"Macroeconomic Models"*/ model examples *"NEWAGE"* and *"GEM-E3"*

#### 3.2.1.1 Characterisation of model family/ model example

Macroeconomic Models are generally based on highly aggregated data that capture the interactions of economic agents (households, firms, government) on markets (goods, factors).

CGE Models, as the prevalent macroeconomic modelling technique, use aggregated value data, which reflect a balanced circle of income. The challenge does not lie in the level of detail but in the degree of consistency regarding underlying quantity and price/currency issues that constitute the value data. The balanced Input-Output-Table is called a social accounting matrix (SAM). It is advisable to limit the data sources to one or a few to ensure consistency. Most CGE models are therefore based on National Accounts of a single country or, at a larger scale, on the worldwide Input-Output-Database GTAP (Global Trade Analysis Project[8]). To reflect the behaviour of the agents, certain assumptions have to be made upon the functional forms, which could rely on assumptions setting values for elasticities of substitution within the production/consumption functions. These values can be either drawn from econometric estimation, surveys or from the literature.

There are different types of CGE Models. In the energy-environment field GEM-E3 and NEWAGE are exemplary approaches. NEWAGE is used at IER at the University of Stuttgart; GEM-E3 is mainly used at EU institutions, such as IPTS in Seville. The GEM-E3 model is a multi-region multi-sector model that covers the interactions between energy, economy, and environment (E3M-Lab 2010; Jaeger et al. 2011; Capros et al. 1997). NEWAGE is a multi-region multi-sector CGE model, which includes data extensions of the GTAP data base towards energy oriented information (electricity generation, $CO_2$ emissions) and qualitative labor representation (Küster et al. 2007; Küster 2009; Ellersdorfer et al. 2004). Other models as a result of the Open Call have been included to complement NEWAGE, GEM-E3 and GTAP-E, namely: GEMED, E3MG and E3ME.[9]

[8] www.gtap.org

[9] E3MG and E3ME are not CGE models but Macroeconometric Models. They build upon a different methodological framework, i.e. econometric estimation of time series or panel data. For further reading, please refer to the E3ME manual, the GEM-E3 Manual, Lucas 1976 and Valadkhani 2004.

#### 3.2.1.2 Analysis and characterisation of existing data

CGE Models are usually based on National Accounts of a single country (Destatis 2010). At a larger scale, they can use the worldwide Input-Output-Database GTAP, which harmonizes National Accounts to ensure consistency (Narayanan et al. 2008). GTAP is a global network of researchers and policy makers conducting quantitative analysis of international policy issues. The centrepiece of GTAP is a global data base describing bilateral trade patterns, production, consumption and intermediate use of commodities and services among 113 regions for all 57 GTAP commodities for a single year (2004 in the case of the current GTAP 7 Data Base; Narayanan et al. 2008).

CGE models based on GTAP are especially suited to perform international analyses that contain trade issues. For analysing relations between sectors within single economies, the input-output-tables and/or SAM of single countries can be used, too.

The NEWAGE model is based on GTAP, while the GEM-E3 model is based on GTAP in addition to Input-Output-Tables from Eurostat. Regarding specific issues, such as energy or environmental aspects, these data may not be sufficient, as for example limited information is given on carbon dioxide emissions. Therefore, additional data are required for describing some economic activities. For example, NEWAGE uses the GTAP database as a starting point and includes additive information on labor qualification, electricity generation and $CO_2$ emissions. The $CO_2$ information comes from the UNFCCC Greenhouse Gas Inventory Database. Labor statistics are issued from studies of the International Labor Organization (ILO). Information on energy and especially electricity generation technologies and costs comes from the International Energy Agency (IEA) and from the results of bottom-up models (such as PRIMES and TIMES). The GEM-E3 model adds environmental statistics from Eurostat, to cover environmental aspects.

For policy analysis, further information is needed to be included into CGE data. In NEWAGE, policy instruments are implemented following German and European climate policies (e.g. EU-ETS or German renewable energies law, EEG). This information comes from directives, laws and the National Allocation Plans. In addition, for dynamic purposes electricity generation in NEWAGE can be compared and/or adjusted to outcomes of bottom-up models such as TIMES-PanEU. Therefore, bottom-up models can serve as data input for CGE models.

Other macroeconomic models from the Open Call use similar data sources. Concerning general economic data, GTAP and National Accounts are employed and complemented by statistics from large non-governmental organizations such as UN, OECD, World Bank, IMF

and WTO. These general statistics include trade issues, subsidies, taxes, tariffs and exchange rates. For more specific purposes, the models use sector specific data regarding electricity, transport and industry, which are taken from statistical offices (Eurostat), energy agencies (e.g. IEA), industry associations (e.g. UNESA), system operators (e.g. REE) or regulators (e.g. BNA). For assessing environmental impacts, data on emissions is provided by UNFCCC or EDGAR databases. The behavioural and technology data on consumption and production mechanisms is taken from the literature, empirical estimation and expert assumptions – as is the case for NEWAGE and GEM-E3.

#### 3.2.1.3 Assessment of the data quality and availability of existing data

National Accounts usually are freely accessible. The same is true for data from organizations, agencies and associations (e.g. IEA, ILO, BDEW, UNFCCC). The GTAP database is publicly available, but requires buying a license. The resolution of the GTAP database is needed to be further extended to capture more sectors and regions (as a reminder, the GTAP 7 version contains 113 regions and 57 sectors). As it is published every 3 years only, the publishing rate is requested by the modelling teams to be increased.

#### 3.2.1.4 Weak points of existing data

The licenses for the GTAP database exhibit substantial costs. A license for the current version costs 5.290 US Dollars for private and 1.035 US Dollars for academic use. Public and private grants are desirable for widening data accessibility of this crucial data base.

Macroeconomic data from international organizations mainly has annual frequency with a time lag of 1-2 years or more. This is due to aggregation mechanisms within the data collection process. Data of National Accounts, such as Input-Output-tables and especially SAMs often need 2-3 years until publishing. For instance, the current Input-Output-Table of Germany published in 2010 is based on data from 2007 (Destatis 2010). A faster process could make analyses more up-to-date. Moreover, the time series oriented Input-Output data is desirable to conduct more profound dynamic analyses. The GTAP Advisory Board is currently discussing this issue (Walmsley 2011).

Some criticism of *external* modellers within the Open Call refers to inconsistencies between different technologies classifications within the macroeconomic data bases (e.g. OECD STAN). In their comments, the modellers state that sector specific data from agencies and associations (e.g. IEA, BDEW, UNESA) is able to better describe technologies and is published faster.

The same comments apply to the assessment of data quality for emissions databases from UNFCCC and EDGAR. There is limited availability of European data on specific taxes, subsidies and transfers particularly in the energy-environment area, e.g. electricity renewables and carbon subsidies, $CO_2$ payments and emission rights.

Another weak point concerns the values for the elasticity parameters of the functional forms which might be often imprecise due to missing data. As there are issued from several sources - the literature, empirical estimation and expert assumptions -, these data have a huge variability concerning the quality and frequency. As this information is generated in a decentralized manner, the frequency is irregular. Assessing behavioural and technology data on consumption and production mechanisms is a crucial task. However, there is still a low number of works dealing with elasticity estimations in energetic and non-energetic sectors, including the consumer behaviour side.

### 3.2.2 Existing data used in the model family "*Macroeconomic models*" and in the "*GTAP- Energy*" model

The chapter 3.2.2 is based on the report on existing data, by Oscar Amerighi, Maria Cristina Tommasino and Umberto Ciorba (ENEA).

#### 3.2.2.1 Characterisation of model family/ model example

The data analysis is conducted for the GTAP-E model (Burniaux, Truong 2002; McDougall, Golub 2007) which is a multi-region, multi-sector, Computable General Equilibrium model.

In particular, GTAP-E is an energy-environmental version of the standard GTAP model. Specifically, it is designed to simulate GHG emissions mitigation policies. It includes an explicit treatment of energy demand, the possibility of inter-factor and inter-fuel substitution, information on carbon dioxide emissions accounting and the possibility of introducing market-based policy instruments such as carbon taxes or emissions trading systems.

The database for macroeconomic models is typically characterized by:

- Tables of transaction values. The database is presented as an input-output table or as a Social Accounting Matrix (SAM). The whole economy of a country, or even of the entire world divided into countries or groups of countries, is covered. A number of different economic sectors, commodities, primary factors and economic agents (sometimes different household types) are taken into account and characterized accordingly.
- Parameters, such as demand elasticity, those capture the behavioural response of agents to price or policy changes.

- Multi-region to global geographical coverage.
- Poor technology details.
- Satellite matrices which may include additional data useful for policy simulations such as labour force migration flows, emissions, and land cover/use data.

For the GTAP-E model, the data that are always needed to run simulations are the following ones:

- Macroeconomic data as previously described.
- Combustion-based $CO_2$ emissions data (Lee 2008).
- Energy Volume data (McDougall, Aguiar 2008).

#### 3.2.2.2 Analysis and characterisation of existing data

The GTAP-E model builds on the GTAP Data Base. The GTAP Data Base is a global database representing the world economy for a given reference year (the year 2004 for the GTAP 7 Data Base).

The GTAP Data Base combines detailed bilateral trade flows, transport and protection data[10] characterizing economic linkages among regions, together with individual country input-output tables that account for inter-sectoral linkages among regions.

The following section evaluates in detail the sources of the last GTAP Data Base version, built by the GTAP network of contributors that is responsible for its extension and updating. Assessment of essential data for the GTAP-E model is also included.

[10] Protection Data include Domestic Support data (OECD PSE/CSE database), Agricultural Export Subsidies (WTO, FAO) and Import Tariffs (Market Access Maps - MacMaps-, ITC/CEPII).

The description of the data sources for GTAP-E builds on the model data collection list, such as presented in Table 7.

**Table 7:** Data sources for GTAP-E

| **Data Source** | **Description of the data taken from the source** |
|---|---|
| World Bank data | Macroeconomic aggregates (GDP, private consumption, governement consumption and investment). |
| UN COMTRADE data | Trade Data |
| OECD PSE/CSE database | Macroeconomic data (output subsidies, land-based payments, labour and capital-based payments). |
| WTO and "Financial report on the European Agricultural Guidance and Guarantee Fund". | Macroeconomic data (agricultural export subsidies). |
| Market Access Maps (MAcMaps) developed by ITC (UNCTAD-WTO, Geneva) and CEPII (Paris) | Macroeconomic data(import tariffs). |
| IMF | Macroeconomic data (income and factors taxes). |
| Calibrated from other data sources | Behavioural information (behavioral parameters such as demand and trade elaticities). |
| IEA database | Model Input Energy (Primary energy consumption for all 113 regions and 57 sectors included in GTAP 7 Data Base). |
| Computations based on IPCC emission factors and GTAP energy volume data | Model Input Energy - CO2 Combustion based emissions. |

Regarding the sector coverage of the data, sectoral information is collected for the entire 57 sectors included in the model. The International Standard Industry Classification (ISIC) is used to define most of the sectors. The agricultural and food processing sectors are instead defined by referring to the UN Central Product Classification (COP).

As for the geographical coverage, data cover all the 113 regions (single countries or groups of countries) included in the model and representative of the world economy. The 113 regions of the model are defined as aggregates of 226 countries for which contributors to GTAP Data Base provided domestic data.

#### 3.2.2.3 Assessment of the data quality and availability of existing data

The GTAP database covering the world economy represents the building block of the GTAP model family.

The time resolution of data provided is typically annual. The database is updated every few years and it can be generally observed a time lag of more than two years between date of publication and reference date of data.

The macroeconomic data are characterized by a good level of detail, completeness and consistency. The underlying input-output tables provided by the GTAP network are heterogeneous in sources, base years, and sectoral detail, thus for achieving consistency, substantial efforts are required to make dissimilar sources comparable.

The GTAP database is fully documented and available under payment of a charge fee between 1000 and 5000 Dollars in 2011.

#### 3.2.2.4 Weak points of existing data

As most macroeconomic models, the main weakness of GTAP-E database is the poor description of energy technologies. Technologies are not explicitly included in the database and only sectoral parameters in the production function show the technological progress of each sector.

Lastly, the delay in time reference of data may be a barrier to evaluate energy policies if a model is static such as the GTAP-E model.

**Key issues about existing data in Macroeconomic Models**

- Based on highly aggregated macroeconomic data
- Existing data:
  - Input-Output-data of National Accounts (worldwide GTAP database)
  - Additive data on macroeconomic (e.g. employment, taxes, tariffs) or more specific issues (e.g. energy, environment)
  - Information on production technology and consumer preferences (substitution elasticities)
- Data quality and availability:
  - Mostly publicly available, but GTAP exhibits substantial fees
  - Limited comparability between different National Account data; additive data often incoherent
- Weak points of existing data:
  - Low frequency (yearly) and significant time lags (e.g. 1-2 years)
  - Poor representation of technologies and preferences in substitution elasticities

## 3.3 Sector Level Models

### 3.3.1 Existing data used in the model family *"Sector Level Models"*/ model example *"MURE"*

The chapter 3.3.1 is based on the report on existing data, by Helena Cabal, Yolanda Lechon Perez (CIEMAT) and Drazen Jaksic (EIHP).

#### 3.3.1.1 Characterisation of model family/ model example

The data analysis is made for the Sector Level model family using the MURE model as the model example.

The MURE ***(Mesures d'Utilisation Rationnelle de l'Energie)*** model is a **simulation tool** that allows to evaluate the energy saving and environmental impact of a given energy policy scenario with reference to a business as usual or baseline trend.

MURE is also an **information platform** on energy efficiency policies in Europe. The MURE measure database provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union and enables the simulation and comparison at a national level of the potential impact of such measures.

**ODYSSEE** is a detailed database on energy efficiency data & indicators, for the EU-27 members plus Norway and Croatia. ODYSSEE is combined with the MURE data base on policy measures MURE in the project ODYSSEE MURE.

Together with the Odyssee project MURE forms the most comprehensive tools for the assessment of energy efficiency trends and policies in Europe.

The MURE tool has been recently used to assess the National Energy Efficiency Plans of some Member States and to determine Energy Efficiency Potentials in the EU Member States up to the year 2030[11].

This type of models requires different kinds of data. Firstly statistical data related to the energy balances of the covered sectors are required. Secondly very detailed data regarding the technological and costs aspects of the different technologies are also required, and finally data on the technological and costs aspects of the efficiency measures are also needed. In the case of the MURE measures database, also information about policies in each of the covered countries is needed.

#### 3.3.1.2 Analysis and characterisation of existing data

The MURE simulation tool database[12] is constructed in four, entirely separate, sections: Household, Transport, Industry and Tertiary which contain the energy conservation measures, statistical data and simulation tool relevant to the four sectors. The software enables the simulation and comparison at a national level of potential impacts of such measures.

The data structure and operating functions of each sector are the same, although the simulation procedures differ.

Three main types of data are provided for each of the EU countries, in each section of the database:

· **Measures,** accessed through the Query function.

· **Statistical data** relevant to the **energy consumption** of the sector, accessed through the Data Management function and the graphs function.

· **Technical and cost data** to enable the calculation of the energy saving potential and cost of measures, accessed through the Technical Parameters function.

[11] Energy saving potentials: http://www.eepotential.eu/esd.php; http://ec.europa.eu/energy/efficiency/studies/doc/2009_03_15_esd_efficiency_potentials_final_report.pdf.

[12] MURE tool database: http://www.mure2.com/
MURE appliances model: http://www.isis-it.com/egrids/toolmure.html.

The simulation tool allows the user to calculate the potential impact of either measures or technologies.

The MURE measure database[13] provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union and enables the simulation and comparison at a national level of the potential impact of such measures. It has been designed and developed within the framework of the SAVE and "Intelligent Energy – Europe" Programmes by a team of European experts, led and co-ordinated by ISIS (Institute of Studies for the Integration of Systems, Rome, Italy) and the Fraunhofer Institute for Systems and Innovation Research ISI (Germany). The development of the MURE database was also supported by national funding in each EU Member State. A permanent network of correspondents within energy efficiency agencies established in all EU Member States guarantees the continuous updating of the database.

The MURE database is constructed in five separate sections as mentioned above, which contain the energy efficiency measures, statistical data and a simulation tool relevant to the four main energy demand sectors. The 5th database contains information on general energy efficiency programmes and on general cross-cutting measures.

The Odyssee database on energy efficiency indicators[14] is a detailed database on energy efficiency data and indicators, for the **EU-27 Members plus Norway and Croatia.** This data base has been developed in the ODYSSEE MURE project coordinated by ADEME (France) and supported by the Intelligent Energy Europe Programme of the European Commission. This project gathers representatives such as energy Agencies from the 27 EU Member States plus Norway and Croatia and it aims at monitoring energy efficiency trends and policy measures in Europe. ODYSSEE is combined with the MURE database on policy measures in the same project.

[13] MURE measure database is different from the MURE database. MURE database can be used to evaluate the effect of different measures or technologies.
MURE II measure database with efficiency measures: http://www.mure2.com/

[14] ODYSEE database: http://www.odyssee-indicators.org/.

Main types of data provided by the Odysee data base are summarised in the following table:

**Table 8:** Main type of data provided by the Odysee data base

| Sector | Branches/Sectors/End uses | Technical & Economic Data | Energy Efficiency Indicators |
|---|---|---|---|
| **Macro** | Total<br>Industry<br>Transport<br>Residential-Tertiary-Agriculture | Primary consumption<br>Final consumption<br>Demography<br>GDP, Value added | Primary energy intensity<br>Final energy intensity<br>Energy efficiency index<br>$CO_2$ emissions<br>$CO_2$ intensity |
| **Industry** | Chemical industry<br>Primary metals<br>Steel<br>Non ferrous<br>Non metallic mineral<br>Cement<br>Glass<br>Paper & Printing<br>Food & beverages<br>Textile<br>Machinery & Fabricated metals<br>Transport equipment<br>Miscellaneous industries<br>Wood<br>Mining<br>Construction | Energy consumption by branch<br>Production index by branch<br>Value added by branch<br>Physical production for intensive products | Energy efficiency Index<br>Energy intensity by branch<br>Energy intensity at adjusted structure<br>Specific consumption by intensive products (toe/ton)<br>$CO_2$ intensity by sector |
| **Trans-port** | Road<br>Cars<br>Two-wheels<br>Bus<br>Trucks & light vehicles<br>Light vehicles<br>Trucks<br>Rail<br>Water<br>Air | Energy consumption by fuel and by mode<br>Stock of vehicles by fuel<br>Registrations by type of vehicle<br>Traffic by mode<br>Annual distance travelled by type of vehicle | Energy efficiency index<br>Specific consumption by vehicle, in liters/100km<br>Specific emissions of $CO_2$ by mode and vehicle |
| **Resi-dential** | Space heating<br>Water heating<br>Cooking<br>Electrical appliances<br>Refrigerators<br>Freezers<br>Washing machine<br>Dish washing machine<br>TV | Energy consumption<br>Stock of dwellings<br>New dwellings<br>Floor area of dwelling<br>Stock of appliances<br>Equipment rate<br>Degree day | Energy efficiency index<br>Specific consumption by dwelling , end uses and by equipment<br>Specific emissions of $CO_2$<br>$CO_2$ indicators |
| **Services, agri-culture** | Hotels & Restaurants<br>Health<br>Education<br>Administration<br>Wholesale & retail trade<br>Private offices<br>Agriculture | Energy consumption<br>Value added<br>Floor area<br>Employment | Energy intensity<br>Electric intensity<br>Specific consumption per employee, floor area<br>$CO_2$ emissions |

Data sources in the Odysee database are more than 150 sources compiled by the European Commission and 26 national Efficiency Agencies within the European net-work of energy efficiency agencies. Data are provided for 27 EU countries plus Norway and Croatia.
The data sources include government ministries, statistical institutions, industry and transport associations, and research institutes, as presented in Table 9.

**Table 9:** Data sources of the ODYSSEE database

| | |
|---|---|
| **Austria** | Statistics Austria, ZAMG, Wldsteel, WKÖ, VÖZ, AtPapier, TU Graz, TU Wien-IEW, TU-IEW |
| **Belgium** | INS, ICN, MAE, FPE, ICN, COBEL, IW, Feder, ECONOTEC, MCom, SNCB, DGTREN, ACEA, Recen, ELECT, BNB |
| **Bulgaria** | NSI, Eurostat, ISI, EEA |
| **Croatia** | CBS/WB, EIHP, CBS, CVH/EIHP |
| **Cyprus** | Cystat, Eurostat, DGTREN |
| **Czech Republic** | Eurostat, CSU, MD, CEZ, MMR |
| **Denmark** | DST, BBR, DEA, IISI,i Trm, Vejdi, DMI, DST, DTV, ELMODELolig, FEHA, TM |
| **Estonia** | ESO, EHR, Eurostat, ARK, ESO, TUT |
| **Finland** | STFIN, AKE, Eurostat, ILMTL, INFOA, ACEA |
| **France** | INSEE, ADEME, MEDDAD, CPDP, COPACEL, CSSF, CFIPC, SNFCC, CEREN, UIC, CCTN, SNCF, SESSI, ACEA |
| **Germany** | STABU, AGE, BMWi, STAHL, VdP, DIW, PROG, ISI, Eurostat, GfK, ACEA, BDZ, BMU, BV, Glas |
| **Greece** | NSSG, Greek Associat, MD, Eureco Study, CRES, NSSG, MD |
| **Hungary** | CSO, GfK, Eurostat, Associations, EC, IT |
| **Ireland** | CSO, DCMNR, SEI, Stahlind, VDP, VRU, DG7, ACEA, Cembureau |
| **Italy** | ISTAT, TERNA, MAP, GRTN, ENEA, ENEL, ENI, Gfk, MAP, MT, DG7, ACEA |
| **Latvia** | CSB, Eurostat, IISI, FAO, RTSD, DGTREN |
| **Lithuania** | LITSO, Eurostat, REGIT, ACRVTI, DGTREN, LEI |
| **Luxembourg** | Statec, Eurostat, ISII, DGTREN |
| **Malta** | NSO, Enemalta, MRA, Eurostat, Gozo, Channel, MTA, ADT |
| **Netherlands** | naCC, BAK, BEK, NEH, naCC, IISI, VNP, ECN, NEH95, GfK, CBS, IISI, RIVM, ACEA, VROM, KNMI, KWR, SenNOV, USGS, VNP |
| **Norway** | SSB, OFV, SSB, Eurostat, FAOSTAT, TØI |
| **Poland** | CSO, GIPA, Eurostat |
| **Portugal** | INE, DGE, ADENE, ANA, APIRAC, CELPA, EURECO, ACAP, Eurostat, ACEA |
| **Romania** | National Statistics, OEN, Dacia-R, APIA, GFK |

| | |
|---|---|
| **Slovakia** | SOSR, DGTREN, Eurostat, GFK, SIEA, IISI, FAO, ZAP, SR |
| **Slovenia** | SOSR, Eurostat, JSI_EEC |
| **Spain** | CNE, INE, MINECO, CNTE, DGTREN, MINER, UNESI, IDAE, MFom, ACEA |
| **Sweden** | SCB, Gasföreningen, STEM, Banverket/SCB, SIKA, VV |
| **United Kingdom** | ONS, CSO, BRE, BERR, CSO, I&SS, CPI, DTI, BERR, DFT, AAS, DUKES, AnAbs, ETSU, Eurostat, Pap Fd, SMMT, VDPF |

The ODYSSEE database is regularly updated. Last update was made in January 2011.

3.3.1.3 Assessment of the data quality and availability of existing data

The **MURE simulation tool database** is quite complete and detailed in the covered sectors.

In the residential sector, data are provided for a complete list of end-use technologies (Space heating, Water heating, Cooking, Electrical appliances, Refrigerators, Freezers, Washing machine, Dish washing machine, TV) and also a quite complete list of efficiency measures.

The industry sector is described disaggregated in many different branches (Chemical industry, Primary metals, Steel, Non-ferrous, Non-metallic mineral, Cement, Glass, Paper & Printing, Food & beverages, Textile, Machinery & Fabricated metals, Transport equipment, Miscellaneous industries, Wood, Mining, and Construction). The different end uses in each branch are also described in detail and many efficiency measures are covered.

Transport sector data is disaggregated in several modes (private transport by different types of cars, passenger collective transport, good transport by trucks and other vehicles, rail transport and water and air transport).

Tertiary sector is described also disaggregated in many different subsectors: hotels and restaurants, health, education, administration, wholesale and retail trade, private offices and agriculture. Several end-use technologies are considered and different efficiency measures are covered.

There are not details (specific documents, databases, etc.) in the source of data introduced in the model that seem to have been compiled by project partners.

Geographical coverage of this database is restricted to the EU-15 countries plus Norway.

The reference year of the data introduced in the several modules of the MURE tool database is different. **Industry** data reference year is 1995, **household** data reference year is 2000, **transport** data reference year is 2005 and **tertiary sector** data reference year is 1995. After these reference years the database has not been updated.

The **MURE measure database** provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union. The database is quite detailed and complete. The permanent network of correspondents within

energy efficiency agencies established in all EU Member States guarantees the continuous updating of the database that includes the most recent policy measures in each country.
This database covers the EU-27 countries plus Norway and Croatia.
Data sources (Table 8) and data providers of the **ODYSEE database** as stated in Table 9 seem to be reliable and many of them are official institutions. However we cannot formally assess it since we have not the details. The database is not free but a fee should be paid to access them. Geographical coverage of the data is the 27 EU countries plus Norway and Croatia. The ODYSSEE database is regularly updated. Last update was made in January 2011.

#### 3.3.1.4 Weak points of existing data

Main weak points of the described model regarding data issues are the following:

- Updating of the data in the MURE simulation tool database. Some of the data included in some of the sectors have not been updated since 1995 and therefore are not representative any more of the described sectors.
- Source of the data in the MURE simulation tool database. The sources are not explicitly shown and their suitability cannot be assessed.
- The ODYSEE database, that seems to be very detailed and up to date, is not free.

**Key issues about existing data in Sector Level Models/ MURE model example**

- Very detailed data on one specific issue are needed
- Existing data used in the MURE model:
  - Statistical data for energy balances and very detailed technology and cost data are necessary
  - Data about efficiency measures and policies
  - More than 150 sources compiled from EC and national Efficiency Agencies (sources include government ministries, statistical institutions, associations and research institutes)
  - Odyssee database is regularly updated (last: 2011)
- Data quality and availability + weak points of existing data:
  - Very detailed data for the sectors households, transport, industry and tertiary
  - Most data are from official institutions and are very reliable
  - Different reference years for the sector data
  - Recent policy measures are continuously updated through the corresponding with agencies in all EU MS
  - In some sectors no update of the reference data since 1995
  - The sources of the MURE database are not explicitly shown

## 3.4 Disaggregated Models

### 3.4.1 Existing data used in the model family *"Disaggregated Models* / model example *"WASP-Greece"*

The chapter 3.4.1 is based on the report on existing data, by George Giannakidis (CRES).

