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Introduction to the Advanced World MARKAL Model and Description of the Inputs

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Abstract

This paper presents a recent version of the advanced multi-region World MARKAL model used to explore CO_2 abatement options.

The report describes the structure and the properties of the World MARKAL model (dynamic optimization, technology explicit model, multi-regional, partial equilibrium framework with price-elastic demands) as well as the base case (input data, calibration assumptions, energy/emissions properties), so that any user who would build another base scenario could reproduce this approach.

The World MARKAL can be considered as one of the first world bottom-up optimization model with so high a level of detail in end-use and supply sectors.

Résumé

Ce rapport présente une version récente du modèle MARKAL-monde avancé et multi-régional. Ce modèle est utilisé pour étudier les stratégies de réduction du CO_2.

Le rapport décrit la structure et les propriétés du modèle (optimisation dynamique, modèle détaillé du point de vue des technologies, modèle multi-régional, équilibre partiel, élasticité des demandes) de même que le scénario de référence (données utilisées, hypothèses de calibrage, caractéristiques énergétiques et environnementales). Un utilisateur potentiel du modèle peut ainsi construire un autre scénario de référence en reproduisant la même approche.

Le modèle MARKAL mondial constitue l'un des premiers modèles d'optimisation ascendants aussi détaillé du point de vue des secteurs de production et de demande énergétiques.

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1 Introduction

Many models have been or are being developed to study climate mitigation options and satisfy either the target defined by the Kyoto Protocol or a longer-term target such as the stabilization of carbon dioxide (CO_2) concentrations[1].

The primary objective of this paper is to present a recent version of the advanced multi-region World MARKAL model which is used by Labriet et al. (2004) and by Labriet and Loulou (2004) to explore CO_2 abatement options under cooperative and non-cooperative frameworks. The World MARKAL can be considered as one of the first world bottom-up optimization model with so high a level of detail in end-use and supply sectors.

Section 2 presents the structure and the properties of the World MARKAL model: dynamic optimization, technology explicit model, multi-regional, partial equilibrium framework with price-elastic demands. Because this paper is not mathematics but rather methodology and results oriented, the detailed mathematical structure of the model is not given in this paper.

The reference energy and emissions scenario is of critical importance to evaluate CO_2 abatement options and costs. Consequently, Section 3 and Section 4 describe respectively the definition of the base case and the technical-economic input data and assumptions at both supply and end-use levels, and presents the energy and emission results for the base case. This scenario has no environmental constraint, and is calibrated to the A1B scenario modeled by the Asian Pacific Integrated Model (AIM) for the Special Report on Emissions Scenarios of the Intergovernmental Panel on Climate Change (Nakicenovic, 2000). The comparison of this scenario with other world scenarios shows that the A1B scenario could be qualified as one of sustained economic growth but also of high new technology penetration, so that resulting emissions are relatively low compared to those obtained if the current energy situation based on fossil fuels is extrapolated in the future.

2 The MARKAL Model

MARKAL is a linear programming model of the production, trading, transformation, distribution and end-uses of various energy forms and some materials that affect GHG emissions (Fishbone and Abilock, 1981; see also Loulou and Kanudia (1999), and references therein). The model has a long and rich history of methodological developments and applications to energy and environmental issues in more than 40 countries around the world[2]. The development of the

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[1] The Energy Modelling Forum (Weyant, 1999) and the IPCC Special Report on Emissions Scenarios (Nakicenovic, 2000) provide structured fora for the comparison of alternative modeling approaches in the context of climate change, including both top-down and bottom-up models. Hourcade and Shukla (2001) make also a good review of the numerous economic studies on the cost of efficient carbon mitigation policies.

[2] MARKAL teams around the world belong to the international consortium of Energy Technology Systems Analysis Programme (ETSAP), an implementing agreement of the International Energy Agency. GERAD researchers are among the prime developers of MARKAL in its modern form, and continue to act as expert modelers within ETSAP.

advanced world multi-region MARKAL has been driven by the need to analyze international environmental issues such as climate change.

This section describes the most important and general characteristics of the model. More detailed information about the model and discussion about the differences between top-down and bottom-up models can be found in, among others: Loulou et al. (2004); Hourcade (1996); International Energy Agency (1998); Loulou et al. (1997).

2.1 A technology explicit model

The current version of World MARKAL includes several thousand technologies in all sectors of the energy system of a given region (Figure 1). Thus, MARKAL is not only technology explicit; it is technology rich as well.

2.2 The 15 regions

Fifteen regions are identified and modeled based upon political, geographical and environmental factors (Table 1). They are aggregated into four regions for reporting purposes in this article. Each regional model is a complete, self-contained MARKAL model. In addition, the 15 models are hard-linked by energy trading variables and by emission permit trading variables if desired, so that they form a single global energy model where actions taken in one region may affect actions taken in all other regions. MARKAL also distinguishes between the trading of oil and petroleum products produced by OPEC from that produced by non-OPEC regions[3].

2.3 Partial equilibrium

MARKAL computes a supply-demand partial economic equilibrium on energy markets. Partial equilibrium models consider the production and consumption of energy services simultaneously. That is, the price of producing an energy service affects energy service demand, while, at the same time, energy service demand affects energy service price. A market is said to have reached an equilibrium price when no consumers wish to purchase any more and no producers wish to produce any more. Operationally, a MARKAL run configures the energy system of a set of regions over 2000-2050 in such a way as to minimize the net discounted total cost of the system (or equivalently maximize the net total surplus, i.e. the sum of producers' and consumers' surpluses), while satisfying the externally defined demands for energy services of the entire

[3] OPEC and Non-OPEC won't be distinguished in the rest of this paper, but future analyses could consider scenarios in which OPEC oil production decisions obey different criteria from those in other regions.

system, subject to detailed technological, geographic and environmental constraints (cost-effectiveness analysis[4]).

The total cost of the system includes, at each time period: annualized investments in technologies, fixed and variable annual operation and maintenance costs of technologies; cost of energy imports and domestic resource production; revenue from energy exports; delivery costs; losses incurred from reduced end-use demands; and taxes and subsidies associated with energy sources, technologies, and emissions.

The MARKAL solution includes, in particular: a set of investments in all technologies selected by the model at each period; a set of operating levels of all technologies at each period; the quantities of fuels produced, imported and or exported at each period; the emissions of pollutants at each period; the implicit prices of all energy services (their shadow prices); the overall system's discounted total cost; the increases or decreases of demands in the current model run as compared to the base case.

The rationale that drives the computation of the equilibrium is based on the following principles:

- All agents have *perfect information* on others and *perfect foresight*: MARKAL is run as a dynamic optimization problem where investment decisions are made with full knowledge of the future; in other words, MARKAL optimizes over the entire modeling horizon at once[5];
- Energy markets are *competitive*: MARKAL simulates the simultaneous competition of all technologies for the satisfaction of economic demands; the model behaves as if every agent minimizes its own cost, and no agent is able to exercise market power (with the notable exception of oil production decisions by OPEC – see Section 4).

As a result of these assumptions, the market price of each commodity (except crude oil) is exactly equal to its marginal value in the overall system and each economic agent maximizes its net profit (or utility in the case of consumers).

2.4 A demand-driven model with elastic demands

In the base case, the model is driven by the demands for a number of *energy services* (also called "useful energy" by some authors) such as: number of apartments to heat, vehicle-kilometers traveled by car, or tonnes of aluminum to produce. The current version of MARKAL includes 42 energy service demand categories (Section 4.2), which must be specified by the user for the

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[4] Alternatively, MARKAL may be used for cost-benefit analyzes if the cost of damages due to emissions is added to the objective function (see Labriet and Loulou, 2004).

[5] MARKAL can also be run in a time-stepped manner (myopically), in which case investment decisions are made at each period without knowledge of future events (see, for example: Energy Information Administration, 2003a and 2003b). The appropriate modeling tactic, as usual, depends on the purpose of the study at hand.

entire time horizon, as well as the seasonal/time-of-day modulation of these demands and their price elasticities, which will serve to define the constant elasticity demand functions. The MARKAL equilibrium for a non-base scenario is then computed by maximizing the total net surplus, defined as the sum of the suppliers and the consumers' surpluses (Samuelson, 1952), which is equivalent to finding the intersections of the supply and demand functions for all commodities in the system. Accounting for price elasticities of demands[6] captures a great deal of the interaction between the energy system and the economy, and MARKAL therefore goes beyond the optimization of the energy sector only since both the supply options and the energy service demands are endogenously computed by the model. The total net surplus has often been considered a valid metric of societal welfare in the microeconomic literature, and this fact confers strong validity to the equilibrium computed by MARKAL. Of course, this still falls short of computing a general equilibrium: to do so would require a mechanism for adjusting the main macroeconomic variables as well, such as consumption, savings, employment, wages, and interest rates, which MARKAL does not. However, the model captures a major element of the feedback effects not previously accounted for in bottom-up energy models.

The initial period is a past period, over which the model has no freedom, and for which the quantities of interest are fixed at their historical values. The initial period's calibration is important because it also influences the model's decisions over several future periods, since the profile of residual capacities is provided over the remaining lives of the technologies existing in the initial period.

3 Inputs: the definition of the base case

It is useful to distinguish between a model's structure and a particular instance of its implementation. The model's structure, as presented in Section 2, exemplifies its fundamental approach for representing and analyzing a problem - it does not change from one implementation to the next, whereas the inputs vary from application to application.

The first two versions of the World MARKAL model were developed through a collaboration of the authors[7] with the US Department of Energy's Energy Information Administration (Energy Information Administration, 2003a, 2003b) and with the International Energy Agency. Sections 3 and 4 describe the specific inputs of the version of the model developed by the authors and used in Labriet et al. (2004) and in Labriet and Loulou (2004).

As cost calculation of an energy policy is based on the comparison of the scenario including the energy policy and a reference scenario or baseline, this baseline is of critical importance for the results analysis. The key factors and assumptions that may underly the reference energy scenarios are:

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[6] It is assumed that cross price elasticities are zero.

[7] The team that collaborated with USDOE-EIA for the construction of the original model included the authors plus Amit Kanudia and Kathleen Vaillancourt from GERAD.

- Population projections, productivity growth rates projections, lifestyle projections, economic projections, which all have an impact on demand projections; impacts may be bi-directional; for example, increased economic growth increases energy-using activities but also leads to increased investment, which speeds the turnover of energy-using equipment and may facilitate the use of more efficient technologies;
- Improvements in energy efficiency;
- Adoption of regulations which could have an impact on energy policies;
- Developments in the relative price of fossil fuels;
- Assumptions related to supply-side issues, for example oil and gas reserves, development of gas distribution networks, the relative abundance of coal; energy policies also play a role, particularly tax and subsidy policies;
- Technological change, such as the spread of combined cycle gas turbines;
- Supply of non-fossil fuel based electricity generation (nuclear and hydro);
- Availability of competitively priced new sources of energy, so-called backstop fuels, for example solar, wind, biomass, and tar sands.

MARKAL being an optimization model, the base case as modeled by MARKAL is an optimized scenario and therefore will not necessarily reflects the real world business-as-usual scenario.

3.1 Scenario A1B

Our base case (noted BAU-A1B) is inspired by the A1B scenario modeled by AIM for the International Panel on Climate Change (Nakicenovic, 2000). This scenario is the most frequently cited one in the literature and it was the most frequently used in the post-SRES mitigation scenarios (Morita and Robinson, 2001). This does not however mean that we assign a higher probability of occurrence to this scenario amongst the six illustrative scenarios analyzed by the IPCC. In fact, the base case should be seen only as a benchmark for the assessment of alternatives, as it does not aim at predicting what will happen or what is the most probable future (Morita and Robinson, 2001; Nakicenovic et al., 1998).

The A1B scenario is roughly characterized by the objective of maximization of income by people and further globalization, rather than pursuing environmental goals and regionalization (Bollen et al., 2000). The main dynamics are a very rapid economic growth and a strong commitment to market-based solutions, relatively high final energy demand because of low energy prices and high income levels, access of all regions to knowledge, technology, and capital, continued innovation and decrease of the cost for advanced electricity generation (renewable, advanced nuclear), large unconventional oil and gas reserves, no dependence on one particular energy source and finally, improvement of the efficiency of energy exploitation technologies, energy conversion, and transport technologies (Nakicenovic, 2000; Riahi and

Roehrl, 2000). It is also described as a technology-driven transition to a post-fossil-fuel-age where the rapid technological change in nuclear and renewable energy technologies results in a phase-out of fossil fuels for economic reasons rather that due to resource scarcity (Nakicenovic et al., 1998).

The base case does not take into account specific energy or environment policies beyond what is already embodied in investment made or regulation actually enforced by law. Nevertheless, the high levels of nuclear and renewable and the transition toward zero carbon sources in the A1B scenario as proposed by AIM make this scenario at least partly normative. Indeed, globalization and fast technological change require the implementation of incentives and policies promoting innovation, adequate investments in energy, capacity building and education, and free trade (Nakicenovic et al., 1998). Section 4 will show and justify that some constraints were added to the MARKAL model in order to reflect some of these A1B characteristics.

The commitment to market-based solutions and the globalization assumption of the A1B scenario are particularly well-adapted to the MARKAL paradigm of cost-effectiveness, since the model assumes efficient markets and perfect information across all economic agents in all regions of the world. However, MARKAL also assumes perfect foresight, which perhaps goes beyond what is practically achievable in the real economy. This is one reason why MARKAL analyses are prospective rather than predictive, and why the focus of our work is more on the insights gained on the underlying determinants of energy decisions than on the specific numerical results from any scenario. In order to provide alternate views of the future, several sensitivity analyses are undertaken, and an alternative base case is modeled and described in Section 3.3. In all cases, the insights are produced by the comparison of the different cases, and more particularly the comparison of the base case(s) with the CO_2 constrained case(s).

3.2 Comparison with other reference scenarios

The comparison of the A1B scenario with the projections provided by other studies or institutions helps to emphasize the characteristics of the scenario. We include: the 2003 International Energy Outlook of the Energy Information Administration (2003c) (noted IEO2003), the 2003 World Energy Outlook of the European Commission (2003) (noted WETO2003) and the other five illustrative scenarios of the IPCC when appropriate (Center for International Earth Science Information Network, 2002a, b).

Population growth of A1B is approximately equivalent to IEO2003 and WETO2003 (Table 3). In accordance with its definition (Section 3.1), the A1B is characterized by a higher GDP annual growth (4.1%, 3.0%, 3.2%)[8] and a much higher penetration of nuclear (7.0%, 0.5%, 0.9%) and renewable (4.0%, 1.7%, 2.1%) technologies than IEO2003 and WETO2003 for the period 2000-2025 (Table 3 3, Table 4). The growth of its nuclear capacity is also the highest of the six illustrative IPCC scenarios (Table 4). The growth of electricity consumption is also

[8] All data between brackets in this section are respectively from: AIM-A1B, IEO2003, WETO2003.

higher. The comparison of the growth of primary coal, gas and oil is less easy to discuss as it may hide several assumptions or effects like the growth of demand but also the higher efficiency of energy conversion in A1B (Table 5). Finally, the annual emissions growth of the A1B scenario is highest for the period 2000-2025 (2.6%, 1.9%, 2.1%), while the increase slows down after 2025 (Table 6). Absolute emissions in 2025 of the different scenarios remain reasonably close (9.6 to 13.1 GtC, including the six illustrative IPCC scenarios) in 2025 but diverge in 2050 (11.2 to 23.1 GtC) (Table 7). The annual emission growth proposed by the A1B between 2000 and 2025 is much more optimistic (i.e. smaller) than the one proposed by the two other studies in OECD (0.3%, 1.1%, 0.7%) and in FSU/EE (0.7%, 1.7%, 1.5%); it is higher in developing countries (4.5%, 2.5%, 3.1%) and intermediate in Asia (3.3%, 3.0%, 3.8%) (Table 7).

To conclude, the A1B scenario could be qualified as one of sustained economic growth but also of high new technology penetration, so that resulting emissions are relatively low compared to those obtained if the current energy situation based on fossil fuels is extrapolated into the future. This scenario can be criticized for its high growth rate, especially in developing countries. Nevertheless, Nakicenovic et al. (2003) explain that R&D expenditures and capital turnover rates required to allow a rapid diffusion of new technologies are correlated with the growth rate, so that the emissions are not systematically correlated to the growth rate. Holtsmark and Alfsen (2004) also argue that the use of market exchange rates to express the economic growth does not lead to an overestimation of the emission growth because both economic growth and emission-intensity improvements in the poor regions are overestimated in the IPCC-SRES scenarios.

3.3 The alternative base case

The high levels of nuclear and renewable shares of electricity generation in the A1B scenario have several consequences. Among them, we note that the emissions of OECD countries start to decrease before 2050, which is optimistic (see Section 3.2). The increase in nuclear capacity is, especially in OECD and in the short and medium terms, far above what several regions are planning. For example, recent projections for Canada propose an annual increase of nuclear capacity of only 1.6 to 2.6% between 2000 and 2025 (National Energy Board, 2003). Moreover, because nuclear plants belong to the class of base load duty cycle technologies, their high levels may be incompatible with the modulation of electricity production in the various diurnal and seasonal time slices.

The modeling of an alternative base case scenario (labeled BAU-FOS) aims at providing a contrasted vision of the future of energy and emissions. We based it on the assumptions that the future share of nuclear and renewable electricity in electricity generation would be lower than what AIM-A1B proposes (Table 8, Table 9, Figure 2), in particular:

a) The fixed level of nuclear electricity generation is reduced by 90% in AFR, CSA, MEA and MEX, by 70% in FSU and EEU, 50% in OECD and Asia regions except JPN and SKO where it is reduced by only 30% in order to avoid that the growth rates of these regions in 2025 fall below EIO2003 projections; under these assumptions, absolute nuclear electricity generation remains higher than EIO2003 and WETO2003 at the world level but far smaller than A1B values (Table 10);

b) The minimal forced levels of renewable electricity generation between 2000 and 2020 are not modified, but they are gradually reduced after 2025 to reach 50% of the BAU-A1B levels in 2050 in all regions.

4 Inputs: description of data

Projecting long-term energy and emission scenarios involves many assumptions and the calibration of the two base cases was done via the following approach[9]:

4.1 General

The general *structure* of the model is described in Section 2. Values for period 2000[10] are based on the year 1999 of energy statistics from the International Energy Agency (2001a, b).

Calibration is a delicate and time-consuming process. It is undertaken by changing the *final demands* for energy services and imposing *inflexible constraints* that are adjusted until the optimal solution is close to the desired one. It is very important to note that any exogenous constraints that are added to the database for calibration purposes or to account for either policy or market behavior - based on factors that are not included in MARKAL, must remain in the model in all scenarios (with or without CO_2 constraints) in order to guarantee the consistency of results. Consequently, any constraint that could prejudice CO_2 mitigation options under environmental constraints must be avoided (for example, upper bounding of renewable options or of gas fired equipment should be avoided) .

The model uses two kinds of *discount rates* (Table 11). On the one hand, the overall long-term annual discount rate used for calculating the net present value of the system is fixed at 5%. This rate is the social discount rate for the whole economy. On the other hand, the discount rates used for annualizing investment costs incurred at any particular period (also called *hurdle rates*) are sector and region specific, so as to reflect the financial and behavioral characteristics appropriate to each economic agent. In particular, discount rates are higher in developing regions than industrialized ones, reflecting the lower capital availability and higher perceived risk; discount rates are higher in sectors such as residential (between 12 and 28%) and transportation (between 12 and 18%) where decisions are made mostly by individual consumers, reflecting the higher cost of capital (and higher risk aversion) of individuals as compared to firms; discount rates of the electricity sector (between 3 and 9.2%) are closer to the long-term social discount

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[9] Any user who would build another base scenario could reproduce this approach.

[10] The initial period is a past period, over which the model has no freedom, and for which the quantities of interest are fixed at their historical values.

rate, and discount rates in other industries (between 7.5 and 13.7%) are intermediate between those of the electricity sector and of other end-use sectors.

GDP and all costs and prices are expressed in US dollars of 2000, calculated at *market exchange rates* (MER) in each region. Measuring economic growth and costs in terms of MER is a widely accepted methodology, while the purchasing power parity approach (PPP) is a preferred measure for assessing differences in economic welfare across different regions (Nakicenovic et al., 2003). Moreover, international trading of energy commodities and/or of carbon permits take place at MER, so that outputs need to be measured in MER for consistency (Nordhaus and Boyer, 1999).

Investment, variable and fixed annual costs of technologies vary across regions in order to reflect differences of labor costs and productivity, land costs, project boundaries (for example, a new power plant may require the building of a road and new power lines in developing countries). Fixed and variable costs are lower in developing regions compared to industrialized regions, while investment costs of all regions except China and India are higher than those of United States (Table 12).

4.2 End-use

Population and GDP projections are two of the three main driving forces[11] of future energy and GHG emissions (Nakicenovic, 2000; European Commission, 2003). The 42 energy service demands categories (Table 13) of MARKAL depend on these projections. They are based on the AIM-A1B scenario. Moreover, the choice of appropriate sensitivity of service demands to these drivers helps to increase or decrease future service demands and then influence total energy consumed by each region if needed for calibration purposes. Resulting service demands per sector are provided in Table 14.

Description of end-use technologies is provided only for transportation sector (Table 17 and Table 18), because technology analysis will not focus on residential and commercial sectors, as their contribution to mitigation strategies is limited.

The *rate of penetration* of new technologies and the rate of change of the fuel proportions at end-use level may be exogenously controlled to reflect non-economic decisions or to reproduce certain behavioral characteristics of observed markets. Indeed, Linear Programming may result in choosing the cheapest resource/technology up to its limit before any other competing alternative is used on the same market. It would then be possible for a single technology to capture the entire market while it is more generally observed that end-users' technological choices result in a market split between several technologies, for a variety of reasons, including individual preferences other than pure financial costs. Note that these constraints are progressively relaxed at future periods. These technology and fuels constraints were adjusted in industrial and residential/commercial sectors in order to accelerate gas and

[11] Technology is the third driving force.

electricity penetration and then calibrate to the rapid introduction of new and more efficient technologies of the A1B scenario. For the same reason, the lower levels of the shares of gas, hydrogen and electricity in final transportation fuels were also adjusted. These constraints are not provided here – except for transportation sector (Table 19) – because their reproduction in a friendly format would require a lot of space. They are available upon request. Moreover, in order to reflect real technical and behavior constraints, biomass in transportation is limited to 40% of energy consumption by the sector.

MARKAL assumes that each demand has a constant *own price elasticity* in a given time period, and that cross price elasticities are null (see Section 2.4). The elasticities are higher for developing countries and countries in transition, in line with the observations (Table 15).

4.3 Resources and international trade

Oil, gas and coal resources are quantified for each region, and are classified as OPEC or non-OPEC where relevant (Table 20 and Table 21). They cover located reserves (remaining resource volume), reserve growth and new discovery for conventional oil, mined oil sands, ultra heavy oil, shale oil, natural gas, hard coal, and brown coal. Unconventional and unconnected gas resources are also available. Costs of reserves and extraction technologies reflect the actual increase of extraction cost with the cumulative level of extraction. Data were obtained from the database of the base case of the SAGE model developed in collaboration with the Energy Information Administration of the US Department of Energy (EIA, Summer 2003). At the world level, the reserves of unconventional and unconnected gas and coal reserves are lower than those provided by the IPCC-TAR (Moomaw and Moreira, 2001) (Table 22). Other reserves are close to the IPCC-TAR data.

The international trade of natural gas, liquefied gas and coal is endogenously modeled. In other words, the amount and price of commodity traded is endogenously computed based on reserves availability, resource costs, technical limit on the development of new extraction projects, and of course demands. This means that the international or regional markets of coal and gas are assumed to be competitive. Electricity is not traded at international level, except between USA and CAN, where exchanges are fixed, by default, at their 2000 values.

In contrast, *the international trade of crude oil and refined petroleum products* (prices and quantities) is exogenously modeled as one world market. This is to reflect the non-competitive market for oil. Since the early 1970's, OPEC has acted as a cartel that periodically fixes its production level, leaving the other producers (Non OPEC) produce the remaining part of the world demand. By so doing, OPEC is able to maintain oil prices that are higher than what they would be in a completely competitive market. In this research, we approximated this situation in a simplified manner as follows: Each region is free to import any amount of crude oil and/or refined petroleum product at a fixed exogenous price. Exports are then adjusted *ex-post* to balance imports at the world level[12]. This requires at least two successive runs of the model. The exogenous oil price trajectory was chosen according to forecasts by a number of institutions, resulting in annual price growths of 0.6% for crude oil and of 0.4% for refined products. The scenarios provided by the National Energy Board (2003), the reference case of the IEO2003 (Energy Information Administration, 2003c) and the scenario "Awash in oil and gas" of the Pew Center (Mintzer et al*.,* 2003) consider a similar assumption. WETO2003 considers an annual increase of oil price around 1.6% between 2000 and 2050 (European Commission, 2003).

