Behavioural Climate Change Mitigation
Options and Their Appropriate Inclusion in
Quantitative Longer Term Policy Scenarios

Technical Report on the appropriate inclusion of results of the analysis in model-based quantitative scenarios

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Preface

This is the final *Technical Report on the appropriate inclusion of results of the analysis in model-based quantitative scenarios*. It is part of the study 'Behavioural climate change mitigation options and their appropriate inclusion in quantitative longer term policy scenarios' for the European Commission, DG Climate Action. The study has been conducted by a consortium led by CE Delft comprising of Fraunhofer ISI and LEI. The aim of the study is threefold:
1. To assess and demonstrate the GHG emission reduction potential of changes in behaviour and consumption patterns.
2. To analyse policy options for the further development of community policies and measures inducing changes in behaviour and consumption patterns. And
3. To identify the linkages with other technical and economic variables in such a way that it can be used in modelling and scenario development.

This report is part of five reports which together constitute the final report of contract 070307/2010/576075/SER/A4. The other reports are:
1. The Main Report.
2. The Transport Domain Final Report.
3. The Housing Domain Final Report.
4. The Food Domain Final Report.

Together, the five reports constitute the final delivery under the contract.

Jasper Faber

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Summary

The Behavioural Climate Change Mitigation Options project has the objective of considering possible options for behavioural change to reduce greenhouse gas emissions. Models are often used to assess the possible impacts of policies and in particular the EU EC4MACS project brings some of the main models used for policy analysis together. The question then arises of how these models can incorporate behavioural policy options and assess the potential impacts. This report examines the structure of the models to be considered for modelling behavioural options and assesses the data requirements for each behavioural option and related policies in the domains transport, housing and food. The models to be considered are:

- ASTRA;
- TREMOVE;
- AGMEMOD;
- CAPRI;
- PRIMES;
- GAINS;
- GEM-E3.

ASTRA and TREMOVE are transport models and are considered for the transport behavioural changes only. AGMEMOD and CAPRI are agricultural sector models and are considered for the food and drink behavioural changes only. PRIMES is an energy system model including the housing sector and transport technologies. The PRIMES model has been linked with the TREMOVE model. Therefore, considerations on behavioural changes in the TREMOVE model are also relevant for the PRIMES and TREMOVE model and PRIMES is considered for the housing related behavioural changes.

GAINS and GEM-E3 are general models. GAINS does not have endogenous demand equations. GAINS can incorporate the impacts of such measures through sectoral and fuel activity level inputs for transport and energy and through changes in the demand coefficients for food and housing energy demand. The GEM-E3 model is not intended to include the details of behavioural changes and it is not recommended to develop a detailed behavioural model to include the behavioural options considered here.

Changes necessary for the models to incorporate the behavioural measures are suggested.
In general, the models are well adapted to allowing for changes in costs and economic policies. Measures and policies that change the structure of behaviour have to be incorporated through recalibrating the demand functions in the models.
Drawing on the analyses of the behavioural changes in the accompanying technical reports, the data for incorporating the behavioural changes into the models is presented in the form of data sheets. Data on the impact of policies relevant for model calibration is also presented in data sheets where available.

1 Introduction

The Behavioural Climate Change Mitigation Options project has the objective of considering possible options for behavioural change to reduce greenhouse gas emissions. Models are often used to assess the possible impacts of policies and in particular the EU EC4MACS project brings some of the main models used for policy analysis together. The question then arises of how these models can incorporate behavioural policy options and assess the potential impacts. This report examines the structure of the models to be considered for modelling behavioural options and assesses the data requirements for each behavioural option in the domains transport, housing and food. The models selected for consideration are briefly described with reference to the behavioural measures to be investigated. Changes necessary for the models to incorporate the behavioural measures are suggested. Drawing on the analyses of the behavioural measures in the accompanying technical reports, the data for incorporating the behavioural measures into the models is presented in the form of data sheets. Data on the impact of policies for model calibration is also presented in data sheets where available.

2 Modelling behavioural options and policies

Selection of models and mapping with domains
This section will provide an initial specification for model changes to incorporate the impacts of behavioural changes from the behavioural changes agreed in WP 1. The models to be considered are:
- ASTRA;
- TREMOVE;
- AGMEMOD;
- CAPRI;
- PRIMES;
- GAINS;
- GEM-E3.

Some of these models are sector specific. ASTRA and TREMOVE are transport models and will be considered for the transport behavioural changes only. AGMEMOD and CAPRI are agricultural sector models and will be considered for the food and drink behavioural changes only. PRIMES is an energy sector model including transport technologies and will be considered for the transport and building behavioural changes. GAINS and GEM-E3 are general models (but have very different model structures) and will be considered initially for all the behavioural changes. However, an assessment will be made of the level of changes to these models necessary to include behavioural changes.

2.1 ASTRA

2.1.1 Model summary

For a description of the model structure, see Schade (2005) and Krail (2009). The ASTRA model was built to provide analyses of the long-term impacts of the European common transport policy. The model can provide forecasts for the EU 27, Norway and Switzerland, up to 2050 and uses a zoning system of up to four regions per country.

The model is mainly used for:
- assessment of the impact of different policy packages, such as combinations of pricing policy, taxation, infrastructure policy or technology policy, on transport;
- R&D policy assessment;
- assessment of the economic impact of regional scale environmental and transport policies;
- assessment of the macroeconomic impact of policies and international economic drivers such as oil prices.

ASTRA is a genuine integrated assessment model, consisting of eight modules, which integrate both macro- and microeconomic elements.

The main features of the model are:
- the model is a simulation model, using a system dynamics structure;
- annual solution up until 2050;
- eight detailed modules: population (POP), macroeconomics (MAC), foreign trade (FOT), regional economics and land use (REM), transport (TRA), vehicle fleet (VFT), environment (ENV) and welfare assessment (WEM);
- five emission types:
  1. Detailed treatment of demand-supply interactions.
  2. Regional treatment of passenger and freight flows.
  3. Detailed treatment of energy use in the transport sector.
  4. Detailed treatment of welfare.
  5. Population forecast calibrated to match Eurostat projections.

In summary, the characteristics of ASTRA are such that the model is:
- elaborated at a European level, with a specific focus on analysis of the effects of different policy packages;
- an integrated model, with its component modules combining both the macro and microeconomic dimensions;
- a classical 4-stage transport model with a simplified representation of transport networks and network capacity feedback, but with a detailed treatment of the economic interactions;
- based on feedback loops between the different modules.

2.1.2 Modelling behavioural options

Buying and using an electric car or plug-in hybrid; Buying and using smaller cars

ASTRA already includes electric vehicles and a range of vehicle sizes (defined by engine size). This reflects the EUROSTAT dtat structure. Where data on vehicles is given for vehicle kerb weight, a mapping of engine size to vehicle weight is necessary. While this is not a one-to-one relationship, in general cars with larger engines are heavier. Car purchases are calculated using a discrete choice (multinomial) logit function, based on fixed and variable relative costs including purchase, fuel and tax/subsidies. Therefore, policies which change the relative price of different technologies are already modelled. However, the logit decision function is calibrated on historical data. This implies a historical set of consumer preferences across the different aspects of the logit function. Therefore, if policies succeed in changing preferences, the logit function would need to be recalibrated, or a set of sensitivity studies undertaken to assess the potential impact of preference changes.

Applying a more fuel-efficient driving style

Applying a more efficient driving style has the effect of reducing fuel consumption of a vehicle. For each vehicle technology, ASTRA has fuel efficiency coefficients as exogenous data inputs. Currently, for conventional petrol and diesel vehicles, these change over time in accordance with the EURO emissions vintages. The adoption of a more efficient driving style would change the realised fuel efficiencies of the vehicle technologies. These fuel efficiency coefficients data would have to be modified to reflect the diffusion of improved driving techniques through the driving population.
This would in turn change the purchase decision, dependent on the relative changes to the costs of car purchase in the logit car purchase decision function, but would not require any further changes to the model. It would also change the travel decision, with a change in vehicle purchase decisions and in the modal split, as relative variable costs between modes and vehicle

types are changed. This is already incorporated in the travel demand functions of ASTRA.