This section refers to the data sources used for the initial development and the continuous update of the WASP-Greece model that is used to analyse the optimum future development of the Greek Electricity production system.

#### 3.4.1.1 Characterisation of model family/ model example

The WASP model of the Greek electricity generation system is based on WASP-IV. WASP-IV is designed to find the economically optimal generation expansion policy for an electric generation system under user-specified constraints. It utilizes a probabilistic estimation of the system production costs, the unserved energy cost, and system reliability, a linear programming technique for determining the optimal dispatch policy satisfying exogenous constraints on

environmental emissions, fuel availability and electricity generation by some plants, and the dynamic method of optimization for comparing the costs of alternative system expansion policies, over the model time horizon.

In the model implementation used in CRES, the necessary annual additions of new generating plants to the system and the corresponding investments are defined for a planning period of 20 years, so that the electric energy and power demand are satisfied, in terms of minimum cost and acceptable levels of reliability. For the given planning period, WASP model through incorporation of the energy and power demand, the existing electricity generation system, the scheduled investments, and various constraints of system expansion, estimates the optimum generation scheme, the plants addition/retirement program, the necessary cash flows, etc.

The input data of the model are:

- Annual peak load estimations
- Seasonal load duration curves (12-month periods used by CRES)
- Technical and economical characteristics of existing and candidate power plants
- Scheduled outages (for maintenance) and equivalent forced outages rates (corresponding to failure probability)
- Predetermined retirement and addition program of power plants
- Seasonal data related to the hydroelectric plants operation and corresponding to different hydrological conditions
- Seasonal data for RES plants (incorporated by CRES as run-of-river hydro plants, as described later)
- Parameters linked to the desired reliability level of the system

The output of WASP model on annual basis and for the planning period includes the following:

- Additions of new power plants
- Electricity generation system scheme
- Produced energy per fuel type
- Fuel consumption for electricity generation
- Energy not served
- Capacity factor of power plants
- Cash flows for the implementation of the optimum investment schedule defined by the simulation

It must be noted that WASP-IV has been thoroughly used for power systems planning mainly based on thermal and large hydro plants. Therefore in order to incorporate the special nature of various RES units, the latter have been treated by CRES as run-of-river hydro plants (without energy storage capability). Through this way, their stochastic, uncontrollable nature can be effectively approached, along with the fact that the produced energy from RES is absolutely prioritized, during the day-ahead dispatching of the power units.

#### 3.4.1.2 Analysis and characterisation of existing data

According to the description presented in the previous section, the model requires a set of very detailed data concerning the existing electricity system and the technical and economic characteristics of technologies available in the future. This requires two distinct sets of data sources a) the data on the existing installations must come from the operators and producers b) the data for the future characteristics should come from technology providers and international sources modified for the local cost, mainly the cost of labor.

The data sources for the existing installations are:

1. Public Power Corporation S.A.
2. Hellenic Transmission System Operator S.A.
3. Independent Power Producers
4. Centre for Renewable Energy Sources and Saving
5. Ministry of Environment Energy and Climate Change
6. Regulatory Authority for Energy

The main data sources for the investment costs of technologies and the forecast of the international energy prices are the International Energy Agency publications.

The types of data that are collected per source are given in Table 10.

**Table 10:** Data Sources and Category

| Data Source | Category of Data | Description of Data | Geographical Resolution |
|---|---|---|---|
| Public Power Corporation S.A. | Company data | Installed capacity of power plants, heat rate, typical maintenance duration, fuel cost, fixed O&M cost, variable O&M cost, heat value, $CO_2$ emission coefficients, hydro plants expected inflow energy, investment costs, construction time | Country level |
| Hellenic Transmission System Operation S.A. | Official statistic source (public source) | Electric Load forecast | Country level |
| Independent Power Producers | Company data | Installed capacity of power plants, heat rate, typical maintenance duration, fuel cost, fixed O&M cost, variable O&M cost, heat value, $CO_2$ emission coefficients, hydro plants expected inflow energy, investment costs, construction time | Country level |
| Ministry of Environment, Energy and Climate Change | Official statistic source (public source) | National targets on the RES technologies mixture | Country Level |
| Regulatory Authority for Energy | Official statistic source (public source) | Technical specifications of the power system market operation (spinning/cold reserve requirements, rules on the share of RES in energy generation). | Country Level |
| Centre for Renewable Energy Sources and Saving | Private statistics | Wind generation profile. | Country Level |
| International Energy Agency | Official statistic source (public source) | Fuel prices forecast and investment costs for emerging technologies. | International |

3.4.1.3 Assessment of the data quality and availability of existing data

The main problem in data collection for the WASP model is related to the data that refer to the existing power plants (installed capacity of power plants, heat rate, typical maintenance duration, fuel cost, fixed and variable O&M costs, heat value, $CO_2$ emission coefficients etc.). It is obvious that these data are very detailed and cannot be freely dispatched by the Power Plant owners in the liberalised market due to confidentiality reasons. In the case of the Greek

WASP application, the data were collected from the Public Power Corporation and the Independent Power producers via the Ministry of Environment Energy and Climate Change and were used by CRES after the signature of a confidentiality agreement. The level of detail of these data is on a unit level (i.e. even more detailed than the power plant level), and they are continually updated.

The official statistics of the Hellenic Transmission System Operator, the Ministry of Environment, Energy and Climate Change and the Regulatory Authority for Energy are publicly available and are updated on an annual basis. Finally, the detailed statistics of the wind and other renewable energy generation profile are derived from studies and monitoring that is performed by CRES, and are updated every 1-2 years on average.

The level of completeness/consistency and the level of detail per data source is presented in Figure 6 below. According to the figure about 30% of the data sources are ranked as highly consistent and detailed.

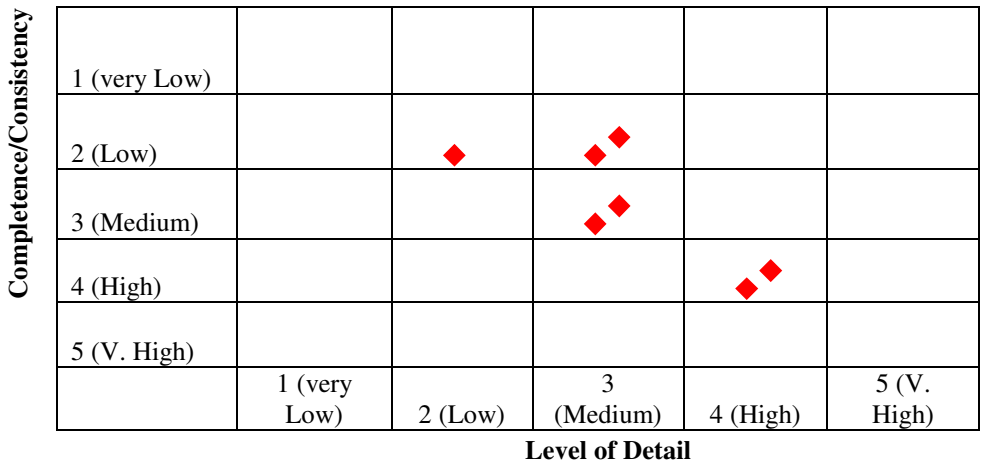


**Figure 6:** Data Completeness/ Consistency and level of detail per source

3.4.1.4 Weak points of existing data

According to the availability description presented in the previous section the main weak point of the existing data sources comes from the fact that the detailed data of the existing power plants are not easily accessible. Unfortunately this issue cannot be easily resolved since the data are provided from independent, private power plant owners and operators. Directly related to this fact is the problem that detailed information of the internal power blocks of the power plants (power level, heat rates etc.) are not available from the power plant owner, even under confidentiality agreements.

The stochastic generation profile of wind and other renewable energy sources power plants need to be updated more frequently and the information had to relate the actual technologies used (type of wind turbine etc.) with the site potential and detailed measurements.

### 3.4.2 Existing data used in the model family *"Disaggregated Models"* and model example *"CGEN"*

The chapter 3.4.2 is based on the report on existing data, by Nazmiye Ozkan and Elisabetta Mocca (PSI).

#### 3.4.2.1 Characterisation of model family/ model example

Disaggregated models are characterized by a high level of detail. They focus on specific parts of energy systems.

An example of disaggregated models is CGEN (Combined Gas and Electric Network Model). CGEN is a nonlinear multi-time period optimisation model. It minimises the total operational cost of the combined gas and electricity networks, whilst meeting the demand requirements over the entire time horizon. It models the gas and electricity network infrastructure components.

CGEN model runs in two modes: planning and operational. The first mode is based on a yearly time step, while the time step of the operational mode can be daily, weekly or monthly.

#### 3.4.2.2 Analysis and characterisation of existing data

Ten sources were examined in order to fill the list with detailed information about the type and quality of the data. The Figure 7 presents the split of sources by sector. The main sources of information are two papers written by CGEN developers, Chaudry et al. 2008, Qadrdan et al. 2010. These journal articles describe the model and provide information about the sources where CGEN data were drawn. Finally, in order to explore in depth the data used by the model, the developers were contacted directly.

CGEN models UK gas and electricity networks. Hence, the geographical resolution of the model is at country level. CGEN covers two energy sectors: electricity and gas.

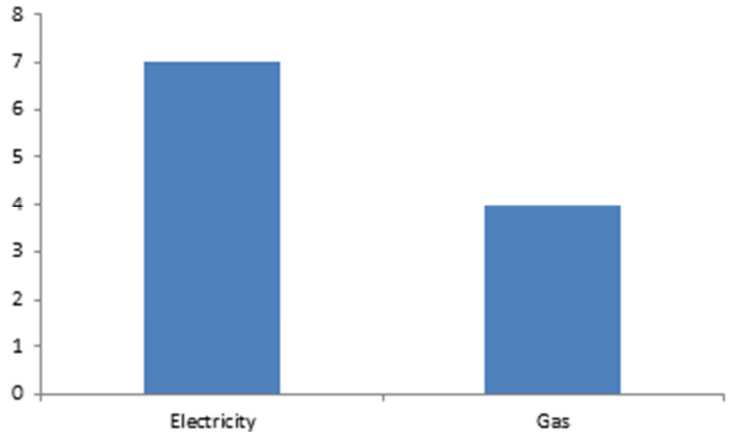


**Figure 7:** Number of data sources by sector

Table 11 presents the type of data and sectors covered and gives a first overview of the data type required for the model calibration.

**Table 11:** Type of data and sectors covered

| Sector | Description of the data |
|---|---|
| Electricity | Installed generation capacity on different buses<br>Maximum capacity of interconnecting GB transmission boundaries<br>Marginal operating costs of power generation<br>Interconnector costs<br>Electricity load shedding cost<br>Efficiency<br>Full ramp up/down<br>Data on National Electricity Transmission System |
| Gas | Maximum supply capacity of different gas terminals<br>Working capacity of gas storage facilities<br>Deliverability rate<br>Cost of gas supplies<br>Operating cost of gas storage facilities<br>Deliverability cost of gas storage facilities<br>Gas load shedding cost<br>Data on Gas transportation system |

The input data employed by CGEN were mainly used to characterize energy quantities, costs, technology characteristics, and demand, as displayed in Figure 8, which indicates also the number of sources used.

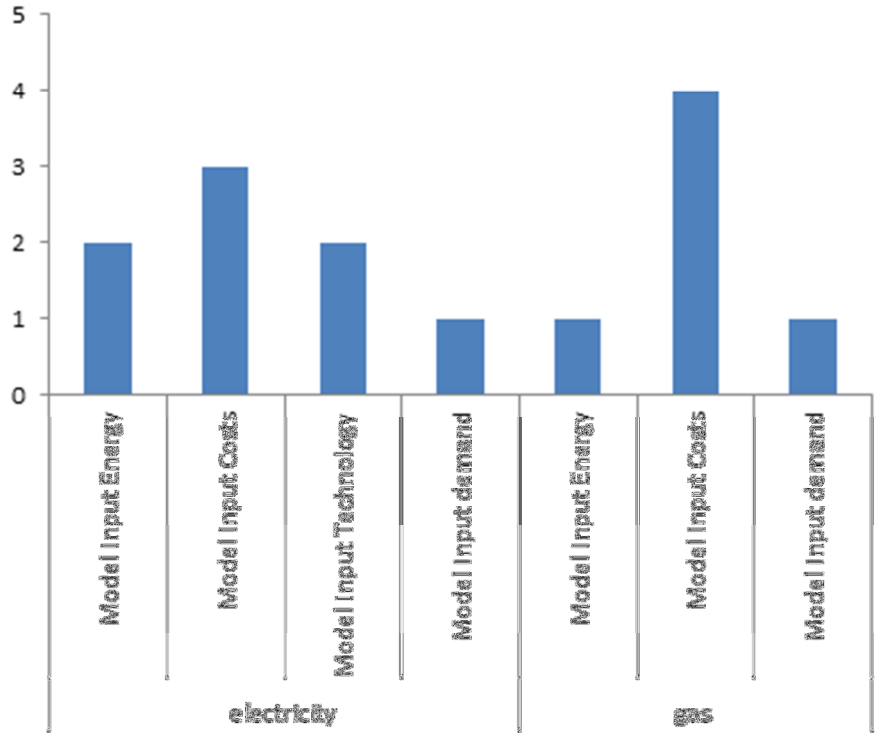


**Figure 8:** Number of sources by category of data and by sector

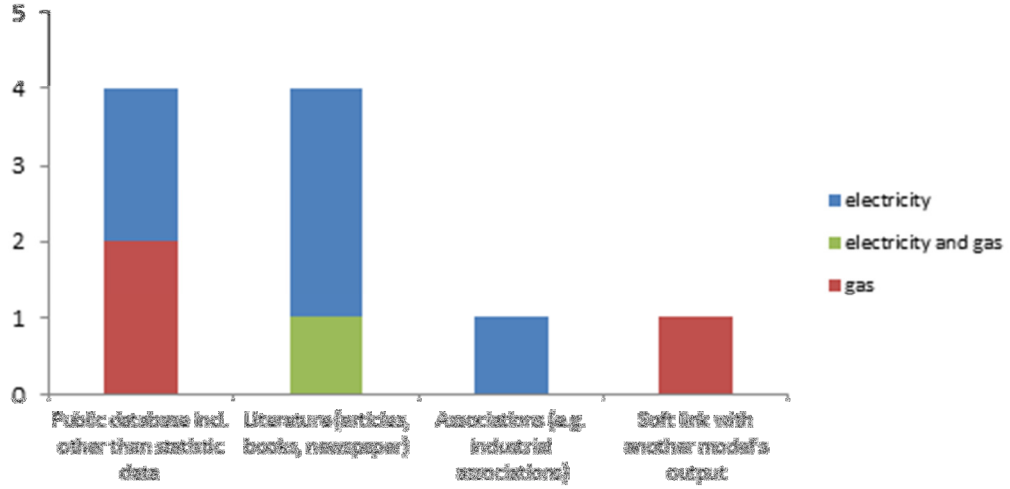


**Figure 9:** Number and type of sources by sector

The assumptions and data that were used in the development of CGEN have been explained in various places. The characterization of electricity sector follows on three journal articles (see for instance Qadrdan et al. 2010; Qadrdan et al. 2009), two public databases (such as National Grid and DTI), and one report published by a professional association (see Power 2004). Data for gas sector is based on two public databases as well as soft linking with another model's output (the UKERC energy 2050 project). Chaudry et al. 2008 discusses these in detail.

3.4.2.3 Assessment of the data quality and availability of existing data

**Time resolution.** The time resolution of the data is mainly annual, except for "maximum capacity of interconnecting GB transmission boundaries", whose time resolution is daily. However, for some categories of data, their time resolution was not clear. These categories include, for electricity data, marginal operating costs of power generation, interconnector costs, electricity load shedding cost, and efficiency; for gas data, cost of gas supplies and gas load shedding cost.

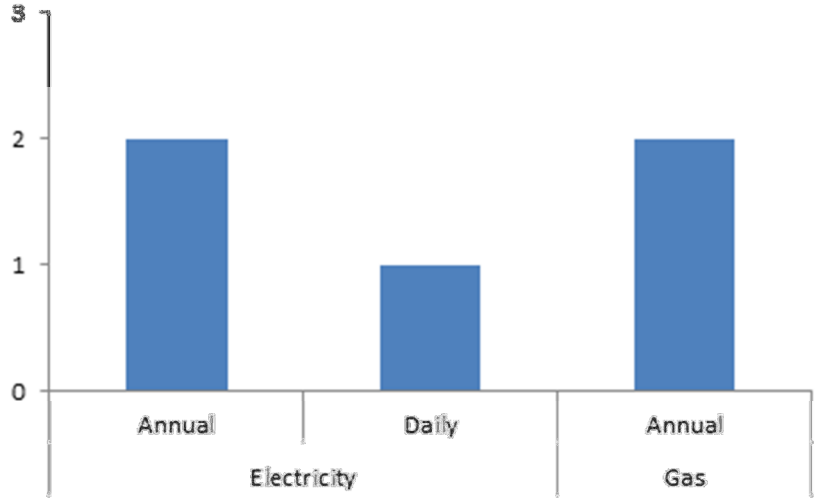


**Figure 10:** Time resolution and frequency of publishing by sector

**Time lag.** The majority of the data are characterized by a time lag between the date of publication and the reference date of 1-2 years or less than one year.

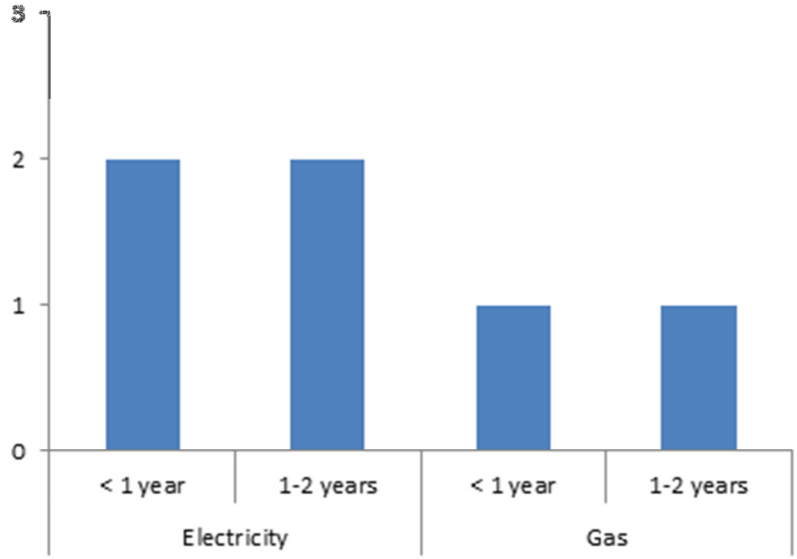


**Figure 11:** Number of sources by time lag and sector

**Frequency of data publishing.** CGEN uses data published annually. These are the National Grid Ten year statement and the National Grid Seven year statement. At the same time, it also follows data presented in various journal articles, for instance Chaudry et al. 2008.

**Completeness and consistency/ level of detail.** The overall consistency and completeness of the data used by CGEN has been classified as very high (5). This is motivated by the fact that, as mentioned before, disaggregated models are very detailed. As a UK specific model, it makes use of the best available data sets on characterization of the gas and electricity. For the same reason, also the level of detail of the data has been ranked "very high".

**File format.** All the data are in pdf format and are available for free previous subscription.

#### 3.4.2.4 Weak points of existing data

There is not a specific weak point about CGEN. However, given the level of detail included to represent actual energy networks, the model cannot be easily adopted for another country. In addition, CGEN can only look at gas and electricity networks hence cannot provide information about the rest of the energy system.

Further details on the limitations are discussed in section 4.4.2.

**Key issues about existing data in Disaggregated Models**

- Model type with very detailed data on a specific part of the energy system
- Model example WASP uses detailed data about the Greek electricity generation system (annual peak load estimations, load curves…)
- Existing data:
  - Detailed data about the existing electricity system (from operators and producers) + data about future technologies (from technology providers or international sources like IEA publications)
  - Sources are official statistics from transmission system operators, ministries or regulatory authorities
  - Most data are either public available or from a confidential agreement
  - Detailed generation profiles for renewables are needed and derived from studies or own monitoring projects
- Data quality and availability + weak points of existing data:
  - Difficult to get all necessary data about existing power plants (maintenance duration, fuel costs…) due to confidential reasons
  - Time resolution mostly on annual level but also daily data, mostly published with a yearly frequency
  - Most data have a very high level of detail and very high completeness/ consistency
  - Detailed information of the internal power blocks of the power plants are not available
  - Data for renewables have to be more frequently updated and must refer to the actual technologies
  - Due to the use of very detailed and specific data, the model can't be easily adopted for another country

## 3.5 Energy Behaviour Tools

### 3.5.1 Existing data used in the model family *"Energy Behaviour Tools"* and model examples *"ESTEEM" and "Climate Bonus"*

The chapter 3.5 is based on the report on existing data, by Annele Eerola, Johanna Kohl (VTT) and Koen Schoots (ECN).

#### 3.5.1.1 Characterisation of model family/ model example

The analysis of the existing data in this paragraph is about the "Energy Behaviour Tools" family. The examples presented here are ESTEEM and Climate Bonus. Energy Behaviour Tools are bottom up tools that are intended to support decision making processes at project level including various stakeholders, e.g. local key-actors such as project managers, implementers and consumers. These tools include typically qualitative and semi-qualitative elements. Information sources are context-specific and information gathered in one case can usually not be transferred to another. The main emphasis is on creating awareness and dialogue among various stakeholders of energy system transitions (citizens and consumers included) and understanding and impacting their behaviour. Energy Behaviour Tools usually do not model or analyse energy systems themselves. Not only objective data but also well-argumented subjective information - including experiences, interests and expectations - is considered valuable for these tools. The tools of this family may also provide with immediate personal-level and context-specific stimuli facilitating changes in behaviour.

The aim of the ESTEEM tool is a structured six-step procedure that is intended to facilitate decision making by increasing the mutual understanding among the stakeholders of specific energy projects. It helps in searching solutions that are acceptable to all stakeholders (see Figure 12). As the context and issues are unique for each energy project, data is hardly transferable between projects and has to be gathered over again for each new project in which the tool is used.

Climate Bonus increases consumers' consciousness of how the choices they make in their households impact their carbon footprint. It combines the use of verified carbon footprints, personalised monitoring and feedback services to households. It aims at lowering the greenhouse gas intensities of consumer purchases by a reward system for consumers who manage to reduce the embodied emissions and a secondary reward system for retailers that successfully reduce the emission intensity of their sales (see Figure 13). The verified carbon footprints can be used each time the tool is deployed. Data on household energy use is specific for each household and is not transferable between awareness projects. This data has to be gathered from the personalized monitoring efforts and feeds into the feedback service by

which a household can determine where a reduction in energy consumption can be achieved most effectively.

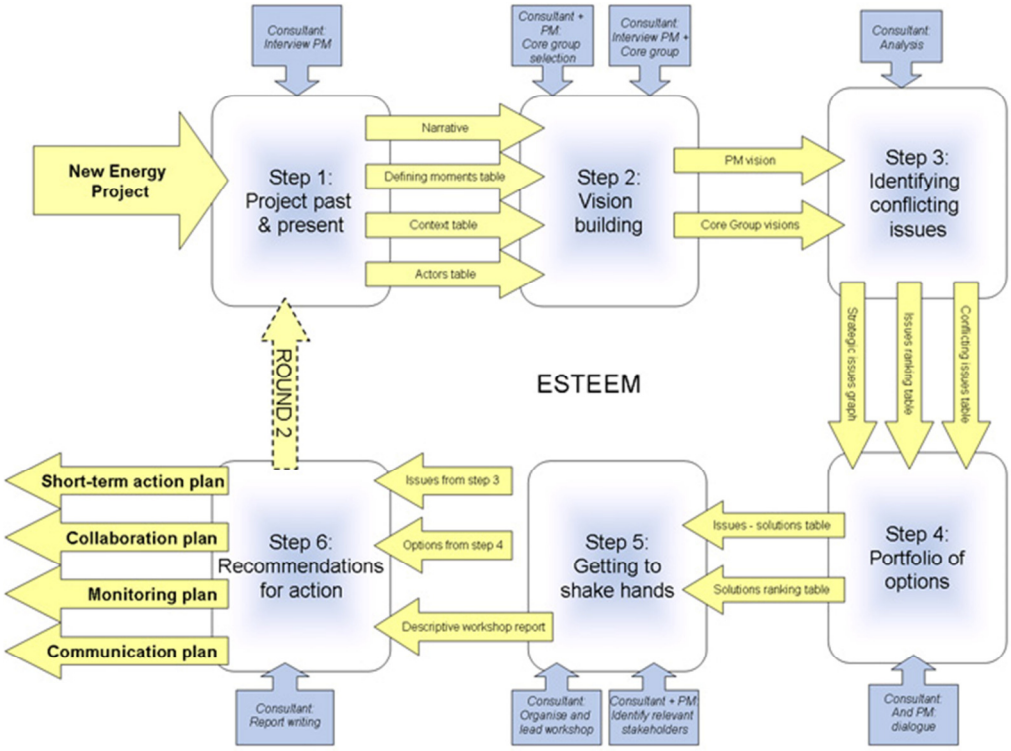


**Figure 12:** The structured six-step ESTEEM procedure

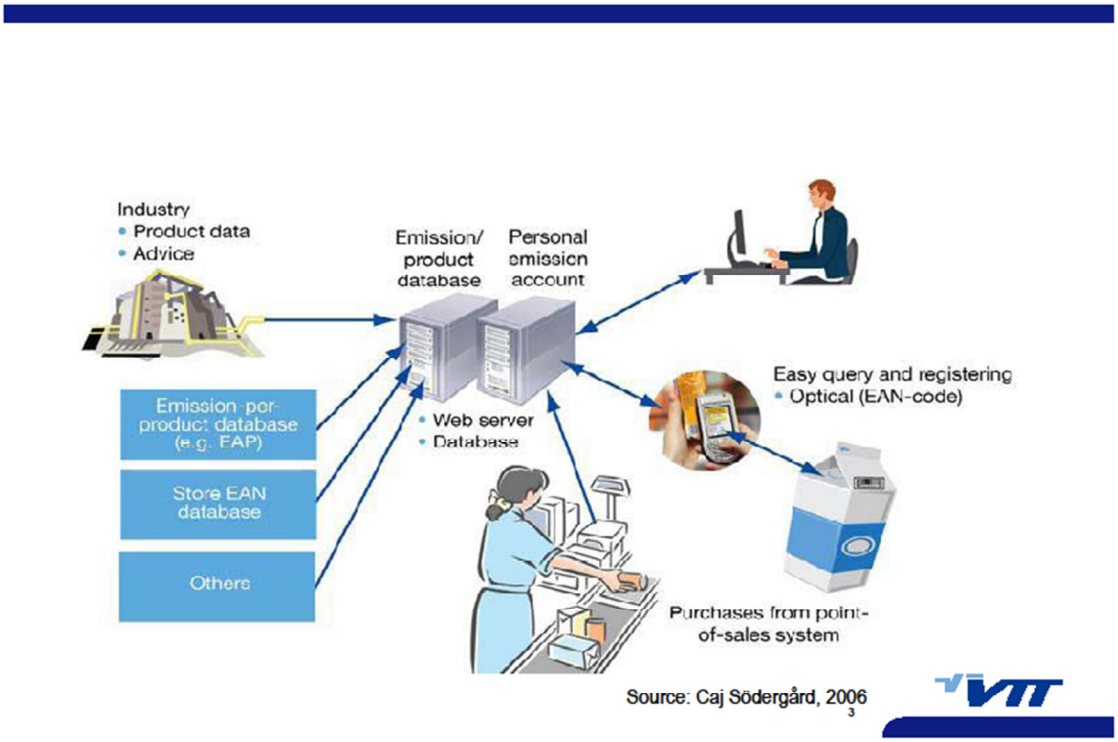


**Figure 13:** System Vision of the Climate Bonus

#### 3.5.1.2 Analysis and characterisation of existing data

A typical feature of the family of Energy Behaviour Tools is that they rely on context-specific data and information that are not necessarily publicly available. As this kind of data can be qualitative or apply to a very specific micro-level system, they are not comparable with the typical data of quantitative models. Therefore, these tools provide important additional and complementary knowledge for making desired transitions to happen or explain why they may fail to occur in the presence of macro-level incentives. The main emphasis of Energy Behaviour Tools is in understanding and impacting the behaviour of various stakeholders including consumers and citizens, rather than modelling and analysing the energy system transitions an a macroscopic scale.