Primary biomass covers solid biomass, landfill gas, liquids from biomass, energy crops, industrial and municipal wastes. Resource availability in each region are deducted from data provided by Food and Agriculture Organization (Trudel, 2004). They are lower than the potentials provided by the IPCC-TAR (Moomaw and Moreira, 2001) (Table 23), which do not consider all practical/technical constraints on the use of land for bioenergy such as the distance of a biomass production site from demand centres or the land-use conflicts. It must be noted that biomass was not fully calibrated to the AIM-A1B scenario for two reasons. First, detailed information was missing to properly understand the links between primary biomass and final liquid, solid and gas energy as provided by IPCC. Second, the contribution of biomass to world energy supply is difficult to model properly because the substitution links with the other fuels have hardly been explored and if so, only in rare field studies (European Commission, 2003). Therefore, statistics on biomass often show very contrasted profiles.

4.4 Electricity generation

Power plants technical-economic data have been reviewed to reflect the literature (European Commission, 2003; Kainuma et al*.,* 2003) and expert knowledge (MARKAL-Canada developed by the authors; SAGE model developed by the authors in collaboration with the Energy International Administration; Dolf Gielen, International Energy Agency). Available power plants cover technologies such as conventional pulverized coal, integrated coal-gasification combined cycle (IGCC), combined cycle gas turbine (CCGT), diesel plants, fuel cells, biomass plants, wind, solar, etc. (Table 25).

Co-firing power plants are available for both coal and gas fired plants. Co-combustion of biomass is kept below 15% and 10% of the coal and gas input, respectively.

The base cases do not take into account *specific energy or environment policies* beyond what is already embodied in investments actually made or regulation actually enforced by law. For example, the high levels of generation of electricity from nuclear plants provided by the AIM-A1B scenario indicate that the phase-out of nuclear planned for the future in some regions is not part of the scenario. However, the high levels of renewables in electricity generation, especially in the short term, assume that policies promoting renewables will be implemented, such as the European Renewables Directive, which has set national targets for the renewable

[12] It was important to balance exports and imports to insure, among other reasons, that GHG emissions from oil extraction are not distorted.

electricity generation so that the overall target reaches 22.1% of the electricity generated in 2010. This target is almost respected in the BAU-A1B (20.6%). Also, we limited coal use in the electricity sector of the two base cases to reflect actual regulations on local air quality.

Each form of *renewable energy* (geothermal, hydroelectricity, wind) is characterized by its own potential, based on the literature (Table 24). The minimal level of total renewable electricity generation (sum of geothermal, hydroelectricity, wind, and solar electricity) is also exogenously controlled in order to reflect the high levels of renewable energy proposed by AIM-A1B scenario and in the alternate base case (Table 9).

The *installed capacity of nuclear power plants* is exogenously fixed at the level provided by the AIM-A1B scenario or by the alternate base case (Table 8), reflecting the fact that the decision to invest or not in nuclear plants in mainly motivated by non-economic factors.

4.5 Hydrogen generation

Hydrogen can be generated by electrolysis of water, reforming of natural gas and partial oxydation of coal, with and without CO_2 capture (Table 28). The cost of hydrogen distribution is assumed to be 2$/GJ. International trade of hydrogen is not included and deserves more attention in future work.

Hydrogen can be consumed either as a pure commodity in the transportation sector (fuel cells) or in a mix with natural gas (respectively 15%-85%) in the industry and residential/commercial sectors.

4.6 Zero-emission-technologies and carbon sinks

Because of its impact on the cost of mitigation carbon, sequestration of carbon is included. It includes: *capture*, which may occur at power plants (IGCC, pulverized coal, NGCC, solid oxide fuel cell SOFC) and/or hydrogen plants[13]; *storage* (oil/gas fields, coalbed methane recovery, aquifers, deep ocean, mineralization) and *transportation* between capture and storage. Sequestration by forests is also available (no capture is needed in this case). It includes four price categories of carbon uptake and has been adjusted to reflect the Bonn and Marrakech agreements for AUS, CAN, EEU, FSU, JPN, USA, WEU, assuming that the agreements are valid for the whole 2000-2050 horizon, while 10% of the annual available potential is used for the other regions. Capture at industry level (iron and steel, ammonia production, cement production) or in the oil extraction sector, is not included in this version of the model (note that, although some options are inexpensive, the potential is rather limited).

Table 29 presents the storage potentials of the sequestration options at the world level. They are provided by the International Energy Agency (Dolf Gielen, private communication).

[13] The price of electricity generated by power plants with CO_2 capture is considered to be 50% higher than the electricity price generated by power plants without capture (Moomaw and Moreira, 2001).

They are similar to data from Kauppi and Sedjo (2001) and Herzog et al. (1997). (Table 30). Table 31 to Table 35 provide details about potentials and costs of sequestration options. Table 27 describes power plants with CO_2 capture. Potentials, costs and social acceptability of CO_2 sequestration are still uncertain and may constitute barriers to wide implementation of these options (Kauppi and Sedjo, 2001).

The regions with the largest potential of sequestration by forests are AFR, CSA, FSU and ODA. The regions with the largest underground reservoirs are AFR, CAN, CSA, FSU, MEA, ODA and USA.

5 Conclusion

It is useful to distinguish between a model's structure and a particular application. The model's structure does not change from one implementation to another, wheras the inputs of he model vary from application to application. The version of the World MARKAL model presented here was calibrated to the scenario A1B of the IPCC. It has been used to analyze CO_2 abatement options under cooperative and non-cooperative frameworks in Labriet et al. (2004) and Labriet and Loulou (2004).

Other versions of the model have been developped by the same team of researchers through a collaboration with the US Department of Energy's Energy Information Administration and with the International Energy Agency. More recently, the MARKAL model has migrated to the newly developed TIMES model (The Integrated MARKAL EFOM System), which was used in the EFDA (European Fusion Development Agreement) project, and will be used in the NEEDS project (New Energy Externalities Developments for Sustainability).

The reader may find more details about the model's structure in Energy Information Administration (2003a, b) and in Loulou et al. (2004). A complete documentation of the MARKAL model generator is available at http://www.etsap.org.

References

Berger, C., R. Dubois, A. Haurie, E. Lessard, R. Loulou, and J.-P. Waaub. 1992. Canadian MARKAL: An Advanced Linear Programming System for Energy and Environmental Modelling. *INFOR*, 30(3), 222-239.

Bollen, J.C, T. Manders and H. Timmer. 2000. The benefits and costs of waiting, early action versus delayed response in the post-SRES stabilization scenarios. *Environmental Economics and Policy Studies*, 3(2), 143-158.

Center for International Earth Science Information Network. 2002a. *Country-level Population and Downscaled Projections for the SRES A1 Scenario, 1990-2100, beta version*. Palisades, NY: CIESIN, Columbia University. http://sres.ciesin.columbia.edu/tgcia/.

Center for International Earth Science Information Network, 2002b. *Country-level GDP and downscaled projections for the SRES A1, A2, B1, and B2 marker scenarios, 1990-2100, beta version*. Palisades, NY: CIESIN, Columbia University. http://sres.ciesin.columbia.edu/tgcia/.

Energy Information Administration. 2003a. *System for the Analysis of Global Energy Markets (SAGE) – Vol.1 – Model Documentation*. Office of Integrated Analysis and Forecasting. Washington, DC: U.S. Department of Energy. http://www.eia.doe.gov/bookshelf/docs.html.

Energy Information Administration. 2003b. *System for the Analysis of Global Energy Markets (SAGE) – Vol.2 – Data Implementation Guide*. Office of Integrated Analysis and Forecasting.Washington, DC: U.S. Department of Energy. http://www.eia.doe.gov/bookshelf/docs.html.

Energy Information Administration. 2003c. *International Energy Outlook 2003*. Office of Integrated Analysis and Forecasting, U.S. Department of Energy. Washington DC: Energy Information Administration. http://www.eia.doe.gov/oiaf/ieo/download.html.

European Commission. 2003. World Energy, Technology and Climate Policy Outlook 2030 – WETO. Directorate General for Research, Energy. Brussels: European Commission, p.137.

Fishbone, L.G. and H. Abilock. 1981. MARKAL, A Linear Programming Model for Energy Systems Analysis: Technical Description of the BNL Version. *International Journal of Energy Research*, 5, 353-375.

Herzog, H., Drake E. and E. Adams. 1997. *CO2 Capture, Reuse, and Storage Technologies for Mitigating Global Climate Change*. Cambridge (MA): Energy Laboratory Massachusetts Institute of Technology. 66 p.

Holtsmark, B. and K. H. Alfsen. 2004. *On the question of PPP corrections to the SRES scenarios*. Policy Note 2004:01. Oslo (Norway): Center for International Climate and Environmental Research, p.11.

Hourcade, J-C (coord.). 1996. Estimating the Costs of Mitigating Greenhouse Gases. In Bruce, J. P., H. Lee and E. F. Haites, *Climate change 1995 : Economical and social dimensions of climate change.* Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change, 263-296. Cambridge (UK): Cambridge University Press.

Hourcade, J-C and P. Shukla. 2001. Global, Regional, and National Costs and Ancillary Benefits of Mitigation. In *Climate Change 2001: Mitigation*, ed. By Metz, B., Davidson, O., Swart, R. and J. Pan, Intergovernmental Panel on Climate Change, Third Assessment Report, Working Group III, 499-559. Cambridge: Cambridge University Press.

International Energy Agency. 1998. *Mapping the Energy Future. Energy Modelling and Climate Change Policy.* Policy Analysis Series, Organisation for Economic Co-operation and Development, Paris (France), p.83.

International Energy Agency. 2001a. *Energy Statistics and Balances of Non-OECD Countries*. Database on CD. Paris (France): IEA Publications.

International Energy Agency. 2001b. *Energy Statistics and Balances of OECD Countries*. Database on CD. Paris (France): IEA Publications.

Kainuma, M., Matsuoka, Y and T. Morita, (ed). 2003. *Climate policy assessment : Asia-Pacific integrated modeling*. Tokyo, New York : Springer, p.402.

Kanudia, A., and R. Loulou. 1998. Robust Responses to Climate Change via Stochastic MARKAL: the case of Québec. *European Journal of Operations Research*, 106, 15-30.

Kauppi, P. and R. Sedjo. 2001. Technological and Economic Potential of Options to Enhance, Maintain, and Manage Biological Carbon Reservoirs and Geo-engineering. In *Climate Change 2001: Mitigation*, edited by Metz, B., Davidson, O., Swart, R. and J. Pan, Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report, Working Group III, 301-343. Cambridge: Cambridge University Press.

Labriet M. and R. Loulou. 2004. From non-cooperative CO2 abatement strategies to the optimal world cooperation: results from the Integrated MARKAL model. *The Energy Journal*, submitted.

Labriet, M. and R. Loulou. 2003. Coupling climate damages and GHG abatement costs in a linear programming framework. *Environmental Modeling and Assessmen*, 8, 261-274.

Labriet, M., R. Loulou and A. Kanudia. 2004. Global energy and CO_2 emission scenarios: analysis with a 15-region world MARKAL model. In *The Coupling of Climate and Economic Dynamics*, A. Haurie and L. Viguier (Guest Editors), Advances to Global Change Research, in press. Dordrecht (Netherlands): Kluwer Academic Publishers.

Loulou, R., G. Goldstein and K. Noble. 2004. *Documentation for the MARKAL Family of Models.* Energy Technology Systems Analysis Programme. http://www.etsap.org/ documentation.asp.

Loulou, R. and A. Kanudia. 2001. Using Advanced Technology-rich models for Regional and Global Economic Analysis of GHG Mitigation. In *Decision and Control: Essays in honor of Alain Haurie,* G. Zaccour (ed.), Book Series Advances in Computational Management Science, 153-175. Boston (MA): Kluwer Academic Publishers.

Loulou, R., and A. Kanudia. 1999. Minimax Regret Strategies for Greenhouse Gas Abatement: Methodology and Application. *Operations Research Letters,* 25, 219-230.

Loulou, R. and A. Kanudia. 1999. The Kyoto Protocol, Inter-Provincial Cooperation, and Energy Trading : a Systems Analysis with integrated MARKAL Models. *Energy Studies Review*, 9(1), 1-23.

Loulou, R., P.R. Shukla and A. Kanudia. 1997. *Energy and Environment Policies for a Sustainable Future.* New Dehli (Inde): Allied Publishers Ltd, p.159.

Morita, T. and J. Robinson. 2001. Greenhouse Gas Emissions Mitigation Scenarios and Implications. In *Climate Change 2001: Mitigation*, edited by Metz, B., Davidson, O., Swart, R. and J. Pan, Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report, Working Group III, 115-166. Cambridge: Cambridge University Press.

Moomaw, W.R. and J.R. Moreira. 2001. Technological and Economic Potential of Greenhouse Greenhouse Gas Emissions Reduction. In *Climate Change 2001: Mitigation*, edited by Metz, B., Davidson, O., Swart, R. and J. Pan, Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report, Working Group III, 167-299. Cambridge: Cambridge University Press.

Mintzer, I., Leonard, J.A. and P. Schwartz. 2003. *US Energy Scenarios for the 21st Century*. Prepared for the Pew Center on Global Climate Change. Airlington (VA): Pew Center on Global Climate Change, p.88.

Nakicenovic, N. (ed.). 2000. *Special Report on Emissions Scenarios. A Special Report of Working III of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, p.599.

Nakicenovic, N., Grübler, A. and A. McDonald (ed.). 1998. *Global Energy Perspectives*. Cambridge: Cambridge University Press, p.299.

Nakicenovic, N., Grübler A., Gaffin S., Jung T.T., Kram T., Morita T., Pitcher H., Riahi K., Schlesinger M., Shukla P.R., Vuuren D., Davis G., Michaelis L., Swart R. and N. Victor. 2003. *IPCC SRES Revisited: A Response*. Energy and Environment, 14(2-3), 187-214.

Nakicenovic, N. and K. Riahi. 2002. *An Assessment of Technological Change Across Selected Energy Scenario*s. Report RR-02-005. Laxenburg (Austria): International Institute for Applied Systems Analysis, p.138.

National Energy Board. 2003. *Canada's Energy Future. Scenarios for Supply and Demand to 2025*. Calgary (Canada): NEB Publications, p.92.

Nordhaus, W. D. and J. Boyer. 1999. *Roll the DICE Again: Economic Models of Global Warming.* Yale University, manuscript edition.

Riahi, K. and R.A. Roehrl. 2000. Energy technology strategies for carbon dioxide mitigation and sustainable development. *Environmental Economics and Policy Studies*, 3(2), 89-123.

Samuelson, 1952. Spatial Price Equilibrium and Linear Programming. *American Economic Review*, 42(2), 283-303.

Trudel, S. 2004 (to be published). *Évaluation des potentiels disponibles d'énergie renouvelable: Approche MARKAL.* Mémoire présenté comme exigence partielle pour l'obtention de la Maîtrise en Sciences de l'environnement. Montréal (Canada): Université du Québec à Montréal.

World Energy Council. 2001. *Survey of Energy Resources*. London: WEC. http://www.worldenergy.org/wec-geis/publications/reports/ser/overview.asp.

Weyant J.P. (ed.). 1999. The Costs of the Kyoto Protocol: a Multi-Model Evaluation. Special Issue of the *Energy Journal*, 398 p.

Appendix A – A Simplified Mathematical Formulation of the MARKAL MODEL

An optimization problem formulation consists of three types of entities:

- *The decision variables:* i.e. the unknowns, to be determined by the optimization,
- *The objective function*: expressing the criterion to minimize or maximize, and
- *The constraints*: equations or inequations involving the decision variables, that must be satisfied by the optimal solution.

The description of the objective function and constraints may be translated into a formal set of mathematical expressions. The appendix presents a streamlined formulation of the equations, which ignores exceptions and some complexities that are not essential to a basic understanding of the principles of the model. It is based on Loulou et al. (2004). Fishbone and Abilock (1981) and Berger et al. (1992) describe earlier incarnations of MARKAL. Among others, Loulou and Kanudia (1999, 2001), Kanudia and Loulou (1998) and Loulou et al. (1997) illustrate applications of different versions of MARKAL model.

The model variables and equations use the following indexes:

r,r': indicates the region (omitted when a single region is modeled);

t: time period;

k: technology;

s: time-slice;

c: commodity (energy or material);

l: price level (used only for multiple sources of the same commodity distinguished only by their unit cost)

A.1 Decision variables

The various kinds of decision variables in a MARKAL model are elaborated here.

INV(r,t,k): new capacity addition for technology *k*, in period *t*, in region *r*. Typical units are PJ/year for most energy technologies, Million tonnes per year (for steel, aluminum, and paper industries), Billion vehicle-kilometers per year (B-vkms/year) for road vehicles and GW for electricity equipment (1GW=31.536 PJ/year). Note that an investment made in period *t* is assumed to occur at the beginning of that period, and remains available until the end of its lifetime. Note that the life of a technology may be a fractional multiple of the period length.

CAP(r,t,k): installed capacity of technology *k*, in period *t*, in region *r.* Typical units: same as for investments.

ACT(r,t,k,s): activity level of technology *k*, in period *t*, in region *r*, during time-slice *s*. Typical units: PJ per year for all energy technologies. *ACT* variables are not defined for end-use technologies, for which it is assumed that activity is always equal to available capacity. With the exception of the conversion technologies, only annual activity is tracked (and the *s* index dropped).

MIN(r,t,c,l): quantity of commodity *c* (PJ per year) extracted in region *r* at price level *l* in period *t*; the coefficient in the objective function is the unit cost of extracting the commodity, as provided by the user. These are domestic production resources, including physical renewables (such as biomass and municipal solid waste).

IMPORT(r,t,c,l), EXPORT(r,t,c,l): quantity of commodity *c*, price level *l,* (PJ per year) exogenously imported or exported by region *r* in period *t*. It is important to note that the model does not automatically balance the quantities exported and imported. In a global model, these quantities must be controlled by the user, if need be. These variables are convenient whenever endogenous trade is not being contemplated. For example, a single region MARKAL model, or one comprising the 3 regions of North America, would have to treat the imports and exports of oil to North America as exogenous; the coefficient of the import or export variable in the objective function is the unit price of importing or exporting the commodity, provided by the user. Note carefully that these variables may become unnecessary in a global model where all commodities are endogenously traded and priced (see *TRADE* variables below).

TRADE(r,t,c,s,imp) and TRADE(r,t,c,s,exp): quantity of commodity *c* (PJ per year) sold (*exp*) or purchased (*imp*) by region *r* to/from all other regions in period *t,* for time-slice *s* (for electricity). This variable represents *endogenous* trade between regions. Trade of any given commodity is balanced by the model in each period, i.e. the algebraic sum of trade variables (possibly multiplied by a loss factor) over all trading regions is equal to 0. Note also that endogenous trade is classified either as *global* or as *bi-lateral*. In the first case, a commodity that exists under the same name in some or all regions is 'put on the market' and may be bought by any other region. This case is convenient for global commodities such as emission permits or crude oil. In the other case (bi-lateral trade), a pair of regions is first identified, and trade must be balanced between these two regions. In both cases, MARKAL allows the modeler to charge transaction costs (or transportation costs) to quantities exported and imported.

D(r,t,d): demand for end-use *d* in region *r*, in period *t*. In non-reference runs, *D(r,t,d)* may differ from the reference case demand for *d*, due to the responsiveness of demands to their own prices (based on each service demand's own-price elasticity).

ENV(r,t,p): Emission of pollutant *p* in period *t* in region *r*.

Remark: Note that most commodities are not represented by formal variables in MARKAL (except imported or exported commodities, emissions, and demands, that have their own variables). Instead, the quantity of each commodity produced or consumed is represented in MARKAL as an expression involving the activities of technologies that produce or consume that commodity. This modeling design choice was made in order to keep the model as parsimonious as possible in the number of variables.

A.2 Objective function

The objective function of MARKAL is the sum over all regions of the discounted present value of the stream of annual costs incurred in each year of the horizon (equation A1). The MARKAL objective is to minimize the total cost of the system, adequately discounted over the planning horizon.

$$NPV = \sum_{r=1}^{R} \sum_{t=1}^{t=NPER} (1+d)^{1-t} \times ANNCOST(r,t) \times \left(1+(1+d)^{-1}+(1+d)^{-2}+\cdots+(1+d)^{1-NYRS}\right) \quad \text{(A1)}$$

with *NPV:* the net present value of the total cost for all regions (obj-function)

ANNCOST(r,t): the annual cost in region *r* for period *t*

d: the general discount rate

NPER: the number of periods in the planning horizon

NYRS: the number of years in each period *t*

R: the number or regions

The total annual cost *ANNCOST(r,t)* is the sum over all technologies *k*, all demand segments *d*, all pollutants *p*, and all input fuels *f,* of the various costs incurred, namely: annualized investments, annual operating costs (including fixed and variable technology costs, fuel delivery costs, costs of extracting and importing energy carriers), minus revenue from exported energy carriers, plus taxes on emissions, plus cost of demand losses.

In each period, the investment costs are first annualized, before being added to the other costs (which are all annual costs) to obtain the annual cost in each period. MARKAL then computes a total net present value of all annual costs, discounted to a user selected reference year.

A.3 Constraints

While minimizing total discounted cost, the MARKAL model must obey a large number of constraints (the so-called *equations* of the model) which express the physical and logical relationships that must be satisfied in order to properly depict the associated energy system. MARKAL constraints are of several kinds. This section lists and briefly discusses the main groups of constraints. If any constraint is not satisfied the model is said to be infeasible, a condition caused by a data error or an over-specification of some requirement.

Satisfaction of demands: For each time period *t*, region *r*, demand *d*, the total activity of end-use technologies servicing a demand must be at least equal to the specified demand.

$$\sum_k CAP(r,t,k) \geq DEMAND(r,t,d) \tag{A2}$$

with *k* end-use technologies such that *k* supplies service demand *d*

Capacity transfer from one period to the next: For each technology *k*, region *r*, period *t,* the available capacity in period *t* is equal to the sum of investments made by the model at past and current periods, and whose physical life has not ended yet, plus capacity in place prior to the modeling horizon and still in place. Investing in a particular technology increases its installed capacity for the duration of the physical life of the technology. At the end of that life, the total capacity for this technology is decreased by the same amount (unless some other investment is decided by the model at that time). However, the model is not forced to use all of the available capacity (see Use of capacity below).

$$CAP(r,t,k) = \sum_{t',t-t'<LIFE(k)} INV(r,t',k) + RESID(r,t,k) \tag{A3}$$

with *RESID(r,t,k)* the capacity of technology *k* due to investments that were made prior to the initial model period and still exist in region *r* at time *t*.

Use of capacity: For each technology *k*, period *t*, region *r*, and time-slice *s*, the activity of the technology may not exceed its available capacity, as specified by a user defined availability factor, except end-use technologies for which activity is assumed to be directly proportional to their installed capacities. For non-conversion technologies only annual availability is tracked, so the *s* index is dropped. In each time period, the model may use some or all of the installed capacity in that period according to the availability factor of that technology. In other words, some capacity may be inactive at some time periods. This will of course occur only if such a decision contributes to minimizing the overall cost.

$$ACT(r,t,k,s) \leq AF(r,t,k,s) \times CAPUNIT \times CAP(r,t,k) \tag{A4}$$

with *CAPUNIT(r,t,k)* the unit conversion between units of capacity and activity

Energy-carrier balance: For each commodity *c,* time period *t*, region *r*, (and time-slice *s* in the case of electricity and low-temperature heat), the disposition of commodity may not exceed its supply. The disposition includes consumption in the region (including grid losses in the case of electricity) plus exports; the supply includes production in the region plus imports.

$$\sum_k OUT(r,t,k,c) \times ACT(r,k,s,c) + \sum_l MIN(r,t,c,l) + \sum_l FR(s) \times IMP(r,t,c,l) +$$

$$+ XCVT(C,i) \times TRADE(r,t,c,s,i) \geq$$

$$\sum_k INP(r,t,k,c) \times ACT(r,k,s,c) + \sum_l FR(s) \times EXP(r,t,c,l) + XCVT(c,o) \times TRADE(r,t,c,s,e) \tag{A5}$$

with *INP(r,t,k,c)* the amount of commodity *c* required to operate one unit of technology *k,* in region *r* and period *t*

OUT(r,t,k,c) the amount of commodity *c* produced per unit of technology *k*

FR(s) the fraction of the year covered by time-slice *s* (equal to 1 for non-seasonal commodities)

XCVT(c,i) transaction or transport costs of importing one unit of *c*

XCVT(c,o) transaction or transport costs of exporting one unit of *c*

Remark: the constraint is = for materials.