There is also a question of whether measures to impact driving styles would also change consumer preferences in favour of smaller vehicles. The rebound effect of more fuel efficient driving leading to lower operating costs of a vehicle and therefore higher travel demand and/or purchase of larger vehicles is already incorporated through the costs of vehicle operation based on fuel consumption of different vehicle sizes. However, if a change in the preference structure apart from a change in costs is also identified in the literature, the travel demand functions would have to be recalibrated.

Making use of ICT to decrease business travel: teleworking and applying visual meetings
The ASTRA model includes specific factors for teleworking to allow the impact of ICT on travel demand to be modelled. This factor would have to be calibrated with the most recent available data for the different EU countries.

2.1.3 Modelling policies and policy packages

Buying and using an electric car or plug-in hybrid; Buying and using smaller cars

Regulative instruments
Regulations that directly influence the ownership or use of electric vehicles have to be incorporated through a recalibration of the logit vehicle choice function. Since ASTRA does not directly take infrastructure availability into account, the impact of infrastructure availability would have to be incorporated through a further recalibration of the logit new car purchase function. However, regulations that change the price paid for electricity can be directly incorporated into the ASTRA model through the operational costs of owning an electric vehicle.

Economic instruments
The ASTRA model already includes taxes and subsidies on car purchases, as well as fuel cost and fuel taxes. Therefore, no changes are required for these measures. Road charging can be incorporated through an average cost per km per year, as an additional cost of ownership.

Communication
The impact of communication policies can be incorporated in the ASTRA model through a recalibration of the logit car purchase choice function.

Direct governmental expenditures
Government purchase of electric cars and a change in the average size of vehicle purchased can be incorporated in the ASTRA model through a shift in the vehicle fleets for the relevant car categories.

Procedural instruments
The impact of voluntary agreements with companies to buy electric or smaller cars can be modelling in ASTRA through changes to the relevant stocks of cars in the fleet.

Applying a more fuel-efficient driving style
Since this measure changes the average fuel consumption of vehicles, once the effect on fuel consumption is known, the fuel consumption coefficients for each type of car can be adjusted accordingly. Policy instruments can be treated as for the other behavioural measures in transport.

Teleworking and applying virtual meetings
Policies for teleworking and virtual meetings that change IT costs and costs of homes and offices cannot be directly modelled in ASTRA. Economic instruments that change the costs of business travel and commuting are already explicitly modelled in the ASTRA travel demand structure.

2.2 TREMOVE

2.2.1 Model summary
Source: TML (2007 Brief description of TREMOVE (TML, 2007).
TREMOVE is developed by Transport & Mobility Leuven and the KU Leuven. TREMOVE is a policy assessment model, designed to study the effects of different transport and environment policies on the emissions of the transport sector. It is designed for the simulation of the development of the transport system in Europe. The model estimates for policies as road pricing, public transport pricing, emission standards, subsidies for cleaner cars, etc., the transport demand, modal shifts, vehicle stock renewal and scrappage decisions as well as the emissions of air pollutants and the welfare level. TREMOVE models both passenger and freight transport, and covers the period 1995-2020. Transport demand data is based on the SCENES model, EUROSTAT and national transport statistics are also used (TML, 2007).

2.2.2 Modelling behavioural options

Buying and using an electric car or plug-in hybrid
TREMOVE has a similar logit purchase decision function to ASTRA, but electric vehicles are not included in the model. If not, it is necessary to add EVs and other alternative fuel vehicles to the model in order to model the decision to purchase and electric or hybrid car. While EVs and fuel cell vehicles are not included in TREMOVE, EU (2010) report a scenario exercise where the TREMOVE vehicle purchase choice logit function was extended to include EVs. Therefore, such a modification could be adopted for the assessment of behavioural options. This would require the development of scenarios with and without behavioural options, with a recalibration of the logit function to implement the change in behaviour.

Buying and using smaller cars
As with the ASTRA model, TREMOVE includes different sizes of petrol and diesel vehicle. This behavioural change can therefore already be modelled.

Applying a more fuel-efficient driving style
As with the ASTRA model, vehicle types have explicit fuel consumption coefficients as data. A difference to ASTRA is that there are fuel efficiency improvements over time estimated, rather than the vintages approach of ASTRA. These consumption coefficients would have to be modified to reflect the diffusion of improved driving techniques through the driving population. As with ASTRA, this will change the relative variable costs of different technologies and modes and hence the split of vehicle purchases and the modal split. The change in relative costs will also change the transport

demand by changing the relative prices applied in the utility functions. These changes are already incorporated in the TREMOVE model structure.
As with ASTRA, rebound effects – an increase in demand and therefore increase in fuel consumption and emissions - from reductions in costs due to more fuel efficient driving will be calculated from the decision structure. However, also as in ASTRA, changes in preferences induced by such price changes would require recalibration of the logit car purchase decision function and the travel decision utility functions.

Making use of ICT to decrease business travel: teleworking and applying visual meetings
This behavioural change would have to be incorporated in a change to the travel demand utility function. Specifically, this would change the labour travel decision between commuting trips and 'other' in the private transport decision function and the production decision of firms in using business travel. Both of these effects would require recalibration or sensitivity analyses of the utility function and the production function respectively.

2.2.3 Modelling policies and policy packages

Buying and using an electric car or plug-in hybrid; Buying and using smaller cars
Since the TREMOVE model does not include electric vehicles, policy instruments that impact on electric vehicles require the incorporation of electric vehicle costs and purchases into the model.

Economic instruments
The TREMOVE model already includes taxes and subsidies on car purchases, as well as fuel cost and fuel taxes. Therefore, no changes are required for these measures. Road charging can be incorporated through an average cost per km per year, as an additional cost of ownership.

Communication
The impact of communication policies can be incorporated in the TREMOVE model through a recalibration of the logit car purchase choice function.

Direct governmental expenditures
A change in the average size of vehicle purchased can be incorporated in the TREMOVE model through a shift in the vehicle fleets for the relevant car categories.

Procedural instruments
The impact of voluntary agreements with companies to buy electric or smaller cars can be modelling in the TREMOVE model through changes to the relevant stocks of cars in the fleet.

Applying a more fuel-efficient driving style
Since this measure changes the average fuel consumption of vehicles, once the effect on fuel consumption is known, the fuel consumption coefficients for each type of car can be adjusted accordingly. Policy instruments can be treated as for the other behavioural measures in transport.

Teleworking and applying virtual meetings

Policies for teleworking and virtual meetings that change IT costs and costs of homes and offices cannot be directly modelled in the TREMOVE model. Economic instruments that change the costs of business travel and commuting are already explicitly modelled in the TREMOVE travel demand structure.

2.3 CAPRI

2.3.1 Brief description of CAPRI (Britz and Witzke, 2008)

CAPRI is designed to model the response of the European agricultural system towards a range of policy interventions. The objective is to evaluate regional and aggregate impacts of the CAP and trade policies on production, income, markets, trade, and the environment. It is a global agricultural sector model with focus on EU 27 and Norway. It is a comparative static equilibrium model, solved by iterating supply and market modules:

- supply module (EU 27 + Norway): covering about 250 regions (NUTS 2 level) or even up to six farm types for each region (in total 1,000 farm-regional models);
- market module: spatial, global multi-commodity model for agricultural products, 40 products, 40 countries in 18 trade blocks.

The equilibrium ensures cleared markets for products and young animals, match of feeding requirements of national herds. Outputs are welfare analysis; environmental indicators. The main data source is Livestock statistics from EUROSTAT.

2.3.2 Modelling behavioural options

Vegetarian diet

The adoption of a vegetarian diet implies a shift in the demand for the relative demands for different categories of food. In the CAPRI model, food demand is incorporated in the closed market balances. "Closed market balances define the first set of constraints and state that the sum of imports (*IMPT*) and production (*GROF*) must be equal to the sum of feed (*FEDM*) and seed (*SEDM*) use, human consumption (*HCOM*), processing (*INDM*, *PRCM*, *BIOF*), losses (*LOSM*) and exports (*EXPT*)" CAPRIS description p. 67 eqn 18.