For example in ESTEEM, the main part of the data is collected directly from various stakeholders during the procedure of using the tool. Information collected concerns the context itself, as well as the interest values and expectations of the stakeholders. Interviews with stakeholders and experts, and discussions in focus groups and workshops are important in this respect. The information collected in previous projects can usually not be used as additional data and information source.

On the other hand, the idea of Climate Bonus is to make effective use of general product and product emission data that has been systematically collected into a common database. These data together with the data provided by individual consumers about their choices defines the resulting carbon footprint stored in personal emission account. The data from individual consumers' energy consumption has to be generated for each new situation in which the tool is used.

#### 3.5.1.3 Assessment of the data quality and availability of existing data

Because of the nature of the tools, the information sources and the data and information they provide are context dependent. The strength of this type of data and information relies often on its concreteness, relevance, depth and systematic collection of multiple viewpoints. The quality of the data also depends on the commitment of those involved. It is therefore difficult to measure the data quality, issues concerning time (time resolution, time lag, frequency of publishing) and other indicators like completeness, level of detail or the data documentation in general terms. The tool themselves also contribute to the cumulative knowledge that can sometimes be used later on in similar types of contexts (time, place, subjects and objects).

#### 3.5.1.4 Weak points of existing data

The weak points of the existing data for the "Energy Behaviour Tools" family follow from the comments above and those in the data list.

- In general it can be stated that the quality of data used by energy behaviour tools varies by context.
- Weak commitment of the users of the tools and/or the stakeholders involved is likely to have a negative effect on the quality of the data and information. Furthermore, the data is usually not transferable between different contexts. On the other hand, if commitment is strong the completeness, concreteness and richness can often be regarded as strengths of this type of data.
- There may be difficulties accessing relevant data and information if it is not provided in user-friendly form or when up-to-date information is confidential or not publicly available.
- The regional coverage of the Climate Bonus data is still limited (the tool has been developed in Finland and it is currently in a demo phase).
- For ESTEEM, several relevant case studies have already been reported. Application of the tool is, however, still in its early phase.

**Key issues about existing data in Energy Behaviour Tools**

- Bottom-up models to support decision making process by including stakeholders
- Existing data:
  - Tools contain mainly qualitative and semi-qualitative information
  - Tools rely on context-specific information sources (like experiences, interests, expectations)
  - Information from previous projects as additional source
  - General data about product and product emission are also used
- Data quality and availability + weak points of existing data:
  - Data are mostly not publicly available and are also not comparable to typical data of quantitative models
  - Data are collected from stakeholders/ individual consumers during the procedure of using the tool (interviews with stakeholders and experts, discussions in focus groups, workshops)
  - Data quality strongly depends on involved stakeholders and their commitments and therewith the quality varies by context
  - Data from different contexts might not be comparable

# 4 Additional Data Requirements

## 4.1 Energy System Models

### 4.1.1 Additional data requirements of the model family "*Energy System Models*"/ model example "*TIMES PanEU*"

4.1.1.1 Description of additional data requirements for model calibration

In this section, additional data requirements for Energy System Models are described, focusing on data needed to improve the model results without changing its structure. This means that better data should replace calculations or assumptions but the model structure itself is not changed.

One key issue concerning data requirements is the need for additional information about the **stock of technologies** which are currently in use. These requirements refer mainly to the end use sectors.

- One sector where this kind of data are required is the residential sector where data are needed, in particular with regard to the age structure of the heating technologies, the fuel they use and the type of heating system. This information in combination with the average lifetime of these heating technologies is needed for the model to calculate the cost optimal date and the replacement investment type, and to calculate and compare the emission and energy reduction potentials between different sectors and countries. Therefore, comprehensive and reliable data about the current efficiencies and the type of fuels of the stock technologies are required. The information on heating technologies is essential to evaluate the different abatement costs of emissions in different sectors and countries and to calculate a cost optimal burden sharing of emission reduction for example between the European Member States.
- The requirement of information on technologies in stock occurs also in the residential, commercial and the industrial sectors, and concerns also the age structure of the existing stock for electric appliances for instance or process heat supply technologies.
- In the industrial sector, there is additional need for data about the specific energy consumption of the existing stock of technologies. For example, in the cement industry it is needed to know which types of kilns are used, how old they are, what kind of fuel and how much fuel they consume. This need exists in all energy intensive subsectors where the modelling is based on production processes.

Another data requirement of the industrial sector is the need for detailed information of the trade flows of semi-finished and finished goods. These numbers are needed for the correct modelling of the technologies but also in order to calculate the potentials of recycling. If the

amount of production differs from the amount of consumption of a product, this influences the availability of scrap which is needed for recycling (for example in the subsectors glass, steel, aluminium or paper).

An additional issue regards the additional information needed to describe **the new technologies**, especially in the end-use sectors where data about investment costs and operation and maintenance costs are poorly available. This information is required, for example, for heating technologies in the residential sector, and even more needed for the description of very heterogeneous industrial sectors. In industry, data on investment costs for technologies like kilns are very difficult to get and often cannot be generalized due to the different existent situations on these sides. In contrast, data about investment costs for the electricity sector are available and there are a lot of publications and other sources which can be used for the modelling work. In addition, comprehensive and reliable information about the evolution of efficiencies of industrial production processes is needed for all subsectors.

Furthermore, one key issue is encountered for the modelling of the generation of **electricity, (district) heat** and steam from autoproducers and CHP in both public electricity and heat sector and in the industrial sector. A clear distinction between public and industrial heat and electricity has to be made. Data are needed for the amount of electricity, district heat and industrial heat produced by public and industrial CHP by country, fuel type and by industrial subsector. In general, additional data about steam production by technology and fuel type for the industrial sector are also required.

Focussing on the **transport sector**, there is a need for more detailed national statistical data such as final energy consumption of road transport by technology (car, bus, heavy/light duty vehicles and motorbikes), average specific fuel consumption, annual mileage, average daily mileage and load factors for each vehicle category. Additional data requirements in this sector are related to the ratio of short and long distance travelling and national projections for the future share of alternative fuels (e.g. natural gas, LPG, hydrogen, electricity, but also the ratio of gasoline and diesel) and powertrains (e.g. electric, hybrid electric, plug-in hybrid electric, fuel cell electric) as well as national projections for the development of passenger and freight transport demand by transport mode.

Additional data are required for accurate modelling of **residential and services sector**. The energy consumption of the residential sector is dominated by the supply of space heat (BDWE 2008). The demand of space heat mainly depends on the type of existing buildings and standard for new buildings. Therefore additional data needs in this sector are related to

building data like number of floors, energy consumption by energy carrier and building, age structure of buildings or building reconstruction information.

An important area where more accurate data are required within the Energy System Models family relates to the behaviour of agents in the end-use sectors. Data in this category include discount factors for the different end-use sectors which reflect the behaviour of the agents in these sectors. Differentiation should be made among end-use sectors themselves, as for instance households have other expectations and economic valuations of investments than the electricity and industrial sector.

More specific issues are raised depending on the model example which is analysed. Focussing on the South African TIMES model (TIMES-GEECO, see Tomaschek et al. 2011), the additional data requirements concern in particular the data on the energy consumption for each end-use sector, water heating and potentials for areas for growing energy crops.

#### 4.1.1.2 Description of additional data requirements for model enlargement

While the previous section described the additional data which are needed to improve the existing model structure, this section presents the data needs to improve and extend models or even to develop new models.

One direction to follow in order to extend the model structure is the implementation of **additional subsectors in the industrial sector**. The TIMES PanEU model for example contains ten energy intensive and five non-intensive subsectors. If additional energy intensive sectors should be modelled, additional data on production processes are needed. In particular for modelling additional non energy-intensive subsectors or for detailing the existing ones, specific data on the useful energy are required. The non energy-intensive industrial subsectors are not characterised by dominating production processes. Therefore they are modelled by different useful energy groups. These groups could be space heat, process heat, heat for hot water, steam, drying, cooling, lighting, compressed air, electricity for ICT or other mechanical appliances, such as described in Gondia 2008, Kuder 2010 or in Blesl et al. 2011 for TIMES PanEU. These data don't exist so far and the demand for useful energy in the already existing non-intensive sectors in the TIMES PanEU (like Food and Tobacco, other Chemicals etc.) are based on internal calculations. If these data would be available, the existing subsectors could be modelled in a higher quality and additional subsectors could be extracted out of the residual entity *other industries* (for example vehicle manufacturing). More precisely for the implementation of these new industrial subsectors or new commodities, data are needed on the demand and the supply of useful energy. The required information relates to the amount of final energy by fuel type and by subsector which is needed to supply the different

useful energy categories; and also needed the amount of useful energy by type (space heat, steam …) and by subsector.

A higher time resolution could be a possible model improvement. To that, data on a more detailed time level are needed. If the total electricity demand is an endogenous model result, like it is in the case of Energy System Models, load curves for each useful demand of the end use sectors are also needed in order to create an overall load curve of the electricity demand. To fulfil this data need, load curves for each end use sectors for the demand for different energy carriers like electricity or gas are needed.

Another area of model extension could be the target to increase the number of internalised model decisions. Instead of working with external and given assumptions more outcomes could be a result of the optimisation done by the model. One example could be the modal split of transport technologies. Instead of using fixed market shares, the split could be a model result. Therefore data are needed about the hurdle rate of the users of the different modes to change their behaviour. Their costs of change, intangible costs or necessary incentives are necessary data on the behaviour of the users in order to internalize the transport modal split.

#### 4.1.1.3 Possible future actions to generate this data

As a result of this analysis, mainly data for the end-use sectors seem to be less available compared to the electricity sector for example. The industrial sector is quite heterogeneous and much information is confidential. In addition, there is no central platform for all industrial data of all subsectors concerning energy related issues. Accordingly, additional data for the industrial sector could be provided by associations of each subsector. Therefore, the requirements concerning statistical information which single companies have to deliver to these associations have to be increased. These data could be collected and provided by organisations which cover the whole sector like energy agencies or with special focus on the industrial sector, like the chamber of commerce.

Additional information which is needed from the industrial sector relates to load curves as mentioned. These data are necessary to improve the time resolution of Energy System Models. They could be based on single company data or on data delivered by energy utility companies. Normally, companies have different tariffs for different times so that this data should be available. Also in the internal accounting information about energy costs could be available.

Compared to the industrial sector, the collection of data on the electricity use of households and their load profile could be performed by electricity utility companies or grid operators. Data on the behaviour of single households could be collected through surveys for instance.

**Key issues about additional data requirements in Energy System Models**

- Additional data requirements:
  - Data about the stock of technologies which are currently in use for the supply but especially the demand sectors (like age structure of technologies, type, efficiencies, average lifetime …)
  - Data about the trade and lifetime of industrial goods (finished and semi-finished) to model the specific consumption and the recycling potentials
  - Costs data for new technologies especially for the end use sectors (investment costs, O&M; very heterogeneous for the industrial sector)
  - Data about autoproducer and CHP (clear distinction between public and industrial, data by type, fuel, country, subsector, production of electricity, heat and steam)
  - Transport sector data like energy consumption of road transport by technology, average specific fuel consumption or annual mileage
  - Data about buildings like number of floors, age structure or reconstruction information
  - Behavioural information to model different discount rates by sector
  - Data about useful energy for the demand sectors (like the non energy-intensive industry and the need for cooling, steam, compressed air…)
  - Load curve data to increase the time resolution of the model (data for different commodities and sectors)
- Possible ways of data generation:
  - Data from industrial associations of the different subsectors on national or international level or the chambers of commerce for the industrial sector (like costs data or information about the stock of existing technologies)
  - Company data for the industrial sector like load curve data or consumption of useful energy
  - Load curve data from utility companies or grid operators
  - Balances of useful energy from statistical offices
  - Behavioural data for example for the residential or transport sector (about modal split) from surveys

## 4.2 Macroeconomic Models

### 4.2.1 Additional data requirements of the model family "*Macroeconomic Models*"/ model example "*NEWAGE*"

#### 4.2.1.1 Description of additional data requirements for model calibration

In general, Computable General Equilibrium (CGE) Models for macroeconomic analyses are calibrated for a specific year using an elaborated database, such as the GTAP database or country-specific National Accounts. The conventional choice of the base year is the latest year for which a set of complete National Accounts exists (currently 2004 for GTAP 7 and, for example, 2007 for German and 2009 for UK Input-Output-Tables; GTAP 8 with base year 2007 is expected to be released by the end of 2011). As stated above, time lags of more than 2 years are required to be reduced to make analyses more up-to-date.

Considering smaller CGE models on a national or European level, it would be useful to have a European Social Accounting Matrix (SAM) with the possibility to extract national SAMs from it. This approach would enable the comparability between European countries. In addition, SAMs of non-EU-countries (e.g. Iceland and Croatia) could be integrated.

The model calibration mainly involves deciding upon functional forms that describe the behavioural relationships between agents, regions and sectors, and their corresponding parameters. The functional forms describe the relationship between inputs and outputs regarding production technologies and consumer's preferences (utility). When constant-elasticity-of-substitution (CES) functions are adopted, their specification is crucial for the outcome of the CGE-model, as they determine whether the input structure in a specific production/consumption activity is rigid or flexible.[15] Substitution elasticities in the CES-functions are specified before calibration. As there is no unique data source, the parameters are issued as already mentioned from the literature, set by assumptions or from empirical estimations by using econometric techniques. CGE-models in the energy-environment field need a stronger foundation of substitution elasticities. It is necessary to extract more data from social sciences (e.g. psychology) and natural sciences (e.g. engineering). Social science studies are able to tackle the question of how consumers behave in their motivation and demand activities, in particular regarding the demand for energy services. Insights from

[15] The model solution of the calibration year reproduces observed prices and quantities, which serve as an anchor point where all the counterfactual scenario analyses start from. The anchor point for the CES-function calibration is described by the cost shares and benchmark quantities. The cost shares of the input factors are calculated as the value share of a specific input divided by the total value of all inputs in one production or consumption activity. They can be taken from GTAP and National Accounts. More important, however, are the curvatures of the CES-functions, as they reflect the behaviour within the production and consumption processes. The curvature is determined by the underlying substitution elasticity.

engineering reveal the technical barriers and possibilities in the supply and provision of energy services and goods. Here, it is important to understand the rebound effect, which may follow from energy efficiency increases (Sorrell 2008). These insights would lead to a more realistic calibration and could help answering questions like (i) how easily certain industries can substitute the purchased electricity for self-made electricity in small combined-heat-and-power plants (ii) how easily households can substitute an oil fired heating system for a heat pump or (iii) how easily households can substitute a diesel car for an electric car satisfying their mobility needs. Section 4.2.1.3 analyses possible future actions in this regard.

#### 4.2.1.2 Description of additional data requirements for model enlargement

In GTAP and National Accounts in general, little information is given on absolute prices or physical quantities. CGE models mainly operate with quantitative data as the product of prices and quantities. In the energy-environment field, however, this result is not easy to interpret. In order to be able to make statements about concrete extraction and/or emission rates of pollutants/resources (e.g. $CO_2$-emissions in tonnes or water usage in $m^3$) it is important to couple monetary value data with physical units.

Within CGE models, prices are set to unity (only relative prices matter) and quantities are defined via indices, with no particular (physical) unit. If the electricity sector delivered electricity in terms of 1 million euros to the manufacturing sector this would reflect 1 million units of electricity regarding a price of 1. To be able to make statements about the corresponding units (e.g. TWh) and its implied prices, data from energy balances has to be incorporated. For example, in the energy specific NEWAGE model, data on electricity production in TWh in the EU is added to the resulting quantity indices. That allows the specification of absolute electricity production (TWh) and prices (€/TWh) in different sectors, regions and years. This procedure can analogously be applied to other goods and resources (e.g. GHG emissions) using Physical Input-Output-Tables (PIOT) or energy balances. To ensure consistency however, it is desirable to have the information on physical units for every industry and natural resource. This is necessary to be able to decompose price and quantity effects, in order to separate scarcity and demand effects.

Detailed PIOT concerning resources, energy and environment are necessary to assess environmental impacts of economic activities. Therefore it is suitable to have national and European PIOT in line with the national and European SAMs in order to connect economic activities with their environmental consequences and with the energy and resource use.

In National Accounts durable goods are commonly treated as consumption flows.[16] However, households treat the purchase of durable goods de facto as investments. But own-supply from the household sector is not marketed, meaning that the services which are produced in households have no market price, and thus there is no comparable sales data on gross value of the service, making it difficult to compare household capital flows with energy expenditure flows (Paltsev 2004). The German Federal Statistical Office records data on capitalized consumer durable goods in satellite accounts only (Destatis 2010). However, this is not directly linked with the National accounts. To analyse energy services properly, data are required to be directly linked with National Accounts.[17]

Concerning requirements from external modellers, collected through the Open Call, further requirements for model enlargement include the need for more details on services, inputs, outputs and trade (e.g. intra and extra-EU trade in services by product category or more detailed breakdown of hours worked by service industry). In the electricity sector, more information is needed on transmission, distribution, generation and sales. In the transport sector, more information is needed on the disaggregation between different modes and uses (commercial, personal, diesel and gas cars, trucks, etc.). Furthermore, more attention is required to be paid to fuels (e.g. regarding its disaggregation between coking and refining activities).

#### 4.2.1.3 Possible future actions to generate this data

Regarding energy and environmental issues, there is substantial need for further research in particular on the following issues.

For analysing energy efficiency, and especially for energy services supply, data on useful energy production in households is required. Conducting household surveys constitutes a useful procedure to generate data on durable goods. The German Mobility Panel is a prominent example of such a household panel (MOP 2007). It reveals detailed up-to-date information about person travel and mobility behaviour. Frondel et al. 2009 use the MOP to estimate fuel-price elasticities and fuel-efficiency elasticities for the German transport sector.

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[16] In final energy demand, typically, energy is not consumed for its own sake. It is consumed to produce useful energy or energy services in combination with other inputs, such as capital, material and labour. In transportation oriented CGE models (e.g. GEM-E3), households derive utility from the consumption of transport services (measured in person-kilometres), and not from the purchase of vehicles, energy or vehicle services separately. Vehicles are purchased, but not consumed at the same time. By providing utility over their lifetime, they are comparable to investment goods that depreciate over time. This is called a durable good. Energy and related services (e.g. maintenance) are nondurable goods as they are consumed in one instance. Durable goods are stocks that provide utility by providing recurrent service flows (Conrad, Schröder 1991).

[17] Jorgenson et al. 2006 have recommended that consumer durables be both treated as assets and their services included in GDP and consequently in National Accounts.

A similar approach would be suitable for the heating demand or other fields where useful energy is demanded, such as industry and commerce. Enlargements in the field of useful energy could be undertaken by energy statisticians, such as working groups for energy balances. To find out demand patterns and motivation of consumers, psychological studies and experiments are considered to reveal promising insights. Midden et al. 2007 tackle technology roles in understanding individuals' conservation of natural resources. More research in this field would improve the performance of capturing consumer behaviour in macroeconomic models. Finally, advanced econometric estimation techniques are useful to provide reliable values for the calibration of substitution elasticities. Robinson et al. 2002 and Nunez 2009, for example, use maximum entropy methods to estimate central substitution elasticity parameters.

### 4.2.2 Additional data requirements of the model family "*Macroeconomic Models*"/ model example "*GTAP-E*"

The chapter 4.2.2 is based on the report on data requirements, by Oscar Amerighi, Maria Cristina Tommasino and Umberto Ciorba (ENEA).

#### 4.2.2.1 Description of data additional requirements for model calibration

The analysis of the GTAP database version 7 (McDougall, Aguiar 2008) and the additional energy data (Lee 2008) used by the GTAP-E model (Burniaux, Truong 2002; McDougall, Golub 2007) highlights some needs of data improvement.

First, it is worth mentioning that a new version of the GTAP Database (version 8) will be available by the end of the year 2011. As announced, significant progress has been made on energy data, protection and taxes. Improvements have also been made in agricultural domestic support and agricultural production targeting. Moreover, additional Input-Output tables have been received for Kuwait, Venezuela and Philippines (Walmsley 2011).

A key feature of the GTAP 8 Data Base is that for the first time of GTAP Data Base, there will be two reference years: 2004 and 2007 allowing a type of time series dataset handling the difficulties in comparison across different GTAP database versions.

Nevertheless, in order to improve the GTAP-E model quality, it seems necessary to improve the **quality of behavioural parameters in functions**.

For the most part, each individual parameter included in the GTAP Database 7 is an independent datum, which stands on its own and does not require any consistency checks with other parameters. Furthermore, the GTAP-E model requires specific parameters for energy commodity substitution. **Elasticities** in model equations are crucial parameters in driving

policy simulation results. Therefore it is needed to improve their quality. Better elasticises can be either drawn from econometric estimations, survey or literature.

Finally, the delay in **updating data**, the reference year in the GTAP Database version 7 corresponds to the global economy in 2004, may be a disadvantage in evaluating energy policies with the GTAP-E model that is a static CGE model.

#### 4.2.2.2 Description of additional data requirements for model enlargement

Concerning the data requirements for model enlargement, it would be preferable to have additional sectors, such as sectors of renewable energy and additional regions in order to have more detailed description of the global economy essential to evaluate climate-change policies.

As most macroeconomic models, the main weakness of the GTAP-E database is the poor description of energy technologies. Technologies are not explicitly included in the database and only sectoral parameters in the production function show the technological progress of each sector. A satellite matrix which describes existing energy technologies and new technologies might be a very useful instrument for analysing the economic impact of energy policies.

#### 4.2.2.3 Possible future actions to generate this data

The consolidated international cooperation from the GTAP network consisting of individuals, agencies and institutions from around the world may well continue providing and updating data. The most common contributions made by individuals in the network are individual country data (I-O tables) following the rules provided by the GTAP Centre Staff (Huff et al. 2000).

However special projects related to energy and environment data collection might be further improved by the GTAP network.

**Key issues about additional data requirements in Macroeconomic Models**

- Additional data requirements:
  - Worldwide consistent national Social-Accounting-Matrices with direct connection to Physical-Input-Output-Tables to assess monetary values, physical units and environmental impacts simultaneously
  - Inclusion of durable goods in National Accounts
  - More profound behavioural and technology information (to calibrate substitution elasticities in CES-functions or other functional forms)
- Possible ways of data generation:
  - Continuous improvement of the GTAP database
  - Conducting econometric estimation, household surveys, psychological or engineering studies to better calibrate preferences and technologies
  - Establishment of working groups in industry associations to provide National Accounts with consistent sector-specific data

## 4.3 Sector Level Models

### 4.3.1 Additional data requirements of the model family "*Sector Level models*"/ model example "*MURE model*"

The chapter 4.3 is mainly based on the report on data requirements, by Helena Cabal, Yolanda Lechon Perez (CIEMAT) and Drazen Jaksic (EIHP).

#### 4.3.1.1 Description of additional data requirements for model calibration

*MURE simulation tool*

For this tool the weak points identified were that some of the data included in some of the sectors, like the industry sector, have not been updated since 1995 and therefore are not representative any more of the described sectors.

There is the possibility to update these data through the data management screen of the tool.


**Figure 14:** Main Data management screen of the MURE simulation tool

To that end, statistical data related to the energy balances of the covered sectors can be updated by the user simply changing the figures that appear in the different screens.

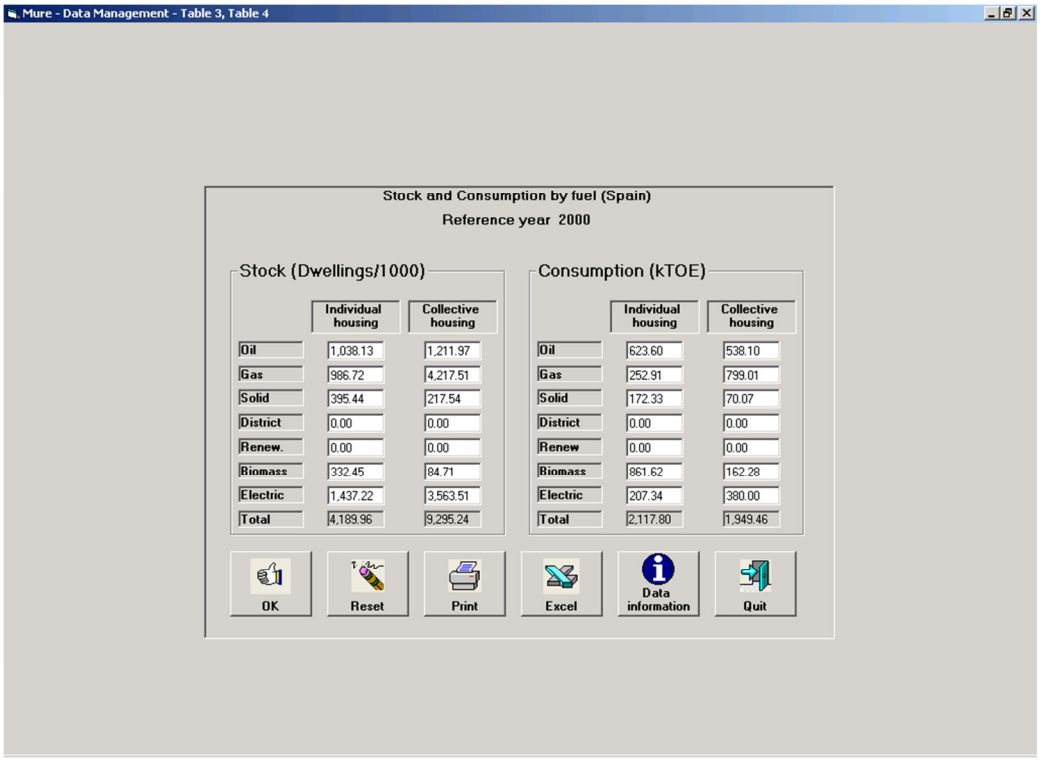


**Figure 15:** Data management screen of the MURE simulation tool, stock and consumption by fuel of dwellings

Secondly very detailed data regarding the technological and costs aspects of the different technologies can also be updated by changing the data appearing in the different cells of the screen.