Peak Load electricity reserve: For each time period *t* and for region *r*, there must be enough installed capacity to exceed the required capacity in the season with largest electricity (heat) commodity *c* demanded by a safety factor called the *peak reserve factor*. This factor is chosen to insure against possible electricity shortfalls due to uncertainties regarding electricity supply that may decrease capacity in an unpredictable way (e.g. water availability in a reservoir, or unplanned equipment down time). Each power plant's capacity may participate to the fulfillment of this constraint to some degree, depending upon the fraction of time the plant runs at peak hour. The peaking time slice is defined as the time slice when load is heaviest (it may be Winter Day in cold countries, Summer Day in warm countries, etc.).

$$\sum_k CAPUNIT \times PEAK(r,t,k,c) \times FR(s) \times CAP(r,t,k) + XCVT(c,i) \times TRADE(r,t,c,s,i) +$$

$$FR(s) \times IMPORT(r,t,c) \geq$$

$$[1 + ERESERVE(r,t,c)] \times \sum_k INP(r,t,k,c) \times FR(s) \times ACT(r,t,k,s)$$

$$+ XCVT(c,o) \times TRADE(r,t,c,s,e) + FR(s) \times EXP(r,t,c) \qquad \text{(A6)}$$

with *ERESERVE(r,t,c)* the region-specific reserve coefficient, which allows for unexpected down time of equipment, for demand at peak, and for uncertain hydroelectric, solar, or wind availability.

Peak(r,t,k,c) (never larger than 1) specifies the fraction of technology *k*'s capacity in a region *r* for a period *t* and commodity *c* (electricity or heat only) that is allowed to contribute to the peak load.

Many types of generating equipment are predictably available during peak load and thus have a peak coefficient equal to unity, whereas others such as wind turbines or solar plants are attributed a peak coefficient less than 1 since they are on average only fractionally available at peak. Note also that in the peak equation, it is assumed that imports of electricity are contributing to the peak of the importing region (exports are of the *firm power* type).

Base Load (electricity generation only): For electricity c, in region r and period t, electricity generating technologies that are labeled as base load must produce the same amount of electricity at night as in the day. They may, however, vary their production from season to season. Therefore, for base load technologies, there are only three *ACT* variables (one per season) instead of 6 for other electric generation technologies (season+day/night). The base load constraint ensures that only a maximum percentage of the total night-time demand for electricity is met by such base load plants.

The user may identify which technologies should be considered as base load technologies by MARKAL; i.e. those whose operation must not fluctuate from day to night in a given season. The user may also specify the maximum fraction of night production that may be supplied from all base load technologies. Typically, nuclear plants and solid fuel plants are included in the Base load set, since they require considerable delays to be shut down or restarted.

$$\sum_{k} INP(r,t,k,c) \times BASELOAD(r,t,c) \times ACT(r,t,k,'N') \geq \sum_{k'} OUT(r,t,k,c) \times ACT(r,t,k,'N') \qquad \text{(A7)}$$

with k the baseload technologies consuming electricity c at night

k' the baseload technologies producing electricity c at night

Baseload(r,t,c) the maximum share of the night demand for electricity c in region r and period t.

Seasonal availability factors (electricity sector only): The user may specify seasonal and even day-night limitations on the use of the installed capacity of equipment. This is especially needed when the operation of the equipment depends on the availability of a resource that cannot be stored, such as Wind and Sun, or that can be partially stored, such as water in a reservoir.

Emission constraints: In each region r, for each time period t, this constraint ensures that the total emission of pollutant p will not be greater than a user-selected upper bound, if such is provided. In MARKAL, pollutants may be emitted when a technology is active, but also when it is inactive (for example a hydro reservoir may emit methane even if no electricity is being produced). Emissions may also occur at the time of construction of the technology, in some instances. In each of these three cases, the emission coefficient is applied to the activity variable, to the capacity variable, or to the investment variable, respectively. This flexibility allows the accurate representation of various kinds of emissions. Technologies may also sequester or otherwise remove emissions as well via the use of a negative emission coefficient. The user may impose on the whole system upper limits on emissions of one or more pollutants. The limits may be set at each time period separately, so as to simulate a particular emission profile (also called emission target), or in a cumulative manner over the whole planning horizon. Emission caps may be set globally for all regions, or for a group of regions, or by sector, etc. Instead of an emission limit, the user may also specify an emission tax *Etax(r,t,p)*. If so, the quantity *ENV(r,t,p) * E tax(r,t,p)* is added to the *ANNCOST* expression, penalizing emissions at a constant rate.

$$ENV(r,t,p) =$$

$$\sum_k \left[EMINV(r,t,p,k) \times INV(r,t,k) + EMCAP(r,t,p) \times CAP(r,t,k) + EMACT(r,t,p,k) \times \sum_s ACT(r,t,k,s) \right]$$

and

$$ENV(r,t,p) \leq ENV\_LIMIT(r,t,p) \qquad \text{(A8)}$$

with *EMINV, EMCAP, EMACT* emission coefficients for pollutant *p* (possibly negative) linked respectively to the construction, the capacity, and the operation of a technology

ENV_LIMIT(r,t,p) the upper limit set by the user on the total emission of pollutant *p* in region *r* at period *t.*

Other constraints: In addition to the standard MARKAL constraints discussed above, the user interested in developing reference case projections of energy market behavior typically introduces many additional linear constraints to express special conditions. User defined constraints may serve many functions in MARKAL. Their general purpose is to constrain the optimization problem in some way to account for factors based either on policy or on market behavior that affect investment decisions. For example, there may a user defined constraint limiting investment in new nuclear capacity (regardless of the type of reactor), or dictating that a certain percentage of new electricity generation capacity must be powered by renewable energy sources.

References

Berger, C., R. Dubois, A. Haurie, E. Lessard, R. Loulou, and J.-P. Waaub. 1992. *Canadian MARKAL: An Advanced Linear Programming System for Energy and Environmental Modelling*. INFOR, 30(3), 222-239.

Fishbone, L.G. and H. Abilock. 1981. MARKAL, A Linear Programming Model for Energy Systems Analysis: Technical Description of the BNL Version. *International Journal of Energy Research*, 5, 353-375.

Kanudia, A., and R. Loulou. 1998. Robust Responses to Climate Change via Stochastic MARKAL: the case of Québec. *European Journal of Operations Research*, 106, 15-30.

Loulou, R., G. Goldstein and K. Noble. 2004. *Documentation for the MARKAL Family of Models.* Energy Technology Systems Analysis Programme. http://www.etsap.org/documentation.asp.

Loulou, R. and A. Kanudia. 2001. Using Advanced Technology-rich models for Regional and Global Economic Analysis of GHG Mitigation. In *Decision and Control: Essays in honor of Alain Haurie,* G. Zaccour (ed.), Book Series Advances in Computational Management Science, 153-175. Boston (MA): Kluwer Academic Publishers.

Loulou, R., and A. Kanudia. 1999. Minimax Regret Strategies for Greenhouse Gas Abatement: Methodology and Application. *Operations Research Letters,* 25, 219-230.

Loulou, R., Shukla, P.R. and A. Kanudia. 1997. *Energy and Environment Policies for a Sustainable Future*. New Dehli (Inde): Allied Publishers Ltd, p.159.

Appendix B – MARKAL Modeling

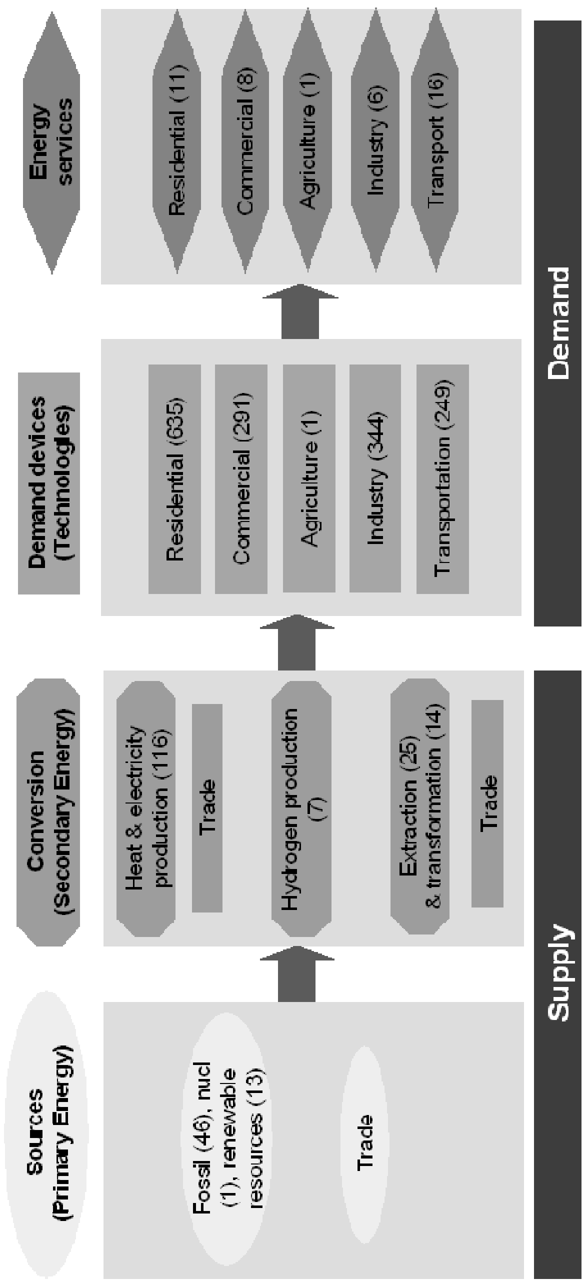


Figure 1: The General Reference Energy System

Table 1: List of the 15 regions

Code	Region	Aggregated Region
AFR	Africa	DC (Developing Countries)
AUS	Australia-New Zealand	OECD (Organisation for Economic Co-operation and Development)
CAN	Canada	OECD
CSA	Central and South America	DC
CHI	China	ASIA
EEU	Eastern Europe	FSU+EE (Former Soviet Union + Eastern Europe)
FSU	Former Soviet Union	FSU+EE
IND	India	ASIA
JPN	Japan	OECD
MEX	Mexico	DC
MEA	Middle-East	DC
ODA	Other Developing Asia	ASIA
SKO	South Korea	ASIA
USA	United States	OECD
WEU	Western Europe	OECD

Table 2: Description of regions

Regions based on individual countries	Africa (AFR)	Central and South America (CSA)	Eastern Europe (EEU)	Former Soviet Union (FSU)	Middle East (MEA)	Other Developing Asia (ODA)	Western Europe (WEU)
Canada (CAN)	Algeria	Argentina	Albania	Armenia	Bahrain	Bangladesh	Austria
United States (USA)	Angola	Bolivia	Bosnia-Herzeg.	Azerbaijan	Cyprus	Brunei	Belgium
Mexico (MEX)	Benin	Brazil	Bulgaria	Belarus	Iran	Chin. Taipei	Denmark
India (IND)	Cameroon	Chile	Croatia	Estonia	Iraq	Indonesia	Finland
China (CHI)	Congo B	Colombia	Czech Rep	Georgia	Israel	North Korea	France[a]
Japan (JPN)	Congo Rep K	Costa Rica	Hungary	Kazakhstan	Jordan	Malaysia	Germany
Australia-NZ (AUS)	Cote d'Ivoire	Cuba	Macedonia	Kyrgyzstan	Kuwait	Myanmar	Gibraltar
South Korea (SKO)	Egypt	Dominican Rep	Poland	Latvia	Lebanon	Nepal	Greece
	Ethiopia	Ecuador	Romania	Lithuania	Oman	Other Asia[e]	Greenland
	Gabon	El Salvador	Slovakia	Moldova	Qatar	Pakistan	Iceland
	Ghana	Guatemala	Slovenia	Russia	Saudi Arabia	Philippines	Ireland
	Kenya	Haiti	Yugoslavia	Tajikistan	Syria	Singapore	Italy[b]
	Libya	Honduras		Turkmenistan	Turkey	Sri Lanka	Luxembourg
	Morocco	Jamaica		Ukraine	Uni Arab Emirates	Thailand	Malta
	Mozambique	Netherlands Antilles		Uzbekistan	Yemen	Vietnam	Netherlands
	Nigeria	Nicaragua					Norway
	Other Africa[f]	Other Latin America[d]					Portugal
	Senegal	Panama					Spain
	South Africa	Paraguay					Sweden
	Sudan	Peru					Switzerland[c]
	Tanzania	Trinidad-Tobago					Uni. Kingdom
	Tunisia	Uruguay					
	Zambia	Venezuela					
	Zimbabwe						

[a] Includes Monaco
[b] Includes San Marino and Vatican City
[c] Includes Liechtenstein
[d] Includes: Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Dominica, French Guiana, Grenada, Guadeloupe, Guyana, Martinique, St. Kitts and Nevis, St. Lucia, St. Vincent and Grenadines, Suriname. Excluded due to lack of data: Aruba, British Virgin Islands, Cayman Islands, Falkland Island, Montserrat, St. Pierre and Miquelon, Turks and Caicos Islands.
[e] Includes: Afghanistan, Bhutan, Fiji, French Polynesia, Kiribati, Maldives, New Caledonia, Papua-New-Guinea, Samoa, Solomon Islands, Vanuatu. Excluded due to lack of data: American Samoa, Cambodia, Christmas Island, Cook Islands, Laos, Macau, Mongolia, Nauru, Niue, Pacific Islands, Tonga, Wake Island.
[f] Includes: Botswana, Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Djibouti, Equatorial Guinea, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Niger, Reunion, Rwanda, Sao Tome and Principe, Seychelles, Sierra Leone, Somalia, Swaziland, Togo, Uganda. Excluded due to lack of data: Comoros, Namibia, St. Helena, Western Sahara.

Appendix C – Definition of the base case

Table 3: Population and GDP annual growth

WORLD	Population					GDP				
	2010	2025	2050	2000-25	2000-50	2010	2025	2050	2000-25	2000-50
A1 AIM (A1B)	1.07%	0.93%	0.31%	1.00%	0.71%	3.55%	4.36%	3.62%	4.09%	3.90%
A2 ASF	1.54%	1.23%	0.53%	1.39%	1.22%	2.38%	2.39%	1.21%	2.42%	2.37%
B1 IMAGE	1.19%	0.87%	0.19%	1.05%	0.71%	3.38%	3.42%	3.02%	3.47%	3.30%
B2 MESSAGE	1.24%	0.98%	0.48%	1.12%	0.86%	3.15%	2.72%	2.50%	2.94%	2.74%
A1T MESSAGE	1.19%	0.86%	0.20%	1.05%	0.71%	3.22%	4.65%	3.29%	4.15%	3.96%
A1F1 MiniCAM	1.20%	0.84%	0.26%	1.06%	0.71%	3.35%	3.78%	3.42%	3.60%	3.64%
IEO 2003	1.20%	0.95%	na	1.09%	na	3.00%	2.97%	na	3.04%	na
WETO 2003	1.20%	0.93%	na	1.04%	na	3.00%	2.97%	na	3.20%	na

Sources: Energy Information Administration (2003) for IEO2003, European Commission (2003) for WETO2003, Center for International Earth Science Information Network (2002a and b) for the other scenarios

Table 4: Annual change rate of nuclear and renewable (for electricity generation) and electricity consumption

WORLD	Nuclear		Renewable*		Electricity consump.	
	2000-25	2000-50	2000-25	2000-50	2000-25	2000-50
A1 AIM (A1B)	7.0%	5.7%	4.0%	5.5%	3.7%	3.9%
A2 ASF	2.7%	3.2%	3.1%	2.7%	3.2%	2.9%
B1 IMAGE	4.4%	4.1%	-0.2%	-0.8%	4.0%	3.2%
B2 MESSAGE	3.4%	3.5%	4.7%	4.2%	3.0%	2.8%
A1T MESSAGE	5.1%	5.4%	5.8%	5.6%	4.0%	3.6%
A1F1 MiniCAM	3.8%	3.4%	6.3%	2.6%	4.7%	4.2%
IEO 2003	0.5%	na	1.7%	na	2.4%	na
WETO 2003	0.9%	na	2.1%	na	3.1%	na

* Renewable include wind, hydroelectricity, geothermal and solar (biomass excluded)

Sources: Energy Information Administration (2003) for IEO2003, European Commission (2003) for WETO2003, Nakicenovic (2000) for the other scenarios

Table 5: Primary energy consumption

WORLD	Primary energy		Coal primary		Gas primary		Oil primary	
	2000-25	2000-50	2000-25	2000-50	2000-25	2000-50	2000-25	2000-50
A1 AIM	2.6%	2.3%	2.2%	1.3%	1.4%	0.5%	4.1%	3.3%
A2 ASF	2.4%	2.0%	2.2%	2.4%	2.0%	0.6%	2.9%	2.7%
B1 IMAGE	1.9%	1.4%	1.3%	0.9%	1.8%	1.0%	2.9%	1.8%
B2 MESSAGE	1.7%	1.5%	0.3%	-0.1%	1.2%	0.6%	2.9%	2.6%
A1T MESSAGE	2.4%	2.2%	1.8%	0.2%	1.2%	1.0%	3.4%	2.7%
A1F1 MiniCAM	2.8%	2.6%	3.1%	2.9%	0.9%	1.5%	4.2%	3.1%
IEO 2003	1.9%	na	1.5%	na	1.8%	na	2.8%	na
WETO 2003	1.9%	na	2.3%	na	1.7%	na	2.6%	na

Sources: Energy Information Administration (2003) for IEO2003, European Commission (2003) for WETO2003, Nakicenovic (2000) for the other scenarios

Table 6: Emissions rate and annual growth at world level

WORLD	CO2 GtC / year			Annual growth	
	2000	2025	2050	2000-25	2000-50
A1 AIM (A1B)	6.9	13.1	16.0	2.6%	1.7%
A2 ASF	6.9	12.3	16.5	2.3%	1.8%
B1 IMAGE	6.9	10.6	11.7	1.7%	1.1%
B2 MESSAGE	6.9	9.6	11.2	1.3%	1.0%
A1T MESSAGE	6.9	11.1	12.3	1.9%	1.2%
A1F1 MiniCAM	6.9	12.9	23.1	2.5%	2.4%
IEO2003	6.4	10.4	0.0	1.9%	na
WETO2003	6.5	11.1	0.0	2.1%	na

Sources: Energy Information Administration (2003) for IEO2003, European Commission (2003) for WETO2003, Nakicenovic (2000) for the other scenarios

Table 7: Emissions rate and annual growth by region

	CO2 GtC/year				Annual growth			
	2025	2025	2025	2050	2000-25	2000-25	2000-25	2000-50
	IEO2003	WETO2003	A1B	A1B	IEO2003	WETO2003	A1B	A1B
OECD	4.1	3.7	3.5	3.4	1.13%	0.70%	0.30%	0.10%
FSU/EE	1.3	1.1	1.1	1.2	1.65%	1.53%	0.70%	0.53%
ASIA	3.3	4.4	4.7	5.7	3.00%	3.79%	3.26%	2.37%
DC	1.7	1.8	3.8	5.7	2.54%	3.11%	4.51%	3.53%
WORLD	10.4	11.1	13.1	16.0	1.93%	2.11%	2.15%	1.70%

Sources: Energy Information Administration (2003) for IEO2003, European Commission (2003) for WETO2003, Nakicenovic (2000) for the other scenarios

Table 8: Nuclear electricity production and annual growth per region (fixed bound)

	BAU-A1B							BAU-FOS						
	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2000-2050**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2000-2050**
	PJ	PJ	PJ	PJ	PJ		%	PJ	PJ	PJ	PJ	PJ	PJ	%
AFR	47	295	1390	2896	3281	3400	8.9%	47	63	139	290	328	340	4.0%
AUS	0	0	0	0	0	0	na	0	0	0	0	0	0	na
CAN	337	600	1083	1521	1570	1570	3.1%	337	450	542	760	785	785	1.7%
CHI	158	658	2798	7626	14045	25475	10.7%	158	658	2798	6500	9300	12737	9.2%
CSA	58	450	1210	2402	6418	17042	12.0%	58	70	121	240	642	1704	7.0%
EEU	263	636	1486	2631	3250	3950	5.6%	263	400	446	789	975	1185	3.1%
FSU	735	1364	2514	3369	3750	4050	3.5%	735	780	830	1011	1125	1215	1.0%
IND	53	282	893	2665	4801	8457	10.7%	53	141	447	1333	2401	4228	9.2%
JPN	1065	2184	2744	3273	3400	3400	2.3%	1065	1300	1921	2291	2380	2380	1.6%
MEA	0	54	485	1827	5852	14205	na	0	5	49	183	585	1420	na
MEX	28	201	915	1876	4448	10354	12.6%	28	40	92	188	445	1035	7.5%
ODA	135	311	923	2716	4722	8319	8.6%	135	155	461	1358	2361	4160	7.1%
SKO	401	750	1386	1993	2432	2749	3.9%	401	750	1386	1800	1850	1924	3.2%
USA	2786	3416	7495	11451	11930	11930	3.0%	2786	3100	3747	5726	5965	5965	1.5%
WEU	3048	3800	4678	6755	7100	7100	1.7%	3048	3200	3350	3450	3550	3550	0.3%
World	9114	15001	30000	53001	76999	1E+05	5.3%	9114	11112	16329	25919	32692	42628	3.1%

Sources: Nakicenovic (2000) for BAU-A1B and calculations by the authors for BAU-FOS

Table 9: Renewable electricity production and annual growth per region (lower bound)

	BAU-A1B							BAU-FOS						
	40	**2010**	**2020**	**2030**	**2040**	**2050**	**2000-2050**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2000-2050**
	PJ	PJ	PJ	PJ	PJ	PJ	%	PJ	PJ	PJ	PJ	PJ	PJ	%
AFR	303	946	1559	3312	6979	20477	8.8%	303	946	1559	2137	3490	6646	6.4%
AUS	171	227	272	385	509	670	2.8%	171	227	272	301	356	415	1.8%
CAN	1132	1524	2310	3932	5976	8797	4.2%	1132	1524	2310	2420	2988	3692	2.4%
CHI	844	1071	1952	5088	12257	29671	7.4%	844	1071	1952	3541	6129	10479	5.2%
CSA	2086	2164	2592	5135	10056	19982	4.6%	2086	2164	2592	3321	4500	7000	2.5%
EEU	245	295	366	472	714	1004	2.9%	245	295	366	411	457	479	1.4%
FSU	945	964	1781	2740	5553	13998	5.5%	945	964	1781	1974	2777	4882	3.3%
IND	350	393	529	1471	3467	8288	6.5%	350	393	529	1001	1734	2944	4.4%
JPN	351	457	675	1084	1651	2443	4.0%	351	457	675	681	826	1023	2.2%
MEA	183	210	670	2268	6703	14977	9.2%	183	210	670	1870	3352	4263	6.5%
MEX	161	225	589	1377	2448	3998	6.6%	161	225	589	858	1224	1589	4.7%
ODA	482	655	1349	3402	8273	20245	7.8%	482	655	1349	2397	4137	7127	5.5%
SKO	15	18	19	45	101	233	5.6%	15	18	19	31	51	84	3.5%
USA	976	2106	3343	5624	8719	13010	5.3%	976	2106	3343	4176	5009	5426	3.5%
WEU	1597	2665	3410	5121	7338	10356	3.8%	1597	2665	3410	3820	4230	4435	2.1%
World	9841	13920	21416	41456	80744	168149	5.8%	9841	13920	21416	28940	41256	60480	3.7%

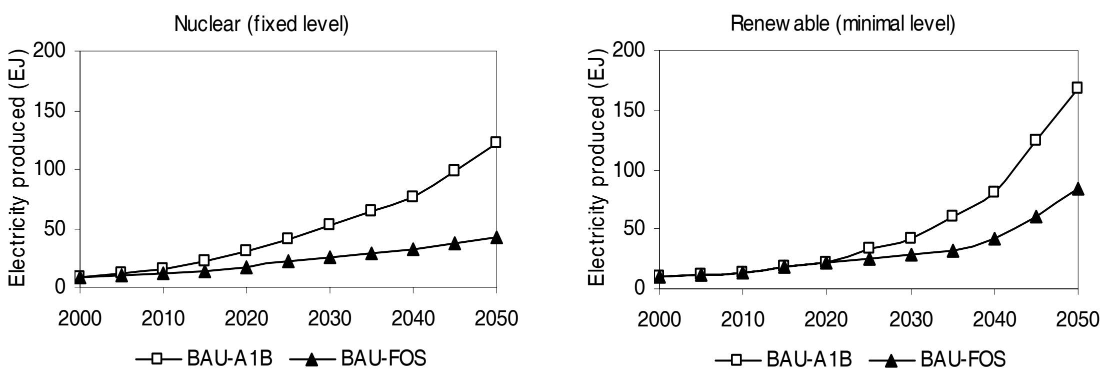
Sources: Nakicenovic (2000) for BAU-A1B and calculations by the authors for BAU-FOS

Table 10: Nuclear and renewable electricity production

	Nuclear (EJ)						Renewable (EJ)					
	2000	2010	2020	2030	2040	2050	2000	2010	2020	2030	2040	2050
BAU-A1B*	9.1	15.0	30.0	53.0	77.0	122.0	9.8	13.9	21.4	41.5	80.8	168.2
BAU-FOS	9.1	11.1	16.3	25.9	32.7	42.6	9.8	14.0	21.5	29.2	42.2	61.1
IEO 2003	8.8	10.0	10.3	na	na	na	11.5	14.6	16.6	na	na	na
WETO 2003	9.4	11.4	11.3	12.6	na	na	10.6	13.4	16.6	19.5	na	na

* AIM-A1B provides slightly different values in 2000 compared to MARKAL scenario BAU-A1B (7.7 EJ for nuclear electricity production and 11.8 EJ for renewable electricity production). MARKAL is not fully calibrated to these values because 2000 data of MARKAL are calibrated to historical data from different national sources. Nevertheless, for analysis purposes, calibration of 2000 data is not required as 2000 belongs to the past, over which the model has no freedom. 2005-2050 data are calibrated.