These are calculated over the dimensions: r, i, t where *r* are the Member States of the EU, *i* are the products, *t* the different forecasting years and incorporate time trends.

There are several options to reflect changes in consumption behaviour in CAPRI. The easiest is to introduce a shift for the behavioural functions of HCOM. At given prices this would introduce a market disequilibrium such that prices and all related variables would adjust to achieve a new market clearing. The final change in consumption quantities would be smaller than the initial shock because prices changes would counteract the initial changes to some extent.

Reducing all animal protein intake including dairy and eggs

This would require a similar approach to a reduction in the demand for meat from a vegetarian diet as proposed above. The difference is that more categories of products i in the HCOM variable would change.

Reducing intake to a healthy level
This behavioural change is also a change in the structure of food demand and therefore in the HCOM variable. It involves a change in the sum over the i products, rather than a relative shift between the consumption of the different products. This implies a change in the market balance equation, but this is already incorporated in the equation structure. Once more, such a change could either be incorporated as a step change between two years t and t+1 in the HCOM variable for all member states r, or a change in the trend for each member state. A scenario analysis to assess the impact of such a change in preferences may necessary, as there may be no relevant historical data at the member state level.

2.3.3 Modelling policies and policy packages

Healthy diet

Regulation introducing mandatory nutrition labelling; Targeted information and awareness raising campaigns and education programme
The impact of nutrition labelling and information campaigns as a policy cannot be directly modelled in the CAPRI model. The impacts of the policy can be incorporated through a recalibration of the demand functions, if the effects are known.

Financing school-based intervention programs
The impact of school-based interventions as a policy cannot be directly modelled in the CAPRI model. The impacts of the policy can be incorporated through a recalibration of the demand functions, if the effects are known.

Consumption taxes
Consumption taxes on food purchases can be incorporated in the CAPRI model through an added cost for the relevant food categories. An ad Valorem tax can be incorporated in the model as a multiplier of the food cost for the different food categories.

Vegetarian diet and Reduced meat diet

Introduce differentiated consumption taxes based on the environmental performance of products
Consumption taxes on food purchases can be incorporated in the CAPRI model through an added cost for the relevant food categories. An ad Valorem tax can be incorporated in the model as a multiplier of the food cost for the different food categories.

Develop an EU-level sustainable food labelling scheme and establish credible certification mechanisms; Launch targeted information and awareness-raising campaigns and education programmes
The impact of nutrition labelling and information campaigns as a policy cannot be directly modelled in the CAPRI model. The impacts of the policy can be incorporated through a recalibration of the demand functions, if the effects are known.

2.4 AGMEMOD

2.4.1 Brief description of AGMEMOD

From: AGMEMOD website: http://www.tnet.teagasc.ie/agmemod/.
The AGMEMOD Partnership model is an econometric, dynamic, multi-product partial equilibrium model that allows us to make projections and simulations in order to evaluate measures, programmes and policies in agriculture at the European Union (EU) level as well as at the Member States level.

The original AGMEMOD Project (Project No. QLRT-2001-02853) involved institutes in the EU 15 group of Member States. In advance of the accession of the so-called 'new' Member States in May 2004 the AG-MEMOD Partnership was expanded in 2002 to include research institutes from 8 of the 10 new EU Member States and institutes from 2 of the current Accession States.

The diverse nature of agricultural production systems and agri-food markets across the EU poses a challenge to economists seeking to develop a model that can be used to analyse policy at an EU and Member State level. The AG-MEMOD Partnership model maintains the analytical consistency of the composite model across national sub-models, while still allowing the national sub-models to reflect the intrinsic diversity of the agri-food sectors in different EU member states.

2.4.2 Modelling behavioural options

As with the CAPRI model, consumption demand enters the model through the market equations. However, the structure of these equations is different. The following is taken from the AGMEMOD description (AGMEMOD, 2011, pp. 5-6):

"When the national level market is not consider as the key market in the Europe Union, the price linkage equations used in the model can be written as:

$$p_{j,t} = f(Kp_{j,t}, p_{j,t-1}, ssr_{j,t}, Kssr_{j,t}, V) \tag{21}$$

where $p_{j,t}$ is the national price of culture j in year t, $Kp_{j,t}$ is the key price of culture j in year t, $ssr_{j,t}$ is the self sufficiency ratio (domestic use divided by production) for commodity j in the country concerned, $Kssr_{j,t}$ is the self sufficiency rate for the same commodity in the key price market, and V a vector of exogenous variables which could have an impact on the national price. When the national price is the key price, the price linkage equations used in the model can be written as:

$$Kp_{j,t} = f(Wp_{j,t}, EIp_{j,t}, Kp_{j,t-1}, Essr_{j,t}, V) \tag{22}$$

where $Wp_{j,t}$ is the corresponding world price, $EIp_{j,t}$ the corresponding European intervention price, $Essr_{j,t}$ is the EU self-sufficiency rate for commodity j, and V a vector of variables which could have an impact on the key price (exchange rates, tariff rate quota levels and subsidised export limits)" (AGMEMOD description pp.5-69).
This shows that the relevant variables are $Kssr_{j,t}$ and $Essr_{j,t}$, the self-sufficiency rates.
These would have to be recalibrated to account for the change in demand due to the behavioural changes.

Vegetarian diet; Reducing all animal protein intake including dairy and eggs
These behavioural changes imply a change in the $Kssr_{j,t}$ and $Essr_{j,t}$ variable coefficients for the relevant meat and dairy and egg products j.

Reducing intake to a healthy level
Reducing the overall level of food consumption demand also implies a change in the $Kssr_{j,t}$ and $Essr_{j,t}$ variable coefficients, in particular a change in the constant term in the estimated equation.

2.4.3 Modelling policies and policy packages

Healthy diet

Regulation introducing mandatory nutrition labelling; Targeted information and awareness raising campaigns and education programme
The impact of nutrition labelling and information campaigns as a policy cannot be directly modelled in the AGMEMOD model. The impacts of the policy can be incorporated through a recalibration of the demand functions, if the effects are known.

Financing school-based intervention programs
The impact of school-based interventions as a policy cannot be directly modelled in the AGMEMOD model. The impacts of the policy can be incorporated through a recalibration of the demand functions, if the effects are known.

Consumption taxes
Consumption taxes on food purchases can be incorporated in the AGMEMOD model through an added cost for the relevant food categories. An ad Valorem tax can be incorporated in the model as a multiplier of the food cost for the different food categories.

Vegetarian diet and Reduced meat diet

Introduce differentiated consumption taxes based on the environmental performance of products
Consumption taxes on food purchases can be incorporated in the AGMEMOD model through an added cost for the relevant food categories. An ad Valorem tax can be incorporated in the model as a multiplier of the food cost for the different food categories.

Develop an EU-level sustainable food labelling scheme and establish credible certification mechanisms; Launch targeted information and awareness-raising campaigns and education programmes
The impact of nutrition labelling and information campaigns as a policy cannot be directly modelled in the AGMEMOD model. The impacts of the policy can be incorporated through a recalibration of the demand functions, if the effects are known.

2.5 PRIMES

The PRIMES model includes energy supply and demand, with transport technologies incorporated to form part of energy demand. Transport and housing behavioural changes are therefore considered. Agriculture is included as part of energy demand from the tertiary sector, but there is no endogenous behavioural component of demand, economic activity of the sector is exogenous. Therefore, behavioural changes in food behaviour affecting demand are not included in the current PRIMES structure and would require a fundamental change to the model if they were to be incorporated. The CAPRI model is a more suitable model for consideration of behavioural changes, as discussed above.