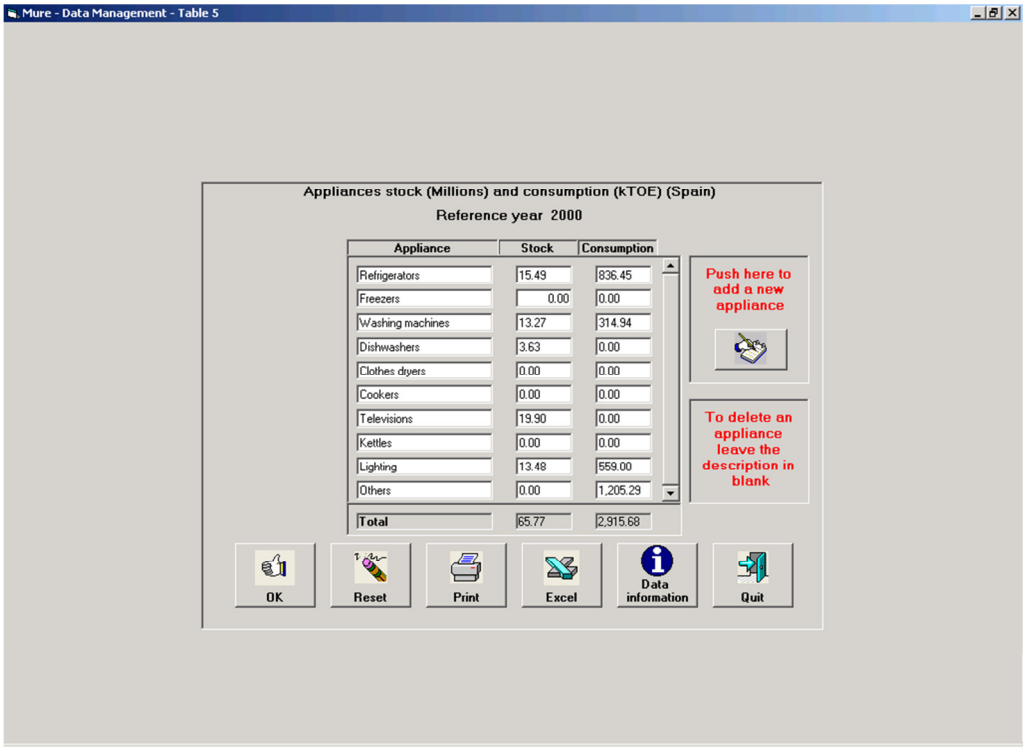


**Figure 16:** Data management screen of the MURE simulation tool, Appliances stock and consumption

Data on the technological and costs aspects of the efficiency measures can also be updated.

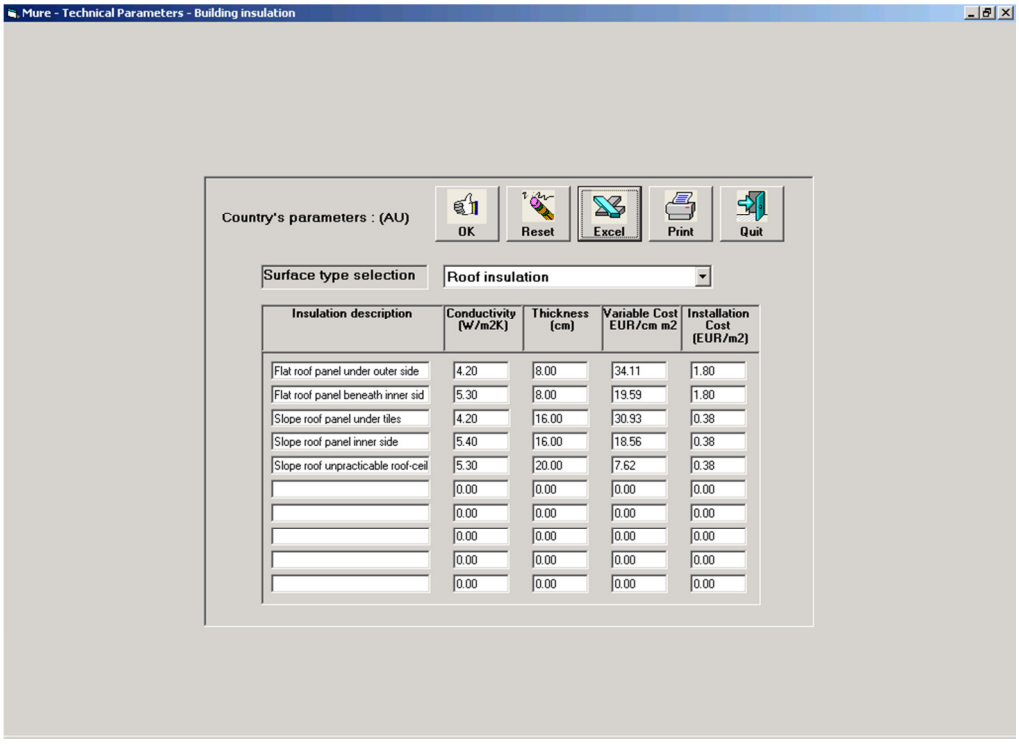


**Figure 17:** Data management screen of the MURE simulation tool, insulation measures

Environmental data provided by the tool can also be changed in the data management section.

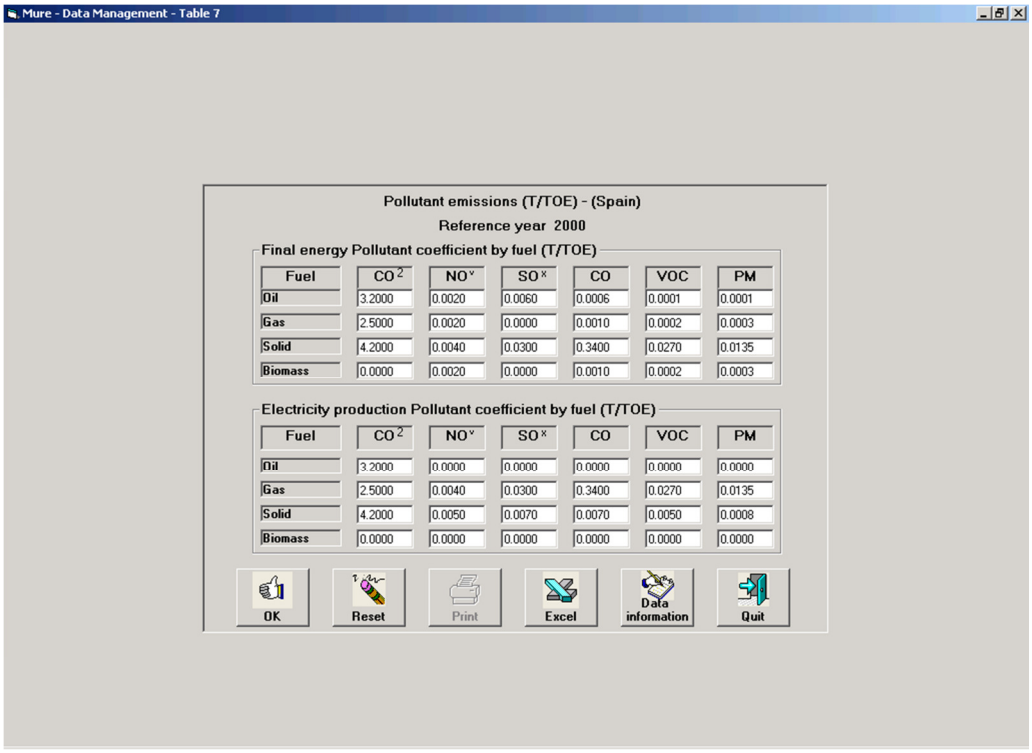


**Figure 18:** Data management screen of the MURE simulation tool, emissions

In the case of the MURE measures database[18] information about policies in each of the covered countries are provided but cannot be updated by the user. In the case of the ODYSEE database, the data is managed by the owner of the database and cannot be changed by the user.

[18] http://www.isisrome.com/mure/aboutmure.html

4.3.1.2 Description of additional data requirements for model enlargement

In the case of the MURE simulation tool there is the possibility, in some sectors, of adding technologies and measures by the user.

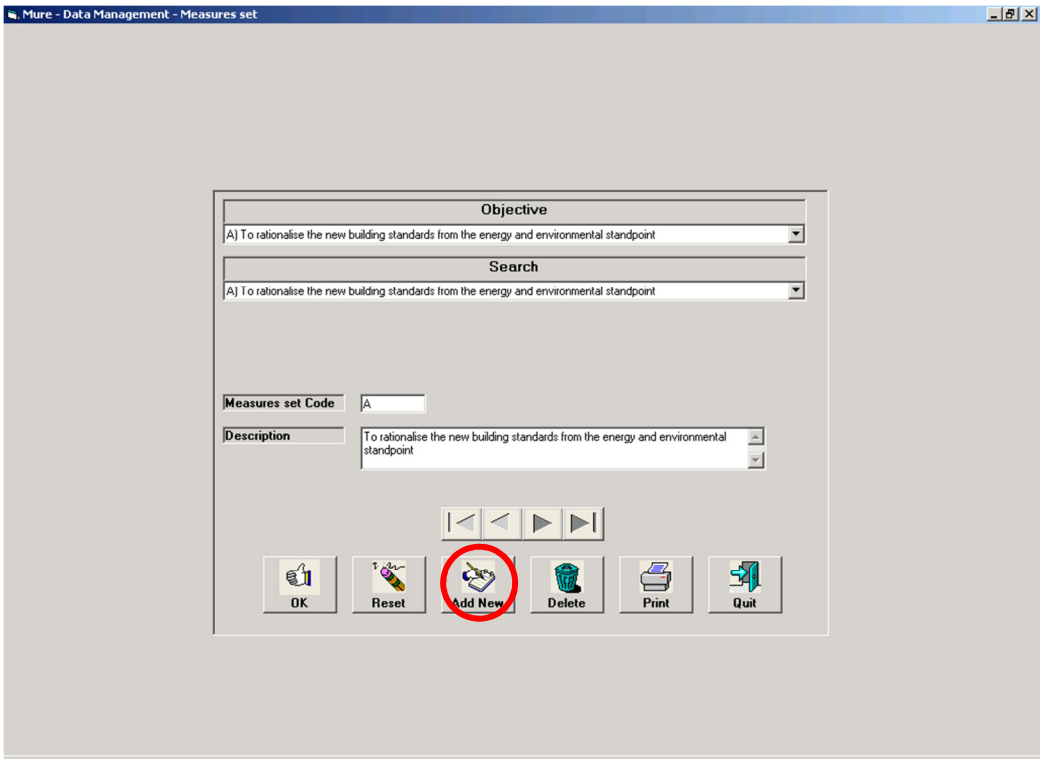


**Figure 19:** Data management screen of the MURE simulation tool, adding technologies and measures

In that case, very detailed data on the energy consumption and emissions of the different technologies and energy savings potential of the energy saving measures are needed. In general though, the tool is quite closed and additions or extensions are not allowed to the user.

4.3.1.3 Possible future actions to generate this data

Data can be collected by any interested user, companies or research institutions, using data from Eurostat, national statistics and technical documents.

**Key issues about additional data requirements in Sector Level Models/ "MURE" example**

- Additional data requirements:
  - Reference values for the single sectors to evaluate efficiency measures have to updated (detailed cost parameters, dwelling data) + adding data for new technologies and measures (very detailed data on energy consumption, emission levels and saving potentials are needed)
- Possible ways of data generation:
  - Data to update the MURE database can be collected by interested users or research institutes
  - Sources to update it could be Eurostat, national statistics or technical documents

## 4.4 Disaggregated Models

### 4.4.1 Additional data requirements of the model family "*Disaggregated Models*"/ model example "*WASP-Greece*"

The chapter 4.4.1 is based on the report on data requirements, by George Giannakidis (CRES).

This section indicates the difficulties in the acquisition of the necessary data for the WASP-IV model for the analysis of the Greek power generation system. Also it includes the description of some necessary input fields for the improvement of the model.

This section provides also a description of the additional requirements for the data used in the WASP model.

#### 4.4.1.1 Description of additional data requirements for model calibration

In order to simulate the generating performance of thermal plants WASP requires two values for the **quantity "heat rate"**, one corresponding to minimum operating level and one described as "average incremental heat rate". These data are expected to be provided by electric utilities. However, because utilities are in general reluctant to provide such information they only provide these two values, which cannot be accurately checked and validated. A more complete overview of the thermal vs. electrical performance of a thermal generating plant could be given and therefore more accurate values in these two fields of the model could be inserted, if detailed information on the heat rates related to more operating levels was available (or a general pattern of the heat rate curves of thermal plants).

WASP model lacks the ability of simulating Renewable Energy Sources in detail due to the basic theoretical background that is used. Additionally, the user often does not have access to up-to-date detailed information of the specific technologies used. This is a problem, particularly in the case of **wind parks**. Although the wind potential data of a site are available, the types of wind generators are not always known. This may affect the way in which wind potential is transformed in electric energy and therefore the way the model input data are created. This issue may also concern other types of RES (e.g. small hydro-plants) which are often treated according to a typical technology profile, according to international experience or historic data.

A significant issue, which is related to the increased RES penetration, is the vague operating framework of the **hydro-pumping plants**. This ambiguity has an impact on the way the load demand is treated (concerning the pumping operation of these plants), but also on the whole contribution of the hydro plants to the electricity generation. It is known that the classical operation of storage units in real life must be revised, so that the integration of non-dispatchable units with high generation uncertainty is achieved without creating operating problems to the rest of the conventional electricity generation system. In WASP the user has to adopt a specific-typical operation mode of these hydro-pumping plants, which of course is dependent on the RES pattern of a scenario, in order to be able to simulate a situation close to the expected one. This kind of data has not been so far accurately defined.

Furthermore, a pending issue concerning the large RES penetration is the amount of **reserve requirements**. In WASP, reserves are treated by the quantity "Reserve margin" in GONGEN module (concerning the excess capacity that must be considered above the peak load) and "Spinning reserves" in the FIXSYS module (concerning the percentage of the capacity of a thermal plant which is committed for spinning reserve services). However, in cases of increased RES penetration the amount of reserve to be considered and also the type of units to participate in the reserve requirements are not clearly defined. Additional data are required to handle this issue.

The load demand in the WASP model is described by load duration curves. This form of input data can be constructed for the base year of a study, using historical data of electricity demand which are provided by the Transmission System Operator. However, the forecasting of the load duration curve of future years lacks accuracy and many times it has been observed that it is drastically revised. Therefore, besides the inherent uncertainty of a load forecasting, the lack of coherent information of the demand evolution affects the validity of the input data in the corresponding WASP module.

#### 4.4.1.2 Description of additional data requirements for model enlargement

WASP has been used for decades in order to perform long-term expansion system planning for power systems based on conventional (thermal and hydro) plants. It was also used in a centralized market environment, and it **cannot represent market competition**. In the present situation many utilities may participate in the electricity market, each one implementing its own expansion plan to the direction of maximizing its profits. Therefore, the concept of expansion planning of WASP may still regard the needs of the market, according to the evolution of demand, fuel costs and available candidate technologies, but the output of the performed studies may not always match with the targets of the competitive stakeholders.

The integration of RES has not been implemented in the model as a particular input choice and there are not particular provisions for that. However, the user can "approach" non-dispatchable RES (especially wind power), by treating them as run-of-river hydro plants (Koritarov et al. 2005). Through this procedure, inflow wind energy can be satisfactorily embedded in the model. However, the special nature of RES (especially wind) cannot be accurately modelled, in the sense that wind variability cannot be adequately described. WASP is a long-term planning tool and therefore there are certain restrictions in the modelling capability it has, due to the methodological restrictions in the model. Therefore the hourly evolution of wind cannot be represented inside the model and therefore some approximations must be made. This may affect the long-term expansion plan, so an exogenous simulation with more suitable models must be carried out. The lack of a more accurate RES representation is one of the significant weak points of the methodology applied in the model and it should be addressed in the development of future model versions.

The abovementioned issue also affects the evolution of the rest of the system in two ways: a) it affects the correct expansion scheme of candidate plants, b) it affects the correct calculation of the energy produced by the non-RES plants. This is the result of the lack of time simulation. In particular, the large hour-by-hour variations of the wind generation should imply the existence and operation of rather flexible units which would be capable to match with the lack or excess of generation. However, this cannot be "seen" by WASP and therefore the investment scheme of future flexible units is not appropriately assessed. "Flexibility" in WASP is only partially approached by the "Minimum Operating Level" of the units, which stands for a better description of the system operation in cases of peak loads.

Another weak point of WASP model is the representation of storage capability of the power system, which is implemented by hydro-pumping units. Hydro-pumping units may be instructed to follow an economic or a forced operation. Economic operation is based on the

financial profit that will the system obtain through the substitution of the operation of thermal plants during high-load hours by the generation of pumping plants. A forced operation obeys in user-defined operation pattern. Both choices are problematic in the present situation of power system with increased participation of RES plants, because they cannot actually approach the new desired operation of the power system, where the effective exploitation of storage capability is necessary (to meet with the unpredictable nature of RES). A modified operation of hydro-pumping plants should be embedded in the model. To this direction the new modified operation cycle (pumping – generation) is required. This means that each year, according to the wind profile, different inflow energy and therefore pumping energy should be utilized (in WASP this is defined by the fields "Cycle Efficiency" and "Max. Feasible Energy"). This is necessary because pumping units should follow the expected wind generation in order to eliminate or reduce the excess wind energy which may occur due to power system restrictions (technical minimum levels of thermal units, the existence of some must-run units for technical reasons, etc.). The desired operation of pumping units should be defined by the system operator based on predictions and probabilistic analysis of the expected wind generation for the future years.

#### 4.4.1.3 Possible future actions to generate this data

The missing or vague data for the accurate insertion in the WASP model should be collected under the responsibility of the main user of the model. The user should clarify and describe in detail the missing elements of the required data. However, this effort is hindered either by the reluctance of the stakeholders, either the lack of organization concerning the ability to access the original databases.

The aggregation of the missing data should be performed by the implicated parts. In the case of Greece this concerns the following (see also 3.4.1.2):

1. Public Power Corporation S.A.
2. Hellenic Transmission System Operator S.A.
3. Independent Power Producers
4. Centre for Renewable Energy Sources and Saving
5. Ministry of Environment Energy and Climate Change
6. Regulatory Authority for Energy
7. International Energy Agency

Some new procedures should be adopted, through which the involved stakeholder would be obliged to provide the necessary data to independent energy institutions. Even under

confidentiality agreements the acquisition of data is a difficult task. Therefore, the Regulatory Authority for Energy should oblige utilities to provide research institutions with the necessary information when national or European studies must be carried out, always under confidentiality agreements.

Additionally, an open-access database should be issued, in which some non-critical data, like wind potential and the related wind generator technologies, are frequently updated.

To this direction, a common effort by the related stakeholders could be made for the effective access to all the required data. This could be the construction of a web-based tool with free access to the non-critical data, and with restricted access (e.g. with password) to the more confidential data. Furthermore, some annually updated editions could be issued including detailed information about the electricity system at a national or European level.

### 4.4.2 Additional data requirements of the model family "*Disaggregated Models*"/ model example "*CGEN*"

The chapter 4.4.2 is based on the report on data requirements, by Nazmiye Ozkan and Elisabetta Mocca (PSI).

#### 4.4.2.1 Description of additional data requirements for model calibration

**Time**. CGEN is a disaggregated model for electricity and gas network, calibrated for a specific year. Consequently, CGEN's time resolution is mostly annual, with the exception of the data used for "Maximum capacity of interconnecting GB transmission boundaries", whose time resolution is daily.

**Costs**. CGEN model performs operational cost minimisation (Qadrdan et al. 2010). The model determines optimal network configurations, according to demand growth for both gas and electricity sectors, and assumptions on the availability of supply choices. It locates the generation units around the electricity grid in order to minimize costs (Chaudry et al. 2007).

**Sector data**. CGEN models the main components of a gas transmission network, including pipelines, compressors, storage facilities and gas terminals. The gas flow through the pipelines is calculated by using a "Panhandle A equation" (Qadrdan et al. 2010). For what concerns the electricity sector, it is represented in CGEN by a DC power flow model (Qadrdan et al. 2010). Finally, the National Transmission System and electricity networks are simplified in CGEN.

CGEN considers the following energy end-use sectors:

- Electricity export;
- Industry;
- Residential/commercial.

#### 4.4.2.2 Description of additional data requirements for model enlargement

**Geographical resolution**. The main limitation of CGEN is its geographical resolution. CGEN is a disaggregated model for the UK gas and electricity sectors, thus the geographical scope is a single country. This means that it cannot be easily adapted for other countries. In order to expand the model structure, data for energy sectors of other countries would be required.

**Higher time resolution in planning mode.** CGEN runs in two modes: planning, with yearly time steps, and operational, in which the time steps are days, weeks and/or months. Although the model has a fairly detailed time horizon, it could be improved by including a seasonal as well as hourly time step when running in planning mode. This would help increasing its accuracy to deal with hourly peak loads and the associated network expansions in a much better way. However, this requires a dataset at a much finer time resolution.

**Exogenous demand.** Given that CGEN is an optimisation model, demand is exogenous. This means that CGEN does not consider demand-price relationship, thus does not capture how consumers' energy demand might change in response to change in prices. There are also other issues around public acceptability of various technologies (for example, nuclear or wind farm etc.) and to our knowledge, as an optimization model, it cannot deal with these social issues.

**Generation technologies**. CGEN includes a fair list of power generation technologies on supply side: nuclear, wind, hydro, pump storage, coal/CCS, oil, combined cycle gas turbines (CCGT), and dual fuel combined heat and power (CHP). However, it seems it is limited to explore what potential roles biomass technologies can play in decarbonizing the UK power sector. As biomass can be gasified, alternative use of gas network for biogas/biomethane delivery could also be added to the mode. Hence, the model can be improved further by inclusion of these other generation technology choices. A further limitation is that CGEN does not deal with intermittency and generation capacity in planning mode (see above) which

again is very important to explore the real potential of renewable technologies in a future UK energy system.

**Additional energy end-users.** Being a disaggregated model, CGEN has limited information on energy system links with other sectors; hence it does not allow wider energy system trade-offs. In order to overcome such limitation, information about the following end energy use sectors could be included:

- Agriculture;
- Transports (fuel cell and electric vehicles);
- Different socio-economic typologies of households, useful for gaining a better understanding of their energy requirements.

With reference to the need to incorporate data on agriculture, it has to be considered how this sector may affect both gas and electricity demand. Information on transports would be useful since they play a pivotal role towards decarbonisation process, for instance through the deployment of hydrogen fuel cell or electric vehicles. Finally, CGEN could be improved by adding data on specific energy demand profiles of the different household typologies (i.e. household composition) and socio-economic groups.

#### 4.4.2.3 Possible future actions to generate this data

In the UK, Department of Energy and Climate Change collects household level energy use data and then it is aggregated and published at local authority level. However, this does not tell us how energy consumption patterns vary across different household groups (2-person versus 4-person family household versus different socio-economic groups etc.). This would help understanding energy behaviour in much informed ways. Such a geographically varied, household-specific electricity demand load curves will help models like CGEN to have a more accurate description of the real world. Surveys as well as monitoring of electricity use of different households groups will help with generating such datasets.

**Key issues about additional data requirements in Disaggregated Models**

- Additional data requirements:
  - Information about the thermal vs. electric generating performance of thermal plants
  - Detailed up-to-date information about renewable technologies (like wind parks and its types of wind generators or small hydro-plants)
  - Forecasting of load duration curves and demand evolution
  - Data for increasing RES integration and electricity storage (hydro-pumping plants, reserve requirements)
  - Data on the same level of detail for other countries to expand the geographical resolution
  - Increase time resolution to seasonal and hourly modelling needs data on a much higher time resolution
  - Information about demand-price relationships and public acceptability
  - Role of biomass for gasification and biogas/ biomethane feed in
  - Data about generation capacity in planning
  - Geographically varied, household-specific electricity demand load curves
- Possible ways of data generation:
  - Power plant data could be provided by electric utilities
  - Power plant operators, new producers, transmission system operators, research centres, ministries, energy agencies, regulating authorities
  - Open access database with non-confidential data
  - Surveys as well as monitoring of electricity use of different households groups

## 4.5 Energy Behaviour Tools

### 4.5.1 Additional data requirements of the model family "*Energy Behaviour Tools*"/ model examples *"ESTEEM"* and *"Climate Bonus"*

The chapter 4.5.1 is based on the report on data requirements, by Annele Eerola, Johanna Kohl (VTT) and Koen Schoots (ECN).

#### 4.5.1.1 Description of additional data requirements

The ESTEEM tool relies on context-specific information sources, making use of available data and information relevant for successful realization of a specific energy project in question. Different types of context-specific information sources (documents, stakeholder interviews, focus group discussions, etc.), and different types of data and information (qualitative/quantitative; objective data/subjective viewpoints), are typically considered in the ESTEEM process. The cases using the ESTEEM tool can be documented and stored in a 'case library' for further uses (as background information for new projects/cases using the ESTEEM tool). Some kind of common rules in documenting the cases, including the specific context, process, outcomes, and data and information sources used, would apparently make it easier to benefit from the lessons-learned in corresponding earlier cases. The ESTEEM process gives a good general-level framework for sharing knowledge across various concrete cases, but there might still be room for improvements in this respect.

The main emphasis in using the ESTEEM tool is in understanding the viewpoints of various stakeholders and in creating acceptance for the realization of the energy project in question, possibly with some modifications in the project plan and its implementation. Changes in attitudes and behaviour are also facilitated in relevant parts. Not only objective data but also experiences, interests and expectations of various stakeholders are considered valuable inputs in the ESTEEM process. Involving all relevant stakeholders - and ensuring their genuine commitment to the ESTEEM process - might be a significant challenge, however. It may also be difficult to guarantee that all relevant information is shared between the participants because of competing interests, confidentiality issues and other corresponding reasons.

The CLIMATE BONUS tool relies on the combined use of verified carbon footprints (possibly visualised through labels), personalised monitoring and feedback services to households regarding the greenhouse gas intensities of their purchases, a reward system (bonuses) for consumers who manage to reduce the embodied emissions, and a secondary reward system for retailers that successfully reduce the emission intensity of their sales.