Sources: Energy Information Administration (2003) for IEO2003, European Commission (2003) for WETO2003, Nakicenovic (2000) for BAU-A1B and calculations by the authors for BAU-FOS.



Sources: Nakicenovic (2000) for BAU-A1B and calculations by the authors for BAU-FOS

Figure 2. Nuclear and renewable electricity generation at the world level

Appendix D – Inputs general

Table 11: Discount rates

	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
Sector discount rate															
Electricity	9.2%	3.6%	4.7%	6.2%	8.2%	6.7%	9.7%	9.0%	3.0%	6.6%	8.2%	9.2%	6.6%	5.2%	4.7%
Residential/ Commercial	28.2%	12.6%	13.7%	25.2%	27.2%	25.7%	18.7%	28.0%	12.0%	25.6%	27.2%	18.2%	15.6%	14.2%	13.7%
Transportation	18.2%	12.6%	13.7%	15.2%	17.2%	15.7%	18.7%	18.0%	12.0%	15.6%	17.2%	18.2%	15.6%	14.2%	13.7%
Industry	13.7%	8.1%	9.3%	10.7%	12.7%	11.3%	14.3%	13.5%	7.5%	11.1%	12.7%	13.7%	11.1%	9.7%	9.3%
General Discount rate															
All sectors	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%

Table 12: Cost multipliers

	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
INVCOST	1.25	1.25	1	0.9	1.25	1	1.25	0.9	1.4	1.25	1	1.25	1	1	1.1
FIXOM	0.7	0.8	1	0.6	0.7	0.7	0.7	0.6	1	0.7	0.8	0.6	0.8	1	0.9
VAROM	0.7	0.8	1	0.6	0.7	0.8	0.7	0.6	1	0.7	0.8	0.6	0.8	1	0.9

Sources: Data were provided Dolf Gielen, International Energy Agency (private communication).

Appendix E – Inputs end-use

Table 13: Energy services and units

Sector	Code	Unit of energy service
Transportation segments (15)		
Autos	TRT	Billion vehicle-km/year
Buses	TRB	Billion vehicle-km/year
Light trucks	TRL	Billion vehicle-km/year
Commercial trucks	TRC	Billion vehicle-km/year
Medium trucks	TRM	Billion vehicle-km/year
Heavy trucks	TRH	Billion vehicle-km/year
Two wheelers	TRW	Billion vehicle-km/year
Three wheelers	TRE	Billion vehicle-km/year
International aviation	TAI	PJ/year
Domestic aviation	TAD	PJ/year
Freight rail transportation	TTF	PJ/year
Passengers rail transportation	TTP	PJ/year
Internal navigation	TWD	PJ/year
International navigation (bunkers)	TWI	PJ/year
Non-energy uses in transport	NEU	PJ/year

Table 13: Energy services and units (continued)

Residential segments (11)		
Space heating	RH1, RH2, RH3, RH4	PJ/year
Space cooling	RC1, RC2, RC3, RC4	PJ/year
Hot water heating	RWH	PJ/year
Lighting	RL1, RL2, RL3, RL4	PJ/year
Cooking	RK1, RK2, RK3, RK4	PJ/year
Refrigerators and freezers	RRF	PJ/year
Cloth washers	RCW	PJ/year
Cloth dryers	RCD	PJ/year
Dish washers	RDW	PJ/year
Miscellaneous electric energy	REA	PJ/year
Other energy uses	ROT	PJ/year
Commercial segments (8)		
Space heating	CH1, CH2. CH3, CH4	PJ/year
Space cooling	CC1, CC2. CC3. CC4	PJ/year
Hot water heating	CHW	PJ/year
Lighting	CLA	PJ/year
Cooking	CCK	PJ/year
Refrigerators and freezers	CRF	PJ/year
Electric equipments	COE	PJ/year
Other energy uses	COT	PJ/year
Agriculture segments (1)		
Agriculture	AGR	
Industrial segments (6)		
Iron and steel	IIS	Millions tonnes
Non ferrous metals	INF	Millions tonnes
Chemicals	ICH	PJ
Pulp and paper	ILP	Millions tonnes
Non metal minerals	INM	PJ
Other industries	IOI	PJ
Other segment (1)		
Other non specified energy consumption	ONO	PJ/year

Notes:

- Industrial energy services are made up of a ‘recipe’ of more detailed services—steam, process heat, machine drive, electrolytic service, other, and feedstock.

- RLi, RCi, RLi, RKi, CHi, CCi represent the demands for some sub-regions when defined in some regions (eg.: USA and CAN).

Table 14: End-Use Demands

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
AFR	AGR [Agricultural demand]	210.9	277.3	334.4	397.9	528.1	601.4
AFR	CC1 [Commercial Cooling]	34.1	75.2	155.2	280.1	587.1	773.8
AFR	CCK [Commercial Cooking]	23.2	38.6	63.1	95.8	184.3	231.5
AFR	CH1 [Commercial Space Heat]	40	78.9	145.3	264.5	667.4	1070.2
AFR	CHW [Commercial Hot Water]	21	46.4	93.8	172.8	355	477.4
AFR	CLA [Commercial Lighting]	155.3	332.3	685.5	1275.7	2593.6	3523.5
AFR	COE [Commercial Office Equipment]	44.9	83.2	171.8	369.1	696.3	815.7
AFR	CRF [Commercial Refrigeration]	32.3	48.5	80.7	134.6	243.4	278.5
AFR	ICH [Chemicals]	919.1	1268.5	1783.3	2461.3	4586.7	5884.6
AFR	IIS [Iron and Steel]	12.2	11.7	11.7	11.7	11.9	11.7
AFR	ILP [Pulp and Paper]	2.9	4.3	6.5	10.8	26.7	41.5
AFR	INF [Non-ferrous metals]	1	1.3	1.9	2.9	6.3	9.2
AFR	INM [Non Metals]	44.4	87.3	164.2	304.5	768.2	1231.8
AFR	IOI [Other Industries]	1576.3	2324.2	3474.7	5164.9	9476	12157.3
AFR	NEU [Non Energy Uses]	0	0.1	0.1	0.1	0.1	0.1
AFR	ONO [Other non-specified consumption]	1150.7	1344.3	1551.7	1776.6	2224.1	2467.7
AFR	RC1 [Residential Cooling]	88.8	197.5	428.6	881.4	2974.3	5033.4
AFR	RCD [Residential Clothes Drying]	3	6.4	14.4	29.9	99.8	170.6
AFR	RCW [Residential Clothes Washing]	3	6.4	14.4	29.9	99.8	170.6
AFR	RDW [Residential Dishwashing]	3	6.3	11.2	18.6	46	67.7
AFR	REA [Residential Other Electric]	132.4	235.7	409.1	818.7	1801.9	2382.1
AFR	RH1 [Residential Space Heat]	852.7	1049.8	1322.7	1584.8	1900	2127.7
AFR	RHW [Residential Hot Water]	912.9	1146.8	1416	1696.6	2034.1	2325.3
AFR	RK1 [Residential Cooking]	2874.5	3418.9	4012.9	4674.6	5364	5935.2
AFR	RL1 [Residential Lighting]	115.6	180.3	295.3	472	880.3	1060.2
AFR	ROT [Residential Other]	0.5	0.6	0.8	0.9	1.1	1.3
AFR	RRF [Residential Refrigeration]	45.1	100.4	213.5	448.1	1481.9	2559
AFR	TAD [Domestic Aviation]	79.7	103	140.1	183.7	295.6	352.5
AFR	TAI [International Aviation]	220.3	275.4	374.7	491.3	774.3	942.9
AFR	TRB [Road Bus Demand]	11.7	15.8	21.5	28.3	44.5	54.2
AFR	TRC [Road Commercial Trucks Demand]	30.8	50.7	80.4	118.6	199.1	255.7
AFR	TRE [Road Three Wheels Demand]	1.6	2.8	4.7	7.4	17	24.9
AFR	TRH [Road Heavy Trucks Demand]	7	11.5	18.3	26.4	44.3	56.9
AFR	TRL [Road Light Vehicle Demand]	82.2	124.5	190.6	268.8	532	647.9
AFR	TRM [Road Medium Trucks Demand]	19.5	32	50.8	74.9	125.8	161.6
AFR	TRT [Road Auto Demand]	129.9	201.7	301	424.6	840.5	1049.7
AFR	TRW [Road Two Wheels Demand]	3	4.3	6.1	8.6	17	23
AFR	TTF [Rail-Freight]	11.8	15.5	20.2	26.5	40.5	49.1
AFR	TTP [Rail-Passengers]	20	25.9	34.2	45.9	69.5	84.2
AFR	TWD [Domestic Internal Navigation]	16.8	25.1	37.2	55	100.8	134.3
AFR	TWI [International Navigation]	283	480.4	743.2	999.8	1389.9	1493.2

Table 14: End-Use Demands (continued)

Region	**End-Use Demand**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
AUS	AGR [Agricultural demand]	81.3	82.8	84.3	85.8	87.2	88.4
AUS	CC1 [Commercial Cooling]	67.2	76.5	87	99	111.6	123.8
AUS	CCK [Commercial Cooking]	5	5.5	5.9	6.3	6.7	7
AUS	CH1 [Commercial Space Heat]	76.2	81.9	89.8	97.9	106.2	113.9
AUS	CHW [Commercial Hot Water]	10.3	11.7	13.2	15	17.1	18.7
AUS	CLA [Commercial Lighting]	204.4	238.9	283.3	335.7	399.4	458
AUS	COE [Commercial Office Equipment]	59.6	80.3	104.8	132.4	157.6	180.7
AUS	COT [Commercial Other]	0.1	0.1	0.1	0.1	0.1	0.1
AUS	CRF [Commercial Refrigeration]	8.5	9.3	10	10.7	11.3	11.8
AUS	ICH [Chemicals]	228.7	265.2	311.2	369.1	432.6	488.3
AUS	IIS [Iron and Steel]	8.8	8.6	9.2	10.2	11.1	11.7
AUS	ILP [Pulp and Paper]	3.4	3.9	4.5	5.4	6.5	7.3
AUS	INF [Non-ferrous metals]	2	2.5	3.2	4.2	5.3	6.6
AUS	INM [Non Metals]	9.1	11	13.9	18.1	22.8	28
AUS	IOI [Other Industries]	481.2	484.5	502.7	538.2	551.8	550.9
AUS	NEU [Non Energy Uses]	0	0	0	0	0	0
AUS	RC1 [Residential Cooling]	24.9	27.7	29.9	31.9	33.9	35.4
AUS	RCD [Residential Clothes Drying]	12.8	13.8	15.2	16.3	17.4	18.1
AUS	RCW [Residential Clothes Washing]	4.2	4.6	5	5.4	5.7	6
AUS	RDW [Residential Dishwashing]	2.1	2.3	2.5	2.7	2.9	3
AUS	REA [Residential Other Electric]	63.2	61.8	68.7	73.8	89.1	95.6
AUS	RH1 [Residential Space Heat]	176	184.2	191	195.4	203.4	205.8
AUS	RHW [Residential Hot Water]	48.1	52.6	56.5	60.3	64	66.2
AUS	RK1 [Residential Cooking]	9.4	10.3	11.1	11.8	12.6	13.1
AUS	RL1 [Residential Lighting]	28.7	33.1	37.5	40.3	43.5	45.4
AUS	RRF [Residential Refrigeration]	27.4	30.4	32.7	35.1	37.2	38.9
AUS	TAD [Domestic Aviation]	85.6	98.3	114.7	138.9	162.8	186.7
AUS	TAI [International Aviation]	132.3	144	171.6	203.5	246.3	282.5
AUS	TRB [Road Bus Demand]	2.3	2.5	2.7	2.9	3.1	3.2
AUS	TRC [Road Commercial Trucks Demand]	2.6	3.2	4.1	4.8	5.6	6.6
AUS	TRE [Road Three Wheels Demand]	1.3	1.4	1.5	1.5	1.5	1.5
AUS	TRH [Road Heavy Trucks Demand]	8.9	10.4	12.4	14.7	17.2	19.8
AUS	TRL [Road Light Vehicle Demand]	35.3	41.2	47.7	52.5	59	63.9
AUS	TRM [Road Medium Trucks Demand]	2	2.4	2.8	3.3	3.9	4.5
AUS	TRT [Road Auto Demand]	206	240.4	278.3	312.6	344.3	373
AUS	TRW [Road Two Wheels Demand]	2.4	2.6	2.8	3	3.2	3.4
AUS	TTF [Rail-Freight]	37.1	39.9	43.7	49.9	56	60.7
AUS	TTP [Rail-Passengers]	13.6	13.8	15.2	16.2	17.7	18.5
AUS	TWD [Domestic Internal Navigation]	37.3	39	42.8	48	54	58
AUS	TWI [International Navigation]	83.8	88.2	96.6	110.3	125.1	136.9

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
CAN	AGR [Agricultural demand]	200.7	206.6	219.5	228.8	234.9	238.6
CAN	CC1 [Commercial Cooling - Western]	50.6	59.3	68.1	77.2	86.6	96
CAN	CC2 [Commercial Cooling - Central]	99.8	124.5	151	178.6	207.9	238.7
CAN	CC3 [Commercial Cooling - Eastern]	23.2	27.8	32.5	37.2	42	46.9
CAN	CCK [Commercial Cooking]	28.6	32.1	35.5	38.8	42	45.2
CAN	CH1 [Commercial Space Heat - Western]	198.5	226.5	260.9	294.2	331.4	362
CAN	CH2 [Commercial Space Heat - Central]	197.9	239.4	290.7	341.1	397	449.4
CAN	CH3 [Commercial Space Heat - Eastern]	180	211.6	245.3	279	313.5	348.4
CAN	CHW [Commercial Hot Water]	78.7	87.4	96.6	105.6	115.6	124.3
CAN	CLA [Commercial Lighting]	643.4	765.6	902.7	1060.1	1210	1364.3
CAN	COE [Commercial Office Equipment]	84.7	143.4	253.4	371.8	540.6	732.9
CAN	COT [Commercial Other]	58.1	59.1	60.8	62.6	66.7	66.9
CAN	CRF [Commercial Refrigeration]	22	24.7	27.3	29.8	32.3	34.8
CAN	ICH [Chemicals]	1101.1	1209.6	1347.9	1524.3	1736.3	1852.6
CAN	IIS [Iron and Steel]	15.8	16.9	17.7	18.3	19	19.4
CAN	ILP [Pulp and Paper]	18.7	21.4	25.7	30	34.9	38.5
CAN	INF [Non-ferrous metals]	2.5	3	4	5.4	7.2	9
CAN	INM [Non Metals]	12.1	14.7	18.7	24.1	30.5	37.4
CAN	IOI [Other Industries]	1173.8	1194.2	1251.7	1332.3	1416.3	1417.5
CAN	NEU [Non Energy Uses]	8.3	9.3	10.3	11.4	12.5	13.6
CAN	RC1 [Residential Cooling - Western]	22.2	25.2	28.9	32.6	36.3	40.1
CAN	RC2 [Residential Cooling - Central]	159.1	180.5	209.3	239.3	270.2	301.5
CAN	RC3 [Residential Cooling - Eastern]	20.8	23.4	26.4	29.2	32	34.8
CAN	RCD [Residential Clothes Drying]	36.6	40.8	47.4	53.4	59.5	65.6
CAN	RCW [Residential Clothes Washing]	3.6	4	4.7	5.3	5.9	6.5
CAN	RDW [Residential Dishwashing]	2.6	2.9	3.4	3.8	4.3	4.7
CAN	REA [Residential Other Electric]	173.6	214.5	306.4	384.9	566.4	712.5
CAN	RH1 [Residential Space Heat - Western]	212.5	239.8	270.1	302.9	339.4	369
CAN	RH2 [Residential Space Heat - Central]	221.6	249.9	284.8	323.5	366.8	403.1
CAN	RH3 [Residential Space Heat - Eastern]	121.6	133.1	147.4	160.9	175.9	187
CAN	RHW [Residential Hot Water]	183.8	201.8	221.2	242.1	265.4	283
CAN	RK1 [Residential Cooking - Western]	16.3	18.4	20.9	23.4	26	28.5
CAN	RK2 [Residential Cooking - Central]	21.6	24.5	28.4	32.5	36.7	40.9
CAN	RK3 [Residential Cooking - Eastern]	6.2	7	7.9	8.8	9.6	10.5
CAN	RL1 [Residential Lighting - Western]	16.8	20.8	26.6	30.4	34.4	38
CAN	RL2 [Residential Lighting - Central]	20.9	23	26.9	30.9	35.4	39.6
CAN	RL3 [Residential Lighting - Eastern]	18.8	20.5	23.1	26	28.9	31.5
CAN	ROT [Residential Other]	17.9	18.1	18.4	18.6	18.8	19
CAN	RRF [Residential Refrigeration]	67.3	76.2	87.2	98.2	109.5	120.8
CAN	TAD [Domestic Aviation]	192.3	221.5	265.4	331.5	416.9	478.3
CAN	TAI [International Aviation]	49.3	55.5	66.1	83.6	104.2	122
CAN	TRB [Road Bus Demand]	0.5	0.5	0.5	0.6	0.6	0.6
CAN	TRC [Road Commercial Trucks Demand]	7.5	9	10.7	12	13.5	14.8
CAN	TRE [Road Three Wheels Demand]	2.3	2.4	2.4	2.4	2.4	2.4
CAN	TRH [Road Heavy Trucks Demand]	17.8	20	22.9	26.1	29.6	32.8
CAN	TRL [Road Light Vehicle Demand]	115.7	126.2	136	145.1	154	159.4
CAN	TRM [Road Medium Trucks Demand]	4.9	5.6	6.4	7.1	8.1	8.9
CAN	TRT [Road Auto Demand]	240.3	262.2	282.5	301.3	319.8	331.1
CAN	TRW [Road Two Wheels Demand]	4.4	4.6	4.9	5	5.2	5.2
CAN	TTF [Rail-Freight]	69.2	69.9	73.1	78	83.7	86.3
CAN	TTP [Rail-Passengers]	10.7	10.4	10.7	11.1	11.7	11.8
CAN	TWD [Domestic Internal Navigation]	88.2	86.3	90.2	97.4	105.6	108.9
CAN	TWI [International Navigation]	80.5	78.8	83.3	89.8	96.4	100.4

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
CHI	AGR [Agricultural demand]	1418.3	1569.6	1738.3	1925.2	2038.1	2113.2
CHI	CC1 [Commercial Cooling - Rural]	5	5.5	6.1	6.8	7.2	7.4
CHI	CC2 [Commercial Cooling - Urban]	95.5	184.5	356.5	689	1019.6	1317.4
CHI	CCK [Commercial Cooking]	71.1	92	114	129.2	137	142.2
CHI	CH1 [Commercial Space Heat - Rural]	63.2	68.5	74.4	84.1	87.2	92.3
CHI	CH2 [Commercial Space Heat - Urban]	243.3	315.8	396.5	452.6	469.3	496.7
CHI	CHW [Commercial Hot Water]	116.9	154.9	190.5	217.5	230.3	238.7
CHI	CLA [Commercial Lighting]	228.4	460.7	957.4	1959.3	3086.3	4180.4
CHI	COE [Commercial Office Equipment]	43.2	226.4	389	1150.7	3310.2	7659.1
CHI	CRF [Commercial Refrigeration]	44.3	50	63.1	72.7	78.4	81.4
CHI	ICH [Chemicals]	3351.9	4671.2	6717.1	9970.8	19404.4	32770.7
CHI	IIS [Iron and Steel]	115.6	132.4	156.4	197.2	224.1	240.8
CHI	ILP [Pulp and Paper]	32.1	44.7	63.2	93.9	172.8	256.6
CHI	INF [Non-ferrous metals]	2.4	3.3	4.8	7.2	13.1	19.5
CHI	INM [Non Metals]	536	758.7	1074.1	1594.4	2934.6	4358.4
CHI	IOI [Other Industries]	3813.3	5314.3	7519.9	11165.4	20555.2	30527.9
CHI	NEU [Non Energy Uses]	0	0	0	0	0	0
CHI	ONO [Other non-specified consumption]	405.8	937.7	2163.5	4992.9	8289.9	11586.8
CHI	RC1 [Residential Cooling - Rural]	31.5	40.7	50.4	57.7	61.2	63.5
CHI	RC2 [Residential Cooling - Urban]	124.3	309.8	721.3	1595.4	2692.1	3800.7
CHI	RCD [Residential Clothes Drying]	0.5	0.7	1.1	1.5	1.9	2.3
CHI	RCW [Residential Clothes Washing]	16	30.6	63.8	127.7	200.9	273
CHI	RDW [Residential Dishwashing]	0.5	1.3	3.3	7.3	10.9	13.3
CHI	REA [Residential Other Electric]	166.6	818.6	1811.2	4006.2	7098.2	9543.9
CHI	RH1 [Residential Space Heat - Rural]	976.2	976.3	989.2	975	999.7	982.5
CHI	RH2 [Residential Space Heat - Urban]	896.4	1170.9	1422.1	1611.1	1709.1	1774.1
CHI	RHW [Residential Hot Water]	456.4	584.2	724.1	803.6	852.4	903.3
CHI	RK1 [Residential Cooking - Rural]	5077.1	5181.1	5249.4	5281.9	5305.3	5322.5
CHI	RK2 [Residential Cooking - Urban]	813.6	906	990.3	1063.7	1128.4	1168.2
CHI	RL1 [Residential Lighting - Rural]	110.1	110	116.3	123.4	130.3	129.8
CHI	RL2 [Residential Lighting - Urban]	143.1	328.1	747.3	1689.6	2851.1	4025.1
CHI	RRF [Residential Refrigeration]	117.3	153.2	186.1	210.8	223.6	232.1
CHI	TAD [Domestic Aviation]	235.5	371.6	608.5	1040	1477.7	1792.2
CHI	TAI [International Aviation]	19.5	70.1	235.2	537.9	734.4	851
CHI	TRB [Road Bus Demand]	11.8	18.4	29.2	46.4	56.8	61
CHI	TRC [Road Commercial Trucks Demand]	8.3	14.3	24.2	41.6	57.2	65.9
CHI	TRE [Road Three Wheels Demand]	3	3.2	3.3	3.4	3.4	3.5
CHI	TRH [Road Heavy Trucks Demand]	12	20.2	34.8	60	82.5	93
CHI	TRL [Road Light Vehicle Demand]	151.1	382.5	800.9	1053.9	1184	1242.1
CHI	TRM [Road Medium Trucks Demand]	8.6	14.8	25	43.1	59.3	68.3
CHI	TRT [Road Auto Demand]	252.1	638.1	1335.9	1758.1	1975	2126.5
CHI	TRW [Road Two Wheels Demand]	36.5	39.9	42.8	45.2	47.2	48.8
CHI	TTF [Rail-Freight]	565.5	934.4	1609.4	2801.4	3895.9	4745.8
CHI	TTP [Rail-Passengers]	91.5	93.1	98.6	104.6	110.4	114
CHI	TWD [Domestic Internal Navigation]	362.4	513	734	1095.1	1362.8	1552.6
CHI	TWI [International Navigation]	249.8	311	394.8	520.5	613	656.7