2.5.1 Brief description of PRIMES (PRIMES, 2010)

PRIMES has the objective of simulating the response of energy consumers and the energy supply systems to different pathways of economic development and exogenous constraints.
PRIMES is a modelling system that simulates a market equilibrium solution for energy supply and demand in the European Union (EU) member states. The model determines the equilibrium by finding the prices of each energy form such that the quantity producers find best to supply match the quantity consumers wish to use. The equilibrium is static (within each time period) but repeated in a time-forward path, under dynamic relationships. The model is behavioural but also represent in an explicit and detailed way the available energy demand and supply technologies and pollution abatement technologies. The system reflects considerations about market economics, industry structure, energy/environmental policies and regulation. These are conceived so as to influence market behaviour of energy system agents. The modular structure of PRIMES reflects a distribution of decision making among agents that decide individually about their supply, demand, combined supply and demand, and prices. Then the market integrating part of PRIMES simulates market clearing.
A fundamental assumption in PRIMES is that producers and consumers both respond to changes in price. The factors determining the demand for and the supply of each fuel are analysed and represented, so they form the demand and/or supply behaviour of the agents. Through an iterative process, the model determines the economic equilibrium for each fuel market. Price-driven equilibrium is considered in all energy and environment markets, including Europe-wide clearing of oil and gas markets, as well as Europe-wide networks, such as the Europe-wide power grid and natural gas network.

PRIMES can support policy analysis in the following fields:
- standard energy policy issues: security of supply, strategy, costs, etc.;
- environmental issues;
- pricing policy, taxation, standards on technologies;
- new technologies and renewable sources;
- energy efficiency in the demand-side;
- alternative fuels;
- energy trade and EU energy provision;
- conversion decentralisation, electricity market liberalisation;
- policy issues regarding electricity generation, gas distribution and refineries.

The main data sources are:
- national energy balances provided by EUROSTAT;
- inventories of national energy policies.

2.5.2 Modelling behavioural options

Transport

The PRIMES model has been linked with the TREMOVE model PRIMES (2010b). Therefore, behavioural changes in the PRIMES-TREMOVE model should be incorporated through their adoption in the TREMOVE model as described above. For the core PRIMES model, behavioural changes would have an impact on the choice function determining the modal split, requiring a recalibration of the modal split functions. However, this approach is not recommended, since the greater detail of the TREMOVE model in transport decision making will provide a more useful basis for assessing detailed policy measures which require changes to consumer decisions.

Housing

The PRIMES model has a detailed residential sector technology model, which models household energy demand through equipment investment decisions and demand for fuels based on the type of building for space heating.

Reducing space heating temperature (= lowering room temperature)

A change in the space heating temperature will change the energy demand for a given heating system type. Therefore, the energy demand coefficients will have to be recalibrated. This change in demand will then change the consumer choices in the model and therefore the overall energy demand for a given level of economic activity, as well as the split between technologies and fuels. These effects are already incorporated in the PRIMES model.

Optimising thermostat settings of heating (e.g. leaving room temperatures at the same level, reducing temperature at night/if absent)

In terms of the PRIMES model, this behavioural change will have a similar impact to a change in room temperatures, by changing the energy demand for a given energy technology in the building. Therefore, a further recalibration of the energy coefficients will be required.

Optimising ventilation behaviour

Air conditioning energy demand is modelled as an independent component of residential energy demand. Similarly to a change in space heating temperature, a change in ventilation behaviour will change the behavioural coefficients of the air conditioning energy demand equation. These coefficients will therefore have to be recalibrated.

2.5.3 Modelling policies and policy packages

The policy package proposed in the Domain report on behavioural measures in housing considers policies for all the measures together. Therefore, this section also considers policy implementation for the three measures together.

Various communication strategies, both for mass and individual target groups

Communications strategies act to change the behaviour of households. Since there is no change in the heating technology employed, the impact of the change in behaviour would have to be modelled by a recalibration of the households' heating and electricity energy demand functions.

Obligations for energy providers to distribute truly informative and adequately frequent heating energy bills

This is also a communication measure. Therefore, this can only be modelled in the PRIMES framework through a further shift in the households' heating and electricity energy demand functions.

Direct governmental expenditures like public investments in infrastructure, e.g. smart meters

Government subsidies or purchase for consumers' use of smart meters can be modelled through changes in the costs of smart meter technology in the PRIMES model household energy technologies. This may require the addition of some control technologies to the PRIMES model. Alternatively, the impact of smart meters could be incorporated in the model by recalibrating the household energy demand functions to include the reduction in demand effect.

Financial incentives for reduced energy consumption or taxation of higher energy consumption

These policies are already included in the PRIMES model.

2.6 GAINS

The GAINS model does not include endogenous demand calculations. Instead, it uses exogenous data and scenarios for around 300 combined sector and fuel type activities e.g. gasoline use in transport. Therefore, the demand side of energy and emissions is exogenous in this model.

2.6.1 Brief description of GAINS (IIASA, 2005)

The objective of GAINS is to explore cost-effective multi-pollutant emission control strategies that meet environmental objectives on air quality impacts (on human health and ecosystems) and greenhouse gases.

The GAINS model is an integrated assessment model that brings together information on the sources and impacts of air pollutant and greenhouse gas emissions and their interactions. GAINS is an extension of the earlier RAINS (Regional Air Pollution Information and Simulation) model, which addressed air pollution aspects only. GAINS brings together data on economic development, the structure, control potential and costs of emission sources, the formation and dispersion of pollutants in the atmosphere and an assessment of environmental impacts of pollution. GAINS addresses air pollution impacts on human health from fine particulate matter and ground-level ozone, vegetation damage caused by ground-level ozone, the acidification of terrestrial and aquatic ecosystems and excess nitrogen deposition) of soils, in addition to the mitigation of greenhouse gas emissions. GAINS describes the interrelations between these multiple effects and the range of pollutants (SO_2, NO_x, PM, NMVOC, NH_3, CO_2, CH_4, N_2O, F-gases) that contribute to these effects at the European scale.

GAINS assesses, for each of the 43 countries in Europe, more than 1,000 measures to control the emissions to the atmosphere. It computes the atmospheric dispersion of pollutants and analyzes the costs and environmental impacts of pollution control strategies. In its optimisation mode, GAINS identifies the least-cost balance of emission control measures across pollutants, economic sectors and countries that meet user-specified air quality and climate targets.

The main data sources are:

- energy balances and agricultural statistics from EUROSTAT;
- national emission inventories from EMEP and from national sources.

2.6.2 Modelling behavioural options

Transport

Buying and using an electric car or plug-in hybrid
The decision to buy an electric car or plug-in hybrid cannot be directly modelled. If these technologies and their energy and emissions characteristics are included in the technology set, a behavioural change in consumption can be reflected as an exogenous change in the relevant combined sector and fuel type coefficient. The change in fuel use and emissions can then be calculated.

Buying and using smaller cars
Since the GAINS model does not model the car purchase decision, a move towards smaller cars can only be included through an exogenous change in the relevant combined sector and fuel type coefficient for mobile sources.

Applying a more fuel-efficient driving style
This behavioural change can be incorporated in the model as a change in the emissions coefficient for the relevant mobile sources.

Making use of ICT to decrease business travel: teleworking and applying visual meetings
Since the GAINS model does not have endogenous demand, a change in business travel can only be incorporated by changing the activity coefficients for the relevant combined sector and fuel type activities.

Food

Since the GAINS model does not have endogenous demand, a change in demand for food can only be incorporated by changing the activity coefficients for the relevant combined sector and fuel type activities.

Technical improvements in the fertilizer industry and in the category 'food, beverages, tobacco and other industries' are incorporated, such that if the economic activity i.e. demand coefficients are changed, the emissions/cost system can be re-optimised and reductions in emissions calculated.

Housing

Since the GAINS model does not have endogenous demand, a change in demand for residential energy services can only be incorporated by changing the activity coefficients for the relevant combined sector and fuel type activities.

Technical improvements in the fertilizer industry and in the category 'glass, pottery and buildings sector' are incorporated, such that if the economic activity i.e. demand coefficients are changed, the emissions/cost system can be re-optimised and reductions in emissions calculated.