By the Climate Bonus tool it is possible to assess the requirements and harmonisation needs for the various information systems and their interfaces. This culminates in a data strategy, in

which a data acquisition, generation and co-ordination strategy and a data quality assurance strategy will be further developed in the future. By the development of the tool, the response of households has been assessed, what the households (as consumers) can amount to and how the responsiveness to various incentives can be rated. Key challenges in the development of the envisaged system concern the comprehensiveness, comparability, transparency and tractability, precision and cost-effectiveness of product chain emission data, while accounting for the need for harmonisation footprint procedures at an international level. On the consumer side, it is essential to ensure sufficiently wide and sustained participation among households.

#### 4.5.1.2 Possible future actions to generate this data

ESTEEM process was developed as a tool for creating acceptance for concrete projects that aim at sustainable development. In other words, it is intended to help in successfully realizing sustainable energy projects in their real-world local contexts. If European and national-level key actors recognize ESTEEM as a valuable tool in facilitating the transitions towards sustainable energy systems, it would be important to signal this to local level actors too. Specific incentives for participating in the ESTEEM process could also be thought of. Project managers using the ESTEEM tool are also in key position in ensuring the required commitment of various stakeholders and in creating trustful atmosphere and relationships, so that all important information can be considered in the ESTEEM process. This should be recognized when selecting project managers for sustainable energy projects, especially when there are challenges related to their social acceptance.

Useful documentation of ESTEEM cases requires that enough attention is paid to this issue by project managers using the ESTEEM tool. Relevance and comparability of case descriptions are key issues in this respect. Common templates for gathering the information and reporting the results are of course helpful in this respect too. Easy access to the process guidelines, templates and earlier cases is a prerequisite for accumulated knowledge. The current websites of the Create Acceptance project and ESTEEM tool provide a good starting point in this respect. The information base, templates and reporting guidelines could, however, be further developed on the basis of experiences gathered so far.

There are three sets of factors that determine the effectiveness of the envisaged CLIMATE BONUS system, being (1) the accuracy, comprehensiveness, and tractability of the recorded emissions per product chain, product group, etc., (2) the appeal and incitement effect of the monitoring and feedback service for consumers, and (3) the deployment strategy of the system in conjunction with product-market strategies of products and product groups included in the system.

Companies, sectors and whole countries should define initial ambition levels with respect to scope, accuracy and addressed potential. This does not mean that these levels would be fixed forever after. A stepwise deployment is recommendable. During operationalization ambition levels would be translated into concrete targets, this may involve temporary compromises in order safeguard overall feasibility and viability of the system. Underdeveloped and hasty strategies bear significant risk of misguiding efforts and investments, thereby creating more cost and less or no intended impacts. Even though in the deployment of carbon footprinting an evolving strategy is called for, this should not interfere with basic choices regarding the architecture and quality principles of the system. In order to ensure that the maximum addressable emission reduction potential of households can be exploited, the architecture of the information system, notably the emission data and carbon footprint generation facility, should enable the provision, handling, verification and updating of highly accurate data.

Even though in initial stages other assessment methods such as input-output analysis may play a significant role the ambition of the envisaged system should be to base ever larger parts of the included carbon footprints on exact, reliable and comparable life cycle assessments of the specific product/service at brand level, while using Environment Product Declarations (EPD), product-category rules (PCR), and generally ensuring sound comparability of carbon footprints of products. In the CLIMATE BONUS project, this ambition level has been coined by the term Reliable estimates of Carbon Footprints (R-CF).

The tested demo-version of the internet monitoring system for households showed that such a service can be developed and does appeal to consumers. The ergonomics of the system has to be improved, whereas more options for personalisation of the monitoring service seem to be relevant, also with respect to the organisation and display mode of the information. Consumers regard the offered service as potentially useful. Their interest to participate in the system and to use it more intensively does require however high standards of user-friendliness, whereas also reliability and credibility of the system are crucial to engage consumers successfully for a longer time. In practice this means among others that automatic registration by means of loyalty cards or bank cards is an important prerequisite for achieving widespread use.

Moreover, the monitoring and feedback system should be adopted by as many retail and service chains as possible. Insufficient coverage in this respect bears a significant risk that the uptake of the system among consumers remains low.

**Key issues about additional data requirements in Energy Behaviour Tools**

- Additional data requirements:
  - Context-specific information sources needed for specific energy projects
  - Establish a "case library" (project documentation) to learn from previous projects
  - In a new process always the relevant various stakeholders and their experiences, interests and expectations have to be considered as input for the tool
  - Need for comprehensive, comparable, transparent and tractably, precise and cost-effective data
  - Carbon footprint data: life cycle assessment of specific products/services at brand level
- Possible ways of data generation:
  - In the process of using the tool, sources are documents, stakeholder interviews, focus group discussions etc. to generate qualitative/ quantitative information and viewpoints.
  - In the process of using the tools the way to generate high quality data is to involve all stakeholders and ensuring their high commitment
  - Recognition of these kind of tools from European and national key actors + specific incentives for participating + ensuring required commitment by involved project managers would make it easier to collect context-specific data
  - Sufficiently wide and sustained participation among households is necessary

# 5 Summary

In total 226 sources and additional data needs were analysed in this study. The analysed data give an overview about the currently used data in the different models and also show the weak points of these data sets as well as the additional data requirements.

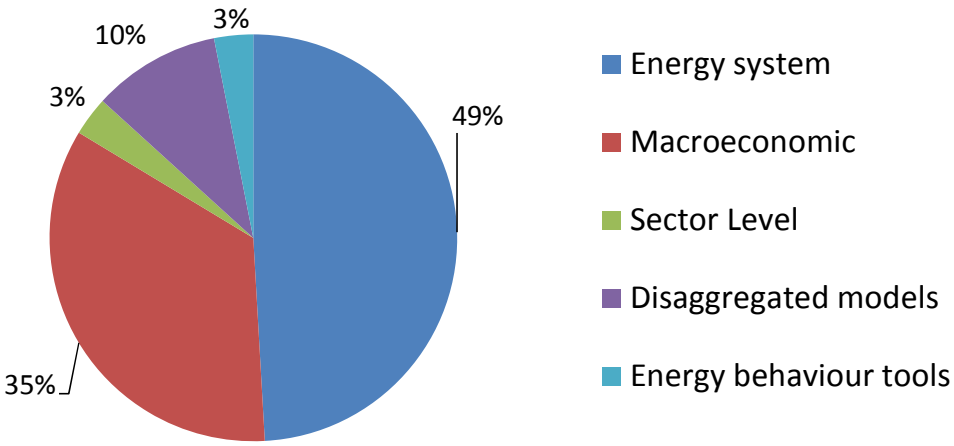


**Figure 20:** Overall split of the analysed sources and needs by model family

Figure 20 indicates that almost half of the collected sources and requirements are related to Energy System Models (49 %). These models are technology rich and cover the whole energy system so that they have a high need for different information about all the sectors. The Energy System Models are followed by Macroeconomic Models (35 % of the evaluated sources), by Disaggregated Models (10 %), Sector Level Models (3 %) and Energy Behaviour Tools (3 %). In addition to quantitative data, the Energy Behaviour tools use qualitative information, which could vary case by case.

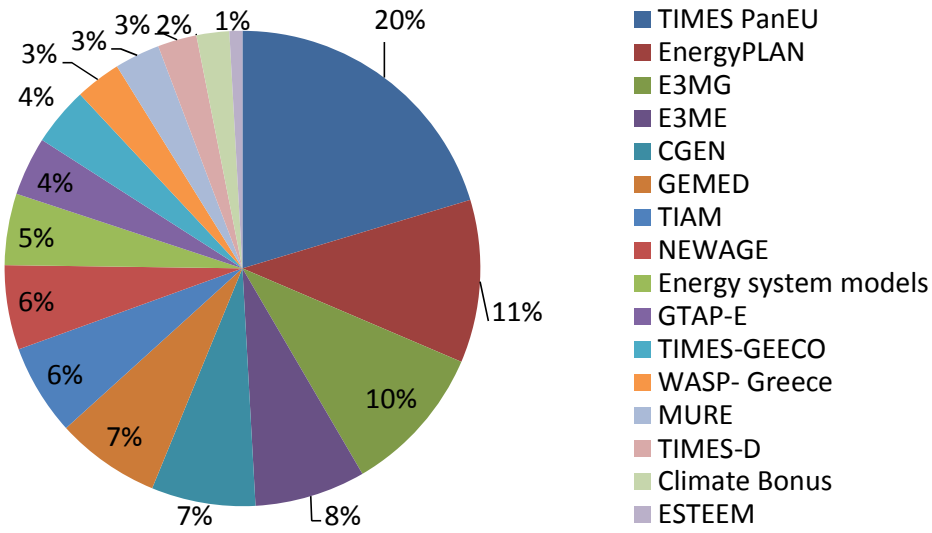


**Figure 21:** Overall split of the analysed sources and needs by model

Focussing on the single models, the models with the most sources and needs evaluated are the Energy System Models TIMES PanEU and EnergyPlan (Figure 21). The TIMES PanEU model covers all Member States of the EU-27 plus Norway, Iceland and Switzerland and is technology rich. Therefore many data sources are needed to model the different sectors in each country. EnergyPlan is developed by the sustainable energy planning research group at the University of Aalborg (Denmark). It is a free program for energy system analysis with different input and output tables and the main target is to assist the design of national energy planning strategies. It is a user friendly tool designed in different tab sheets and programmed in Delphi Pascal (Connolly et al. 2010; Connolly 2010; Lund 2011).

The evaluation of the used data and data needs for the EnergyPLAN model is a result of the Open Call. That means that this data assessment was done not by ATEsT partners but by an external modelling team. In total, 58 % of the assessed data and requirements came from ATEsT partners and the other part was a result of the Open Call (Figure 22 left). Other models playing a key role concerning the number of sources assessed in this study were the Macroeconomic Models E3MG 10 % (global energy-environment-economy) and E3ME 8 % (European energy-environment-economy) followed by the Disaggregated Model CGEN and the Macroeconomic Model GEMED 7 %.

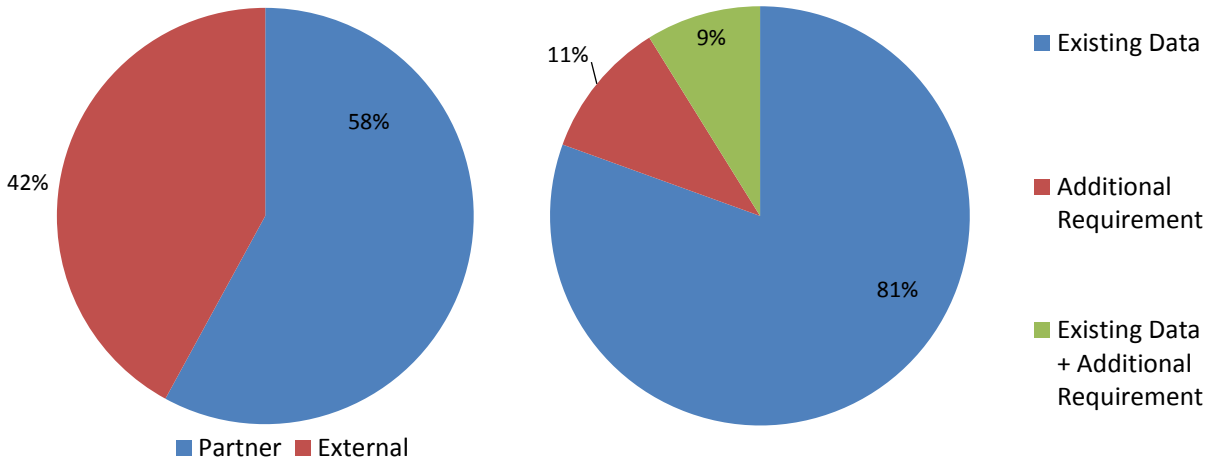


**Figure 22:** Overall split of the analysed sources and needs by modelling teams (left) and by evaluation type (right)

The different model families have different purposes, different approaches and therewith different data in use. The Energy System Models analysed in this study mainly use official public statistics (Figure 23). But also “literature” and “information from associations” play a key role as a source. The data from associations are mainly used in the industrial sector which is also modelled in detail in the model example TIMES PanEU. Looking at Macroeconomic Models in this study, the data sources are dominated clearly by official public statistics.

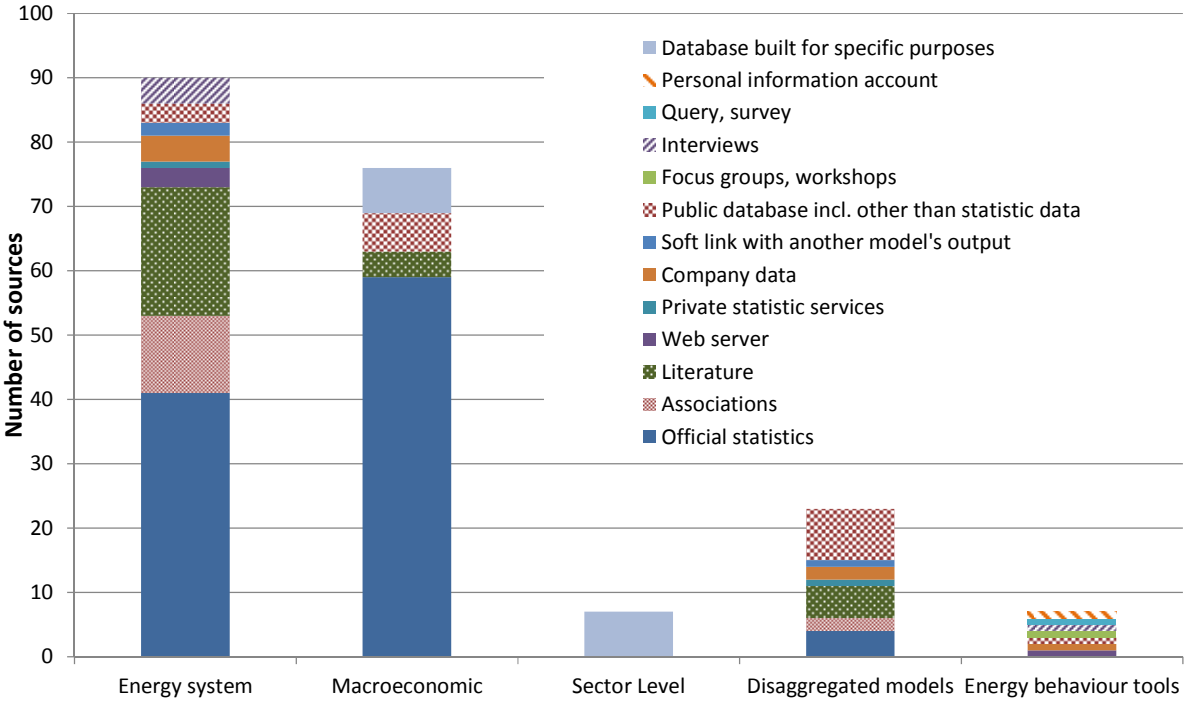


**Figure 23:** Overall split of the analysed sources by source category

Another difference among the models is the category of data sets taken from this source (Figure 24). Energy Behaviour Tools use in contrast to the other models and tools *behavioural information*, *qualitative information in interests, values and expectations* as well as *qualitative information on context*. According to their model character, the technology rich Energy System Models mainly use energy and technology input data while the Macroeconomic Models use mainly macroeconomic data. The other important category at this model type is "*other model input*" which includes general information about population or exchange rates.

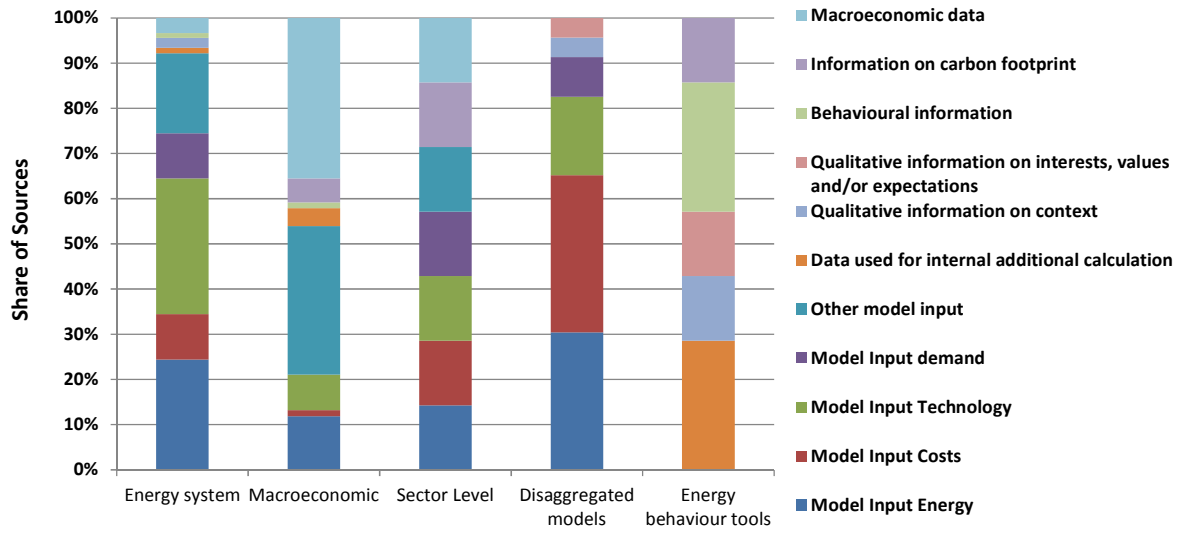


**Figure 24:** Overall split of the analysed sources by data type

This report analyses also the quality of the data sources and attempts to highlight the weak points by model family. One indicator to measure the quality is the time resolution of the provided data. The dominating resolution in most of the models is the annual level (77 % of all sources). However, the time resolution of the information used in Energy Behaviour Tools depends on the issue of focus (all sources used in Energy Behaviour Tools). This indicates the particular nature of this model family. A more detailed time resolution is relevant at Disaggregated Models and at the Energy System Model EnergyPLAN.

Concerning the time lag between the date of publishing and the reference date, most information used in the models have a time lag between one and two years (48 % off all sources) followed by less than a year (23 %). The Energy System Models analysed here also use future-oriented data, about 20 % of the data sets used in Energy System Models are of this kind (12 % of all sources used in all models). They are needed for the demand calibration or concern the expectations about technological developments or renewable potentials.

The frequency of data publishing evaluates also the data quality. The data analysed are dominated by yearly updated data (52 %). Differing from this frequency, the Sector Level models of this study use mainly data which are continuously updated which could make it more difficult to stay up to date with the model. Disaggregated Models and Energy Behaviour Tools also use data which are not periodically updated (31 % of the data used in Disaggregated Models; 33 % in Energy Behaviour Tools). Also this frequency makes it harder to keep the model calibrated to the latest publications. The majority of sources used in Energy Behaviour Tools are not published (67 % of the sources used in Energy Behaviour Tools). This refers to the way of data collection via interviews or workshops.

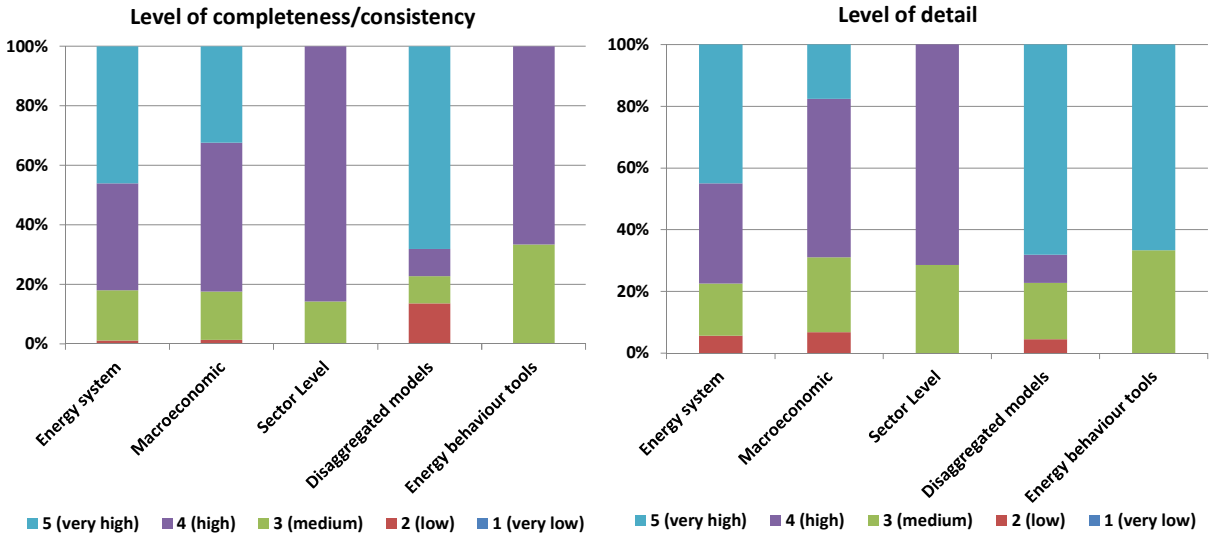


**Figure 25:** Overall split of the analysed sources by level of completeness/consistency and detail

Another indicator to evaluate the data quality is the ranking of "completeness/consistency" and the "level of detail" (Figure 25). Admitting that the ranking depends on personal requirements and expectations on the data, the results show that the most data used are ranked "high" (4) or even "very high" (5). In total, 41 % of the sources have a *very high* completeness/ consistency (41 % are on *high* level) and 36 % have a *very high* level of detail (38 % are on *high* level). The number of sources below a level of high is quite low, showing the highest numbers of sources on a low level of completeness/ consistency at Disaggregated Models (14 %).

The other categories which are used to assess the currently used data according to their quality are the file format of the data source and the availability of an additional documentation for the data. Most data sources are in excel (41 %) or PDF (40 %) format. While Energy System Models mostly rely on PDF sources, Macroeconomic Models mainly use excel sources which are easier to process. Concerning additional document almost all sources offer up to date information about the data (92 %). Among different model families, only Energy Behaviour Tools also use a higher amount of data without additional documentation. This refers again to the way the data used in this model type are collected.

Concerning the availability of the used data, in total 72 % of the data are public and free. This category dominates especially the data of Energy System, Macroeconomic and Disaggregated Models. Only Sector Level Models use mainly public sources for which a fee is necessary. For the Energy Behaviour Tools, there are not many different sources which could have been put in the data collection list, and personal contacts are used instead in this model family.

The analysis of the data weak points is performed by model family as presented in Table 12. General weak points are that some sources which are needed for every region of the model are available only for one country and in the specific language of this country. As a result, not all model regions are calibrated with the same quality which could have an impact on the burden sharing of emission reduction targets. This affects mainly Energy System Models. Other data sets exist just in aggregated form and the modelling team has to split the information the covered regions based on assumptions. Concerning regional aspects, another issue is that national statistics often do not fit to international statistics and in general data from different sources rarely fit to each other. The use of different balancing rules seems to be one reason for that. Moreover, some sources are not free of charge.

**Table 12:** Summary of weak points of existing data by model family

| Model Family | Weak Points |
|---|---|
| **Energy System** | Data availability and file format of data for some countries in transition (important for global modelling and TIMES Southafrica) |
| | Data often available just as PDF (file format not easy to process) |
| | Being up to date with the model calibration when databases are continuously updated |
| | Reports do not cover all relevant technologies, countries or are available just in one language |
| | Data are just available on aggregated level or average numbers |
| | Use of different balancing methods (for example CHPs) |
| | Different statistics or publications do not fit to each other (even from one source) |
| | Comparability of values about specific energy consumption (primary energy vs. final energy, balancing of heat/steam/electricity, by-products like black liquor or blast furnace gas, influence of intermediate goods like pulp) |
| | Split between industrial (final energy) and public sector not always consistent and comparable (power plants, CHP, blast furnaces, coke oven) |
| | Price of access to data |
| | Forecast data (no detailed years given) about technological parameters |
| **Macroeconomic** | Costs for data (GTAP database) |
| | Time lag until data are published Input-Output tables) |
| | Inconsistencies between different technologies classifications within the macroeconomic data bases and also emission data bases |
| | Limited availability of data on specific taxes, subsidies and transfers particularly in the energy-environment area |
| | Elasticity parameters are often set by assumptions and not computed for the behaviour of consumers and producers in energetic and non-energetic sectors (huge variability concerning quality and frequency of data) as well as data concerning consumer behaviour |
| **Sector Level** | Data included in the database are not updated (the base year is 1995 in the model MURE) |
| **Disaggregated** | Very detailed data of the existing power plants are not easily accessible |
| | Detailed information of the internal power blocks of the power plants are not available (power plants, heat rates, etc.) |
| | Stochastic generation profiles of wind and other renewable energy sources power plants are not updated frequently enough and do not relate the actual technologies used (type of wind turbine etc.) with the site potential and detailed measurements |
| **Energy Behaviour** | Quality of data varies by context (and the commitment of the users of the tools) |
| | Data from different contexts might not be comparable |
| | Some up-to-date information may be confidential or not publicly available |

The analysis addresses also the issue of the additional data requirements, together with the weak points identified by model family. Table 13 and Table 14 give an overview of the additional data requirements and possible ways and sources to generate it.

The analysis of Energy System Models shows that this model family needs many different sources because of the detailed modelling of different regions and sectors. A specific challenge is that all data are needed for all regions covered by the model. This strong point of multi-regional models often becomes a weak point. Furthermore, the use of different balancing methods between the different regions might become challenging. The additional

data requirements of Energy System Models points out firstly the need for technological information about the existing stocks, such as the efficiency or lifetime, and additional information on technology cost, especially for modelling the demand sectors, like the industrial sector. Additional needs are addressed in the CHP modelling with concern to data on electricity, heat and steam production split by technology, energy carrier, autoproducer or public CHP, and industrial sub-sector.

For a model extension or improvement, there are data needs concerning energy balances of useful energy, like the demand for space heat, process heat or cooling. A key requirement made by the modelling teams of this family relates to additional data with a higher time resolution to enable modeller to include more time slices in the model; and with a larger geographical coverage to can include new regions, e.g. Turkey and Croatia. To that, the implementation of a higher time resolution needs special load curve data of different energy commodities (like electricity and heat) and different sectors.

The analysis of Macroeconomic models (like NEWAGE, GEM-E3 and GTAP-E) show that these models are based in general on highly aggregated data. This is an essential property, but often misses details on technology, preferences or environmental impacts, which play a crucial role for the outcome of specific macroeconomic topics such as the macroeconomic impacts of environmental policy instruments, the role of capital and energy as main input factors in the production and the consumption of energy services.

For performing international comparisons, national data need to be consistent and deepened by region, sectors and commodities. This is what GTAP tries to provide as a global database, which is continuously improved. Nevertheless, it would be useful to have standardized national Social Accounting Matrices for all European countries with corresponding Physical Input-Output-Tables, to reflect the interactions between resources, energy and environmental factors. In dynamic settings, frequencies of data have to be altered and time lags shortened.