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
CSA	AGR [Agricultural demand]	611.1	921.5	1144.7	1310.6	1394.4	1453.7
CSA	CC1 [Commercial Cooling]	275.8	607.9	1311.2	2521.6	3371.8	3939.6
CSA	CCK [Commercial Cooking]	86.3	102.2	118.1	127.5	132.6	136
CSA	CH1 [Commercial Space Heat]	47.2	57.7	68.8	76	79.2	81.5
CSA	CHW [Commercial Hot Water]	107.2	133.8	156.9	172.6	179.8	185.1
CSA	CLA [Commercial Lighting]	769.3	1094.7	1574.9	2221.5	2747.9	3164.6
CSA	COE [Commercial Office Equipment]	77.4	464.9	888.4	1243.6	2119.4	2679.4
CSA	CRF [Commercial Refrigeration]	111.2	123.7	143	153.4	167.3	163.7
CSA	ICH [Chemicals]	1551.4	4367.8	9763.1	13984.3	17302	17261
CSA	IIS [Iron and Steel]	36.4	43.9	50.6	58.8	65.6	69
CSA	ILP [Pulp and Paper]	10.3	17.6	30.1	52	95	145.8
CSA	INF [Non-ferrous metals]	2.2	3.1	4.5	6.5	13	21.6
CSA	INM [Non Metals]	76.8	132.5	226.9	392	784	1309.6
CSA	IOI [Other Industries]	3091.2	6746.6	14945.2	29143.1	37297	47709.5
CSA	NEU [Non Energy Uses]	0.3	0.6	1.1	2.2	3.2	4.2
CSA	ONO [Other non-specified consumption]	125.4	247	482.9	936.7	1365.2	1793.7
CSA	RC1 [Residential Cooling]	291.3	444	572.8	703.7	844.2	972.3
CSA	RCD [Residential Clothes Drying]	0.6	1.1	2.2	3.8	5.1	5.8
CSA	RCW [Residential Clothes Washing]	0.6	1.1	2.2	3.8	5.1	5.8
CSA	RDW [Residential Dishwashing]	0.6	1.1	2.1	3.8	5.1	5.8
CSA	REA [Residential Other Electric]	234.1	987.7	1735.3	2596.1	4769.6	6213
CSA	RH1 [Residential Space Heat]	35.7	43.1	51.3	60	69.5	77.1
CSA	RHW [Residential Hot Water]	540.6	710.2	877.4	1038.7	1175	1269.5
CSA	RK1 [Residential Cooking]	1576.6	1850.8	2089.3	2293.4	2421.3	2452.2
CSA	RL1 [Residential Lighting]	253.9	439.2	801.6	1374.1	1744.9	1789.5
CSA	RRF [Residential Refrigeration]	141.3	184.6	222.8	265.8	292.4	299.9
CSA	TAD [Domestic Aviation]	159.5	266.3	493.2	914	1087	1205.9
CSA	TAI [International Aviation]	122.6	172.4	264.9	442.3	551.8	605.2
CSA	TRB [Road Bus Demand]	62.4	70.4	78.9	87.4	96	102.7
CSA	TRC [Road Commercial Trucks Demand]	38.6	67.6	117.6	203.2	247.6	285.1
CSA	TRE [Road Three Wheels Demand]	2.7	4.2	6.2	8.3	9.3	9.7
CSA	TRH [Road Heavy Trucks Demand]	40.3	70.5	120.2	207.6	258.1	291.2
CSA	TRL [Road Light Vehicle Demand]	117.5	199.7	343.9	615.7	883.3	1102.1
CSA	TRM [Road Medium Trucks Demand]	70.8	123.9	215.4	372.3	453.4	522.2
CSA	TRT [Road Auto Demand]	290.1	492.9	848.6	1519.5	2179.8	2775.2
CSA	TRW [Road Two Wheels Demand]	15	23.8	35.1	46.9	52.2	54.6
CSA	TTF [Rail-Freight]	19.3	25.3	33.6	45.5	54.5	61.6
CSA	TTP [Rail-Passengers]	11.7	13	14.4	16.1	17.9	18.9
CSA	TWD [Domestic Internal Navigation]	114.5	149.9	197.4	267.3	316.7	351.2
CSA	TWI [International Navigation]	477.1	618	813.8	1090.3	1305.9	1432.7

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
EEU	AGR [Agricultural demand]	427.1	521.4	611.6	670.2	710	736.3
EEU	CC1 [Commercial Cooling]	6.9	9.1	11.9	15.6	19.5	22.5
EEU	CCK [Commercial Cooking]	40.2	48.6	57	62.5	66.2	68.7
EEU	CH1 [Commercial Space Heat]	299.5	365.7	430.7	515.7	595.7	652
EEU	CHW [Commercial Hot Water]	79.4	96.3	114.2	136.7	157.9	172.8
EEU	CLA [Commercial Lighting]	377.8	447.4	537.8	643.9	743.8	814.2
EEU	COE [Commercial Office Equipment]	61.5	134.7	308	570.9	998	1366.2
EEU	COT [Commercial Other]	5	5.9	6.9	8.3	9.6	10.3
EEU	CRF [Commercial Refrigeration]	24.2	26.4	32.3	39.3	46.1	49.7
EEU	ICH [Chemicals]	804.7	952.9	1127.7	1350	1536.3	1625.6
EEU	IIS [Iron and Steel]	30.2	35.2	41.6	50.6	57.6	60.9
EEU	ILP [Pulp and Paper]	5.3	6.2	7.4	8.9	10	10.7
EEU	INF [Non-ferrous metals]	0.5	0.6	0.8	0.9	1	1.1
EEU	INM [Non Metals]	40.2	47.7	56.4	68.6	76.8	81.3
EEU	IOI [Other Industries]	944.3	1071.9	1233.1	1418.4	1589	1681.1
EEU	NEU [Non Energy Uses]	18.6	34	59.1	99.7	148.2	191.8
EEU	ONO [Other non-specified consumption]	179.8	351.5	686.5	1340.7	2339.3	3379.1
EEU	RC1 [Residential Cooling]	21	24	27.6	31.7	35.7	38.5
EEU	RCD [Residential Clothes Drying]	36.5	43.3	50.7	55.5	59	61.3
EEU	RCW [Residential Clothes Washing]	6.9	7.7	9.6	10.5	11.2	11.6
EEU	RDW [Residential Dishwashing]	3.5	4	4.8	5.3	5.6	5.8
EEU	REA [Residential Other Electric]	131.1	316.3	743.6	1709	3049.3	4146.4
EEU	RH1 [Residential Space Heat]	1292.9	1384.3	1485	1593.3	1691.9	1723.2
EEU	RHW [Residential Hot Water]	179.8	217.5	257.3	307.3	357.1	392.9
EEU	RK1 [Residential Cooking]	146.3	156.7	168.1	180.3	191.5	199
EEU	RL1 [Residential Lighting]	52.6	59.9	71.9	85.8	99.7	109.8
EEU	RRF [Residential Refrigeration]	51.8	62.8	72	78.8	83.7	87
EEU	TAD [Domestic Aviation]	9.2	10.6	12.1	13.6	14.7	15.3
EEU	TAI [International Aviation]	44.5	49.4	56	63.5	69.5	69.7
EEU	TRB [Road Bus Demand]	6.7	8	9.5	11.4	13.2	14.6
EEU	TRC [Road Commercial Trucks Demand]	16.1	19.7	23.1	25.3	26.8	27.8
EEU	TRE [Road Three Wheels Demand]	1	1	1.1	1.2	1.3	1.3
EEU	TRH [Road Heavy Trucks Demand]	12.4	15.1	17.3	19	20.1	20.9
EEU	TRL [Road Light Vehicle Demand]	37.1	44.4	52.1	57	61.7	62.7
EEU	TRM [Road Medium Trucks Demand]	11.8	14.4	16.9	18.5	19.6	20.3
EEU	TRT [Road Auto Demand]	87.5	104.7	122.8	134.5	142.5	147.8
EEU	TRW [Road Two Wheels Demand]	3.6	3.8	4.1	4.4	4.7	4.9
EEU	TTF [Rail-Freight]	38.7	45.8	53.2	58.9	63	64.7
EEU	TTP [Rail-Passengers]	38.1	39.1	42	45.5	48.8	50.2
EEU	TWD [Domestic Internal Navigation]	18.8	22.3	25.6	28.3	30.6	31.4
EEU	TWI [International Navigation]	44.1	50.6	59.4	65.1	70.4	73

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
FSU	AGR [Agricultural demand]	1058.1	1291.8	1515.2	1660.4	1758.9	1824.1
FSU	CC1 [Commercial Cooling]	9.9	13	17.1	22.4	27.9	32.2
FSU	CCK [Commercial Cooking]	90.6	109.5	128.4	140.7	149.1	154.6
FSU	CH1 [Commercial Space Heat]	1055.7	1288.8	1549.2	1854.6	2142.4	2345.1
FSU	CHW [Commercial Hot Water]	157.1	191.8	225.9	270.5	312.4	342
FSU	CLA [Commercial Lighting]	527	745.6	1122.1	1662.3	2295.8	2873.2
FSU	COE [Commercial Office Equipment]	85.8	187.8	429.6	796.3	1360.5	1861.4
FSU	COT [Commercial Other]	6.4	7.5	8.6	9.4	10	10.1
FSU	CRF [Commercial Refrigeration]	33.7	39.5	52.7	69.1	87.6	100.9
FSU	ICH [Chemicals]	3595.9	4192.6	4960.5	6033.1	6759.2	7150.7
FSU	IIS [Iron and Steel]	70.4	82.1	98.7	118.1	134.4	142.2
FSU	ILP [Pulp and Paper]	4.1	4.8	5.6	6.7	7.7	8.1
FSU	INF [Non-ferrous metals]	3.3	4	4.7	5.7	6.4	6.9
FSU	INM [Non Metals]	42	49.7	59.7	71.5	80.1	86.1
FSU	IOI [Other Industries]	5325.3	6140.1	6954	7999	8961.6	9631.9
FSU	NEU [Non Energy Uses]	2.1	3.2	4.7	6.9	9.6	11.8
FSU	ONO [Other non-specified consumption]	1205.3	1294.1	1389.7	1492.4	1580.9	1639.5
FSU	RC1 [Residential Cooling]	44.2	57.7	75.1	97.7	122.6	142.1
FSU	RCD [Residential Clothes Drying]	112.1	133.7	156.2	170.7	181.1	191.9
FSU	RCW [Residential Clothes Washing]	33.1	36.2	47.2	56.2	65.2	73.1
FSU	RDW [Residential Dishwashing]	6.6	7.6	9.3	10.2	10.8	11.2
FSU	REA [Residential Other Electric]	198.4	476.4	1252.9	2185.2	2757.2	2922
FSU	RH1 [Residential Space Heat]	5707.9	6667.7	7788.9	8692	9221.9	9577.9
FSU	RHW [Residential Hot Water]	517.9	630.2	742.6	884.7	1025.8	1127
FSU	RK1 [Residential Cooking]	524.3	640.1	750.8	822.7	871.5	903.8
FSU	RL1 [Residential Lighting]	100.8	121.5	159.3	213.4	266.1	306.7
FSU	RRF [Residential Refrigeration]	132.3	161	188.7	229.4	260.7	286.4
FSU	TAD [Domestic Aviation]	23	25.8	30.1	32.9	36.4	37.8
FSU	TAI [International Aviation]	572.9	615.9	695.7	786.5	861.9	895.2
FSU	TRB [Road Bus Demand]	11.4	13.7	16	17.5	18.5	19.3
FSU	TRC [Road Commercial Trucks Demand]	16.8	20.6	24.1	26.4	28	29
FSU	TRE [Road Three Wheels Demand]	6	6.4	6.9	7.4	7.8	8.1
FSU	TRH [Road Heavy Trucks Demand]	15.2	18.6	21.3	23.4	25.3	26.2
FSU	TRL [Road Light Vehicle Demand]	151.6	184.5	211.2	230.9	250	254.5
FSU	TRM [Road Medium Trucks Demand]	14.9	18.2	21.4	23.4	24.8	25.7
FSU	TRT [Road Auto Demand]	206.5	251.2	287.6	314.4	333.6	346.4
FSU	TRW [Road Two Wheels Demand]	10.3	10	9.8	9.7	9.5	9.4
FSU	TTF [Rail-Freight]	239.6	283.7	329.4	364.7	390.3	404.8
FSU	TTP [Rail-Passengers]	199.6	233.2	272.4	300.9	322.5	335
FSU	TWD [Domestic Internal Navigation]	52.1	60.4	70.2	77.7	83.1	86.2
FSU	TWI [International Navigation]	28.6	32.2	37	41.4	44.8	45.5

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
IND	AGR [Agricultural demand]	407.8	442.9	480.1	519.7	553.3	575
IND	CC1 [Commercial Cooling - Region 1]	1.7	2	2.4	2.8	3.2	3.4
IND	CC2 [Commercial Cooling - Region 2]	32.9	74.5	163.9	319.3	491.4	602.5
IND	CCK [Commercial Cooking]	5.7	6.7	8	8.8	9.4	9.8
IND	CH1 [Commercial Space Heat]	0.1	0.1	0.1	0.1	0.1	0.1
IND	CH2 [Commercial Space Heat - Region 2]	1.7	2.2	3	4.1	5.3	6
IND	CHW [Commercial Hot Water]	20.9	25.7	31.4	34.1	37.1	38.5
IND	CLA [Commercial Lighting]	187.9	345.1	505.1	654.9	825	985
IND	COE [Commercial Office Equipment]	17.2	75.6	382.4	590.4	960.1	1018
IND	COT [Commercial Other]	10.3	12.5	14.6	16.2	17.2	17.5
IND	CRF [Commercial Refrigeration]	5.7	6.3	7.6	7.9	9.2	8.5
IND	ICH [Chemicals]	1202	1566.5	2090.8	2819.1	5801.2	9922.2
IND	IIS [Iron and Steel]	18.5	20.8	24	27.1	32.7	34.2
IND	ILP [Pulp and Paper]	3.3	4.2	5.7	7.6	14.9	22
IND	INF [Non-ferrous metals]	0.5	0.7	1	1.3	2.6	3.9
IND	INM [Non Metals]	87.6	114.2	154.9	205.6	404.9	605.3
IND	IOI [Other Industries]	1024.6	1335.3	1782.2	2403.1	4660.5	6853.7
IND	NEU [Non Energy Uses]	0	0	0	0	0	0
IND	ONO [Other non-specified consumption]	29.1	34.2	40.1	46.8	52.9	57.1
IND	RC1 [Residential Cooling - Region 1]	3.7	4.2	4.6	4.9	5.2	5.3
IND	RC2 [Residential Cooling - Region 2]	69.9	96.9	128.8	159.3	184.3	203
IND	RCD [Residential Clothes Drying]	1.2	1.5	2	2.4	2.8	3.1
IND	RCW [Residential Clothes Washing]	7.4	9.3	11.9	14.3	16.7	18.5
IND	RDW [Residential Dishwashing]	1.2	1.6	2	2.4	2.8	3.1
IND	REA [Residential Other Electric]	98.4	349.6	665.4	1083.8	2270.3	2700.2
IND	RH1 [Residential Space Heat]	61.6	68.4	75.4	81	85	85.6
IND	RH2 [Residential Space Heat - Region 2]	55.3	71.4	91.3	113.4	137.4	159.8
IND	RHW [Residential Hot Water]	961.6	1294.8	1786.9	2476.5	3337	4018.5
IND	RK1 [Residential Cooking - Region 1]	3132.3	3482.3	3783.8	4021.8	4190	4291.4
IND	RK2 [Residential Cooking - Region 2]	1336.3	1649.2	1987.7	2343.7	2711.4	3088.3
IND	RL1 [Residential Lighting - Region 1]	101.6	110.4	125.2	128.9	142.4	137.6
IND	RL2 [Residential Lighting - Region 2]	147.3	190.9	248.2	301.7	389.4	434.1
IND	RRF [Residential Refrigeration]	36.9	48	59.1	71	82	90.5
IND	TAD [Domestic Aviation]	2.2	5.8	14.8	27.6	38	44.9
IND	TAI [International Aviation]	103.3	136.8	193.6	284.7	409.1	459.6
IND	TRB [Road Bus Demand]	15.2	26.6	45.5	76	117.1	153.8
IND	TRC [Road Commercial Trucks Demand]	22.3	37.4	62	101.8	152.2	196.2
IND	TRE [Road Three Wheels Demand]	0.5	0.5	0.6	0.6	0.6	0.6
IND	TRH [Road Heavy Trucks Demand]	18	28.2	43	66.2	91.7	106.5
IND	TRL [Road Light Vehicle Demand]	53.6	106.4	185.2	226.7	263.4	277.3
IND	TRM [Road Medium Trucks Demand]	36.3	60.8	98.7	156.7	210.6	253.4
IND	TRT [Road Auto Demand]	79.5	157.9	274.8	336.4	381.1	411.4
IND	TRW [Road Two Wheels Demand]	2.7	3	3.2	3.3	3.4	3.4
IND	TTF [Rail-Freight]	39.9	60.8	93.4	144	208.5	254.5
IND	TTP [Rail-Passengers]	62.1	69.5	77.1	82.3	89.7	90.5
IND	TWD [Domestic Internal Navigation]	26.2	34.3	46.1	62.8	80.6	92.6
IND	TWI [International Navigation]	3.8	4.5	5.4	6.7	8	8.6

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
JPN	AGR [Agricultural demand]	425.9	453.8	475.3	497.4	518.7	537.3
JPN	CC1 [Commercial Cooling]	310.5	333.1	357.3	383	408.7	432.2
JPN	CCK [Commercial Cooking]	114.1	119.5	124.4	127.3	129.8	130.7
JPN	CH1 [Commercial Space Heat]	374.3	391.9	405.9	415	421.8	427.8
JPN	CHW [Commercial Hot Water]	254.5	262.5	270.4	276.5	281.1	282.1
JPN	CLA [Commercial Lighting]	1096	1251.2	1435.4	1698.7	2009.9	2269.8
JPN	COE [Commercial Office Equipment]	323.4	435.7	604.7	837.7	1155	1482.7
JPN	COT [Commercial Other]	77.4	78.2	79.7	82.4	83.8	83.2
JPN	CRF [Commercial Refrigeration]	77.4	81.1	84.4	86.4	88.2	89.7
JPN	ICH [Chemicals]	1842.1	2131.2	2501.9	2914.9	3342.5	3684.5
JPN	IIS [Iron and Steel]	93.5	89.3	87.9	89.3	89.3	87.9
JPN	ILP [Pulp and Paper]	29.9	31.8	37.2	43.2	49.6	52.6
JPN	INF [Non-ferrous metals]	1.2	1.6	2	2.6	2.9	3.3
JPN	INM [Non Metals]	81.3	85.6	90.6	97.1	104.9	109.1
JPN	IOI [Other Industries]	2256.9	2272.3	2357.7	2524.2	2588	2542.3
JPN	NEU [Non Energy Uses]	10.6	12.5	14.8	17.6	20.6	23.6
JPN	ONO [Other non-specified consumption]	0.4	0.4	0.5	0.6	0.7	0.8
JPN	RC1 [Residential Cooling]	488.4	553.2	613.3	669.2	724	777.5
JPN	RCD [Residential Clothes Drying]	24.2	26	29.5	32.2	34.9	37.4
JPN	RCW [Residential Clothes Washing]	9.3	10.1	11.4	12.4	13.4	14.4
JPN	RDW [Residential Dishwashing]	9.3	10.2	11.4	12.4	13.4	14.4
JPN	REA [Residential Other Electric]	211.5	255.4	344	493	731.3	931.3
JPN	RH1 [Residential Space Heat]	717.2	793.6	869.7	944.8	1018.2	1078.7
JPN	RHW [Residential Hot Water]	463	501.7	539.5	576.1	611.3	638.6
JPN	RK1 [Residential Cooking]	187.3	207.3	227.2	246.8	266	284.6
JPN	RL1 [Residential Lighting]	341.4	407.5	480.9	529.3	572.7	605.4
JPN	RRF [Residential Refrigeration]	156.7	174.3	190.9	209.3	225.3	242
JPN	TAD [Domestic Aviation]	156.8	180	210.1	254.4	304.4	342
JPN	TAI [International Aviation]	265	288.3	332.3	421	493.4	565.8
JPN	TRB [Road Bus Demand]	4	4	3.9	3.8	3.7	3.6
JPN	TRC [Road Commercial Trucks Demand]	55	62.3	68.1	74.6	81.8	85.4
JPN	TRE [Road Three Wheels Demand]	3.6	3.6	3.6	3.6	3.5	3.5
JPN	TRH [Road Heavy Trucks Demand]	2.7	3.1	3.6	4.1	4.5	4.9
JPN	TRL [Road Light Vehicle Demand]	145.2	169.4	196.1	215.9	242.6	262.8
JPN	TRM [Road Medium Trucks Demand]	13.5	15.7	18.2	20	22.5	23.9
JPN	TRT [Road Auto Demand]	519.7	589.1	656.6	719.2	773.6	823.8
JPN	TRW [Road Two Wheels Demand]	6.8	6.8	6.7	6.6	6.4	6.3
JPN	TTF [Rail-Freight]	6	6.1	6.3	6.7	7	7.2
JPN	TTP [Rail-Passengers]	97.4	97.2	103.1	114.1	123.1	128.8
JPN	TWD [Domestic Internal Navigation]	107.1	105.9	108.6	117.4	123.7	126.8
JPN	TWI [International Navigation]	64.7	64	65.7	70.2	74.8	77.5

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
MEA	AGR [Agricultural demand]	308.4	578	1005	1671.4	2698.4	3565.2
MEA	CC1 [Commercial Cooling]	10.6	29.9	78.9	190.6	421	639.6
MEA	CCK [Commercial Cooking]	13.7	17.1	21.1	24.9	29.1	33
MEA	CH1 [Commercial Space Heat]	223.9	323.8	465.5	656.9	918.7	1121.3
MEA	CHW [Commercial Hot Water]	51.6	142	382.8	905.8	2020.7	3101.4
MEA	CLA [Commercial Lighting]	356	985.6	2603.4	6189.4	13807.9	21089.9
MEA	COE [Commercial Office Equipment]	111.6	502.7	1852.4	2834.2	4274.8	7553.9
MEA	COT [Commercial Other]	13.6	16.5	19.2	21.1	22.7	23.2
MEA	CRF [Commercial Refrigeration]	3.4	6.5	13.8	26.8	54.1	76.1
MEA	ICH [Chemicals]	1685.9	5653.9	16117	24403.7	26221.8	26903.6
MEA	IIS [Iron and Steel]	26.4	26.3	26.9	28.4	29.4	30
MEA	ILP [Pulp and Paper]	1.9	3	4.9	7.8	14.8	21.6
MEA	INF [Non-ferrous metals]	0.7	0.9	1.3	1.7	3.5	5.4
MEA	INM [Non Metals]	48.6	79.8	130.4	208	387.3	566.5
MEA	IOI [Other Industries]	2604.5	8734.8	11962.2	13695.6	16571.6	31970.3
MEA	NEU [Non Energy Uses]	10.3	17.6	27.6	39.6	53.7	64.3
MEA	ONO [Other non-specified consumption]	1701.7	2006.8	2339.5	2705.1	3115.2	3381.9
MEA	RC1 [Residential Cooling]	281.7	508.5	895	1446	2206.8	2624
MEA	RCD [Residential Clothes Drying]	35.5	62.7	106.9	171.9	295.2	403.2
MEA	RCW [Residential Clothes Washing]	0.6	1	1.8	2.9	5	6.8
MEA	RDW [Residential Dishwashing]	0.6	0.7	0.9	1.1	1.3	1.4
MEA	REA [Residential Other Electric]	256	743	2041.2	2802.7	4087.3	6472.8
MEA	RH1 [Residential Space Heat]	239.2	286.4	344.8	410.8	481.2	540.6
MEA	RHW [Residential Hot Water]	616.2	1019.5	1663.1	2701.8	4546.2	6272
MEA	RK1 [Residential Cooking]	758.3	957.8	1168.6	1392.4	1630.7	1832
MEA	RL1 [Residential Lighting]	171.2	355.4	763.9	1505.1	3229.4	5051.2
MEA	RRF [Residential Refrigeration]	149.2	329.5	700.9	1395.5	2934.4	4634.1
MEA	TAD [Domestic Aviation]	43.3	66.6	103.1	155.4	236.2	297.4
MEA	TAI [International Aviation]	333.9	497.1	769.2	1121.5	1763.1	2220
MEA	TRB [Road Bus Demand]	19.9	23.9	28.8	34.3	40.2	45.1
MEA	TRC [Road Commercial Trucks Demand]	66.8	120.6	209.4	354.2	591	805.7
MEA	TRE [Road Three Wheels Demand]	5	6	6.7	7.3	7.6	7.8
MEA	TRH [Road Heavy Trucks Demand]	17.6	31.8	54.1	91.4	127.9	156.1
MEA	TRL [Road Light Vehicle Demand]	146.2	235.8	384.6	624.8	1072.7	1414.1
MEA	TRM [Road Medium Trucks Demand]	41	74.1	128.7	217.6	304.3	364
MEA	TRT [Road Auto Demand]	242.2	400.6	637.2	1035.1	1777.3	2342.8
MEA	TRW [Road Two Wheels Demand]	11.4	13.9	16.7	19.9	23.3	26.2
MEA	TTF [Rail-Freight]	6.2	9.5	14.4	21.7	32.6	40.9
MEA	TTP [Rail-Passengers]	3.9	4.6	5.6	6.6	7.8	8.8
MEA	TWD [Domestic Internal Navigation]	8.3	10	12.3	14.8	17.9	19.6
MEA	TWI [International Navigation]	156.1	295.4	537.6	924	1498.7	2006.7