2.6.3 Modelling policies and policy packages

Since the GAINS model does not include policy variables other than the cost of emissions mitigation technologies, the policy measures discussed in this project for implementing behavioural measures cannot be modelled directly. If the impacts on activity for the transport and housing energy sectors is known, the changed demands for energy and changed emissions can be incorporated into the GAINS model as exogenous activity changes.

2.7 GEM-E3

2.7.1 Brief description of GEM-E3 (Capros et al.)

The objective of GEM-E3 is to model the macro-economic impacts of emission control strategies for all Member States of the EU. **GEM-E3** is an applied general equilibrium model, simultaneously representing **World** regions or **European** countries, linked through endogenous bilateral trade and environmental flows. The European model covers the EU countries, Switzerland and four Accession countries and it is being extended towards the other associated countries.

The GEM-E3 (World and Europe) model is an applied general equilibrium model, simultaneously representing World regions or European countries, linked through endogenous bilateral trade flows and environmental flows. The European model is including the EU countries, the Accession Countries and Switzerland. GEM-E3 aims at covering the interactions between the economy, the energy system and the environment.

GEM-E3 includes all simultaneously interrelated markets and represents the system at the appropriate level with respect to geography, the sub-system (energy, environment, economy) and the dynamic mechanisms of agent’s behaviour.

1. It formulates separately the supply or demand behaviour of the economic agents which are considered to optimise individually their objective while market derived prices guarantee global equilibrium.
2. It considers explicitly the market clearing mechanism and the related price formation in the energy, environment and economy markets: prices are computed by the model as a result of supply and demand interactions in the markets and different market clearing mechanisms, in addition to perfect competition, are allowed.
3. The model is simultaneously multinational (for the EU or the World) and specific for each country/region; appropriate markets clear European/World wide, while country/region-specific policies and distributional analysis are supported.
4. Although global, the model exhibits a sufficient degree of disaggregation concerning sectors, structural features of energy/environment and policy-oriented instruments (e.g. taxation). The model formulates production technologies in an endogenous manner allowing for price-driven derivation of all intermediate consumption and the services from capital and labour. In the electricity sector, the choice of production factors can be based on the explicit modelling of technologies. For the demand-side the model formulates consumer behaviour and distinguishes between durable (equipment) and consumable goods and services.
5. The model is dynamic, recursive over time, driven by accumulation of capital and equipment. Technology progress is explicitly represented in the production function, either exogenous or endogenous, depending on R&D expenditure by private and public sector and taking into account spill overs effects.

6. The model formulates pollution permits for atmospheric pollutants and flexible instruments allowing for a variety options, including: allocation (grandfathering, auctioneering, etc.), user-defined bubbles for traders, various systems of exemptions, various systems for revenue recycling, etc.
7. The specification of consumption follows the generalised Leontief type of model. The household behaviour is based on an inter-temporal model of the household sector with two stages. In a first stage the households decide each year on the allocation of their expected resources between present and future consumption of goods and leisure, by maximising over their entire life horizon an inter-temporal utility function subject to an inter-temporal budget constraint defining total available resources. In the second stage households allocate their total consumption expenditure between expenditure on non-durable consumption categories (food, culture, etc.) and services from durable goods (cars, heating systems and electric appliances).

2.7.2 Modelling behavioural options

The GEM-E3 model is a traditional Walrasian macroeconomic general equilibrium model. Demand behaviour or consumption is modelled using a Cobb-Douglas utility function to allocated demand across durable and non-durable goods categories. Demands are based on price elasticities across the different consumption goods. The model includes cars and heating systems as durable goods; food and housing operation, fuels and power, operation of transport as non-durable goods.

As is stated in the manual 'Models designed to study trade and fiscal policy do not necessarily represent the full detail of production technologies and consumption patterns, but instead put emphasis on public budgeting and international trade links' (p. 10). The model is in principle suited to model price/cost-induced behavioural change on the available level of aggregation (13 types of consumer goods, while distinguishing between Durable e.g. heating devices and non-Durable goods linked with these durables (e.g. heating fuel. The consumer will change his behaviour by substituting to some degree a more expensive (taxed) good for a less expensive good. However, the model is not intended to include the details of specific behavioural changes and it is not recommended to develop a detailed behavioural model to include the specific behavioural options considered here.

2.7.3 Modelling policies and policy packages

The GEM-E3 model can analyse scenarios and consumption effects based on price changes, however the focus of the model so far has been on the whole economy (including households). The focus could shift towards households if needed. Scenarios based on direct price changes can be analysed. The scenarios that could be analysed include: consumption taxes such as beef tax (with some data work), VAT change, CO_2 tax, the effects on consumption of CO_2 cap, etc.
Hence the following policies could be modelled:

- Financial incentives for reduced energy consumption or taxation of higher energy consumption.
- Direct governmental expenditures like public investments in infrastructure, e.g. smart meters (requiring extra assumptions and changes in model).
- Consumption taxes/Introduce differentiated consumption taxes based on the environmental performance of products.
- Economic instruments: The model has been used extensively to compare different instruments (cap-and-trade, tax, permits, auctioning, etc.).

3 Data for incorporation of behavioural measures into the models

3.1 Introduction

This section presents data sheets for the behavioural measures analysed and where available, data on policy impacts for incorporation into the models discussed in Section 2 above. The data sheets are separated into parameters for the measure, the estimated impacts on emissions and quantified impacts of policies.

How to interpret the tables
Specific parameter values can be directly incorporated into the data of the model. Overall mitigation potentials show values of overall results against which the model output can be checked. The most suitable combination of model calibration parameters can be selected by the modeller in order for the model to produce scenario results that match these CO_2 reductions compared to a baseline run.

3.2 Transport behavioural changes and policies

3.2.1 Transport behavioural changes

Variables to be adjusted and estimation of values
The variables for which calibration data are available for behavioural measures are the purchase and running cost variables and the overall GHG emissions. Price elasticities of fuel policies have also been estimated. These are included in the transport models. The policy measures variables for economic policies which comprise changes to prices of vehicles and fuels are also available in some cases. Since these variables apply to behaviours which are not yet widely diffused in the EU (or other societies), there is little empirical evidence available on which to base estimates. For teleworking and virtual meetings, there is little information available. Estimates of the change in demand in response to these measures are required. The scattered data available has been reviewed and summarised in the following tables. This has two implications. Firstly, the values estimated are uncertain. Secondly, it is not known whether the values would be representative over the EU population. Therefore, the distribution of possible values is not known. Therefore, sensitivity analyses should be conduced to investigate the changes in model results that are found with a range of behavioural and policy variable values.

Data sheet electric cars
For the TREMOVE model, EU (2010) add BEVs (battery electric vehicles) and PHEVs plug-in hybrid electric vehicles) to the first tier of the logit vehicle choice function and PHEVs only to the second tier of the logit vehicle choice function.
The data sheets show the estimates from the literature described in the domain report for transport.

Table 1 Estimates of impacts of buying and using electric cars

Measures characteristics	2020	2030	2050
Additional Purchase cost of vehicle compared to conventional vehicle BEVs	€ 11,000 to € 17,000 for small cars € 20,000 to € 28,000 for large cars	€ 3,000 to € 15,000 for small cars € 7,000 to € 24,000 for large cars	N/a
Additional annual running cost of vehicle compared to conventional vehicle BEVs	Maintenance costs reduced by 55% Insurance costs increased by 50-55%	Maintenance costs reduced by 55% Insurance costs increased by 50-55%	N/a
Additional Purchase cost of vehicle compared to conventional vehicle PHEVs	€ 7,000 to € 11,000 for small cars and € 7,000 to € 13,000 for large cars	Cost reduction of € 6,000 to cost increase € 13,000 for large cars	
Additional annual running cost of vehicle compared to conventional vehicle PHEVs	Insurance costs increased by 55%	Insurance costs increased by 55%	
Overall Mitigation Potential			
Buying and using electric cars			
Relative reduction in CO_2 emissions per pkm	19-34%	64-72%	82-90%
Absolute CO_2 mitigation potential (Mton)	96-174	330-371	420-462
Buying and using plug-in hybrid cars			
Relative reduction in CO_2 emissions per pkm	11-22%	39-56%	49-69%
Absolute CO_2 mitigation potential (Mton)	56-113	198-286	251-354

Data sheet Purchase smaller cars

The behavioural measure smaller cars does not require change to the cost and emissions parameters of the car technologies in the models, as the ASTRA and TREMOVE models already include a range of car sizes.