Moreover, Macroeconomic models need insights from social and natural sciences for the specification of production and utility functions. Engineering studies will help describing the production possibilities, feasibility and costs of different technologies. Psychological studies (e.g. household surveys) and econometric estimation studies would help describing consumer needs and behaviour (e.g. mobility, residential heating). This information is crucial to calibrate substitution elasticities of the underlying CES-functions or to create new functional forms to reflect aggregate demand and supply mechanisms adequately.

The analysis of Sector Level, such as the MURE model, addresses caveats in updating the data related to sectors, according to the structure presented in the data description.

**Table 13:** Summary of additional data requirements and ways of data generation by model family (part I)

| Model Family | Additional Requirements | Possible Ways or Source of Data Collection |
|---|---|---|
| **Energy System** | Data about the stock of technologies (age structure, current efficiencies, type of technology) | Surveys |
| | Trade flows of semi-finished goods and specific energy consumption to produce this goods to compare subsector energy consumptions across Europe | Macroeconomic data from statistical offices, industrial associations |
| | Data on recycling potentials (production and consumption values and average expected useful life of these goods) | Statistical offices, industrial associations |
| | Cost data of new technologies (investment costs, O&M costs, especially for the end use sectors) | Supplier, Companies, Associations |
| | Data about electricity and heat/steam production from public and industrial CHP | Consistent balancing, provided by statistical offices |
| | Steam use and production (supply and demand technologies, steam parameters) | Industrial companies, Associations |
| | Transport data (energy consumption of road transport by technology [car, bus, heavy/light duty vehicles, motorbikes], average specific fuel consumption, annual mileage, average daily mileage and load factors etc.) | Statistical offices, Associations |
| | Building data for the residential/ commercial sector (number of floors, energy consumption by energy carrier and building, age structure of buildings or building reconstruction information) | Statistical offices |
| | Information about behaviour in the end-use sectors | Surveys, Scientific analyses and publications |
| | Data about useful energy (for example process heat, cooling, compressed air in the industrial sector) | Companies, industrial associations |
| | Load curve data for different commodities and user groups | Utility company data, grid operators, single company or household data |
| **Macroeconomic** | Sector specific data like technology classifications | Agencies and associations |
| | European Social Accounting Matrix (SAM) with the possibility to extract national SAMs | Statistical offices (i.e. Eurostat) |
| | Substitution elasticities | Scientific projects (social and natural sciences); Sophisticated econometric estimation techniques |

**Table 14:** Summary of additional data requirements and ways of data generation by model family (part II)

| Model Family | Additional Requirements | Possible Ways or Source of Data Collection |
|---|---|---|
| **Macroeconomic** | Detailed Physical Input-Output-Tables (PIOT) concerning resources, energy and environment | Statistical offices (i.e. Eurostat); consistent with European SAMs |
| | Data on useful energy production in households, data on durable goods (utility over lifetime like transport services) | Household surveys (household panels); Energy statisticians(working groups for energy balances) |
| | Demand patterns and motivation of consumers | Psychological studies and experiments (research) |
| | Sector specific data: Service (Input, Output, trade), Electricity (transmission, distribution), transport (modes and uses) | |
| **Sector Level** | Necessary to update MURE database (Model example) | |
| **Disaggregated** | Data on Existing Power Plants | In general: Data collection under the responsibility of the main user (example WASP); in case of WASP GREECE: Public Power Corporation S.A., Hellenic Transmission System Operator S.A., Independent Power Producers Centre for Renewable Energy Sources |
| | Thermal vs. electrical performance of a thermal generating plant (detailed information on the heat rates related to more operating levels) | |
| | Data of types of wind generators at specific sites (+ other types of renewable energy sources) | |
| | Load forecasting | |
| | Operating framework of the hydro-pumping plants | |
| | Amount of reserve requirements (at increasing level of RES) | |
| | Geographically varied, household-specific electricity demand load curves | Utility company data, grid operators, single company or household data |
| | Information about demand-price relationships and public acceptability | Data from research institutes based on household surveys |
| **Energy Behaviour** | Data varies by context; generation of new information for each new model process | Users of the tools (high commitment needed) |
| | Establish a "case library" (project documentation) to learn from previous projects | Users of the tool and project managers |
| | Qualitative/quantitative; objective data/subjective viewpoints of various stakeholders (standard process for new process and new question) | Stake holder interviews, focus group discussions |
| | Carbon footprint data: life cycle assessment of specific products/services at brand level | Research institutes |

The Disaggregated Models family raises the issue of geographical model extension to other countries and the need for additional data with higher time resolution, as highlighted for the Energy System Models family, too. Concerning the time resolution, the level of detail is already high, as compared to Energy System Models, but even finer data as already used are

needed to be able deal with for example hourly peak loads. Another data requirement which refers to the Disaggregated Models and also to Energy System Models concerns the issue of public acceptability and demand-price relationships. These behaviours are almost not included in these model families, since their consideration would require additional and reliable data.

The analysis of Energy Behaviour Tools shows the particularity of this model family. The ESTEEM tool, as a typical example, is always used in a new and context-specific process. That means that depending on the question which is to be analysed, new information need to be generated systematically. In this case, the key issue is to boost the participation of all actors involved in the ESTEEM process. This would need also to improve the documentation in a case library.

To generate the additional required data, depending on the data category, different ways are possible. Some data, e.g. load curves, could be delivered by the utility companies or grid operators. Other data, e.g. cost data in the industry, could possibly be generated by industrial associations through surveys made among their members. Other data, on e.g. behavioural information, clearly need surveys to generate this information, such as suggested in Table 13 and Table 14.

The analysis performed within this Work Package joins the findings of the previous Work Packages that each Policy Question should be answered with different types of models and/or tools. From data viewpoint, each model type employs different ways of generating the required information. To improve the existing model platform, additional data are required and the availability of high quality data is a key issue for the future development of these models.

Particularly important data attributes for model improvements and enlargements are the availability of more detailed data, e.g. higher time and geographical resolutions, the data consistency and comparability of databases among countries, regions and sectors. On the other hand, depth of information and context-specific understanding may be even more important when changes in behaviour are strived for.

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# **Appendix A:** Data list Energy System Models

Data/data sources used in model/model family

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 1 | Energy system | TIMES-D | Energiedaten des Bundesministeriums für Wirtschaft und Technologie | Official statistic source (public source) | Model Input Energy | Other model input | Framework data, primary energy consumption and production, energy imports, electricity generation, final energy consumption by sector, emissions, energy indicators, energy prices for Germany | All sectors mentioned above in the drop down menu | | Country |
| 2 | Energy system | TIMES-D | AG Energiebilanzen | Official statistic source (public source) | Model Input Energy | | Energy balances for Germany, primary energy production and consumption, final energy consumption by sector | All sectors mentioned above in the drop down menu | | Country |
| 3 | Energy system | TIMES-D | GENESIS database of the Federal Statistical Office Germany | Official statistic source (public source) | Model Input demand | Other model input | Framework data, demand data, energy consumption data for Germany | All sectors mentioned above in the drop down menu | | Country |
| 4 | Energy system | TIMES-D | National Trend Tables for the German Atmospheric Emission Reporting | Official statistic source (public source) | Other model input | Information on carbon footprint | Emission data on GHG and other air pollutants by sector for Germany | All sectors mentioned above in the drop down menu | | Country |
| 5 | Energy system | several energy system models | UNFCCC Greenhouse Gas Inventory Data | Official statistic source (public source) | Other model input | Information on carbon footprint | GHG emission data for UNFCCC countries | All sectors mentioned above in the drop down menu | | Country |
| 6 | Energy system | several energy system models | IEA Statistics | Official statistic source (public source) | Model Input Energy | Other model input | Energy Projections for IEA Countries, primary and finanl energy consumption, capacities, prices and taxes etc. | All sectors mentioned above in the drop down menu | | Country |
| 7 | Energy system | several energy system models | IEA World Energy Outlook | Official statistic source (public source) | Model Input Energy | Other model input | Global framework data, primary energy consumption and production, energy imports, electricity generation, final energy consumption by sector, emissions, energy prices etc. also for future periods | All sectors mentioned above in the drop down menu | | Group of Countries |
| 8 | Energy system | several energy system models | IMF World Economic Outlook Database | Official statistic source (public source) | Macroeconomic data | | Global macroeconomic data (GDP, commodity prices, inflation etc.) | Others | Consumers, citizens, society | Country |
| 9 | Energy system | TIMES-D | Statistics of the German Association of Energy and Water Industries (BDEW) | Associations (e.g. industrial associations) | Model Input Energy | Model Input Technology | Data on gas and electricity networks, energy investments, energy prices etc., mostly for Germany, some EU data | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Electricity, gas | Country |
| 10 | Energy system | TIMES-D | Federal Institute for Geosciences and Natural Resources (BGR), Data on Energy resources | Official statistic source (public source) | Model Input Energy | | Data on energy resources and reserves (global) | Others | Primary energy supply | Country |
| 11 | Energy system | several energy system models | IEA Energy Technology Perspectives | Official statistic source (public source) | Model Input Technology | Model Input Costs | Data on energy technology (capacities and costs), also for future periods | All sectors mentioned above in the drop down menu | | Group of Countries |
| 12 | Energy system | several energy system models | Projected Costs of Generating Electricity, OECD Study | Literature (articles, books, newspaper) | Model Input Costs | | Data on electricity generation costs | Electricity | | Group of Countries |
| 13 | Energy system | TIMES PanEU | UNFCCC GHG inventory Reports | Official statistic source (public source) | Other model input | | GHG emisision statistics per country and sector | All sectors mentioned above in the drop down menu | | Country |
| 14 | Energy system | TIMES PanEU | IEA Coal Information | Official statistic source (public source) | Model Input Energy | | statistics on coal for OECD countries | All sectors mentioned above in the drop down menu | | Country |
| 15 | Energy system | TIMES PanEU | IEA Natural Gas Information | Official statistic source (public source) | Model Input Energy | | statistics on natural gas for OECD countries | All sectors mentioned above in the drop down menu | | Country |
| 16 | Energy system | TIMES PanEU | IEA World Energy Outlook | Official statistic source (public source) | Model Input Costs | | Forcast energy consumption and structure for main world regions | All sectors mentioned above in the drop down menu | | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 17 | Energy system | TIMES PanEU | EUROSTAT | Official statistic source (public source) | Model Input Energy | Other model input | statistics on energy, prices, socio economic parameters for EU countries | All sectors mentioned above in the drop down menu | | Country |
| 18 | Energy system | TIMES PanEU | European Biodiesel Board | Web server | Model Input Technology | Model Input Energy | Biodiesel production, consumption, capacities by country | Others | Conversion | Country |
| 19 | Energy system | TIMES PanEU | EPER (European Pollutant Emission Registry) of European Environmental Agency | Official statistic source (public source) | Other model input | | emission statistics per emission source | Others | Conversion | Location within a country |
| 20 | Energy system | TIMES PanEU | Platts Power Plant database | Private statistic services | Model Input Technology | | Statistics on capacities and typ of installed power plants worldwide | Electricity | | Location within a country |
| 21 | Energy system | TIMES PanEU | Tradewind | Official statistic source (public source) | Model Input Energy | Other model input | wind power availability / energy production | Electricity | | Country |
| 22 | Energy system | TIMES PanEU | IEA Renewables Information | Official statistic source (public source) | Model Input Energy | | statistics on renewable energies for OECD countries | Electricity | | Country |
| 23 | Energy system | TIMES PanEU | IEA Electricity Information | Official statistic source (public source) | Model Input Energy | | statistics on electricity for OECD countries | Electricity | | Country |
| 24 | Energy system | TIMES PanEU | Eurostat database | Official statistic source (public source) | Model Input Energy | | Final Energy Consumption by industrial Subsector, energy carrier and EU member state | Industry | | Country |
| 25 | Energy system | TIMES PanEU | Key Statistics +Annual Report (CEPI) | Associations (e.g. industrial associations) | Model Input Technology | Model Input demand | Amount of paper and pulp produced and consumed by country; Information about pulping technologies | Industry | | Country |
| 26 | Energy system | TIMES PanEU | BAT documents (European Comission) | Official statistic source (public source) | Model Input Technology | Model Input demand | Description of the industrial subsectors in the EU member states, use of technologies and specific energy consumption | Industry | | Country |
| 27 | Energy system | TIMES PanEU | IEA-Industry books [Tracking industrial Energy Efficiency and CO2 Emissions; Energy Technology Transition for industry] | Official statistic source (public source) | Model Input Technology | Model Input Energy | Data about available technologies, specific energy consumption by country and technology options | Industry | | Country |
| 28 | Energy system | TIMES PanEU | Steel Statistical Yearbook + World steel in figures (world steel association) | Associations (e.g. industrial associations) | Model Input Technology | Model Input demand | Data for steel production and technologies used for production of iron and steel | Industry | | Country |
| 29 | Energy system | TIMES PanEU | Steel in figures | Associations (e.g. industrial associations) | Model Input Technology | Model Input demand | Steel production; crude steel production | Industry | | Country |
| 30 | Energy system | TIMES PanEU | World Copper factbook (International Copper Study Group) | Associations (e.g. industrial associations) | Model Input Technology | | Copper mining and production | Industry | | Country |
| 31 | Energy system | TIMES PanEU | Activity Report (Cembureau) | Associations (e.g. industrial associations) | Model Input Technology | Model Input demand | Cement production | Industry | | Country |
| 32 | Energy system | TIMES PanEU | Umweltdaten (Verein Deutscher Zementwerke) [Data for German cement Industry from German cement association] | Associations (e.g. industrial associations) | Model Input Energy | Model Input Technology | Cement production, use of kilns, specific consumption of fuels and electricity [data only for Germany] | Industry | | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 33 | Energy system | TIMES PanEU | Chlorine Industry Review (Euro Chlor) | Associations (e.g. industrial associations) | Model Input Technology | | Use of different technologies for chlor production | Industry | | Country |
| 34 | Energy system | TIMES PanEU | Minerals Yearbook (USGS) | Official statistic source (public source) | Model Input Technology | Model Input demand | Data of production levels and technology data | Industry | | Country |
| 35 | Energy system | TIMES PanEU | CHP in the EU, Turkey and Norway from eurostat | Official statistic source (public source) | Model Input Energy | Model Input Technology | Data about electricity and heat production of autoproducers | Industry | | Country |
| 36 | Energy system | TIMES PanEU | National reports on the implementation of Directive 2003/30/EC of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport | Official statistic source (public source) | Model Input Energy | Qualitative information on context | Production/consumption of biofuels, biofuel quotas/targets, promotion schemes | Transport | | Country |
| 37 | Energy system | TIMES PanEU | European LPG Association (AEGPL) | Associations (e.g. industrial associations) | Model Input Technology | | Stock of LPG vehicles and distribution infrastructure | Transport | | Country |
| 38 | Energy system | TIMES PanEU | International Association for Natural Gas Vehicles (IANGV) | Associations (e.g. industrial associations) | Model Input Technology | | Natural gas vehicle stock, fuel infrastructure by country | Transport | | Country |
| 39 | Energy system | TIMES PanEU | Natural Gas Vehicle Association Europe (NGVA) | Associations (e.g. industrial associations) | Model Input Technology | Model Input Energy | Natural gas vehicle stock, fuel infrastructure by country, natural gas consumption, prices… by country | Transport | | Country |
| 40 | Energy system | TIMES PanEU | ACEA (European Automobile Manufacturer´s Association | Associations (e.g. industrial associations) | Model Input Technology | | New vehicle registrations by country/ type of vehicle/ fuel, spcific CO2-emissions of new cars | Transport | | Country |
| 41 | Energy system | TIMES PanEU | International transport Forum | Web server | Model Input demand | | Statistical data, mainly concerning passenger and freight demand and transport related emissions | Transport | | Country |
| 42 | Energy system | TIMES PanEU | Boeing Current Market Outlook | Company data | Model Input demand | | Forecast of air traffic volumes and airplane demand | Transport | | Group of Countries |
| 43 | Energy system | TIMES PanEU | Airbus Global Market Forecast | Company data | Model Input demand | | Forecast of air traffic volumes and airplane demand | Transport | | Group of Countries |
| 44 | Energy system | TIMES PanEU | Joint Research Centre - EUCAR - CONCAWE Collaboration: Well-to-Wheels Analysis of Future Autmotive Fuels and Powertrains in the European Context. Well-to-Wheels/Well-to-Tank/Tank-toWheels Report incl. Apendixes | Literature (articles, books, newspaper) | Model Input Technology | | Efficiencies, costs, emissions of different car technologies as well as technologies for alternative fuel production | Transport | | Country |
| 45 | Energy system | TIMES PanEU | TREMOVE model | Soft link with another model's output | Model Input Technology | Model Input demand | Statistical and projected data concerning vehicle stock, transport demand, emissions, specific fuel consumption... | Transport | | Country |
| 46 | Energy system | TIMES PanEU | Verkehr in Zahlen | Literature (articles, books, newspaper) | Model Input Technology | Model Input Energy | Statistics concerning vehicle stocks, fuel consumption, transport demand, average annual mileage etc. for Germany | Transport | | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 47 | Energy system | TIMES PanEU | Kraftfahrtbundesamt | Official statistic source (public source) | Model Input Technology | | Statistics concerning vehicle stocks, new registrations etc. for Germany | Transport | | Country |
| 48 | Energy system | TIMES PanEU | Blesl et al 2009 Blesl, M.; Bruchof, D.; Hartmann, N.; Özdemir, D.; Fahl, U.; Eltrop, L.; Voß, A.: Entwicklungsstand und Perspektiven der Elektromobilität. Studie im Auftrag des Zentrums für Energieforschung Stuttgart e. V. (ZfES). Stuttgart. Dezember 2009. | Literature (articles, books, newspaper) | Model Input Technology | | Technology data (costs, efficiencies…) of different hybrid/plug-in hybrid/battery electric/fuel cell electric vehicle concepts | Transport | | Country |
| 49 | Energy system | several energy system models | | | | | | | | |
| 50 | Energy system | several energy system models | | | | | | | | |
| 51 | Energy system | several energy system models | | | | | | | | |
| 52 | Energy system | several energy system models | | | | | | | | |
| 53 | Energy system | several energy system models | | | | | | | | |
| 54 | Energy system | TIMES PanEU | | | | | | | | |
| 55 | Energy system | TIMES PanEU | | | | | | | | |
| 56 | Energy system | TIMES PanEU | | | | | | | | |
| 57 | Energy system | TIMES PanEU | | | | | | | | |
| 58 | Energy system | TIMES PanEU | | | | | | | | |
| 59 | Energy system | TIMES PanEU | | | | | | | | |
| 60 | Energy system | TIMES PanEU | | | | | | | | |
| 61 | Energy system | TIMES PanEU | | | | | | | | |
| 62 | Energy system | TIMES PanEU | | | | | | | | |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 63 | Energy system | TIMES PanEU | | | | | | | | |
| 64 | Energy system | TIMES-GEECO | StatsSA Census 2001 | Official statistic source (public source) | Macroeconomic data | Other model input | population, number of households, annual income, building type (South Africa) | Buildings | | Project location |
| 65 | Energy system | TIMES-GEECO | StatsSA General Household Survey 2005 | Official statistic source (public source) | Behavioural information | Data used for internal additional calculation | share of households using different fuel types for cooking, lighting, space heating (South Africa) | Buildings | | Project location |
| 66 | Energy system | TIMES-GEECO | Provincial Economic Review and Outlook 2007-2009 | Official statistic source (public source) | Qualitative information on context | Data used for internal additional calculation | GDP and number of employees by economic sector sector (South Africa) | Industry | commerce | Project location |
| 67 | Energy system | TIMES-GEECO | IEA 2008 | Official statistic source (public source) | Qualitative information on context | Data used for internal additional calculation | energy by sector (South Africa) | Industry | commerce | Country |
| 68 | Energy system | TIMES-GEECO | Energy Balance for South Africa | Official statistic source (public source) | Data used for internal additional calculation | Other model input | indicatars for sectoral energy use (industry and commerce) | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Industry, Commerce | Country |
| 69 | Energy system | TIMES-GEECO | | | | | | | | |
| 70 | Energy system | TIMES-GEECO | | | | | | | | |
| 71 | Energy system | TIMES-GEECO | | | | | | | | |
| 72 | Energy system | TIMES-GEECO | | | | | | | | |
| 73 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | IEA Energy Balances | Official statistic source (public source) | Model Input Energy | | Primary, secondary and final energy consumption by energy carrier, countries or groups of countries, and sector | All sectors mentioned above in the drop down menu | | Country |
| 74 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | GEM-E3 or GEMINI-E3 | Soft link with another model's output | Macroeconomic data | | | All sectors mentioned above in the drop down menu | | Country |
| 75 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | UN Population Projections | Official statistic source (public source) | Other model input | | Projected pop per country | Others | | Country |
| 76 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | International Monetary Fund | Official statistic source (public source) | Other model input | | Short term GDP growth | Others | Whole economy | Country |
| 77 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | IPCC reports | Literature (articles, books, newspaper) | Other model input | | All topics mentioned in the drop down menu: Techno-economic description of technologies (especially the future technologies), energy potentials, sequestration potentials, emission scenarios, costs, qualitative information, behaviors, etc. | All sectors mentioned above in the drop down menu | | Group of Countries |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 78 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | IEA reports (ETP, WEO) | Literature (articles, books, newspaper) | Other model input | | All topics mentioned in the drop down menu: Techno-economic description of technologies (especially the future technologies), energy potentials, sequestration potentials, emission scenarios, costs, qualitative information, behaviors, etc. | All sectors mentioned above in the drop down menu | | Group of Countries |
| 79 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | US-DOE-EIA reports (outlooks) | Literature (articles, books, newspaper) | Other model input | | Many topics mentioned in the drop down menu: energy potentials, energy prices, emission scenarios, costs, qualitative information, etc. | All sectors mentioned above in the drop down menu | | Group of Countries |
| 80 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | SAIC, USDOE-EIA | Official statistic source (public source) | Other model input | | All topics mentioned in the drop down menu: Techno-economic description of technologies (especially the future technologies), energy potentials. | All sectors mentioned above in the drop down menu | | Group of Countries |
| 81 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | Specialized literature on energy use and resources (World Energy Council; BP Statistics; US Geological Survey) | Literature (articles, books, newspaper) | Model Input Energy | | Energy potentials, Techno-economic description of technologies, sequestration potentials, etc. | Others | | Group of Countries |
| 82 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | Specialized literature on bioenergy (Smeets et al., 2004; agriculture models like Magpie; databases like FAPRI; etc.) | Literature (articles, books, newspaper) | Model Input Energy | | Bioenergy potentials (crops, forestry, etc.) | Others | | Group of Countries |
| 83 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | Specialized literature on non-energy sectors (EMF22 data, Sathaye et al., 2005; Prinn et al., 2008; UNFCCC; etc.). | Literature (articles, books, newspaper) | Other model input | | Non-energy sectors (forestry, non-energy emissions, land0use, etc.) | Others | | Group of Countries |
| 84 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | UNFCCC | Official statistic source (public source) | Other model input | | GHG emissions per sector | All sectors mentioned above in the drop down menu | | Group of Countries |
| 85 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | Experts, projects (eg. Navigant Consultants for renewable power plants. , etc.) | Interviews (experts, stakeholders) | Other model input | | All topics mentioned in the drop down menu: Techno-economic description of technologies (especially the future technologies), energy potentials, sequestration potentials, emission scenarios, costs, qualitative information, behaviors, etc. | All sectors mentioned above in the drop down menu | | Group of Countries |
| 86 | Energy system | TIMES Integrated Assessment Model (TIAM-WORLD) | Specialized literature on climate (IPCC; Nordhaus and Boyer, 1999) and climate models | Literature (articles, books, newspaper) | Other model input | | Climate module | Others | | |
| 87 | Energy system | EnergyPLAN | Historical National Energy Balance | Official statistic source (public source) | Model Input Energy | Model Input demand | Total Primary Energy Requirement by fuel (including oil, gas, peat, coal, renewables, electricity) and sector (including power plants, energy storage, transport, industry, residential, services, and agriculture) | All sectors mentioned above in the drop down menu | | Country |
| 88 | Energy system | EnergyPLAN | Historical National Energy Balance | Official statistic source (public source) | Other model input | | Aggregated efficiency of power plants | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Electricity and Heat | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 89 | Energy system | EnergyPLAN | Forecasted National Energy Balance | Official statistic source (public source) | Model Input Energy | Model Input demand | Total Primary Energy Requirement by fuel (including oil, gas, peat, coal, renewables, electricity) and sector (including power plants, energy storage, transport, industry, residential, services, and agriculture) | All sectors mentioned above in the drop down menu | | Country |
| 90 | Energy system | EnergyPLAN | Forecasted National Energy Balance | Official statistic source (public source) | Other model input | | Aggregated efficiency of power plants | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Electricity and Heat | Country |
| 91 | Energy system | EnergyPLAN | Transmission System Operator | Public database incl. other than statistic data | Model Input demand | | Hourly distribution of electricity demand. | Electricity | | Country |
| 92 | Energy system | EnergyPLAN | Electricity Transmission System Op'erator | Public database incl. other than statistic data | Model Input Technology | | Plant capacities, including CHP, Fossil Fuels, energy storage, interconnection, and Renewables. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Electricity and Heat | Country |
| 93 | Energy system | EnergyPLAN | District Heating Operator | Company data | Model Input demand | | Hourly heating demand for district heating | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Industry and Buildings | Location within a country |
| 94 | Energy system | EnergyPLAN | National Meteorological Agency | Official statistic source (public source) | Model Input demand | | Degree day data is used to estimate the hourly heating demand if no district heating is already in place. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Industry and Buildings | Location within a country |
| 95 | Energy system | EnergyPLAN | Hourly Transport Demand | Literature (articles, books, newspaper) | Model Input demand | | Hourly transport demand | Transport | | Country |
| 96 | Energy system | EnergyPLAN | Individual Boiler and CHP Efficiencies | Literature (articles, books, newspaper) | Model Input Technology | | Efficiency of boilers used in houses and buildings. | Buildings | | Country |
| 97 | Energy system | EnergyPLAN | Hourly Solar Distribution | Literature (articles, books, newspaper) | Model Input demand | | Hourly solar heat production | Buildings | | Country |
| 98 | Energy system | EnergyPLAN | Industrial Generation | Company data | Model Input Energy | | Heat and electricity production from industry | Industry | | Country |
| 99 | Energy system | EnergyPLAN | National Energy Agency | Literature (articles, books, newspaper) | Model Input Technology | | Carbon dioxide emissions per unit of energy produced by each fuel. | All sectors mentioned above in the drop down menu | | Country |
| 100 | Energy system | EnergyPLAN | IEA World Energy Outlook | Literature (articles, books, newspaper) | Model Input Costs | | Cost of coal, fuel oil, diesel, petrol, natural gas, LPG, waste, biomass, dry biomass, wet biomass. | All sectors mentioned above in the drop down menu | | Country |
| 101 | Energy system | EnergyPLAN | Danish Energy Agency | Literature (articles, books, newspaper) | Model Input Costs | | Fuel handling costs for coal, fuel oil, diesel, petrol, natural gas, LPG, waste, biomass, dry biomass, wet biomass. | All sectors mentioned above in the drop down menu | | Country |
| 102 | Energy system | EnergyPLAN | National Revenue Office | Web server | Model Input Costs | | Taxes on fuels | All sectors mentioned above in the drop down menu | | Country |
| 103 | Energy system | EnergyPLAN | Danish Energy Agency | Literature (articles, books, newspaper) | Model Input Costs | | Variable operation and maintenance costs for each plant within the energy system. | All sectors mentioned above in the drop down menu | | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 104 | Energy system | EnergyPLAN | Danish Energy Agency | Literature (articles, books, newspaper) | Model Input Costs | | Fixed operation and maintenance costs for each plant within the energy system. | All sectors mentioned above in the drop down menu | | Country |
| 105 | Energy system | EnergyPLAN | Danish Energy Agency | Literature (articles, books, newspaper) | Model Input Costs | | Investment costs for each plant within the energy system. | All sectors mentioned above in the drop down menu | | Country |
| 106 | Energy system | EnergyPLAN | Electricity Market Operator | Public database incl. other than statistic data | Model Input Costs | | Hourly market price for electricity | Electricity | | Country |
| 107 | Energy system | EnergyPLAN | Project Developer | Interviews (experts, stakeholders) | Model Input Technology | | Electricity and heat production from waste | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Electricity and Heat | Country |
| 108 | Energy system | EnergyPLAN | Project Developer | Interviews (experts, stakeholders) | Model Input Technology | | Electricity and heat from geothermal operated by an absorption heat pump on steam from waste CHP plants | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Electricity and Heat | Country |
| 109 | Energy system | EnergyPLAN | Project Developer | Interviews (experts, stakeholders) | Model Input Technology | | Biomass required to create other forms of bioenergy such as biogas, biodiesel, and biopetrol. | All sectors mentioned above in the drop down menu | | Country |
| 110 | Energy system | EnergyPLAN | | | | | | | | |
| 111 | Energy system | EnergyPLAN | | | | | | | | |