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
MEX	AGR [Agricultural demand]	113.7	165.4	239	343.4	418.5	482.2
MEX	CC1 [Commercial Cooling]	34	113.2	368.4	1106.3	1998	2940
MEX	CCK [Commercial Cooking]	69.9	88.6	113.1	147	172	190.9
MEX	CH1 [Commercial Space Heat]	17.6	23.3	30.9	42.3	48.6	55.6
MEX	CHW [Commercial Hot Water]	14.8	18.5	22.1	24.4	25.5	26.2
MEX	CLA [Commercial Lighting]	74.4	106.7	154.1	218	269.9	310.9
MEX	COE [Commercial Office Equipment]	15.4	123.9	453	622.6	834.1	1187.3
MEX	CRF [Commercial Refrigeration]	15.4	17.7	23.2	30.7	36.5	39.9
MEX	ICH [Chemicals]	494	1594.9	3976.2	6247.5	6656.5	6745.6
MEX	IIS [Iron and Steel]	10.8	15.8	23.6	35	43.5	50
MEX	ILP [Pulp and Paper]	3.7	6.8	10.9	14.3	15.8	16
MEX	INF [Non-ferrous metals]	0.3	0.5	0.9	1.2	1.2	1.3
MEX	INM [Non Metals]	30.9	45.1	66.4	100.1	124.6	145.1
MEX	IOI [Other Industries]	548.7	1743.9	5115.9	9971.4	12345.9	14003
MEX	NEU [Non Energy Uses]	0	0	0	0	0	0
MEX	RC1 [Residential Cooling]	57.6	92.4	153.2	257.5	354.8	431
MEX	RCD [Residential Clothes Drying]	0.1	0.1	0.2	0.3	0.4	0.4
MEX	RCW [Residential Clothes Washing]	0.1	0.2	0.2	0.3	0.4	0.4
MEX	RDW [Residential Dishwashing]	0.1	0.2	0.3	0.5	0.7	0.9
MEX	REA [Residential Other Electric]	47.6	270.5	846.7	1100.1	1501.6	2068.2
MEX	RH1 [Residential Space Heat]	4	4.4	4.9	5.4	5.8	6.1
MEX	RHW [Residential Hot Water]	122.5	137.8	152.6	167.3	181.8	193.2
MEX	RK1 [Residential Cooking - Region 1]	68	76.8	87.6	100.3	108.7	114.6
MEX	RK2 [Residential Cooking - Region 2]	132.5	177.5	242.7	334.9	406.9	463
MEX	RL1 [Residential Lighting - Region 1]	4.6	5.5	7.1	9.2	11	11.9
MEX	RL2 [Residential Lighting - Region 2]	24.3	30.6	41.9	57.8	71.7	79.9
MEX	RRF [Residential Refrigeration]	30	45.9	70.7	114.8	149.6	184.8
MEX	TAD [Domestic Aviation]	18.6	27.3	43.2	72.2	99.9	119.8
MEX	TAI [International Aviation]	105.3	150	234.2	383.2	536.5	657.1
MEX	TRB [Road Bus Demand]	19.7	22.1	24.5	26.9	29.2	31
MEX	TRC [Road Commercial Trucks Demand]	14.6	25.7	45.1	78.2	106.4	132.8
MEX	TRE [Road Three Wheels Demand]	1.4	1.6	1.7	1.7	1.8	1.8
MEX	TRH [Road Heavy Trucks Demand]	8.9	15.7	26.9	46.7	63.6	79.4
MEX	TRL [Road Light Vehicle Demand]	53.5	92.7	168.4	307.3	445.8	572.6
MEX	TRM [Road Medium Trucks Demand]	25.6	45.2	77.5	137.3	186.6	233.2
MEX	TRT [Road Auto Demand]	119.5	206.3	361.9	658.3	955	1200.3
MEX	TRW [Road Two Wheels Demand]	6.2	7.1	7.8	8.6	9.3	9.9
MEX	TTF [Rail-Freight]	18.3	27.6	42.2	64.7	82.7	97.9
MEX	TTP [Rail-Passengers]	8	8.3	8.8	9.5	10	10.3
MEX	TWD [Domestic Internal Navigation]	0	0	0	0	0	0
MEX	TWI [International Navigation]	35.9	46.8	61.9	83.1	99.5	109.2

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
ODA	AGR [Agricultural demand]	326.3	435	537	659.1	769.8	846.2
ODA	CC1 [Commercial Cooling]	142.5	265	487.7	891	1432.1	1938.7
ODA	CCK [Commercial Cooking]	34.7	49.7	71.9	103.7	141.9	172.2
ODA	CH1 [Commercial Space Heat]	106.5	131.9	158.6	176.2	187.5	194.8
ODA	CHW [Commercial Hot Water]	90.3	109.6	125.6	141.5	153.7	160.8
ODA	CLA [Commercial Lighting]	322.5	437.4	575.7	707.1	825.6	970
ODA	COE [Commercial Office Equipment]	124.1	622.5	1469.3	2119.4	3515.5	10094.1
ODA	COT [Commercial Other]	2.5	3	3.6	4	4.3	4.3
ODA	CRF [Commercial Refrigeration]	75.2	82.5	99.1	106.2	114.2	116.2
ODA	ICH [Chemicals]	1211.4	1984.6	3271.2	5441.4	8234.7	10437.8
ODA	IIS [Iron and Steel]	14.3	20	29.3	42.2	55.6	64
ODA	ILP [Pulp and Paper]	10.2	15.6	24	37.4	53.8	65.8
ODA	INF [Non-ferrous metals]	0.1	0.2	0.3	0.5	0.7	0.9
ODA	INM [Non Metals]	43.2	67.2	103.8	161.8	229.8	289.1
ODA	IOI [Other Industries]	4043	6441	9940.9	15495.2	22255.7	27262
ODA	NEU [Non Energy Uses]	0	0	0	0	0	0
ODA	ONO [Other non-specified consumption]	261.6	533.4	1074.5	2146.4	3711.3	5276.3
ODA	RC1 [Residential Cooling]	122.5	343.9	961.6	2518.1	5422.1	8341
ODA	RCD [Residential Clothes Drying]	5.1	6.6	8.1	9.4	10.6	11.6
ODA	RCW [Residential Clothes Washing]	15.3	19.9	24.4	28.2	31.9	34.7
ODA	RDW [Residential Dishwashing]	5.1	6	7	7.9	8.9	9.6
ODA	REA [Residential Other Electric]	152.6	519.5	1708.3	2395.8	3110.7	3466.7
ODA	RH1 [Residential Space Heat]	492.2	579.5	662.3	733.1	818	886.6
ODA	RHW [Residential Hot Water]	723.6	875.7	990.5	1118.7	1248.4	1353
ODA	RK1 [Residential Cooking]	3158	3718.6	4249.7	4799.8	5356	5805
ODA	RL1 [Residential Lighting]	365.4	669.9	1246.6	2195.2	3689.7	4994.7
ODA	ROT [Residential Other]	34.1	35.8	36.9	37.5	37.9	38.2
ODA	RRF [Residential Refrigeration]	50.9	61.6	69.6	78.7	89.6	95.1
ODA	TAD [Domestic Aviation]	26.4	35.9	50.9	75	102.6	117
ODA	TAI [International Aviation]	712.4	1024	1552.3	2502	3570.6	4009.2
ODA	TRB [Road Bus Demand]	45.2	52.4	59.9	67.7	75.5	81.9
ODA	TRC [Road Commercial Trucks Demand]	35.9	56.7	88.9	138.6	182.5	204.2
ODA	TRE [Road Three Wheels Demand]	2.4	2.6	2.8	2.9	3.1	3.2
ODA	TRH [Road Heavy Trucks Demand]	55.8	88.1	135.3	211	291.5	338.1
ODA	TRL [Road Light Vehicle Demand]	126.5	248.4	426	516.1	576.2	616
ODA	TRM [Road Medium Trucks Demand]	53.6	90.5	151.5	238.3	319.4	383.9
ODA	TRT [Road Auto Demand]	201.5	405.8	678.6	822	941.4	981.2
ODA	TRW [Road Two Wheels Demand]	20.8	24.5	28	31.7	35.3	38.3
ODA	TTF [Rail-Freight]	18.4	22.6	27.6	33.9	40	44
ODA	TTP [Rail-Passengers]	8.4	9.5	10.9	12.3	13.8	14.9
ODA	TWD [Domestic Internal Navigation]	125.2	198.4	318.3	512.6	751.9	951.7
ODA	TWI [International Navigation]	969.7	1485.2	2160.6	3109.6	4130.9	4811.4

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
SKO	AGR [Agricultural demand]	149.2	198	243.3	297	347.4	382.2
SKO	CC1 [Commercial Cooling]	105.5	132.8	159	176.1	187.5	194.8
SKO	CCK [Commercial Cooking]	32.4	39.6	47.1	52	55.6	57.9
SKO	CH1 [Commercial Space Heat]	256.4	316	378.5	419.1	446.3	463.7
SKO	CHW [Commercial Hot Water]	153.8	189.7	224.3	246.5	262.5	272.8
SKO	CLA [Commercial Lighting]	298.6	375.9	450.2	498.5	530.8	551.6
SKO	COE [Commercial Office Equipment]	68	133.6	282.5	573.7	1013	1396.9
SKO	CRF [Commercial Refrigeration]	20.6	25.7	30.6	33.7	36.1	37.6
SKO	ICH [Chemicals]	1237.1	1881.9	2878.3	4506.3	6393	7841.1
SKO	IIS [Iron and Steel]	40.3	54.6	80.3	116.6	151.1	171.9
SKO	ILP [Pulp and Paper]	7.7	11.8	18	27.3	39	47.8
SKO	INF [Non-ferrous metals]	16	24.7	38.4	59.2	84	104.6
SKO	INM [Non Metals]	46.8	70.1	108.9	170.4	241.8	301.2
SKO	IOI [Other Industries]	604.2	904.8	1383.6	2166.7	3122.1	3829.3
SKO	NEU [Non Energy Uses]	18	28.2	43.8	67.4	95.7	119.2
SKO	ONO [Other non-specified consumption]	191.4	224.9	263.4	307.7	348.2	375.7
SKO	RC1 [Residential Cooling]	48.4	106.2	228.3	434.7	687.2	854.1
SKO	RCD [Residential Clothes Drying]	4.4	9.4	20.6	39.1	61.9	76.9
SKO	RCW [Residential Clothes Washing]	2.5	2.5	2.9	3	3.1	3.1
SKO	RDW [Residential Dishwashing]	1.2	1.3	1.4	1.5	1.5	1.6
SKO	REA [Residential Other Electric]	59.8	232.3	947.7	1727.8	2283.1	2494.7
SKO	RH1 [Residential Space Heat]	148.9	200.4	263.7	358.7	463.2	532.3
SKO	RHW [Residential Hot Water]	74.6	100.4	132.8	177.1	228.7	268.2
SKO	RK1 [Residential Cooking]	100.2	134.9	181.2	241.6	311.9	365.8
SKO	RL1 [Residential Lighting]	58.9	60	62.2	65.4	67.1	67.1
SKO	RRF [Residential Refrigeration]	14.9	16	16.3	16.8	17.6	17.6
SKO	TAD [Domestic Aviation]	124.7	183.8	279.5	440.2	637.8	777.9
SKO	TAI [International Aviation]	29	41.4	62.1	95.8	145.2	175.1
SKO	TRB [Road Bus Demand]	6.1	6.4	6.6	6.8	7	7.1
SKO	TRC [Road Commercial Trucks Demand]	11.2	19.1	30.2	44.4	58.1	68.6
SKO	TRE [Road Three Wheels Demand]	0.7	0.7	0.7	0.7	0.7	0.7
SKO	TRH [Road Heavy Trucks Demand]	8.9	15.1	23.5	34.5	45.2	53.4
SKO	TRL [Road Light Vehicle Demand]	38.8	63.3	98.8	143.4	194.6	228
SKO	TRM [Road Medium Trucks Demand]	7.1	12.1	18.8	27.7	37	42.8
SKO	TRT [Road Auto Demand]	72.8	121.3	185.5	269.1	357.9	427.8
SKO	TRW [Road Two Wheels Demand]	4.1	4.4	4.5	4.7	4.8	4.9
SKO	TTF [Rail-Freight]	14	19.9	28.3	41.2	56.5	67.3
SKO	TTP [Rail-Passengers]	4.7	4.7	4.9	5.1	5.2	5.2
SKO	TWD [Domestic Internal Navigation]	166.1	200.7	244.4	301.5	356.3	387.9
SKO	TWI [International Navigation]	242	267.3	306.5	365.7	422.6	456

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
USA	AGR [Agricultural demand]	781.8	853.5	908.6	964.9	1021.2	1069
USA	CC1 [Commercial Cooling - Northeast]	379.6	429.8	460.3	471.2	479	484.2
USA	CC2 [Commercial Cooling - South]	1285	1683.8	2048.6	2358.6	2603.6	2781.2
USA	CC3 [Commercial Cooling - Midwest]	446.8	517.3	569.8	615.8	650.1	674
USA	CC4 [Commercial Cooling - West]	417.5	558.7	728.2	891.2	1027.5	1130.3
USA	CCK [Commercial Cooking]	342.6	379.6	418.6	452.3	486.1	519.7
USA	CH1 [Commercial Space Heat - Northeast]	568.9	621.9	650.5	672.3	686.3	692.1
USA	CH2 [Commercial Space Heat - South]	546.7	665.6	780.9	904.8	1024.5	1134.8
USA	CH3 [Commercial Space Heat - Midwest]	712.8	785.2	858	925.3	990.7	1053.8
USA	CH4 [Commercial Space Heat - West]	419.5	525.8	651.9	793.7	948.7	1115.1
USA	CHW [Commercial Hot Water]	902.2	999.6	1080.2	1179.1	1267.2	1354.8
USA	CLA [Commercial Lighting]	7025	8490.7	9908.6	11632.9	13203.9	14775
USA	COE [Commercial Office Equipment]	614.2	927.8	1570.9	2670.3	3646.8	4346.6
USA	COT [Commercial Other]	684.7	790.3	893.8	1015.3	1155.4	1262.8
USA	CRF [Commercial Refrigeration]	237.3	265.6	289.9	313.3	336.7	359.9
USA	ICH [Chemicals]	5501.1	7582.7	9158.3	11325.2	12379.6	12865.3
USA	IIS [Iron and Steel]	98.6	112.5	129.5	158.4	189.1	212.7
USA	ILP [Pulp and Paper]	85.7	97.3	111.9	130	149.7	165.3
USA	INF [Non-ferrous metals]	7.2	8.8	11	14	17.2	20.3
USA	INM [Non Metals]	83.9	94.3	103.2	118.9	131.1	139
USA	IOI [Other Industries]	8157	8380.1	8855.7	9642.8	9976.6	10001
USA	NEU [Non Energy Uses]	203.6	255.7	312.6	376.3	442.4	505.4
USA	RC1 [Residential Cooling - Northeast]	113.7	117.2	121.2	125.1	128.8	132.1
USA	RC2 [Residential Cooling - South]	1229.1	1407	1583.8	1763.3	1943.2	2121.7
USA	RC3 [Residential Cooling - Midwest]	290.9	314.6	338.6	362.3	385.2	407.2
USA	RC4 [Residential Cooling - West]	121.7	136.3	152.3	168.7	185.2	201.4
USA	RCD [Residential Clothes Drying]	301.4	325.8	360.7	394.8	426.7	458
USA	RCW [Residential Clothes Washing]	31.6	33.6	37.8	41.3	44.7	48
USA	RDW [Residential Dishwashing]	22.7	24.4	27.2	29.7	32.1	34.5
USA	REA [Residential Other Electric]	1502.5	1709.4	2168.2	2988.3	4046.3	5071.3
USA	RH1 [Residential Space Heat - Northeast]	1117	1137.8	1178	1210.5	1244.1	1275.3
USA	RH2 [Residential Space Heat - South]	959.3	1075.5	1193.9	1315.4	1435.9	1554.4
USA	RH3 [Residential Space Heat - Midwest]	1390.8	1486.8	1582.9	1677	1766.9	1833.7
USA	RH4 [Residential Space Heat - West]	650.6	708.9	762.9	824.5	884.4	942.3
USA	RHW [Residential Hot Water]	1439.9	1550.4	1647.7	1753.9	1878.5	1961.7
USA	RK1 [Residential Cooking - Northeast]	349.1	383.2	418.1	453.4	488.2	522.2
USA	RL1 [Residential Lighting - Northeast]	486.3	562.3	648.2	734.5	793.9	852.2
USA	ROT [Residential Other]	132.2	133.5	134.8	135.9	137	138
USA	RRF [Residential Refrigeration]	582.8	642.8	701.1	767.2	829.3	890.1
USA	TAD [Domestic Aviation]	2949.5	4237.5	6879.8	8592.8	9307.4	9485.8
USA	TAI [International Aviation]	872.5	1160.7	1706.8	2112.6	2315.5	2409
USA	TRB [Road Bus Demand]	19.2	20.1	20.8	22.1	23	23.8
USA	TRC [Road Commercial Trucks Demand]	109.6	147.8	195.7	244.8	303.8	362.3
USA	TRE [Road Three Wheels Demand]	5.5	5.9	6.3	6.5	6.6	6.7
USA	TRH [Road Heavy Trucks Demand]	224.1	310.2	456.3	528.7	551.9	574.2
USA	TRL [Road Light Vehicle Demand]	1553.9	1766	1977.6	2162	2366.7	2532.6
USA	TRM [Road Medium Trucks Demand]	59.9	87.6	133.2	153	165.8	172.5
USA	TRT [Road Auto Demand]	2351.5	2608.6	2836.3	3041.1	3255.9	3433.3
USA	TRW [Road Two Wheels Demand]	8.1	8.8	9.4	10	10.6	11.1
USA	TTF [Rail-Freight]	485.6	576	685.9	816.3	939.8	1031
USA	TTP [Rail-Passengers]	80.4	80.5	85.4	98.4	106.9	114.4
USA	TWD [Domestic Internal Navigation]	336.8	360.9	397.2	454.8	518.1	555
USA	TWI [International Navigation]	1236.2	1310.6	1441.9	1651.6	1881.7	2058.3

Table 14: End-Use Demands (continued)

Region	End-Use Demand	2000	2010	2020	2030	2040	2050
WEU	AGR [Agricultural demand]	1022.7	1067	1112.9	1160.5	1206.6	1246.6
WEU	CC1 [Commercial Cooling]	1037.2	1151.2	1277	1415.5	1558.2	1688.9
WEU	CCK [Commercial Cooking]	120.7	126.6	133.9	137.5	140.5	141.6
WEU	CH1 [Commercial Space Heat]	1344.7	1415.2	1484.2	1524	1554.2	1579.8
WEU	CHW [Commercial Hot Water]	541.1	575.2	597.2	613.3	625.4	635.7
WEU	CLA [Commercial Lighting]	3471.5	4508.5	5597.6	6686.8	7775.9	8865
WEU	COE [Commercial Office Equipment]	372.8	580.3	1025.5	1354.2	1381	1403.8
WEU	COT [Commercial Other]	130.8	128.2	128.3	132.4	135	134.3
WEU	CRF [Commercial Refrigeration]	159.5	176	194.6	215.3	239.2	261.4
WEU	ICH [Chemicals]	5595.9	6271.9	7129.3	8352.6	9542.4	10506.6
WEU	IIS [Iron and Steel]	123.3	124.1	130.8	137.8	146.9	150.7
WEU	ILP [Pulp and Paper]	81.3	97.3	116.2	139	160.9	171.2
WEU	INF [Non-ferrous metals]	4.9	5.7	7.4	9.7	12.9	16.7
WEU	INM [Non Metals]	111.5	135.8	159.7	181.8	201.8	209.8
WEU	IOI [Other Industries]	5051.1	5138.5	5435.9	5824.5	6000.4	6003.6
WEU	NEU [Non Energy Uses]	96.3	102.4	108.2	114.3	120.1	125.1
WEU	ONO [Other non-specified consumption]	580.2	711.1	870.5	1064.3	1284	1503.6
WEU	RC1 [Residential Cooling]	411.7	434.7	451.7	467.6	482.4	493.5
WEU	RCD [Residential Clothes Drying]	163.4	166.1	176.5	182.8	188.5	192.9
WEU	RCW [Residential Clothes Washing]	27.2	27.8	29.4	30.5	31.4	32.1
WEU	RDW [Residential Dishwashing]	27.2	28	29.4	30.5	31.6	32.1
WEU	REA [Residential Other Electric]	958.8	1451.4	2941.9	4064.1	4813.9	5546.3
WEU	RH1 [Residential Space Heat]	5529	5791.9	6002.3	6151.6	6410.2	6492
WEU	RHW [Residential Hot Water]	930.5	974.8	1010.2	1035.3	1078.9	1092.6
WEU	RK1 [Residential Cooking]	391.8	410.4	425.3	440.3	454.2	464.6
WEU	RL1 [Residential Lighting]	331.9	347.5	375.5	396.1	408.7	411.7
WEU	RRF [Residential Refrigeration]	381.3	394.9	405.6	416.3	426.2	433.5
WEU	TAD [Domestic Aviation]	434.2	599.5	941.3	1071.3	1086.3	1130.2
WEU	TAI [International Aviation]	1589.3	2103.3	3061	3634.1	3862.7	4018.8
WEU	TRB [Road Bus Demand]	24	23.9	23.4	23.2	22.9	23
WEU	TRC [Road Commercial Trucks Demand]	112.1	127	140.9	159.3	182.3	200.7
WEU	TRE [Road Three Wheels Demand]	9.2	9.3	9.2	9.2	9.1	9.1
WEU	TRH [Road Heavy Trucks Demand]	153.1	205.6	294.4	332.9	342.5	356.4
WEU	TRL [Road Light Vehicle Demand]	442.2	556.9	732.7	759.2	747.8	772.5
WEU	TRM [Road Medium Trucks Demand]	97.1	130.4	186.6	211.1	221.6	226
WEU	TRT [Road Auto Demand]	1085.9	1367.6	1799.4	1864.4	1836.3	1910.5
WEU	TRW [Road Two Wheels Demand]	17.3	17.4	17.2	17	16.9	16.7
WEU	TTF [Rail-Freight]	99.9	104.3	111	123.2	133.1	143.5
WEU	TTP [Rail-Passengers]	233.3	217.9	220.5	222.6	220.5	221.1
WEU	TWD [Domestic Internal Navigation]	283.9	283.7	293.6	316.6	336.3	354
WEU	TWI [International Navigation]	1336.6	1335.6	1382.1	1490.7	1566.7	1666.9