Table 2 **Estimates of impacts of buying and using smaller cars**

Measures characteristics	**2020**	**2030**	**2050**
Lower Purchase cost of vehicle compared to average conventional vehicle	50% of cost of average car	50% of cost of average car	50% of cost of average car
Lower maintenance and insurance cost of vehicle compared to average conventional vehicle	60%	60%	60%
Lower taxes	Country specific	Country specific	Country specific
Overall Mitigation Potential **Reduction in CO_2 emissions/pkm Compared to average ICE car**			
Relative reduction in CO_2 emissions per pkm	17-20%	18-21%	18-21%
Absolute CO_2 mitigation potential (Mton)	80-96	74-88	71-84

Data sheet More fuel efficient driving style

Table 3 **Estimates of the impact of a more efficient driving style**

Measures characteristics	**2020**	**2030**	**2050**
Cost of eco-driving course	€ 50-€ 100	€ 50-€ 100	€ 50-€ 100
Purchase of ICT tools	€ 15	€ 15	€ 15
Avoided fuel costs For average consumption 7.5l/100km fuel price € 1.50/l	€ 170		
Overall Mitigation Potential **Reduction in CO_2 emissions/pkm Compared to average ICE car**			
Relative reduction in CO_2 emissions per pkm	10%	7%	2%
Absolute CO_2 mitigation potential (Mton)	47	32	10

Data sheet Teleworking and virtual meetings

These changes involve a change in travel demand and trip generation. Therefore, a recalibration of trip generation is required in the models.

Table 4 **Potential share of passenger kilometres and CO_2 emissions to be saved by applying teleworking and virtual meetings**

	2020	2030	2050
Commuting trips			
Relative share pkm commuting in total number of pkm of passenger transport	13%	12%	12%
Relative share CO_2 emissions due to commuting in total CO_2 emissions of passenger transport	11%	10%	9%
Business trips			
Relative share pkm business trips in total number of pkm of passenger transport	11%	12%	12%
Relative share CO_2 emissions due to business trips in total CO_2 emissions of passenger transport	11%	13%	13%

Table 5 **Estimates of impacts of virtual meetings and teleworking**

Measures characteristics	2020	2030	2050
Lower mobility costs	Reduction in personal travel costs Teleworking 5 to 8% Virtual meetings 6 to 9%	Reduction in personal travel costs Teleworking 5 to 8% Virtual meetings 6 to 9%	Reduction in personal travel costs Teleworking 5 to 8% Virtual meetings 6 to 9%
Changes in energy costs for heating, air conditioning and electricity	No empirical evidence available	No empirical evidence available	No empirical evidence available
Lower costs due to smaller offices	No empirical evidence available	No empirical evidence available	No empirical evidence available
Less parking places necessary at the office	No empirical evidence available	No empirical evidence available	No empirical evidence available
Increased productivity of teleworkers and virtual meetings	No empirical evidence available	No empirical evidence available	No empirical evidence available
Investment costs in ICT	No empirical evidence available	No empirical evidence available	No empirical evidence available
Overall Mitigation Potential **Reduction in CO_2 emissions/pkm Compared to average ICE car**			
Teleworking			
Relative reduction in CO_2 emissions of total passenger transport	5-6%	6-7%	6-8%

Measures characteristics	2020	2030	2050
Absolute CO_2 mitigation potential (Mton)	35-45	38-47	40-49
Applying virtual meetings	6%	6%	9%
Relative reduction in CO_2 emissions of total passenger transport	6%	6%	9%
Absolute CO_2 mitigation potential (Mton)	39	35	55

3.2.2 Transport behavioural policies

Variables to be adjusted and estimation of values

The transport models have detailed structures for modelling fiscal policies to affect car purchase and use. Fuel taxes in particular are already included in most policy scenarios. The structure of trip generation and travel demand does not include a differentiated consideration of driving style, or of life/work decisions involving travel vs. the extended use of ICT. Therefore, such effects would have to be incorporated in the models by recalibrating the trip generation and travel demand variables. The CO_2 reductions found in the literature and shown in the tables can be used as a check against the CO_2 emissions reductions induced through e.g. fiscal policies increasing fuel prices and leading to more purchases of smaller and electric cars and a reduction in travel as costs of travel are increased. The data for policy packages fro transport behavioural changes analysed are summarised in Table 6, Table 7 and Table 8.

Table 6 Data sheet Policies to support purchase of smaller cars

Policy (package)	CO_2 reduction due to smaller cars	Total CO_2 reduction
CO_2 differentiated purchase tax	3-4%	6-10%
CO_2 differentiated company car tax	2-3%	4-7%
10% fuel tax increase	0.5%	3-4%
20% fuel tax increase	1%	6-8%
Spatial policies favourable to small cars	?	?
Supportive communication strategy	Not significant	Not significant
Policy package 1 (incl. fuel tax increase of 10%)	At least 6-8%	At least 13-21%
Policy package 2 (incl. fuel tax increase of 20%)	At least 6-9%	At least 16-25%

Table 7 Data sheet Policies to support fuel efficient driving

Policies	Policy example	Quantified data	Quantified data
Regulation	Require eco-driving in driving courses	Negligible cost	
Subsidies	Subsidies for eco-driving courses	5-25% emissions reductions compared to the baseline immediately after the course	3% emissions reductions compared to the baseline long term
Energy taxes		Fuel consumption elasticity 0.1-0.15	
Information campaigns	No quantifiable effect estimated		
Eco-driving campaigns and courses for government employees	No empirical evidence available		
Voluntary agreements with companies for eco-driving courses	No empirical evidence available, low effectiveness of this instrument in other contexts		

Table 8 Data sheet Policies to support teleworking and virtual meetings

Policies	Policy example	Quantified data
Regulation	European Framework Agreement on Telework	No quantifiable effect estimated
Subsidies for teleworking and virtual meeting equipment and business use of homes		No empirical evidence available
Broadband IT infrastructure provision for virtual meetings		No empirical evidence available
Fuel taxes and road use charges for stimulating teleworking and virtual meetings	No empirical evidence available	Fuel consumption elasticity -0.3 to -0.4
Information campaigns: best practice, experiences of teleworkers and virtual meetings	No empirical evidence available	
Teleworking and virtual meetings for government employees	No empirical evidence available	
Voluntary agreements with companies for teleworking and virtual meetings	No empirical evidence available, low effectiveness of this instrument in other contexts	

3.3 Housing behavioural changes and policies

3.3.1 Housing behavioural changes

Variables to be adjusted

There is very limited quantitative information available on the details of behavioural measures in housing. Overall GHG emissions reductions have been estimated. The behavioural changes examined can be incorporated in models with housing energy demand through a change in the energy demand per household. The models do not have a detailed representation of decisions about energy behaviour, other than overall responses to energy prices and an average performance of energy technologies in buildings.