Assessment of data/data sources

| Assessment of data/data sources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 1 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 4 (high) | Excel download | Available | Public + free | | |
| 2 | Annual | 1-2 years | Continuously Updated | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 3 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 4 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 5 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 6 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 4 (high) | Excel download | Available | Public + charge fee | | |
| 7 | Annual | 1-2 years | Yearly | 5 (very high) | 3 (medium) | PDF | Available | Public + charge fee | 120-240 € | |
| 8 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 9 | Annual | 1-2 years | Continuously Updated | 3 (medium) | 4 (high) | Web account/webpage | Available | Public + free | | |
| 10 | Annual | 1-2 years | Yearly | 3 (medium) | 5 (very high) | PDF | Available | Public + free | | |
| 11 | Annual | 2-4 Years | Every two years | 3 (medium) | 4 (high) | PDF | Available | Public + charge fee | 80 -160 € | The report does not cover all types of energy technologies |
| 12 | Annual | 1-2 years | Not periodically | 3 (medium) | 4 (high) | PDF | Available | Public + charge fee | 56-280 € | |
| 13 | Annual | 1-2 years | Yearly | 5 (very high) | 4 (high) | Excel download | Available | Public + free | | |
| 14 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + charge fee | | |
| 15 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + charge fee | | |
| 16 | Depends on issue in focus | 1-2 years | Yearly | 5 (very high) | 3 (medium) | PDF | Available | Public + charge fee | | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 17 | Monthly | 2-4 Years | Continuously Updated | 5 (very high) | 4 (high) | Excel download | Available | Public + free | | partially different accounting methodes (esp. District heat and steam) among countries |
| 18 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Web account/webpage | Available | Public + free | | |
| 19 | Annual | 2-4 Years | More than two years | 4 (high) | 5 (very high) | Access database | Available | Public + free | | |
| 20 | Annual | < 1 year | Yearly | 4 (high) | 5 (very high) | Access database | Available | Public + charge fee | | lack of data for transition and developing countries |
| 21 | Annual | Future-oriented projections | Not periodically | 4 (high) | 5 (very high) | PDF | Available | Public + free | | |
| 22 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + charge fee | | |
| 23 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + charge fee | | |
| 24 | Monthly | 1-2 years | Continuously Updated | 5 (very high) | 4 (high) | Excel download | Available | Public + free | | Because the values are permanentely update, sometimes even values for years in the past change. In addition, the values sometimes do not fit to national statistics. |
| 25 | Annual | < 1 year | Yearly | 4 (high) | 5 (very high) | PDF | Available | Public + free | | |
| 26 | Depends on issue in focus | 2-4 Years | Not periodically | 3 (medium) | 5 (very high) | PDF | Available | Public + free | | |
| 27 | Depends on issue in focus | 2-4 Years | Not periodically | 3 (medium) | 5 (very high) | PDF | Available | Public + charge fee | University arrangement | |
| 28 | Annual | < 1 year | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + free | | |
| 29 | Monthly | < 1 year | < 1 year | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 30 | Annual | < 1 year | Yearly | 3 (medium) | 2 (low) | PDF | Not available | Public + free | | |
| 31 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | PDF | Available | Public + free | | |
| 32 | Annual | < 1 year | Yearly | 4 (high) | 5 (very high) | PDF | Available | Public + free | | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 33 | Annual | 1-2 years | Not periodically | 4 (high) | 4 (high) | PDF | Available | Public + free | | |
| 34 | Seasonal | 1-2 years | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | | |
| 35 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | PDF | Not available | Public + free | | Not always consistent to other eurostat publications |
| 36 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + free | | Low level of detail in some member states |
| 37 | Annual | 1-2 years | Not periodically | 2 (low) | 2 (low) | Web account/webpage | Available | Public + free | | Detailed data sometimes only for selected countries |
| 38 | Annual | 1-2 years | Continuously Updated | 3 (medium) | 3 (medium) | Web account/webpage | Available | Public + free | | |
| 39 | Annual | < 1 year | Continuously Updated | 4 (high) | 3 (medium) | Web account/webpage | Available | Public + free | | |
| 40 | Monthly | < 1 year | Continuously Updated | 4 (high) | 3 (medium) | Excel download | Available | Public + free | | No detailed information on vehicles based on alternative fuels and power trains |
| 41 | Depends on issue in focus | 1-2 years | Continuously Updated | 4 (high) | 2 (low) | PDF | Available | Public + free | | |
| 42 | Annual | Future-oriented projections | Yearly | 4 (high) | 2 (low) | PDF | Available | Public + free | | Aggregated data for different world regions, only average annual growth rates for the period 2009 to 2029 |
| 43 | Annual | Future-oriented projections | Yearly | 4 (high) | 2 (low) | PDF | Available | Public + free | | Aggregated data for different world regions, only average annual growth rates for the period 2009 to 2029 |
| 44 | Depends on issue in focus | Future-oriented projections | Not periodically | 3 (medium) | 4 (high) | PDF | Available | Public + free | | No details on when the forecasted cost, efficiency and emission levels are reached, no regional differentiation |
| 45 | Annual | Future-oriented projections | Not periodically | 4 (high) | 4 (high) | Excel download | Available | Public + free | | Some statistic data (e.g. specific fuel consumption) does not always fit to other statistical sources |
| 46 | Annual | 1-2 years | Yearly | 4 (high) | 5 (very high) | Other database system | Available | Public + charge fee | | Data only for Germany |

| | Assessment of data/data sources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 47 | Depends on issue in focus | < 1 year | Continuously Updated | 4 (high) | 4 (high) | Excel download | Available | Public + free | | Data only for Germany, some data is not free |
| 48 | Depends on issue in focus | Future-oriented projections | Not periodically | 4 (high) | 4 (high) | PDF | Available | Public + free | | Report written in German |
| 49 | | | | | | | | | | |
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## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 63 | | | | | | | | | | |
| 64 | Annual | > 4 years | More than two years | 3 (medium) | 3 (medium) | Paper Report | Available | Public + free | | |
| 65 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Paper Report | Available | Public + free | | data only denotes share of households using a specific fuel, but does not indicate the quantity. Furthermore, data is extrapolated to include the entire population, but literature states that not all households can afford to space heat. So, here the number will indicate that 100% space heat - does not reflect in the energy balance! |
| 66 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Paper Report | Available | Public + free | | data must be correlated with national and international data on the same economic sectors |
| 67 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Paper Report | Available | Public + free | | only national, must still be cross-tabulated with other data sources to get regional or sub-sector specific information |
| 68 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Web account/webpage | Available | Public + free | | |
| 69 | | | | | | | | | | |
| 70 | | | | | | | | | | |
| 71 | | | | | | | | | | |
| 72 | | | | | | | | | | |
| 73 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | | |
| 74 | Annual | Future-oriented projections | Not published | 4 (high) | 4 (high) | Other database system | Available | | | |
| 75 | Annual | Future-oriented projections | Every two years | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 76 | Annual | Future-oriented projections | Continuously Updated | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 77 | Depends on issue in focus | Future-oriented projections | More than two years | 3 (medium) | 4 (high) | PDF | Available | Public + free | | |

| Assessment of data/data sources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
| Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| Depends on issue in focus | Future-oriented projections | Yearly | 5 (very high) | 4 (high) | PDF | Available | Public + charge fee | | |
| Depends on issue in focus | Future-oriented projections | Yearly | 5 (very high) | 4 (high) | PDF | Available | Public + free | PDF and xls are available and used | |
| | | | | | | | | | |
| Depends on issue in focus | Future-oriented projections | Not periodically | 5 (very high) | 4 (high) | PDF | Available | Public + free | | |
| Depends on issue in focus | Future-oriented projections | Not periodically | 4 (high) | 4 (high) | PDF | Available | Public + free | | |
| Depends on issue in focus | Future-oriented projections | Not periodically | 3 (medium) | 3 (medium) | Excel download | Available | Public + free | | |
| Annual | 1-2 years | Continuously Updated | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| Depends on issue in focus | Future-oriented projections | Not periodically | 5 (very high) | 5 (very high) | PDF | Available | Personal contact required | | |
| Depends on issue in focus | Future-oriented projections | Not periodically | 5 (very high) | 5 (very high) | PDF | Available | Public + free | | |
| Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 89 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 90 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 91 | Hourly | < 1 year | Continuously Updated | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | €0 | |
| 92 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 93 | Hourly | < 1 year | Continuously Updated | 5 (very high) | 5 (very high) | Excel download | Available | Personal contact required | €0 | |
| 94 | Daily | < 1 year | Continuously Updated | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | €45 | |
| 95 | Hourly | > 4 years | Not published | 3 (medium) | 3 (medium) | Excel download | Not available | Personal contact required | €0 | |
| 96 | Annual | > 4 years | Not periodically | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 97 | Hourly | > 4 years | Not published | 5 (very high) | 5 (very high) | Excel download | Not available | Personal contact required | €0 | |
| 98 | Hourly | < 1 year | Not published | 5 (very high) | 5 (very high) | Excel download | Available | Personal contact required | €0 | |
| 99 | Annual | 1-2 years | Not periodically | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 100 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + charge fee | €120-€240 | |
| 101 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 102 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | Web account/webpage | Available | Public + free | €0 | |
| 103 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 104 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 105 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | Available | Public + free | €0 | |
| 106 | Hourly | < 1 year | Continuously Updated | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | €0 | |
| 107 | Annual | | Not published | 5 (very high) | 5 (very high) | | Not available | Private | €0 | This data is project specific and is obtained from the project developers. Hence, it varies for each project. |
| 108 | Annual | | Not published | 5 (very high) | 5 (very high) | | Not available | Private | €0 | This data is project specific and is obtained from the project developers. Hence, it varies for each project. |
| 109 | Annual | | Not published | 5 (very high) | 5 (very high) | | Not available | Private | €0 | This data is project specific and is obtained from the project developers. Hence, it varies for each project. |
| 110 | | | | | | | | | | |
| 111 | | | | | | | | | | |

Additional requirements/ further data needs

## Additional requirements/ further data needs

Lack of data (data you would like to see available)

| | Sector covered by required data | Additional comments on the sector coverage (if needed) | Geographical resolution of required data | Description of the lack of data/additional data need |
|---|---|---|---|---|
| 49 | Others | Residential | Country | Investments costs for heating technologies, energy using appliances |
| 50 | Others | Residential | Country | Age structure of stock of heating technologies, energy using appliances |
| 51 | Others | Service Sector | Country | Investments costs for process heat technologies |
| 52 | Others | Service Sector | Country | Age structure of stock of process heat technologies |
| 53 | Others | Residential | Country | Information on behavioural factors |
| 54 | Transport | | Country | Statistic national data concerning final energy consumption of road transport by technology (car, bus, heavy/light duty vehicles, motorbikes) |
| 55 | Transport | | Country | Average specific fuel consumption, annual mileage, average daily mileage, load factors in each vehicle category; ratio of short and long distance travelling, |
| 56 | Transport | | Country | National projections for the future share of alternative fuels (e.g. natural gas, LPG, hydrogen, electricity, but also the ratio of gasoline and diesel) and powertrains (e.g. electric, hybrid electric, plug-in hybrid electric, fuel cell electric), national projections for the development of passenger and freight transport demand by transport mode |
| 57 | Electricity | Electricity + Heat | Country | district heating statistics on heat and electricity production by plant typ and fuel |
| 58 | Electricity | | Country | Load profiles by sector (electricity consumption of residential sector, …) |
| 59 | Industry | | Country | Steam production |
| 60 | Industry | | Country | Data about costs for different production processes (subsector specific technologies) |
| 61 | Industry | | Country | Data about existing technologies/stock (specific consumption; life time) |
| 62 | Industry | | Country | Data on useful energy especially for non energy intensive subsectors |
| 63 | Industry | | Country | data for heat and electricity production from autoproducers by country, subsector and energy carrier |
| 64 | Buildings | | Project location | |
| 69 | Buildings | | Project location | energy consumption data for each end-use; information on water heating |
| 70 | Industry | | Project location | regional data missing information on energy consumption per sector and consistency in subsectors for national data |
| 71 | Industry | | Project location | regional data on industrial and commercial energy consumption by sub-sector -> shows regional differences in relation to energy consumed and GDP |
| 72 | Others | Energy Supply | Country | potential on grwoing areas for energy crops |
| 73 | Industry | Subsectors | Country | Steam generation in the industrial sector by subsectors, energy carrier and technology (like CHP, boiler) |
| 110 | Transport | | Country | As electric vehicles become more prominent, they will become an integral part of managing an energy system. Hence, the hourly demand for transport will be necessary to simulate various tranport alternatives. At present, very little data is available outlining what the hourly transport demand is, particularly in relation to the total vehicle fleet i.e. parked and mobile cars. |
| 111 | Electricity | | Project location | It is possible to get the aggregated energy efficiency for power plants, but due to commercial sensitivity it is not possible to get the efficiency of individual plants. Hence, this data should be publicly available so the consequnces of alternative plants can be assessed. |

# **Appendix B:** Data list Macroeconomic Models

Data/data sources used in model/model family

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 1 | Macroeconomic | NEWAGE | GTAP | Official statistic source (public source) | Macroeconomic data | | Worldwide Input-Output-Table | All sectors mentioned above in the drop down menu | | Country |
| 2 | Macroeconomic | NEWAGE | IO-Tables and/or SAMs | Official statistic source (public source) | Macroeconomic data | | Country-specific Input-Output (IO) Tables and/or Social-Accounting-Matrices (SAMs) | All sectors mentioned above in the drop down menu | | Country |
| 3 | Macroeconomic | NEWAGE | GTAP | Official statistic source (public source) | Macroeconomic data | | Worldwide Input-Output-Table | All sectors mentioned above in the drop down menu | | Country |
| 4 | Macroeconomic | NEWAGE | Relevant literature on CGE modelling | Literature (articles, books, newspaper) | Other model input | | Elasticities of Substitution and Transformation | All sectors mentioned above in the drop down menu | | Country |
| 5 | Macroeconomic | NEWAGE | United Nations Framework Convention on Climate Change (UNFCCC) | Official statistic source (public source) | Information on carbon footprint | | Greenhouse Gas Inventory Data | All sectors mentioned above in the drop down menu | | Country |
| 6 | Macroeconomic | NEWAGE | EU-ETS, German EEG | Public database incl. other than statistic data | Data used for internal additional calculation | | Data taken form directives, laws and measures concerning feed-in-tariffs | All sectors mentioned above in the drop down menu | | Country |
| 7 | Macroeconomic | NEWAGE | Kyoto-Protocol and/or National Allocation Plans (NAP) | Public database incl. other than statistic data | Information on carbon footprint | | Data taken form directives, laws and measures concerning GHG emission caps | All sectors mentioned above in the drop down menu | | Country |
| 8 | Macroeconomic | NEWAGE | International Energy Agency (IEA) | Official statistic source (public source) | Model Input Energy | | Energy balances | Electricity | | Country |
| 9 | Macroeconomic | NEWAGE | International Labor Organization (ILO) | Official statistic source (public source) | Other model input | | Labor data | Others | Citizens, society | Country |
| 10 | Macroeconomic | NEWAGE | Output of bottom-up models (mainly TIMES PanEU) | Database built for specific purposes | Model Input Costs | | Electricity generation cost information | Electricity | | Country |
| 11 | Macroeconomic | NEWAGE | Output of bottom-up models (mainly TIMES PanEU) | Database built for specific purposes | Model Input Technology | | Electricity generation technology information | Electricity | | Country |
| 12 | Macroeconomic | NEWAGE | | | | | | | | |
| 13 | Macroeconomic | NEWAGE | | | | | | | | |
| 14 | Macroeconomic | GTAP-E | IEA database | Official statistic source (public source) | Model Input Energy | | Primary energy consumption for all 113 regions included in the GTAP database | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 15 | Macroeconomic | GTAP-E | Computations based on IPCC emission factors and GTAP energy volume data | Database built for specific purposes | Model Input Energy | | Energy-related GHG emissions | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 16 | Macroeconomic | GTAP-E | World Bank data | Official statistic source (public source) | Macroeconomic data | | GDP, private and government consumption, investment, population | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 17 | Macroeconomic | GTAP-E | UN COMTRADE data | Official statistic source (public source) | Macroeconomic data | | Trade data at the sector level | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 18 | Macroeconomic | GTAP-E | OECD PSE/CSE database | Official statistic source (public source) | Macroeconomic data | | Domestic support (e.g., output and input subsidies, land-based payments, labor- and capital-based payments) | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 19 | Macroeconomic | GTAP-E | WTO and "Financial report on the European Agricultural Guidance and Guarantee Fund" | Database built for specific purposes | Macroeconomic data | | Agricultural export subsidies | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 20 | Macroeconomic | GTAP-E | Market Access Maps (MAcMaps) developed by ITC (UNCTAD-WTO, Geneva) and CEPII (Paris) | Database built for specific purposes | Macroeconomic data | | Import tariffs | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 21 | Macroeconomic | GTAP-E | IMF | Official statistic source (public source) | Macroeconomic data | | Income and factor taxes | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 22 | Macroeconomic | GTAP-E | Calibrated from other data sources | Database built for specific purposes | Behavioural information | | Behavioral parameters (demand and trade elasticities) | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | 57 sectors: 1-26 Agricultural and Food processing sectors by reference Central Product Classification (UN Statistics). 27-57 International Standard Industry Classification (ISIC3 UN Statistics) | Country |
| 23 | Macroeconomic | GEMED | GTAP | Official statistic source (public source) | Other model input | | Elasticities of Substitution and Transformation | All sectors mentioned above in the drop down menu | | Country |
| 24 | Macroeconomic | GEMED | Relevant literature on CGE modelling | Literature (articles, books, newspaper) | Other model input | | Elasticities of Substitution and Transformation | All sectors mentioned above in the drop down menu | | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 25 | Macroeconomic | GEMED | INE - instituto nacional de estadistica, Spain | Official statistic source (public source) | Macroeconomic data | | Spanish national accounts and symetric Input-Output (IO) Tables | All sectors mentioned above in the drop down menu | | Country |
| 26 | Macroeconomic | GEMED | INE - instituto nacional de estadistica, Spain | Official statistic source (public source) | Information on carbon footprint | | Air emissions satellite accounts | All sectors mentioned above in the drop down menu | | Country |
| 27 | Macroeconomic | GEMED | INE - instituto nacional de estadistica, Spain | Official statistic source (public source) | Data used for internal additional calculation | | INE environmental taxes accounts | All sectors mentioned above in the drop down menu | | Country |
| 28 | Macroeconomic | GEMED | EU-ETS, German EEG | Public database incl. other than statistic data | Data used for internal additional calculation | | Data taken form directives, laws and measures concerning feed-in-tariffs | All sectors mentioned above in the drop down menu | | Country |
| 29 | Macroeconomic | GEMED | Kyoto-Protocol and/or National Allocation Plans (NAP) | Public database incl. other than statistic data | Information on carbon footprint | | Data taken form directives, laws and measures concerning GHG emission caps | All sectors mentioned above in the drop down menu | | Country |
| 30 | Macroeconomic | GEMED | International Energy Agency (IEA) | Official statistic source (public source) | Model Input Energy | Model Input Costs | Energy balances | Electricity | | Country |
| 31 | Macroeconomic | GEMED | IEA Statistics | Official statistic source (public source) | Model Input Energy | Model Input Costs | Energy Projections for Spain, primary and final energy consumption, capacities, prices and taxes etc. | All sectors mentioned above in the drop down menu | | Country |
| 32 | Macroeconomic | GEMED | CNE | Official statistic source (public source) | Model Input Energy | Model Input Costs | Data on gas and electricity networks and demand, energy investments, energy prices and tariffs, etc., for Spain | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | | Country |
| 33 | Macroeconomic | GEMED | MINISTERIO DE INDUSTRIA, TURISMO Y COMERCIO | Public database incl. other than statistic data | Model Input Energy | Model Input Costs | Energy balances for Spain, primary energy production and consumption, final energy consumption by sector | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | | Country |
| 34 | Macroeconomic | GEMED | ESIOS | Official statistic source (public source) | Model Input Technology | | Historical hourly operation, demand and production by technology | Electricity | | Country |
| 35 | Macroeconomic | GEMED | REE | Public database incl. other than statistic data | Model Input Technology | | Historical electricity production installed capacity | Electricity | | Country |
| 36 | Macroeconomic | GEMED | UNESA | Literature (articles, books, newspaper) | Model Input Technology | | electricity sector costs information | Electricity | | Country |
| 37 | Macroeconomic | GEMED | European Comission reference reports and EIA (US energy information administration) | Literature (articles, books, newspaper) | Model Input Technology | | Electricity technologies eficiency, operational and combustibles costs | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | | Group of Countries |
| 38 | Macroeconomic | GEMED | IEA Energy Technology Perspectives | Official statistic source (public source) | Model Input Technology | | Data on energy technology (capacities and costs), existent and future estimations | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | | Group of Countries |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 39 | Macroeconomic | E3ME | Eurostat | Official statistic source (public source) | Macroeconomic data | | National Accounts Detailed Breakdown by industry, by product, by consumption purpose | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 40 | Macroeconomic | E3ME | Eurostat | Official statistic source (public source) | Other model input | | Population, labour force and unemployment by age group. | Others | | Country |
| 41 | Macroeconomic | E3ME | Eurostat | Official statistic source (public source) | Other model input | | Country specific Input-Output tables | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 42 | Macroeconomic | E3ME | Eurostat | Official statistic source (public source) | Macroeconomic data | | Extra and intra-EU trade flows by product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 43 | Macroeconomic | E3ME | Eurostat | Official statistic source (public source) | Other model input | | Bilateral trade flows data. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 44 | Macroeconomic | E3ME | ILO | Official statistic source (public source) | Macroeconomic data | | Average weekly hours worked by industry. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 45 | Macroeconomic | E3ME | OECD STAN | Official statistic source (public source) | Macroeconomic data | | National accounts and trade data by industry and by product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 46 | Macroeconomic | E3ME | AMECO | Official statistic source (public source) | Other model input | | Exchange rates, interest rates, tax incomes, benefits received. | Others | Regional totals | Country |
| 47 | Macroeconomic | E3ME | AMECO | Official statistic source (public source) | Other model input | | Exchange rates, interest rates, tax incomes, benefits received. | Others | Regional totals | Country |
| 48 | Macroeconomic | E3ME | DG Taxation and Customs Union, Taxes in Europe database | Official statistic source (public source) | Other model input | | Taxes | Others | Regional totals | Country |
| 49 | Macroeconomic | E3ME | Eurostat | Official statistic source (public source) | Other model input | | Materials demand | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 50 | Macroeconomic | E3ME | Eurostat | Official statistic source (public source) | Other model input | | Electricity generation and capacity | Electricity | | Country |
| 51 | Macroeconomic | E3ME | IEA | Official statistic source (public source) | Model Input Energy | | Energy balances and prices | All sectors mentioned above in the drop down menu | | Country |
| 52 | Macroeconomic | E3ME | European Environment Agency | Official statistic source (public source) | Other model input | | CO2 emissions | All sectors mentioned above in the drop down menu | | Country |
| 53 | Macroeconomic | E3ME | EDGAR | Official statistic source (public source) | Other model input | | Non-CO2 emissions | All sectors mentioned above in the drop down menu | | Country |
| 54 | Macroeconomic | E3ME | Croatia National Statistics Office | Official statistic source (public source) | Macroeconomic data | | National Accounts data by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 55 | Macroeconomic | E3ME | Turkey National Statistics Office | Official statistic source (public source) | Macroeconomic data | | National Accounts data by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 56 | Macroeconomic | E3MG | Eurostat | Official statistic source (public source) | Macroeconomic data | | National Accounts Detailed Breakdown by industry, by product, by consumption purpose | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 57 | Macroeconomic | E3MG | Eurostat | Official statistic source (public source) | Other model input | | Population, labour force and unemployment by age group. | Others | | Country |
| 58 | Macroeconomic | E3MG | OECD STAN | Official statistic source (public source) | Macroeconomic data | | National accounts and trade data by industry and by product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 59 | Macroeconomic | E3MG | ILO | Official statistic source (public source) | Other model input | | Average weekly hours worked by industry. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 60 | Macroeconomic | E3MG | IEA | Official statistic source (public source) | Model Input Energy | | Energy Balances and prices | All sectors mentioned above in the drop down menu | | Country |
| 61 | Macroeconomic | E3MG | EDGAR | Official statistic source (public source) | Other model input | | CO2 and non-CO2 emissions | All sectors mentioned above in the drop down menu | | Country |
| 62 | Macroeconomic | E3MG | Enerdata | Database built for specific purposes | Other model input | | Electricity generation and capacity | Electricity | | Country |
| 63 | Macroeconomic | E3MG | OECD STAN | Official statistic source (public source) | Macroeconomic data | | National Accounts Detailed Breakdown by industry and product | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 64 | Macroeconomic | E3MG | OECD | Official statistic source (public source) | Other model input | | Bilateral Trade flows data. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Industry, Transport | Country |
| 65 | Macroeconomic | E3MG | OECD | Official statistic source (public source) | Other model input | | Input-Output coefficients. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 66 | Macroeconomic | E3MG | UN | Official statistic source (public source) | Macroeconomic data | | National Accounts data by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 67 | Macroeconomic | E3MG | UN | Official statistic source (public source) | Macroeconomic data | | National Accounts data. | Others | Regional totals | Country |
| 68 | Macroeconomic | E3MG | UN | Official statistic source (public source) | Other model input | | Exchange rates, interest rates, tax incomes, benefits received. | Others | Regional totals | Country |
| 69 | Macroeconomic | E3MG | UN | Official statistic source (public source) | Other model input | | Population, labour force and unemployment by age group. | Others | | Country |
| 70 | Macroeconomic | E3MG | WTO | Official statistic source (public source) | Macroeconomic data | | Trade data | Others | Services | Country |
| 71 | Macroeconomic | E3MG | AMECO | Official statistic source (public source) | Other model input | | Exchange rates, interest rates, tax incomes, benefits received. | Others | Regional totals | Country |
| 72 | Macroeconomic | E3MG | AMECO | Official statistic source (public source) | Other model input | | Exchange rates, interest rates, tax incomes, benefits received. | Others | Regional totals | Country |
| 73 | Macroeconomic | E3MG | National Statistics Office of Brazil | Official statistic source (public source) | Macroeconomic data | | National accounts breakdown by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 74 | Macroeconomic | E3MG | National Statistics Office of Brazil | Official statistic source (public source) | Other model input | | Population, labour force and unemployment by age group. | Others | | Country |
| 75 | Macroeconomic | E3MG | National Statistics Office of China | Official statistic source (public source) | Macroeconomic data | | National accounts breakdown by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 76 | Macroeconomic | E3MG | National Statistics Office of India | Official statistic source (public source) | Macroeconomic data | | National accounts breakdown by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 77 | Macroeconomic | E3MG | National Statistics Office of Russia | Official statistic source (public source) | Macroeconomic data | | National accounts breakdown by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country |
| 78 | Macroeconomic | E3MG | National Statistics Office of Russia | Official statistic source (public source) | Macroeconomic data | | National accounts breakdown by industry and product. | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Industry, Transport | Country |