Table 15: Elasticities of End-Use Demands

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
AFR	CC1	-0.40	-0.25	-0.40	-0.25
AFR	CCK	-0.10	-0.05	-0.10	-0.05
AFR	CH1	-0.20	-0.10	-0.20	-0.10
AFR	CHW	-0.25	-0.15	-0.25	-0.15
AFR	CLA	-0.25	-0.15	-0.25	-0.15
AFR	COE	-0.40	-0.20	-0.40	-0.20
AFR	CRF	-0.20	-0.15	-0.20	-0.15
AFR	ICH	-0.10	-0.10	-0.10	-0.10
AFR	IIS	-0.10	-0.10	-0.10	-0.10
AFR	ILP	-0.10	-0.10	-0.10	-0.10
AFR	INF	-0.10	-0.10	-0.10	-0.10
AFR	INM	-0.10	-0.10	-0.10	-0.10
AFR	IOI	-0.10	-0.10	-0.10	-0.10
AFR	RC1	-0.25	-0.10	-0.25	-0.10
AFR	RCD	-0.10	-0.05	-0.10	-0.05
AFR	RCW	-0.10	-0.05	-0.10	-0.05
AFR	RDW	-0.10	-0.05	-0.10	-0.05
AFR	REA	-0.40	-0.30	-0.40	-0.30
AFR	RH1	-0.15	-0.05	-0.15	-0.05
AFR	RHW	-0.20	-0.15	-0.20	-0.15
AFR	RK1	0.00	0.00	0.00	0.00
AFR	RL1	-0.20	-0.10	-0.20	-0.10
AFR	ROT	-0.15	-0.15	-0.15	-0.15
AFR	RRF	-0.40	-0.30	-0.40	-0.30
AFR	TAD	-0.20	-0.20	-0.20	-0.20
AFR	TAI	-0.30	-0.30	-0.30	-0.30
AFR	TRB	-0.15	-0.15	-0.15	-0.15
AFR	TRC	-0.10	-0.10	-0.10	-0.10
AFR	TRE	-0.10	-0.10	-0.10	-0.10
AFR	TRH	-0.10	-0.10	-0.10	-0.10
AFR	TRL	-0.60	-0.40	-0.60	-0.40
AFR	TRM	-0.10	-0.10	-0.10	-0.10
AFR	TRT	-0.60	-0.40	-0.60	-0.40
AFR	TRW	-0.10	-0.10	-0.10	-0.10
AFR	TTF	-0.10	-0.10	-0.10	-0.10
AFR	TTP	-0.10	-0.10	-0.10	-0.10
AFR	TWD	-0.10	-0.10	-0.10	-0.10
AFR	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
AUS	CC1	-0.15	-0.05	-0.15	-0.05
AUS	CCK	-0.05	0.00	-0.05	0.00
AUS	CH1	-0.10	0.00	-0.10	0.00
AUS	CHW	-0.10	0.00	-0.10	0.00
AUS	CLA	-0.15	0.00	-0.15	0.00
AUS	COE	-0.05	0.00	-0.05	0.00
AUS	COT	-0.15	-0.15	-0.15	-0.15
AUS	CRF	0.00	0.00	0.00	0.00
AUS	ICH	-0.10	-0.10	-0.10	-0.10
AUS	IIS	-0.10	-0.10	-0.10	-0.10
AUS	ILP	-0.10	-0.10	-0.10	-0.10
AUS	INF	-0.10	-0.10	-0.10	-0.10
AUS	INM	-0.10	-0.10	-0.10	-0.10
AUS	IOI	-0.10	-0.10	-0.10	-0.10
AUS	RC1	-0.15	-0.05	-0.15	-0.05
AUS	RCD	-0.05	0.00	-0.05	0.00
AUS	RCW	-0.05	0.00	-0.05	0.00
AUS	RDW	-0.05	-0.03	-0.05	-0.03
AUS	REA	-0.20	-0.05	-0.20	-0.05
AUS	RH1	-0.05	0.00	-0.05	0.00
AUS	RHW	-0.05	0.00	-0.05	0.00
AUS	RK1	0.00	0.00	0.00	0.00
AUS	RL1	-0.10	0.00	-0.10	0.00
AUS	RRF	-0.05	-0.03	-0.05	-0.03
AUS	TAD	-0.20	-0.20	-0.20	-0.20
AUS	TAI	-0.30	-0.20	-0.30	-0.20
AUS	TRB	-0.15	-0.05	-0.15	-0.05
AUS	TRC	-0.15	-0.05	-0.15	-0.05
AUS	TRE	-0.05	-0.05	-0.05	-0.05
AUS	TRH	-0.15	-0.05	-0.15	-0.05
AUS	TRL	-0.15	-0.05	-0.15	-0.05
AUS	TRM	-0.15	-0.05	-0.15	-0.05
AUS	TRT	-0.15	-0.05	-0.15	-0.05
AUS	TRW	-0.05	-0.05	-0.05	-0.05
AUS	TTF	-0.15	-0.05	-0.15	-0.05
AUS	TTP	-0.15	-0.10	-0.15	-0.10
AUS	TWD	-0.20	-0.15	-0.20	-0.15
AUS	TWI	-0.20	-0.15	-0.20	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
CAN	CC1	-0.15	-0.05	-0.15	-0.05
CAN	CC2	-0.15	-0.05	-0.15	-0.05
CAN	CC3	-0.15	-0.05	-0.15	-0.05
CAN	CCK	-0.05	0.00	-0.05	0.00
CAN	CH1	-0.10	0.00	-0.10	0.00
CAN	CH2	-0.10	0.00	-0.10	0.00
CAN	CH3	-0.10	0.00	-0.10	0.00
CAN	CHW	-0.10	0.00	-0.10	0.00
CAN	CLA	-0.15	0.00	-0.15	0.00
CAN	COE	-0.05	0.00	-0.05	0.00
CAN	COT	-0.15	-0.15	-0.15	-0.15
CAN	CRF	0.00	0.00	0.00	0.00
CAN	ICH	-0.10	-0.10	-0.10	-0.10
CAN	IIS	-0.10	-0.10	-0.10	-0.10
CAN	ILP	-0.10	-0.10	-0.10	-0.10
CAN	INF	-0.10	-0.10	-0.10	-0.10
CAN	INM	-0.10	-0.10	-0.10	-0.10
CAN	IOI	-0.10	-0.10	-0.10	-0.10
CAN	RC1	-0.15	-0.05	-0.15	-0.05
CAN	RC2	-0.15	-0.05	-0.15	-0.05
CAN	RC3	-0.15	-0.05	-0.15	-0.05
CAN	RCD	-0.05	0.00	-0.05	0.00
CAN	RCW	-0.05	0.00	-0.05	0.00
CAN	RDW	-0.05	-0.03	-0.05	-0.03
CAN	REA	-0.20	-0.05	-0.20	-0.05
CAN	RH1	-0.05	0.00	-0.05	0.00
CAN	RH2	-0.05	0.00	-0.05	0.00
CAN	RH3	-0.05	0.00	-0.05	0.00
CAN	RHW	-0.05	0.00	-0.05	0.00
CAN	RK1	0.00	0.00	0.00	0.00
CAN	RK2	0.00	0.00	0.00	0.00
CAN	RK3	0.00	0.00	0.00	0.00
CAN	RL1	-0.10	0.00	-0.10	0.00
CAN	RL2	-0.10	0.00	-0.10	0.00
CAN	RL3	-0.10	0.00	-0.10	0.00
CAN	ROT	-0.10	-0.10	-0.10	-0.10
CAN	RRF	-0.05	-0.03	-0.05	-0.03
CAN	TAD	-0.20	-0.20	-0.20	-0.20
CAN	TAI	-0.30	-0.20	-0.30	-0.20
CAN	TRB	-0.15	-0.05	-0.15	-0.05
CAN	TRC	-0.15	-0.05	-0.15	-0.05
CAN	TRE	-0.05	-0.05	-0.05	-0.05
CAN	TRH	-0.15	-0.05	-0.15	-0.05
CAN	TRL	-0.15	-0.05	-0.15	-0.05
CAN	TRM	-0.15	-0.05	-0.15	-0.05
CAN	TRT	-0.15	-0.05	-0.15	-0.05
CAN	TRW	-0.05	-0.05	-0.05	-0.05
CAN	TTF	-0.15	-0.05	-0.15	-0.05
CAN	TTP	-0.15	-0.10	-0.15	-0.10
CAN	TWD	-0.20	-0.15	-0.20	-0.15
CAN	TWI	-0.20	-0.15	-0.20	-0.15

Table 15: Elasticities of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
CHI	CC1	-0.40	-0.25	-0.40	-0.25
CHI	CC2	-0.40	-0.25	-0.40	-0.25
CHI	CCK	-0.10	-0.05	-0.10	-0.05
CHI	CH1	-0.20	-0.10	-0.20	-0.10
CHI	CH2	-0.25	-0.15	-0.25	-0.15
CHI	CHW	-0.25	-0.15	-0.25	-0.15
CHI	CLA	-0.25	-0.15	-0.25	-0.15
CHI	COE	-0.40	-0.20	-0.40	-0.20
CHI	CRF	-0.20	-0.15	-0.20	-0.15
CHI	ICH	-0.10	-0.10	-0.10	-0.10
CHI	IIS	-0.10	-0.10	-0.10	-0.10
CHI	ILP	-0.10	-0.10	-0.10	-0.10
CHI	INF	-0.10	-0.10	-0.10	-0.10
CHI	INM	-0.10	-0.10	-0.10	-0.10
CHI	IOI	-0.10	-0.10	-0.10	-0.10
CHI	RC1	-0.25	-0.10	-0.25	-0.10
CHI	RC2	-0.25	-0.15	-0.25	-0.15
CHI	RCD	-0.10	-0.05	-0.10	-0.05
CHI	RCW	-0.10	-0.05	-0.10	-0.05
CHI	RDW	-0.10	-0.05	-0.10	-0.05
CHI	REA	-0.40	-0.30	-0.40	-0.30
CHI	RH1	-0.15	-0.05	-0.15	-0.05
CHI	RH2	-0.20	-0.10	-0.20	-0.10
CHI	RHW	-0.20	-0.15	-0.20	-0.15
CHI	RK1	0.00	0.00	0.00	0.00
CHI	RK2	0.00	0.00	0.00	0.00
CHI	RL1	-0.20	-0.10	-0.20	-0.10
CHI	RL2	-0.25	-0.15	-0.25	-0.15
CHI	RRF	-0.40	-0.30	-0.40	-0.30
CHI	TAD	-0.20	-0.20	-0.20	-0.20
CHI	TAI	-0.30	-0.30	-0.30	-0.30
CHI	TRB	-0.15	-0.15	-0.15	-0.15
CHI	TRC	-0.10	-0.10	-0.10	-0.10
CHI	TRE	-0.10	-0.10	-0.10	-0.10
CHI	TRH	-0.10	-0.10	-0.10	-0.10
CHI	TRL	-0.60	-0.40	-0.60	-0.40
CHI	TRM	-0.10	-0.10	-0.10	-0.10
CHI	TRT	-0.60	-0.40	-0.60	-0.40
CHI	TRW	-0.10	-0.10	-0.10	-0.10
CHI	TTF	-0.10	-0.10	-0.10	-0.10
CHI	TTP	-0.10	-0.10	-0.10	-0.10
CHI	TWD	-0.10	-0.10	-0.10	-0.10
CHI	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
CSA	CC1	-0.40	-0.25	-0.40	-0.25
CSA	CCK	-0.10	-0.05	-0.10	-0.05
CSA	CH1	-0.25	-0.15	-0.25	-0.15
CSA	CHW	-0.25	-0.15	-0.25	-0.15
CSA	CLA	-0.25	-0.15	-0.25	-0.15
CSA	COE	-0.40	-0.20	-0.40	-0.20
CSA	CRF	-0.20	-0.15	-0.20	-0.15
CSA	ICH	-0.10	-0.10	-0.10	-0.10
CSA	IIS	-0.10	-0.10	-0.10	-0.10
CSA	ILP	-0.10	-0.10	-0.10	-0.10
CSA	INF	-0.10	-0.10	-0.10	-0.10
CSA	INM	-0.10	-0.10	-0.10	-0.10
CSA	IOI	-0.10	-0.10	-0.10	-0.10
CSA	RC1	-0.25	-0.15	-0.25	-0.15
CSA	RCD	-0.20	-0.15	-0.20	-0.15
CSA	RCW	-0.20	-0.15	-0.20	-0.15
CSA	RDW	-0.20	-0.15	-0.20	-0.15
CSA	REA	-0.40	-0.30	-0.40	-0.30
CSA	RH1	-0.20	-0.10	-0.20	-0.10
CSA	RHW	-0.15	-0.10	-0.15	-0.10
CSA	RK1	0.00	0.00	0.00	0.00
CSA	RL1	-0.20	-0.15	-0.20	-0.15
CSA	RRF	-0.40	-0.30	-0.40	-0.30
CSA	TAD	-0.20	-0.20	-0.20	-0.20
CSA	TAI	-0.30	-0.30	-0.30	-0.30
CSA	TRB	-0.15	-0.15	-0.15	-0.15
CSA	TRC	-0.10	-0.10	-0.10	-0.10
CSA	TRE	-0.10	-0.10	-0.10	-0.10
CSA	TRH	-0.10	-0.10	-0.10	-0.10
CSA	TRL	-0.40	-0.30	-0.40	-0.30
CSA	TRM	-0.10	-0.10	-0.10	-0.10
CSA	TRT	-0.40	-0.30	-0.40	-0.30
CSA	TRW	-0.10	-0.10	-0.10	-0.10
CSA	TTF	-0.10	-0.10	-0.10	-0.10
CSA	TTP	-0.10	-0.10	-0.10	-0.10
CSA	TWD	-0.10	-0.10	-0.10	-0.10
CSA	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
EEU	CC1	-0.40	-0.25	-0.40	-0.25
EEU	CCK	-0.10	-0.05	-0.10	-0.05
EEU	CH1	-0.25	-0.15	-0.25	-0.15
EEU	CHW	-0.25	-0.15	-0.25	-0.15
EEU	CLA	-0.25	-0.15	-0.25	-0.15
EEU	COE	-0.40	-0.20	-0.40	-0.20
EEU	COT	-0.15	-0.15	-0.15	-0.15
EEU	CRF	-0.20	-0.15	-0.20	-0.15
EEU	ICH	-0.10	-0.10	-0.10	-0.10
EEU	IIS	-0.10	-0.10	-0.10	-0.10
EEU	ILP	-0.10	-0.10	-0.10	-0.10
EEU	INF	-0.10	-0.10	-0.10	-0.10
EEU	INM	-0.10	-0.10	-0.10	-0.10
EEU	IOI	-0.10	-0.10	-0.10	-0.10
EEU	RC1	-0.25	-0.15	-0.25	-0.15
EEU	RCD	-0.20	-0.15	-0.20	-0.15
EEU	RCW	-0.20	-0.15	-0.20	-0.15
EEU	RDW	-0.20	-0.15	-0.20	-0.15
EEU	REA	-0.40	-0.30	-0.40	-0.30
EEU	RH1	-0.20	-0.10	-0.20	-0.10
EEU	RHW	-0.15	-0.10	-0.15	-0.10
EEU	RK1	0.00	0.00	0.00	0.00
EEU	RL1	-0.20	-0.15	-0.20	-0.15
EEU	RRF	-0.40	-0.30	-0.40	-0.30
EEU	TAD	-0.20	-0.20	-0.20	-0.20
EEU	TAI	-0.30	-0.30	-0.30	-0.30
EEU	TRB	-0.15	-0.15	-0.15	-0.15
EEU	TRC	-0.10	-0.10	-0.10	-0.10
EEU	TRE	-0.10	-0.10	-0.10	-0.10
EEU	TRH	-0.10	-0.10	-0.10	-0.10
EEU	TRL	-0.40	-0.30	-0.40	-0.30
EEU	TRM	-0.10	-0.10	-0.10	-0.10
EEU	TRT	-0.40	-0.30	-0.40	-0.30
EEU	TRW	-0.10	-0.10	-0.10	-0.10
EEU	TTF	-0.10	-0.10	-0.10	-0.10
EEU	TTP	-0.10	-0.10	-0.10	-0.10
EEU	TWD	-0.10	-0.10	-0.10	-0.10
EEU	TWI	-0.15	-0.15	-0.15	-0.15

Table 15: Elasticities of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
FSU	CC1	-0.40	-0.25	-0.40	-0.25
FSU	CCK	-0.10	-0.05	-0.10	-0.05
FSU	CH1	-0.25	-0.15	-0.25	-0.15
FSU	CHW	-0.25	-0.15	-0.25	-0.15
FSU	CLA	-0.25	-0.15	-0.25	-0.15
FSU	COE	-0.40	-0.20	-0.40	-0.20
FSU	COT	-0.15	-0.15	-0.15	-0.15
FSU	CRF	-0.20	-0.15	-0.20	-0.15
FSU	ICH	-0.10	-0.10	-0.10	-0.10
FSU	IIS	-0.10	-0.10	-0.10	-0.10
FSU	ILP	-0.10	-0.10	-0.10	-0.10
FSU	INF	-0.10	-0.10	-0.10	-0.10
FSU	INM	-0.10	-0.10	-0.10	-0.10
FSU	IOI	-0.10	-0.10	-0.10	-0.10
FSU	RC1	-0.25	-0.15	-0.25	-0.15
FSU	RCD	-0.20	-0.15	-0.20	-0.15
FSU	RCW	-0.20	-0.15	-0.20	-0.15
FSU	RDW	-0.20	-0.15	-0.20	-0.15
FSU	REA	-0.40	-0.30	-0.40	-0.30
FSU	RH1	-0.20	-0.10	-0.20	-0.10
FSU	RHW	-0.15	-0.10	-0.15	-0.10
FSU	RK1	0.00	0.00	0.00	0.00
FSU	RL1	-0.20	-0.15	-0.20	-0.15
FSU	RRF	-0.40	-0.30	-0.40	-0.30
FSU	TAD	-0.20	-0.20	-0.20	-0.20
FSU	TAI	-0.30	-0.30	-0.30	-0.30
FSU	TRB	-0.15	-0.15	-0.15	-0.15
FSU	TRC	-0.10	-0.10	-0.10	-0.10
FSU	TRE	-0.10	-0.10	-0.10	-0.10
FSU	TRH	-0.10	-0.10	-0.10	-0.10
FSU	TRL	-0.40	-0.30	-0.40	-0.30
FSU	TRM	-0.10	-0.10	-0.10	-0.10
FSU	TRT	-0.40	-0.30	-0.40	-0.30
FSU	TRW	-0.10	-0.10	-0.10	-0.10
FSU	TTF	-0.10	-0.10	-0.10	-0.10
FSU	TTP	-0.10	-0.10	-0.10	-0.10
FSU	TWD	-0.10	-0.10	-0.10	-0.10
FSU	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
IND	CC1	-0.40	-0.25	-0.40	-0.25
IND	CC2	-0.40	-0.25	-0.40	-0.25
IND	CCK	-0.10	-0.05	-0.10	-0.05
IND	CH1	-0.20	-0.10	-0.20	-0.10
IND	CH2	-0.25	-0.15	-0.25	-0.15
IND	CHW	-0.25	-0.15	-0.25	-0.15
IND	CLA	-0.25	-0.15	-0.25	-0.15
IND	COE	-0.40	-0.20	-0.40	-0.20
IND	COT	-0.15	-0.15	-0.15	-0.15
IND	CRF	-0.20	-0.15	-0.20	-0.15
IND	ICH	-0.10	-0.10	-0.10	-0.10
IND	IIS	-0.10	-0.10	-0.10	-0.10
IND	ILP	-0.10	-0.10	-0.10	-0.10
IND	INF	-0.10	-0.10	-0.10	-0.10
IND	INM	-0.10	-0.10	-0.10	-0.10
IND	IOI	-0.10	-0.10	-0.10	-0.10
IND	RC1	-0.25	-0.10	-0.25	-0.10
IND	RC2	-0.25	-0.15	-0.25	-0.15
IND	RCD	-0.10	-0.05	-0.10	-0.05
IND	RCW	-0.10	-0.05	-0.10	-0.05
IND	RDW	-0.10	-0.05	-0.10	-0.05
IND	REA	-0.40	-0.30	-0.40	-0.30
IND	RH1	-0.15	-0.05	-0.15	-0.05
IND	RH2	-0.20	-0.10	-0.20	-0.10
IND	RHW	-0.20	-0.15	-0.20	-0.15
IND	RK1	0.00	0.00	0.00	0.00
IND	RK2	0.00	0.00	0.00	0.00
IND	RL1	-0.20	-0.10	-0.20	-0.10
IND	RL2	-0.25	-0.15	-0.25	-0.15
IND	RRF	-0.40	-0.30	-0.40	-0.30
IND	TAD	-0.20	-0.20	-0.20	-0.20
IND	TAI	-0.30	-0.30	-0.30	-0.30
IND	TRB	-0.15	-0.15	-0.15	-0.15
IND	TRC	-0.10	-0.10	-0.10	-0.10
IND	TRE	-0.10	-0.10	-0.10	-0.10
IND	TRH	-0.10	-0.10	-0.10	-0.10
IND	TRL	-0.60	-0.40	-0.60	-0.40
IND	TRM	-0.10	-0.10	-0.10	-0.10
IND	TRT	-0.60	-0.40	-0.60	-0.40
IND	TRW	-0.10	-0.10	-0.10	-0.10
IND	TTF	-0.10	-0.10	-0.10	-0.10
IND	TTP	-0.10	-0.10	-0.10	-0.10
IND	TWD	-0.10	-0.10	-0.10	-0.10
IND	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
JPN	CC1	-0.15	-0.05	-0.15	-0.05
JPN	CCK	-0.05	0.00	-0.05	0.00
JPN	CH1	-0.10	0.00	-0.10	0.00
JPN	CHW	-0.10	0.00	-0.10	0.00
JPN	CLA	-0.15	0.00	-0.15	0.00
JPN	COE	-0.05	0.00	-0.05	0.00
JPN	COT	-0.15	-0.15	-0.15	-0.15
JPN	CRF	0.00	0.00	0.00	0.00
JPN	ICH	-0.10	-0.10	-0.10	-0.10
JPN	IIS	-0.10	-0.10	-0.10	-0.10
JPN	ILP	-0.10	-0.10	-0.10	-0.10
JPN	INF	-0.10	-0.10	-0.10	-0.10
JPN	INM	-0.10	-0.10	-0.10	-0.10
JPN	IOI	-0.10	-0.10	-0.10	-0.10
JPN	RC1	-0.15	-0.05	-0.15	-0.05
JPN	RCD	-0.05	0.00	-0.05	0.00
JPN	RCW	-0.05	0.00	-0.05	0.00
JPN	RDW	-0.05	-0.03	-0.05	-0.03
JPN	REA	-0.20	-0.05	-0.20	-0.05
JPN	RH1	-0.05	0.00	-0.05	0.00
JPN	RHW	-0.05	0.00	-0.05	0.00
JPN	RK1	0.00	0.00	0.00	0.00
JPN	RL1	-0.10	0.00	-0.10	0.00
JPN	RRF	-0.05	-0.03	-0.05	-0.03
JPN	TAD	-0.20	-0.20	-0.20	-0.20
JPN	TAI	-0.30	-0.20	-0.30	-0.20
JPN	TRB	-0.15	-0.05	-0.15	-0.05
JPN	TRC	-0.15	-0.05	-0.15	-0.05
JPN	TRE	-0.05	-0.05	-0.05	-0.05
JPN	TRH	-0.15	-0.05	-0.15	-0.05
JPN	TRL	-0.15	-0.05	-0.15	-0.05
JPN	TRM	-0.15	-0.05	-0.15	-0.05
JPN	TRT	-0.15	-0.05	-0.15	-0.05
JPN	TRW	-0.05	-0.05	-0.05	-0.05
JPN	TTF	-0.15	-0.05	-0.15	-0.05
JPN	TTP	-0.15	-0.10	-0.15	-0.10
JPN	TWD	-0.20	-0.15	-0.20	-0.15
JPN	TWI	-0.20	-0.15	-0.20	-0.15