Data sheet Reducing space heating temperature

Table 9 Data sheet Reducing space heating temperature

Measures characteristics	2020	2030	2050
Assumed share of buildings with district heating	8.5% (current value from literature)		
Assumed share of buildings without room temperature control	10% (current value from literature)		
Costs of reducing room temperature	No costs identified	No costs identified	No costs identified
Overall Mitigation Potential			
CO_2 emissions for the housing domain	425 Mt CO_2	362 Mt CO_2	299 Mt CO_2
Reduction of maximum abatement potential (as % of total CO_2 emissions)			
People with special needs	35%	35%	35%
Technical constraints	10%	10%	10%
Realistic maximum abatement potential (as Mt CO_2)			
Reduction by 1°C	22	19	16
Reduction by 2°C	45	38	32

Data sheet Optimising thermostat settings

Table 10 Data sheet Optimising thermostat settings

Measures characteristics	2020	2030	2050
Costs e.g. thermometer purchase	No empirical evidence available	No empirical evidence available	No empirical evidence available
Operational/maintenance costs	Assumed negligible	Assumed negligible	Assumed negligible
Overall Mitigation Potential			
Reduction of maximum abatement potential (as % of total CO_2 emissions)			
People with special needs	35%	35%	35%
Technical constraints	20%	15%	10%
Realistic maximum abatement potential (as Mt CO_2)			
Absolute Potential	33	30	26

Data sheet Optimising ventilation behaviour

Table 11 Data sheet Optimising ventilation behaviour

Changes characteristics	2020	2030	2050
Costs e.g. thermometer purchase	Assumed negligible	Assumed negligible	Assumed negligible
Operational/maintenance costs	Assumed negligible	Assumed negligible	Assumed negligible
Reduction of maximum abatement potential (as % of total CO_2 emissions)	25	25	25
Realistic maximum abatement potential Assumed equal to theoretical potential (as Mt CO_2)			
Absolute Potential	32	32	31

3.3.2 Housing behavioural policies

Variables to be adjusted

The overall effects of policies for behavioural change in households in the three areas have been estimated. The impact of energy taxation is already incorporated in the PRIMES model through shifts in energy prices. The impact of communications strategies and detailed billing can be incorporated through a recalibration of the household energy demand function. Government direct expenditure can be incorporated as investment costs, leading to a change in the energy efficiency of housing or a shift in the diffusion of energy saving technologies in houses.

Table 12 Summary of policy impacts for housing behavioural policies

Policies	Policy example	Quantified data
Regulation		
Energy certificates for buildings		No quantifiable effect estimated
Smart metering		No quantifiable effect estimated
Real Time Displays (RTDs) Home Energy Advice packages (HEAs)	UK CERT	1.1% savings total from baseline in 2011 UK update
Energy taxes		No quantifiable effect estimated
Provision of small energy saving devices	Stromspar-Check: Germany	31% households change to efficient ventilation behaviour 25% households change to lowering room temperatures
Communications	Informative billing: Norway	6% decrease in home electricity use including space heating

Data sheet Summary of abatement potential for the three changes combined

Table 13 Data sheet Summary of abatement potential

	2020	2030	2050
Realistic maximum abatement potential (as Mt CO_2)			
Lowering Room Temperature			
Reduction by 1°C	22	19	16
Reduction by 2°C	45	38	32
Optimised Thermostat Settings	21	18	15
Improved Ventilation	32	32	31
Total (2°C)	98	88	78
Total (1°C)	75	69	62
Realistic abatement potential addressable by the policy package (as Mt CO_2)			
Policy Impact (only informational)	25%	33%	33%
Potential realistically addressed by the policy package (only informational) (1°C)	19	23	21
Share of potential compared to total CO_2 emissions for the housing domain	4%	6%	7%

Data sheet Costs of policies to implement behavioural changes in housing

Table 14 **Data sheet costs of policies to implement behavioural changes in housing**

	Cost	Comments
Communication Strategies	Unknown	
Detailed billing	< 10 € per dwelling and year	Additional costs for data acquisition and
Direct Government expenditures	100 € per dwelling	Smart meter costs
Energy taxation	Balanced	

3.4 Food behavioural changes and policies

3.4.1 Food behavioural changes

Variables to be adjusted

Since the aggregated food models considered do not have detailed behavioural models, the impact of the behavioural changes can be implemented through recalibrating the food demand functions. The changed distribution of food demands has been estimated. Policy variables are shown for economic measures could be directly input into the models. Costs of policies are also indicated.

3.4.1.1 Healthy diet

Table 15 shows the distribution of kilograms for healthy eating. This is a reduction in daily intake to 2,500 kilocalories and 500 grams of fruits and vegetables.

Table 15 **The distribution of kilograms under Behavioural change 3: Healthy diet (250 gram of fruit and 250 gram of vegetables per day while reducing the total calories to 2,500)**

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	82.68	79.17	74.15	99.84	113.19
Rice	3.34	3.10	3.79	2.81	2.68
Beef	11.83	12.74	13.24	8.84	6.04
Pork	28.07	30.90	24.85	22.98	34.42
Sheep & Goat	2.41	2.13	2.34	3.22	0.68
Poultry	14.39	14.45	13.78	13.50	16.64
Equidae	0.56	0.82	0.47	0.23	0.00
Milk	57.30	68.78	46.72	52.97	62.83
Cheese & Butter	13.79	14.86	12.92	13.50	13.76
Eggs	8.96	9.13	8.42	8.21	7.51
Veg. fats & Oils	12.21	13.69	12.20	12.57	5.90
Fresh fruits	91.25	91.25	91.25	91.25	91.25
Nuts & Dried fruits	5.50	5.44	6.69	5.39	3.17
Vegetable (no potatoes)	91.25	91.25	91.25	91.25	91.25
Potatoes	54.00	64.37	36.72	52.17	86.65
Sugar	23.00	26.93	18.33	20.14	29.20
Honey	0.47	0.57	0.31	1.01	0.42
Wine (lt/head)	19.79	14.61	29.00	15.33	7.65

3.4.1.2 Reduced animal protein intake

Table 16 shows the distribution of kilograms under the change: Less animal protein intake, maintaining the calorie intake

Table 16 Distribution of kilograms under Behavioural Change @@: Less animal protein intake, maintaining the calorie intake

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	133.48	119.84	137.82	152.38	151.43
Rice	4.88	4.18	6.37	4.10	3.31
Beef	14.88	14.81	19.14	11.08	6.43
Pork	35.31	35.92	35.94	28.81	36.66
Sheep & Goat	3.03	2.48	3.38	4.04	0.72
Poultry	18.10	16.79	19.92	16.93	17.72
Equidae	0.70	0.96	0.67	0.29	0.00
Milk	72.08	79.95	67.55	66.40	66.91
Cheese & Butter	17.34	17.28	18.69	16.93	14.65
Eggs	11.27	10.61	12.17	22.95	8.00
Veg. fats & Oils	17.86	18.51	20.52	18.31	7.30
Fresh fruits	95.43	74.92	141.47	70.63	55.72
Nuts & Dried fruits	8.04	7.35	11.25	7.85	3.93
Vegetable (no potatoes)	147.27	95.61	191.95	172.72	68.16
Potatoes	79.00	87.01	61.75	76.04	107.30
Sugar	33.65	36.40	30.83	29.36	36.16
Wine (lt/head)	28.95	19.75	48.76	22.34	9.48

3.4.1.3 Vegetarian diet

For the vegetarian diet the change dietary choices modelled is to stop all meat consumption, fish or sea food consumption, while total calorie intake remains unchanged. Table 17 shows the change in food demand and Table 18 the reduction in CO_2 emissions per capita.

Table 17 Vegetarian diet changes in demand

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	173.47	160.04	181.00	189.99	187.50
Rice	4.88	4.18	6.37	4.10	3.31
Beef	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00
Sheep & Goat	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00
Equidae	0.00	0.00	0.00	0.00	0.00
Milk	83.82	92.96	78.55	77.20	77.81
Cheese & Butter	20.17	20.09	21.73	19.68	17.03
Eggs	13.11	12.33	14.15	11.96	9.30
Veg. fats & Oils	17.86	18.51	20.52	18.31	7.30
Fresh fruits	95.43	74.92	141.47	70.63	55.72
Nuts & Dried fruits	8.04	7.35	11.25	7.85	3.93
Vegetable (no potatoes)	191.38	127.69	252.09	215.36	84.39
Potatoes	79.00	87.01	61.75	76.04	107.30
Sugar	33.65	36.40	30.83	29.36	36.16
Wine (lt/head)	28.95	19.75	48.76	22.34	9.48

3.4.2 Food behavioural policies

Variables to be adjusted

The policies to support behavioural changes in food have two components. Firstly, the policies involve combinations of consumption taxes and information measures. The policy costs of information measures have been estimated and would have to be included in government budget (fiscal) variables. Consumption taxes can easily be treated in the models as a shift in food prices.