Assessment of data/data sources

| | Assessment of data/data sources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 1 | Annual | 2-4 Years | More than two years | 5 (very high) | 2 (low) | Other database system | Available | Public + charge fee | approx. € 3750,- (private) and € 750,- (academic) | |
| 2 | Annual | 1-2 years | Yearly | 4 (high) | 2 (low) | Excel download | Available | Public + free | | Country-specific IO-Tables or SAMs are not always comparable with each other due to different accounting standards |
| 3 | Annual | 2-4 Years | More than two years | 5 (very high) | 2 (low) | Other database system | Available | Public + charge fee | approx. € 3750,- (private) and € 750,- (academic) | |
| 4 | Depends on issue in focus | | Not periodically | 3 (medium) | 3 (medium) | PDF | Available | Public + free | | |
| 5 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 6 | Depends on issue in focus | | Not published | 5 (very high) | 5 (very high) | PDF | Available | Public + free | | |
| 7 | Depends on issue in focus | 1-2 years | Not periodically | 5 (very high) | 4 (high) | PDF | Available | Public + free | | |
| 8 | Annual | < 1 year | Continuously Updated | 5 (very high) | 4 (high) | Excel download | Available | Public + free | | |
| 9 | Annual | 1-2 years | Continuously Updated | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 10 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 4 (high) | Other database system | Not available | Private | | |
| 11 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 4 (high) | Other database system | Not available | Private | | |
| 12 | | | | | | | | | | |
| 13 | | | | | | | | | | |
| 14 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | Unknown | |
| 15 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | Unknown | |
| 16 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 17 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | Unknown | |
| 18 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Other database system | Available | Public + charge fee | Unknown | Lack of information for some countries. Database relies on information from other sources. |
| 19 | Annual | 1-2 years | Not periodically | 3 (medium) | 3 (medium) | Other database system | Available | Private | | Lack of information for some countries. Country data available for different reference years. |
| 20 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Other database system | Available | Public + charge fee | Unknown | |
| 21 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | Unknown | GTAP-7 database (released in 2008) uses information for the base year 2004. |
| 22 | | | | | | | | | | |
| 23 | Annual | 2-4 Years | More than two years | 5 (very high) | 2 (low) | Other database system | Available | Public + charge fee | approx. € 3750,- (private) and € 750,- (academic) | limited information on sector specific estimated elasticities |
| 24 | Annual | | Not periodically | 3 (medium) | 3 (medium) | PDF | Available | Public + free | | Low number of works dealing with elasticity estimation in non energetic sectors, specialy to the Spanish case. Very low number of publications focused on estimations of demand behavior. |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 25 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | Lack of specific sector activities disagregations important to energetic issues. |
| 26 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 27 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | Limited availability of data on specific taxes, subsidies and transfers (electricity renewables and carbon subsidies, CO2 payments and emission rights,…) |
| 28 | Depends on issue in focus | | Not published | 5 (very high) | 5 (very high) | PDF | Available | Public + free | | |
| 29 | Depends on issue in focus | 1-2 years | Not periodically | 5 (very high) | 4 (high) | PDF | Available | Public + free | | |
| 30 | Annual | < 1 year | Continuously Updated | 5 (very high) | 4 (high) | Excel download | Available | Public + free | | |
| 31 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 4 (high) | Excel download | Available | Public + charge fee | | |
| 32 | Annual | 1-2 years | Continuously Updated | 5 (very high) | 4 (high) | PDF | Available | Public + free | | |
| 33 | Annual | 1-2 years | Continuously Updated | 4 (high) | 4 (high) | PDF | Available | Public + free | | |
| 34 | Hourly | < 1 year | Continuously Updated | 5 (very high) | 5 (very high) | Other database system | Available | Public + free | | |
| 35 | Annual | < 1 year | Continuously Updated | 5 (very high) | 5 (very high) | PDF | Available | Public + free | | |
| 36 | Annual | 2-4 Years | | 4 (high) | 3 (medium) | PDF | Available | Public + free | | |
| 37 | Depends on issue in focus | | Not periodically | | | PDF | | Public + free | | |
| 38 | Annual | 1-2 years | Every two years | 3 (medium) | 4 (high) | PDF | Available | Public + charge fee | | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 39 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 40 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 41 | Annual | > 4 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 42 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Excel download | Available | Public + free | | |
| 43 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Excel download | Available | Public + free | | |
| 44 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Excel download | Available | Public + free | | |
| 45 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 46 | Annual | < 1 year | < 1 year | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 47 | Annual | Future-oriented projections | < 1 year | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 48 | Annual | < 1 year | Yearly | 2 (low) | 3 (medium) | Web account/webpage | Available | Public + free | | |
| 49 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 50 | Annual | < 1 year | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 51 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | | |
| 52 | Annual | 2-4 Years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 53 | Annual | 2-4 Years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 54 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + free | | |
| 55 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Excel download | Available | Public + free | | |
| 56 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 57 | Annual | 1-2 years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 58 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 59 | | 1-2 years | Yearly | 4 (high) | 3 (medium) | Excel download | Available | Public + free | | |
| 60 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | | |
| 61 | Annual | 2-4 Years | Yearly | 5 (very high) | 5 (very high) | Excel download | Available | Public + free | | |
| 62 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | | |
| 63 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | No consistent classification betweentgeneration and capapcity technology classifications. |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 64 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 65 | Annual | > 4 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 66 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Excel download | Available | Public + free | | |
| 67 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Excel download | Available | Public + free | | |
| 68 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 69 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 70 | Annual | < 1 year | Yearly | 4 (high) | 2 (low) | Excel download | Available | Public + free | | |
| 71 | Annual | < 1 year | < 1 year | 3 (medium) | 4 (high) | Excel download | Available | Public + free | | |
| 72 | Annual | Future-oriented projections | < 1 year | 3 (medium) | 4 (high) | Excel download | Available | Public + free | | |
| 73 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | Excel download | Available | Public + free | | |
| 74 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | Excel download | Available | Public + free | | |
| 75 | Annual | 1-2 years | Yearly | 4 (high) | 3 (medium) | PDF | Available | Public + free | | |
| 76 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Excel download | Available | Public + free | | |
| 77 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Excel download | Available | Public + free | | |
| 78 | Annual | 1-2 years | Yearly | 3 (medium) | 3 (medium) | Excel download | Available | Public + free | | |

Additional requirements/ further data needs

## Additional requirements/ further data needs

Lack of data (data you would like to see available)

| | Sector covered by required data | Additional comments on the sector coverage (if needed) | Geographical resolution of required data | Description of the lack of data/additional data need |
|---|---|---|---|---|
| 12 | Transport | | Country | Data on personal transport modes and usage |
| 13 | Others | Residential | Country | Data on residential heating systems and building structure |
| 25 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Electricity, Transport, Industry | Country | Electricity: Transmission, distribution, generation and comercialization disaggregation. Fuels: disaggregation between coke, refine and nuclear fuel activities. Transport: disaggregation between different modes and uses, comercial, personal, diesel and gas cars, trucks, ... |
| 41 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country | IO tables for Iceland and Croatia. |
| 42 | Others | Services | Country | Intra and Extra-EU trade in services by product category. |
| 43 | Others | Services | Country | Intra and Extra-EU trade in services by product category and trade partner. |
| 44 | Others | Services | Country | More detalied breakdown of hours worked by service industry. |
| 54 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country | Time series should include more years. |
| 55 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country | Time series should include more years. |
| 59 | Others | Services | Country | More detalied breakdown of hours worked by service industry. |

## Additional requirements/ further data needs

Lack of data (data you would like to see available)

| | Sector covered by required data | Additional comments on the sector coverage (if needed) | Geographical resolution of required data | Description of the lack of data/additional data need |
|---|---|---|---|---|
| 70 | Others | Services | Country | More detailed breakdown of services trade. |
| 75 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country | Time series should include more years. |
| 76 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country | Time series should include more years. |
| 77 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Gas, Electricity,Industry, Transport | Country | Time series should include more years. |
| 78 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Industry, Transport | Country | More detailed sectoral breakdown. |

# **Appendix C:** Data list Sector Level Models

Data/data sources used in model/model family

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 1 | Sector Level | MURE | Endogenous, MURE DB | Database built for specific purposes | Macroeconomic data | | General financial and economic data and general scenario setting data (reference year, number of forecast step, number of years by step) | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Transport, Industry, buildings | Country |
| 2 | Sector Level | MURE | Endogenous, MURE DB | Database built for specific purposes | Model Input Technology | | Number, type and average life and market share of the different technologies | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Transport, Industry, buildings | Country |
| 3 | Sector Level | MURE | Endogenous, MURE DB | Database built for specific purposes | Model Input Energy | | National and average energy consumption by sector, technology, appliance etc | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Transport, Industry, buildings | Country |
| 4 | Sector Level | MURE | Endogenous, MURE DB | Database built for specific purposes | Model Input demand | | Forecast of the annual sales of a selected technology, by each of the years of the time interval defined | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Transport, Industry, buildings | Country |
| 5 | Sector Level | MURE | | | Model Input Costs | | Cost data of different technologies and measures | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Transport, Industry, buildings | |
| 6 | Sector Level | MURE | Endogenous, MURE DB | Database built for specific purposes | Information on carbon footprint | | Specific pollutant emission coefficients on CO2 | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Transport, Industry, buildings | Country |
| 7 | Sector Level | MURE | Endogenous, MURE DB | Database built for specific purposes | Other model input | | Specific pollutant emission coefficients on non GHG | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Transport, Industry, buildings | Country |

Assessment of data/data sources

| Assessment of data/data sources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 1 | Annual | > 4 years | Continuously Updated | 3 (medium) | 3 (medium) | Access database | Available | Public + charge fee | | |
| 2 | Annual | > 4 years | Continuously Updated | 4 (high) | 4 (high) | Access database | Available | Public + charge fee | | |
| 3 | Annual | > 4 years | Continuously Updated | 4 (high) | 4 (high) | Access database | Available | Public + charge fee | | |
| 4 | Annual | > 4 years | Continuously Updated | 4 (high) | 3 (medium) | Access database | Available | Public + charge fee | | |
| 5 | | | Continuously Updated | 4 (high) | 4 (high) | Access database | Available | Public + charge fee | | |
| 6 | Annual | > 4 years | Continuously Updated | 4 (high) | 4 (high) | Access database | Available | Public + charge fee | | |
| 7 | Annual | > 4 years | Not periodically | 4 (high) | 4 (high) | Excel download | Available | Public + charge fee | | |

# **Appendix D:** Data list Disaggregated Models

Data/data sources used in model/model family

| | Model Group/ model family | Specific model | Data/data sources used in model/model family | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 1 | Disaggregated models | CGEN | National Grid website and National Grid (2009). "Operating the Electricity Transmission Networks in 2020 Initial Consultation" | Public database incl. other than statistic data | Model Input Energy | | Installed generation capacity on different buses | Electricity | | Country |
| 2 | Disaggregated models | CGEN | Chaudry, M., Jenkins, N., Strbac, G. (2008). Multi-time period combined gas and electricity network optimisation, Electric Power Systems Research, 78, 1265–1279 | Literature (articles, books, newspaper) | Model Input Energy | | Maximum capacity of interconnecting GB transmission boundaries | Electricity | | Country |
| 3 | Disaggregated models | CGEN | Power, P.B. (2004).The cost of generating electricity, Published by The Royal Academy of Engineering. | Associations (e.g. industrial associations) | Model Input Costs | | Marginal operating costs of power generation | Electricity | | Country |
| 4 | Disaggregated models | CGEN | Ryan, A., 2007.FR-UK-IE Regional initiative Balancing NGET pricing, National Grid. | Literature (articles, books, newspaper) | Model Input Costs | | Interconnector costs | Electricity | | Country |
| 5 | Disaggregated models | CGEN | Kariuki, K., Allan, R. (1996). Evaluation of reliability worth and value of lost load, in: IEE Proceedings—Generation Transmission and Distribution, 143, 171–180. | Literature (articles, books, newspaper) | Model Input Costs | | Electricity load shedding cost | Electricity | | Country |
| 6 | Disaggregated models | CGEN | Power, P.B. (2004).The cost of generating electricity, Published by The Royal Academy of Engineering. | Associations (e.g. industrial associations) | Model Input Technology | | Efficiency | Electricity | | Country |
| 7 | Disaggregated models | CGEN | IEEE (1999). The IEEE reliability test system—1996, IEEE Transactions on Power Systems 14,1010–1020. | Literature (articles, books, newspaper) | Model Input Technology | | Full ramp up/down | Electricity | | Country |
| 8 | Disaggregated models | CGEN | National Grid, GB Seven Year Statement 2008 | Public database incl. other than statistic data | Model Input demand | | Data on National Electricity Transmission System | Electricity | | Country |
| 10 | Disaggregated models | CGEN | National Grid, Ten Year Statement 2008 | Public database incl. other than statistic data | Model Input Energy | | Maximum supply capacity of different gas terminals | Gas | | Country |
| 11 | Disaggregated models | CGEN | National Grid, Ten Year Statement 2008 | Public database incl. other than statistic data | Model Input Energy | | Working capacity of gas storage facilities | Gas | | Country |
| 12 | Disaggregated models | CGEN | National Grid, Ten Year Statement 2008 | Public database incl. other than statistic data | Model Input Energy | | Deliverability rate | Gas | | Country |
| 13 | Disaggregated models | CGEN | The UKERC Energy 2050 project | Soft link with another model's output | Model Input Costs | | Cost of gas supplies | Gas | | Country |
| 14 | Disaggregated models | CGEN | Chaudry, M., Jenkins, N., Strbac, G. (2008). Multi-time period combined gas and electricity network optimisation, Electric Power Systems Research, 78, 1265–1279 | Literature (articles, books, newspaper) | Model Input Costs | | Operating cost of gas storage facilities | Gas | | Country |
| 15 | Disaggregated models | CGEN | National Grid, Ten Year Statement 2008 | Public database incl. other than statistic data | Model Input Costs | | Deliverability cost of gas storage facilities | Gas | | Country |

| | Model Group/ model family | Specific model | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 16 | Disaggregated models | CGEN | DTI, 2006. Gas security of supply ,Energy Review Consultation. | Public database incl. other than statistic data | Model Input Costs | | Gas load shedding cost | Gas | | Country |
| 17 | Disaggregated models | CGEN | National Grid, Ten Year Statement 2008 | Public database incl. other than statistic data | Model Input demand | | Data on Gas transportation system | Gas | | Country |
| 18 | Disaggregated models | WASP - Greece | Public Power Corporation S.A. | Company data | Model Input Technology | Model Input Costs | Installed capacity of power plants, heat rate, typical maintenance duration, fuel cost, fixed O&M cost, variable O&M cost, heat value, CO2 emmission coefficients, hydro plants expected inflow energy, investment costs, construction time | Electricity | | Country |
| 19 | Disaggregated models | WASP-Greece | Hellenic Transmission System Operation S.A. | Official statistic source (public source) | Model Input Energy | | Load forecast | Electricity | | Country |
| 20 | Disaggregated models | WASP-Greece | International Energy Agency | Official statistic source (public source) | Model Input Costs | Model Input Technology | Fuel prices forecast and investement costs for emerging technologies. | Electricity | | Group of Countries |
| 21 | Disaggregated models | WASP-Greece | Independent Power Producers | Company data | Model Input Technology | Data used for internal additional calculation | Installed capacity of power plants, heat rate, typical maintenance duration, fuel cost, fixed O&M cost, variable O&M cost, heat value, CO2 emmission coefficients, hydro plants expected inflow energy, investment costs, construction time | Electricity | | Country |
| 22 | Disaggregated models | WASP-Greece | Centre for Renweable Energy Sources and Saving | Private statistic services | Model Input Energy | Data used for internal additional calculation | Wind generation profile | Electricity | | Country |
| 23 | Disaggregated models | WASP-Greece | Ministry of Environment, Energy and Climate Change | Official statistic source (public source) | Qualitative information on interests, values and/or expectations | | National targets on the RES technologies mixture | Electricity | | Country |
| 24 | Disaggregated models | WASP-Greece | Regulatory Authority for Energy | Official statistic source (public source) | Qualitative information on context | Data used for internal additional calculation | Technical specifications of the power system market operation (spinning/cold reserve requirements, rules on the paricipation of RES in energy generation) | Electricity | | Country |

Assessment of data/data sources

| | Assessment of data/data sources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 1 | Annual | < 1 year | | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 2 | Daily | 1-2 years | | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 3 | | 1-2 years | | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 4 | | | | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 5 | | | | | | PDF | | Public + free | | |
| 6 | | 1-2 years | | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 7 | | | | 5 (very high) | 5 (very high) | | | Public + free | | |
| 8 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 10 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 11 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 12 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 13 | | | | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 14 | Annual | 1-2 years | | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 15 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | | Public + free | | |

## Assessment of data/data sources

| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 16 | | | | 5 (very high) | 5 (very high) | | | Public + free | | |
| 17 | Annual | < 1 year | Yearly | 5 (very high) | 5 (very high) | PDF | | Public + free | | |
| 18 | Depends on issue in focus | 1-2 years | Not periodically | 2 (low) | 3 (medium) | Paper Report | Available, but not up to date | Private | 0 € | Not easily accessed |
| 19 | Annual | Future-oriented projections | Yearly | 3 (medium) | 3 (medium) | PDF | Available | Public + free | 0 € | Not thorougly presented |
| 20 | Annual | 1-2 years | Yearly | 4 (high) | 4 (high) | PDF | Available | Public + charge fee | 150 € | |
| 21 | Depends on issue in focus | 1-2 years | Not periodically | 2 (low) | 3 (medium) | Paper Report | Available, but not up to date | Private | 0 € | Not easily accessed |
| 22 | Depends on issue in focus | 1-2 years | More than two years | 4 (high) | 4 (high) | Other database system | Available | Private | 0 € | Need for more regular updating |
| 23 | Annual | Future-oriented projections | Not periodically | 2 (low) | 2 (low) | Other database system | Available | Public + free | 0 € | Need for consistent and realistic analysis of policy scenarios |
| 24 | Depends on issue in focus | 2-4 Years | Not periodically | 3 (medium) | 3 (medium) | PDF | Available | Public + free | 0 € | Need for continuous updating with the varying market circumstances |

Additional requirements/ further data needs

## Additional requirements/ further data needs

Lack of data (data you would like to see available)

| | Sector covered by required data | Additional comments on the sector coverage (if needed) | Geographical resolution of required data | Description of the lack of data/additional data need |
|---|---|---|---|---|
| 18 | Electricity | | Country | Detailed Information on the internal power blocks of the plants (power level, heat rates) is missing. |
| 19 | Electricity | | Country | Details of the Load curve profile (load factor) is missing. |
| 20 | Electricity | | Group of Countries | |
| 21 | Electricity | | Country | Detailed Information on the internal power blocks of the plants (power level, heat rates) is missing. |
| 22 | Electricity | | Country | Up-to-date information connecting wind data with the actual wind turbine technologies used at the sites were measurements are performed. |
| 23 | Electricity | | Country | Detailed analysis on the technical specifications of the preferred RES technologies |
| 24 | Electricity | | Country | Unclear Quantification of the reserve requirements refereing to the increased RES penetration.. |

# **Appendix E:** Data list Energy Behaviour Tools

Data/data sources used in model/model family

| | Model Group/ model family | Specific model where data are used for | Data/data sources used in model/model family | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data source | | Category of data | Additional category of data (if necessary) | Description of the data taken from the source (like primary energy consumption by fuel/sector/country, capacities,…) | Sector coverage of the data | | Geographical resolution of data |
| | | | Name of data source | Classification of data source | | | | Sector which is covered | Additional comments on the sector coverage (if needed) | |
| 1 | Energy behaviour tools | Climate Bonus | | | | | | | | |
| 2 | Energy behaviour tools | Climate Bonus | | Public database incl. other than statistic data | Data used for internal additional calculation | | combining different data sources on human behaviour and carbon footprint | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | at least transportation, electricity and buildings | Country |
| 3 | Energy behaviour tools | Climate Bonus | | Personal information account | Behavioural information | | personal energy (carbon) consumption registration | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | at least transportation, electricity and buildings | Country |
| 4 | Energy behaviour tools | Climate Bonus | | Query, survey | Information on carbon footprint | | user information on tool development and content | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | at least transportation, electricity and buildings | Country |
| 5 | Energy behaviour tools | Climate Bonus | | Web server | Behavioural information | | registration of personal consumption data via internet or phone | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | at least transportation, electricity and buildings | Country |
| 6 | Energy behaviour tools | Climate Bonus | | Company data | Data used for internal additional calculation | | data system (codes) used for collecting information on carbon footprint | Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | at least transportation, electricity and buildings | Country |
| 7 | Energy behaviour tools | ESTEEM | | Interviews (experts, stakeholders) | Qualitative information on context | Qualitative information on interests, values and/or expectations | In addition: Interviews also with project manager to collect data on defining moments in the past and data on stakeholders involved | All sectors mentioned above in the drop down menu | Depending on the sectoral composition of the stakeholders involved | Project location |
| 8 | Energy behaviour tools | ESTEEM | | Focus groups, workshops | Qualitative information on interests, values and/or expectations | Qualitative information on context | Stakeholder workshop to discuss expectations of stakeholders about specific energy project | All sectors mentioned above in the drop down menu | Depending on the sectoral composition of the stakeholders involved | Project location |
| 9 | | | | | | | | | | Actor location/residence |

Assessment of data/data sources

| | Assessment of data/data sources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quality of data/data source | | | | | | | Availability | | Description of weak points of the existing / used data |
| | Time resolution of data provided | Time lag (between date of publication and reference date) | Frequency of data publishing | Completeness/ Consistency (see guidelines for additional information) | Level of detail (see guidelines for additional information) | File format | Data documentation | Status | Price (in € or €/year if it is an annual fee for a subscription; please state the unit) | |
| 1 | | | | | | | | | | |
| 2 | Depends on issue in focus | < 1 year | Not periodically | 3 (medium) | 3 (medium) | Web account/webpage | Not available | Personal contact required | | Still a demo which will be improved |
| 3 | Depends on issue in focus | | | | | | | | | |
| 4 | Depends on issue in focus | | | | | | | | | |
| 5 | Depends on issue in focus | | | | | | | | | |
| 6 | Depends on issue in focus | | | | | | | | | |
| 7 | | | Not published | 4 (high) | 5 (very high) | Paper Report | Not available | Personal contact required | | |
| 8 | | | Not published | 4 (high) | 5 (very high) | Paper Report | Not available | Personal contact required | | In workshop uncertaain if all stakeholders delivered all issues at hand, whether all stakeholders are present |
| 9 | | | | | | | | | | |

Additional requirements/ further data needs

| Additional requirements/ further data needs | | | |
|---|---|---|---|
| Lack of data (data you would like to see available) | | | |
| Sector covered by required data | Additional comments on the sector coverage (if needed) | Geographical resolution of required data | Description of the lack of data/additional data need |
| Several of the above mentioned sectors but not all (please name the sectors in the next cell but choose only from the above mentioned ones) | Service sector | Group of Countries | |
| All sectors mentioned above in the drop down menu | presence of ALL stakeholders not easy to reach | | |

## **Appendix F:** Guidelines how to use the data list

| **How to use this data list (Guidelines)** |
|---|
| • This list is meant to collect the data (and data sources) used in your models, to assess this data and to state additional data requirements. |
| • The model families (+examples) are described in the worksheet "Overview". |
| • Please use the corresponding worksheet for your model (according to the model family it belongs to). |
| • Please use one single row per source (sources should not be clustered; every source should be assessed separately). |
| • If you take different data from one source with different geographical or time resolution please use a new separate row for this data (even if it is from the same source and the source then covers more than one row). |
| • If there are different resolutions (time or geographical) of data please state the most detailed level which is available (even if you use a more aggregated one). |
| • Concerning the assessment of "completeness/consistency" [column "O"] +<br>"level of detail" [column "P"]:<br>=> This assessment should be relative to your personal expectations and data needs, it is a personal rating based on your own needs<br>=> If you need for example data on an annual level and the source provides annual data then your expectations/needs are complete fulfilled (rate "very high")<br>=> Depending on the number of expected elements missing (like years, countries, fuel types, technologies), decrease your ranking<br>=> This should help to discover the weak points of the data you are using, it is not meant to compare different sources used in different models (due to different needs and expectations). |
| • Please use a separate row for additional data needs/additional data requirements (column "V" - "Y"). |
| • The orange cells mean that suggestions are to be chosen from the drop down menus; while free text can be inserted in the other cells. |
| • An example for one data source is provided in the worksheet "Energy_System" for the TIMES PanEU model [row 6]. |
| • An example for an additional need/requirement for data is provided in the worksheet "Energy_System" at [row 7]. |