Table 18 Summary of policy variables

Policy package costs (healthy diet)	Cost per person (in€ ppp) 2010		Total costs (in mln. €) 2010 for EU-27	
Healthy diet	**Min. costs**	**Max. costs**	**Min. costs (in mln. €)**	**Max. costs (in mln. €)**
Regulation introducing mandatory nutrition labelling	0.25	0.85	127	424
Financing school-based intervention programs	0.77	1.54	60	120
Targeted information and awareness raising campaigns and education programme	0.38	1.54	193	771
Introducing consumption taxes	0.02	0.10	12	50
Total cost			*392*	*1366*
Vegetarian diet and reduced meat diet	**Min. costs**	**Max. costs**	**Min. costs (in mln. €)**	**Max. costs (in mln. €)**
Introduce differentiated consumption taxes based on the environmental performance of products	0.02	0.10	12	50
Develop an EU-level sustainable food labelling scheme and establish credible certification mechanisms	0.25	0.85	127	424
Launch targeted information and awareness-raising campaigns and education programmes.	0.38	1.54	30	120
Total cost			*169*	*594*

3.4.2.1 Healthy diet

Table 19 and Table 20 show the proportional impact and the reduction in food demand estimated for the behavioural change to a healthy diet. Table 21 shows the overall reduction in GHG emissions.

Table 19 The total impact of the policy package (Healthy Diet)

The policy measure	2020	2030	2050
Labelling	7.5%	7.5%	7.5%
Mass media campaigns	10%	10%	10%
School-based intervention	3.4%	5.7%	10.4%
VAT and excises	3%	3%	3%
Total impact (= reduction of difference in consumption of food products between current diet and healthy diet	20%	22%	26%

Table 20 The total impact of the policy package on the change towards a healthy diet, 2020, 2030 and 2050

(Kg/head)	European Union (27 countries) Current diet	European Union (27 countries) *2020 diet*	European Union (27 countries) *2030 diet*	European Union (27 countries) *2050 diet*
Cereals (including bread)	121	113	113	111
Rice	5	5	5	4
Beef	17	16	16	16
Pork	41	38	38	38
Sheep & Goat	4	3	3	3
Poultry	21	20	20	19
Equidae	1	1	1	1
Milk	84	79	78	77
Cheese & Butter	20	19	19	19
Eggs	13	12	12	12
Veg. fats & Oils	18	17	17	16
Fresh fruits	95	95	95	94
Nuts & Dried fruits	8	8	7	7
Vegetable (no potatoes)	133	125	124	123
Potatoes	79	74	74	73
Sugar	34	32	31	31
Wine (lt/head)	29	27	27	27

Table 21 **Impact of the healthy diet policy package on GHG emissions, 2020, 2030 and 2050**

	2020	2030	2050
Projected population EU-27 (millions)	514	522	524
BAU food emissions ($Mt\ CO_2$ eq.)	651	661	663
Of which: in EU ($Mt\ CO_2$ eq.)	544	552	554
Of which: outside EU ($Mt\ CO_2$ eq.)	107	108	109
Emissions healthy diet policy package ($Mt\ CO_2$ eq.)	607	612	607
Of which: in EU ($Mt\ CO_2$ eq.)	507	512	507
Of which: outside EU ($Mt\ CO_2$ eq.)	100	101	100
Total difference ($Mt\ CO_2$ eq.)	44	48	56
Of which: in EU ($Mt\ CO_2$ eq.)	37	41	47
Of which: outside EU ($Mt\ CO_2$ eq.)	7	8	9

3.4.2.2 Reduced animal protein

Table 22 shows the average impact of the package as a whole.

Table 22 **Total impact of the policy package (Reduced animal protein intake)**

The policy measure	Impact on animal protein consumption
Labelling	0.5%
VAT	5.0%
Total (sum)	5.5%

Table 23 shows the total impact of the policy package on the BAU situation for reduced animal protein intake in 2020. The diet and emissions are presented for 2020, but because the diet and the population are projected to remain constant over time, the situation in 2030 and 2050 is not significantly different.

Table 23 The total impact of the policy package on the BAU situation from reduced animal protein intake

Food item	European Union (27 countries) BAU diet (kg/head)	*Total emissions 2020 (Mt CO_2 eq.)*	European Union (27 countries) Diet after implementation of policy package (kg/head)	*Total emissions 2020* after implementation of policy package *(Mt CO_2 eq.)*
Cereals (including bread)	121	65	122	65
Rice	5	7	5	7
Beef	17	162	17	161
Pork	41	91	41	90
Sheep & Goat	4	30	3	30
Poultry	21	27	21	27
Equidae	1	7	1	7
Milk	84	46	83	46
Cheese & Butter	20	66	20	65
Eggs	13	11	13	11
Veg. fats & Oils	18	16	18	16
Fresh fruits	95	21	95	21
Nuts & Dried fruits	8	3	8	3
Vegetable (no potatoes)	133	52	134	53
Potatoes	79	23	79	23
Sugar	34	9	34	9
Wine (lt/head)	29	14	29	14
Total		651		648

4 Conclusions

4.1 Behavioural structure in the models considered

The models considered in this project fall into two categories: sector specific models (ASTRA, TREMOVE, CAPRI, AGMEMOD, PRIMES) an aggregated models (GAINS, GEM-E3). For the behavioural changes considered for transport, the ASTRA and TREMOVE models have detailed representations of transport behaviour and choices. They incorporate logit discrete choice functions for automobile purchases, and differentiated coefficients for emissions for a set of automobile types. For purchase of electric vehicles, ASTRA includes electric vehicles in the set of technologies considered and therefore does not require modification to consider electric vehicle purchase. TREMOVE does not include electric vehicles, but EU (2010) report a method by which calculations outside model can be used to incorporate electric vehicles into TREMOVE results. A change towards purchase of smaller cars requires recalibration of the parameters in the logit discrete choice function for vehicle purchase. A move to a more fuel efficient driving style can be incorporated through a change in the technology coefficients for energy use per vehicle km.
A reduction in demand through the application of ICT requires a recalibration of the passenger travel demand functions. As is shown in the E4MACS project, a modelling link is being established between the PRIMES and TREMOVE models, so relevant results may also apply to PRIMES-TREMOVE. The GAINS model can incorporate these behavioural changes in transport through changes in the activity coefficient parameters. For the behavioural change considered for food, a change to a vegetarian diet and a reduction in animal protein can be incorporated through a recalibration of the parameters of the preferences in the demand function of the CAPRI model. The AGMEMOD model can consider these changes through changes in the self-sufficiency rates. A move towards a reduction in food intake requires a recalibration of the overall demand function in the CAPRI model and through a further change in the self-sufficiency rates in the AGMEMOD model. The GAINS model cannot allow for changes in food demand directly. The behavioural changes considered will change the national emissions inventories and if these changes are calculated with agricultural models, the alterations in inventories can be incorporated into the GAINS data inputs.
For behavioural changes in housing, the PRIMES model has a detailed representation of energy technologies in buildings.
GEM-E3 is designed as a macroeconomic model, although it includes consumption functions which can be modified to reflect fiscal policy.

4.2 Overall assessment of modelling behavioural options

In order to represent behavioural change options in a model, a detailed representation of consumer behaviour is required. The sectoral models all include consumer choices, driven almost exclusively by prices. Therefore they can analyse responses to changes in prices including fiscal policy. In all, the models, the choice structure or underlying preferences in economic terms are fixed. Behavioural changes such as a desire to drive a car with lower emissions or to eat less in order to be more healthy cannot be directly modelled and have to be indirectly incorporated through recalibrations of the consumer chice functions in the sectoral models. In our assessment, since the GAINS model does not incorporate consumer demand functions, such changes must be indirectly incorporated through changes to the energy demand inputs.

Such recalibrations require empirical data. This is difficult because there is relatively little data available in the literature on the impacts of options for behavioural change and supporting policies. This means that the data presented in this report should be regarded as having a high degree of uncertainty. Therefore, modelling exercises for behavioural changes with these models should include sensitivity studies to check on the implications of different variable values.

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