Table 15: Elasticities of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
MEA	CC1	-0.40	-0.25	-0.40	-0.25
MEA	CCK	-0.10	-0.05	-0.10	-0.05
MEA	CH1	-0.20	-0.10	-0.20	-0.10
MEA	CHW	-0.25	-0.15	-0.25	-0.15
MEA	CLA	-0.25	-0.15	-0.25	-0.15
MEA	COE	-0.40	-0.20	-0.40	-0.20
MEA	COT	-0.15	-0.15	-0.15	-0.15
MEA	CRF	-0.20	-0.15	-0.20	-0.15
MEA	ICH	-0.10	-0.10	-0.10	-0.10
MEA	IIS	-0.10	-0.10	-0.10	-0.10
MEA	ILP	-0.10	-0.10	-0.10	-0.10
MEA	INF	-0.10	-0.10	-0.10	-0.10
MEA	INM	-0.10	-0.10	-0.10	-0.10
MEA	IOI	-0.10	-0.10	-0.10	-0.10
MEA	RC1	-0.25	-0.10	-0.25	-0.10
MEA	RCD	-0.10	-0.05	-0.10	-0.05
MEA	RCW	-0.10	-0.05	-0.10	-0.05
MEA	RDW	-0.10	-0.05	-0.10	-0.05
MEA	REA	-0.40	-0.30	-0.40	-0.30
MEA	RH1	-0.15	-0.05	-0.15	-0.05
MEA	RHW	-0.20	-0.15	-0.20	-0.15
MEA	RK1	0.00	0.00	0.00	0.00
MEA	RL1	-0.20	-0.10	-0.20	-0.10
MEA	RRF	-0.40	-0.30	-0.40	-0.30
MEA	TAD	-0.20	-0.20	-0.20	-0.20
MEA	TAI	-0.30	-0.30	-0.30	-0.30
MEA	TRB	-0.15	-0.15	-0.15	-0.15
MEA	TRC	-0.10	-0.10	-0.10	-0.10
MEA	TRE	-0.10	-0.10	-0.10	-0.10
MEA	TRH	-0.10	-0.10	-0.10	-0.10
MEA	TRL	-0.60	-0.40	-0.60	-0.40
MEA	TRM	-0.10	-0.10	-0.10	-0.10
MEA	TRT	-0.60	-0.40	-0.60	-0.40
MEA	TRW	-0.10	-0.10	-0.10	-0.10
MEA	TTF	-0.10	-0.10	-0.10	-0.10
MEA	TTP	-0.10	-0.10	-0.10	-0.10
MEA	TWD	-0.10	-0.10	-0.10	-0.10
MEA	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
MEX	CC1	-0.40	-0.25	-0.40	-0.25
MEX	CCK	-0.10	-0.05	-0.10	-0.05
MEX	CH1	-0.25	-0.15	-0.25	-0.15
MEX	CHW	-0.25	-0.15	-0.25	-0.15
MEX	CLA	-0.25	-0.15	-0.25	-0.15
MEX	COE	-0.40	-0.20	-0.40	-0.20
MEX	CRF	-0.20	-0.15	-0.20	-0.15
MEX	ICH	-0.10	-0.10	-0.10	-0.10
MEX	IIS	-0.10	-0.10	-0.10	-0.10
MEX	ILP	-0.10	-0.10	-0.10	-0.10
MEX	INF	-0.10	-0.10	-0.10	-0.10
MEX	INM	-0.10	-0.10	-0.10	-0.10
MEX	IOI	-0.10	-0.10	-0.10	-0.10
MEX	RC1	-0.25	-0.15	-0.25	-0.15
MEX	RCD	-0.20	-0.15	-0.20	-0.15
MEX	RCW	-0.20	-0.15	-0.20	-0.15
MEX	RDW	-0.20	-0.15	-0.20	-0.15
MEX	REA	-0.40	-0.30	-0.40	-0.30
MEX	RH1	-0.20	-0.10	-0.20	-0.10
MEX	RHW	-0.15	-0.10	-0.15	-0.10
MEX	RK1	0.00	0.00	0.00	0.00
MEX	RK2	0.00	0.00	0.00	0.00
MEX	RL1	-0.20	-0.15	-0.20	-0.15
MEX	RL2	-0.20	-0.15	-0.20	-0.15
MEX	RRF	-0.40	-0.30	-0.40	-0.30
MEX	TAD	-0.20	-0.20	-0.20	-0.20
MEX	TAI	-0.30	-0.30	-0.30	-0.30
MEX	TRB	-0.15	-0.15	-0.15	-0.15
MEX	TRC	-0.10	-0.10	-0.10	-0.10
MEX	TRE	-0.10	-0.10	-0.10	-0.10
MEX	TRH	-0.10	-0.10	-0.10	-0.10
MEX	TRL	-0.40	-0.30	-0.40	-0.30
MEX	TRM	-0.10	-0.10	-0.10	-0.10
MEX	TRT	-0.40	-0.30	-0.40	-0.30
MEX	TRW	-0.10	-0.10	-0.10	-0.10
MEX	TTF	-0.10	-0.10	-0.10	-0.10
MEX	TTP	-0.10	-0.10	-0.10	-0.10
MEX	TWD	-0.10	-0.10	-0.10	-0.10
MEX	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
ODA	CC1	-0.40	-0.25	-0.40	-0.25
ODA	CCK	-0.10	-0.05	-0.10	-0.05
ODA	CH1	-0.20	-0.10	-0.20	-0.10
ODA	CHW	-0.25	-0.15	-0.25	-0.15
ODA	CLA	-0.25	-0.15	-0.25	-0.15
ODA	COE	-0.40	-0.20	-0.40	-0.20
ODA	COT	-0.15	-0.15	-0.15	-0.15
ODA	CRF	-0.20	-0.15	-0.20	-0.15
ODA	ICH	-0.10	-0.10	-0.10	-0.10
ODA	IIS	-0.10	-0.10	-0.10	-0.10
ODA	ILP	-0.10	-0.10	-0.10	-0.10
ODA	INF	-0.10	-0.10	-0.10	-0.10
ODA	INM	-0.10	-0.10	-0.10	-0.10
ODA	IOI	-0.10	-0.10	-0.10	-0.10
ODA	RC1	-0.25	-0.10	-0.25	-0.10
ODA	RCD	-0.10	-0.05	-0.10	-0.05
ODA	RCW	-0.10	-0.05	-0.10	-0.05
ODA	RDW	-0.10	-0.05	-0.10	-0.05
ODA	REA	-0.40	-0.30	-0.40	-0.30
ODA	RH1	-0.15	-0.05	-0.15	-0.05
ODA	RHW	-0.20	-0.15	-0.20	-0.15
ODA	RK1	0.00	0.00	0.00	0.00
ODA	RL1	-0.20	-0.10	-0.20	-0.10
ODA	ROT	-0.15	-0.15	-0.15	-0.15
ODA	RRF	-0.40	-0.30	-0.40	-0.30
ODA	TAD	-0.20	-0.20	-0.20	-0.20
ODA	TAI	-0.30	-0.30	-0.30	-0.30
ODA	TRB	-0.15	-0.15	-0.15	-0.15
ODA	TRC	-0.10	-0.10	-0.10	-0.10
ODA	TRE	-0.10	-0.10	-0.10	-0.10
ODA	TRH	-0.10	-0.10	-0.10	-0.10
ODA	TRL	-0.60	-0.40	-0.60	-0.40
ODA	TRM	-0.10	-0.10	-0.10	-0.10
ODA	TRT	-0.60	-0.40	-0.60	-0.40
ODA	TRW	-0.10	-0.10	-0.10	-0.10
ODA	TTF	-0.10	-0.10	-0.10	-0.10
ODA	TTP	-0.10	-0.10	-0.10	-0.10
ODA	TWD	-0.10	-0.10	-0.10	-0.10
ODA	TWI	-0.15	-0.15	-0.15	-0.15

Table 15: Elasticities of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
SKO	CC1	-0.25	-0.15	-0.25	-0.15
SKO	CCK	-0.25	-0.15	-0.25	-0.15
SKO	CH1	-0.20	-0.15	-0.20	-0.15
SKO	CHW	-0.40	-0.25	-0.40	-0.25
SKO	COE	-0.25	-0.15	-0.25	-0.15
SKO	ICH	-0.10	-0.10	-0.10	-0.10
SKO	IIS	-0.10	-0.10	-0.10	-0.10
SKO	ILP	-0.10	-0.10	-0.10	-0.10
SKO	INF	-0.10	-0.10	-0.10	-0.10
SKO	INM	-0.10	-0.10	-0.10	-0.10
SKO	IOI	-0.10	-0.10	-0.10	-0.10
SKO	RC1	-0.25	-0.15	-0.25	-0.15
SKO	RCD	-0.20	-0.15	-0.20	-0.15
SKO	RCW	-0.20	-0.15	-0.20	-0.15
SKO	RDW	-0.20	-0.15	-0.20	-0.15
SKO	REA	-0.40	-0.30	-0.40	-0.30
SKO	RH1	-0.20	-0.10	-0.20	-0.10
SKO	RHW	-0.15	-0.10	-0.15	-0.10
SKO	RK1	0.00	0.00	0.00	0.00
SKO	RL1	-0.15	-0.15	-0.15	-0.15
SKO	RRF	-0.40	-0.30	-0.40	-0.30
SKO	TAD	-0.20	-0.20	-0.20	-0.20
SKO	TAI	-0.30	-0.30	-0.30	-0.30
SKO	TRB	-0.15	-0.15	-0.15	-0.15
SKO	TRC	-0.10	-0.10	-0.10	-0.10
SKO	TRE	-0.10	-0.10	-0.10	-0.10
SKO	TRH	-0.10	-0.10	-0.10	-0.10
SKO	TRL	-0.40	-0.30	-0.40	-0.30
SKO	TRM	-0.10	-0.10	-0.10	-0.10
SKO	TRT	-0.40	-0.30	-0.40	-0.30
SKO	TRW	-0.10	-0.10	-0.10	-0.10
SKO	TTF	-0.10	-0.10	-0.10	-0.10
SKO	TTP	-0.10	-0.10	-0.10	-0.10
SKO	TWD	-0.10	-0.10	-0.10	-0.10
SKO	TWI	-0.15	-0.15	-0.15	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
USA	CC1	-0.15	-0.05	-0.15	-0.05
USA	CC2	-0.15	-0.05	-0.15	-0.05
USA	CC3	-0.15	-0.05	-0.15	-0.05
USA	CC4	-0.15	-0.05	-0.15	-0.05
USA	CCK	-0.05	0.00	-0.05	0.00
USA	CH1	-0.10	0.00	-0.10	0.00
USA	CH2	-0.10	0.00	-0.10	0.00
USA	CH3	-0.10	0.00	-0.10	0.00
USA	CH4	-0.10	0.00	-0.10	0.00
USA	CHW	-0.10	0.00	-0.10	0.00
USA	CLA	-0.15	0.00	-0.15	0.00
USA	COE	-0.05	0.00	-0.05	0.00
USA	COT	-0.15	-0.15	-0.15	-0.15
USA	CRF	0.00	0.00	0.00	0.00
USA	ICH	-0.10	-0.10	-0.10	-0.10
USA	IIS	-0.10	-0.10	-0.10	-0.10
USA	ILP	-0.10	-0.10	-0.10	-0.10
USA	INF	-0.10	-0.10	-0.10	-0.10
USA	INM	-0.10	-0.10	-0.10	-0.10
USA	IOI	-0.10	-0.10	-0.10	-0.10
USA	RC1	-0.15	-0.05	-0.15	-0.05
USA	RC2	-0.15	-0.05	-0.15	-0.05
USA	RC3	-0.15	-0.05	-0.15	-0.05
USA	RC4	-0.15	-0.05	-0.15	-0.05
USA	RCD	-0.05	0.00	-0.05	0.00
USA	RCW	-0.05	0.00	-0.05	0.00
USA	RDW	-0.05	-0.03	-0.05	-0.03
USA	REA	-0.20	-0.05	-0.20	-0.05
USA	RH1	-0.05	0.00	-0.05	0.00
USA	RH2	-0.05	0.00	-0.05	0.00
USA	RH3	-0.05	0.00	-0.05	0.00
USA	RH4	-0.05	0.00	-0.05	0.00
USA	RHW	-0.05	0.00	-0.05	0.00
USA	RK1	0.00	0.00	0.00	0.00
USA	RL1	-0.10	0.00	-0.10	0.00
USA	ROT	-0.10	-0.10	-0.10	-0.10
USA	RRF	-0.05	-0.03	-0.05	-0.03
USA	TAD	-0.20	-0.20	-0.20	-0.20
USA	TAI	-0.30	-0.20	-0.30	-0.20
USA	TRB	-0.15	-0.05	-0.15	-0.05
USA	TRC	-0.15	-0.05	-0.15	-0.05
USA	TRE	-0.05	-0.05	-0.05	-0.05
USA	TRH	-0.15	-0.05	-0.15	-0.05
USA	TRL	-0.15	-0.05	-0.15	-0.05
USA	TRM	-0.15	-0.05	-0.15	-0.05
USA	TRT	-0.15	-0.05	-0.15	-0.05
USA	TRW	-0.05	-0.05	-0.05	-0.05
USA	TTF	-0.15	-0.05	-0.15	-0.05
USA	TTP	-0.15	-0.10	-0.15	-0.10
USA	TWD	-0.20	-0.15	-0.20	-0.15
USA	TWI	-0.20	-0.15	-0.20	-0.15

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
WEU	CC1	-0.15	-0.05	-0.15	-0.05
WEU	CCK	-0.05	0.00	-0.05	0.00
WEU	CH1	-0.10	0.00	-0.10	0.00
WEU	CHW	-0.10	0.00	-0.10	0.00
WEU	CLA	-0.15	0.00	-0.15	0.00
WEU	COE	-0.05	0.00	-0.05	0.00
WEU	COT	-0.15	-0.15	-0.15	-0.15
WEU	CRF	0.00	0.00	0.00	0.00
WEU	ICH	-0.10	-0.10	-0.10	-0.10
WEU	IIS	-0.10	-0.10	-0.10	-0.10
WEU	ILP	-0.10	-0.10	-0.10	-0.10
WEU	INF	-0.10	-0.10	-0.10	-0.10
WEU	INM	-0.10	-0.10	-0.10	-0.10
WEU	IOI	-0.10	-0.10	-0.10	-0.10
WEU	RC1	-0.15	-0.05	-0.15	-0.05
WEU	RCD	-0.05	0.00	-0.05	0.00
WEU	RCW	-0.05	0.00	-0.05	0.00
WEU	RDW	-0.05	-0.03	-0.05	-0.03
WEU	REA	-0.20	-0.05	-0.20	-0.05
WEU	RH1	-0.05	0.00	-0.05	0.00
WEU	RHW	-0.05	0.00	-0.05	0.00
WEU	RK1	0.00	0.00	0.00	0.00
WEU	RL1	-0.10	0.00	-0.10	0.00
WEU	RRF	-0.05	-0.03	-0.05	-0.03
WEU	TAD	-0.20	-0.20	-0.20	-0.20
WEU	TAI	-0.30	-0.20	-0.30	-0.20
WEU	TRB	-0.15	-0.05	-0.15	-0.05
WEU	TRC	-0.15	-0.05	-0.15	-0.05
WEU	TRE	-0.05	-0.05	-0.05	-0.05
WEU	TRH	-0.15	-0.05	-0.15	-0.05
WEU	TRL	-0.15	-0.05	-0.15	-0.05
WEU	TRM	-0.15	-0.05	-0.15	-0.05
WEU	TRT	-0.15	-0.05	-0.15	-0.05
WEU	TRW	-0.05	-0.05	-0.05	-0.05
WEU	TTF	-0.15	-0.05	-0.15	-0.05
WEU	TTP	-0.15	-0.10	-0.15	-0.10
WEU	TWD	-0.20	-0.15	-0.20	-0.15
WEU	TWI	-0.20	-0.15	-0.20	-0.15

Table 16: Maximal Variations of End-Use Demands

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
AFR	AGR	0.10	0.10	0.10	0.10
AFR	CC1	0.10	0.10	0.10	0.10
AFR	CCK	0.10	0.10	0.10	0.10
AFR	CH1	0.20	0.20	0.20	0.20
AFR	CHW	0.20	0.20	0.20	0.20
AFR	CLA	0.15	0.15	0.15	0.15
AFR	COE	0.20	0.20	0.20	0.20
AFR	CRF	0.15	0.15	0.15	0.15
AFR	ICH	0.15	0.15	0.15	0.15
AFR	IIS	0.15	0.15	0.15	0.15
AFR	ILP	0.15	0.15	0.15	0.15
AFR	INF	0.15	0.15	0.15	0.15
AFR	INM	0.15	0.15	0.15	0.15
AFR	IOI	0.15	0.15	0.15	0.15
AFR	RC1	0.10	0.10	0.10	0.10
AFR	RCD	0.10	0.10	0.10	0.10
AFR	RCW	0.10	0.10	0.10	0.10
AFR	RDW	0.10	0.10	0.10	0.10
AFR	REA	0.20	0.20	0.20	0.20
AFR	RH1	0.20	0.10	0.20	0.10
AFR	RHW	0.20	0.20	0.20	0.20
AFR	RK1	0.00	0.00	0.00	0.00
AFR	RL1	0.10	0.10	0.10	0.10
AFR	ROT	0.20	0.20	0.20	0.20
AFR	RRF	0.20	0.20	0.20	0.20
AFR	TAD	0.20	0.20	0.20	0.20
AFR	TAI	0.30	0.30	0.30	0.30
AFR	TRB	0.15	0.15	0.15	0.15
AFR	TRC	0.20	0.20	0.20	0.20
AFR	TRE	0.10	0.10	0.10	0.10
AFR	TRH	0.20	0.20	0.20	0.20
AFR	TRL	0.25	0.25	0.25	0.25
AFR	TRM	0.20	0.20	0.20	0.20
AFR	TRT	0.25	0.25	0.25	0.25
AFR	TRW	0.10	0.10	0.10	0.10
AFR	TTF	0.10	0.20	0.10	0.20
AFR	TTP	0.10	0.15	0.10	0.15
AFR	TWD	0.10	0.10	0.10	0.10
AFR	TWI	0.20	0.20	0.20	0.20
AUS	AGR	0.10	0.10	0.10	0.10
AUS	CC1	0.15	0.10	0.15	0.10
AUS	CCK	0.10	0.00	0.10	0.00
AUS	CH1	0.10	0.00	0.10	0.00
AUS	CHW	0.10	0.00	0.10	0.00
AUS	CLA	0.15	0.00	0.15	0.00
AUS	COE	0.15	0.00	0.15	0.00
AUS	COT	0.10	0.10	0.10	0.10
AUS	CRF	0.00	0.00	0.00	0.00
AUS	ICH	0.15	0.15	0.15	0.15
AUS	IIS	0.15	0.15	0.15	0.15
AUS	ILP	0.15	0.15	0.15	0.15
AUS	INF	0.15	0.15	0.15	0.15
AUS	INM	0.15	0.15	0.15	0.15
AUS	IOI	0.15	0.15	0.15	0.15
AUS	RC1	0.15	0.10	0.15	0.10
AUS	RCD	0.05	0.00	0.05	0.00
AUS	RCW	0.05	0.00	0.05	0.00
AUS	RDW	0.05	0.05	0.05	0.05
AUS	REA	0.15	0.10	0.15	0.10
AUS	RH1	0.10	0.00	0.10	0.00
AUS	RHW	0.10	0.00	0.10	0.00
AUS	RK1	0.00	0.00	0.00	0.00
AUS	RL1	0.15	0.00	0.15	0.00
AUS	RRF	0.05	0.05	0.05	0.05
AUS	TAD	0.20	0.20	0.20	0.20
AUS	TAI	0.30	0.30	0.30	0.30
AUS	TRB	0.10	0.10	0.10	0.10
AUS	TRC	0.20	0.20	0.20	0.20
AUS	TRE	0.10	0.10	0.10	0.10
AUS	TRH	0.20	0.20	0.20	0.20
AUS	TRL	0.20	0.10	0.20	0.10
AUS	TRM	0.20	0.20	0.20	0.20
AUS	TRT	0.20	0.10	0.20	0.10
AUS	TRW	0.10	0.10	0.10	0.10
AUS	TTF	0.10	0.20	0.10	0.20
AUS	TTP	0.10	0.15	0.10	0.15
AUS	TWD	0.10	0.10	0.10	0.10
AUS	TWI	0.20	0.20	0.20	0.20
CAN	AGR	0.10	0.10	0.10	0.10
CAN	CC1	0.15	0.10	0.15	0.10
CAN	CC2	0.15	0.10	0.15	0.10
CAN	CC3	0.15	0.10	0.15	0.10
CAN	CCK	0.10	0.00	0.10	0.00
CAN	CH1	0.10	0.00	0.10	0.00
CAN	CH2	0.10	0.00	0.10	0.00
CAN	CH3	0.10	0.00	0.10	0.00
CAN	CHW	0.10	0.00	0.10	0.00
CAN	CLA	0.15	0.00	0.15	0.00
CAN	COE	0.15	0.00	0.15	0.00
CAN	COT	0.10	0.10	0.10	0.10
CAN	CRF	0.00	0.00	0.00	0.00
CAN	ICH	0.15	0.15	0.15	0.15
CAN	IIS	0.15	0.15	0.15	0.15
CAN	ILP	0.15	0.15	0.15	0.15
CAN	INF	0.15	0.15	0.15	0.15
CAN	INM	0.15	0.15	0.15	0.15
CAN	IOI	0.15	0.15	0.15	0.15
CAN	RC1	0.15	0.10	0.15	0.10
CAN	RC2	0.15	0.10	0.15	0.10
CAN	RC3	0.15	0.10	0.15	0.10
CAN	RCD	0.05	0.00	0.05	0.00
CAN	RCW	0.05	0.00	0.05	0.00
CAN	RDW	0.05	0.05	0.05	0.05
CAN	REA	0.15	0.10	0.15	0.10
CAN	RH1	0.10	0.00	0.10	0.00
CAN	RH2	0.10	0.00	0.10	0.00
CAN	RH3	0.10	0.00	0.10	0.00
CAN	RHW	0.10	0.00	0.10	0.00
CAN	RK1	0.00	0.00	0.00	0.00
CAN	RK2	0.00	0.00	0.00	0.00
CAN	RK3	0.00	0.00	0.00	0.00
CAN	RL1	0.15	0.00	0.15	0.00
CAN	RL2	0.15	0.00	0.15	0.00
CAN	RL3	0.15	0.00	0.15	0.00
CAN	ROT	0.10	0.10	0.10	0.10
CAN	RRF	0.05	0.05	0.05	0.05
CAN	TAD	0.20	0.20	0.20	0.20
CAN	TAI	0.30	0.30	0.30	0.30
CAN	TRB	0.10	0.10	0.10	0.10
CAN	TRC	0.20	0.20	0.20	0.20
CAN	TRE	0.10	0.10	0.10	0.10
CAN	TRH	0.20	0.20	0.20	0.20
CAN	TRL	0.20	0.10	0.20	0.10
CAN	TRM	0.20	0.20	0.20	0.20
CAN	TRT	0.20	0.10	0.20	0.10
CAN	TRW	0.10	0.10	0.10	0.10
CAN	TTF	0.10	0.20	0.10	0.20
CAN	TTP	0.10	0.15	0.10	0.15
CAN	TWD	0.10	0.10	0.10	0.10
CAN	TWI	0.20	0.20	0.20	0.20

Table 16: Maximal Variations of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
CHI	AGR	0.10	0.10	0.10	0.10
CHI	CC1	0.10	0.10	0.10	0.10
CHI	CC2	0.20	0.20	0.20	0.20
CHI	CCK	0.10	0.10	0.10	0.10
CHI	CH1	0.20	0.20	0.20	0.20
CHI	CH2	0.20	0.20	0.20	0.20
CHI	CHW	0.20	0.20	0.20	0.20
CHI	CLA	0.15	0.15	0.15	0.15
CHI	COE	0.20	0.20	0.20	0.20
CHI	CRF	0.15	0.15	0.15	0.15
CHI	ICH	0.15	0.15	0.15	0.15
CHI	IIS	0.15	0.15	0.15	0.15
CHI	ILP	0.15	0.15	0.15	0.15
CHI	INF	0.15	0.15	0.15	0.15
CHI	INM	0.15	0.15	0.15	0.15
CHI	IOI	0.15	0.15	0.15	0.15
CHI	RC1	0.10	0.10	0.10	0.10
CHI	RC2	0.20	0.20	0.20	0.20
CHI	RCD	0.10	0.10	0.10	0.10
CHI	RCW	0.10	0.10	0.10	0.10
CHI	RDW	0.10	0.10	0.10	0.10
CHI	REA	0.20	0.20	0.20	0.20
CHI	RH1	0.20	0.10	0.20	0.10
CHI	RH2	0.20	0.10	0.20	0.10
CHI	RHW	0.20	0.20	0.20	0.20
CHI	RK1	0.00	0.00	0.00	0.00
CHI	RK2	0.00	0.00	0.00	0.00
CHI	RL1	0.10	0.10	0.10	0.10
CHI	RL2	0.20	0.20	0.20	0.20
CHI	RRF	0.20	0.20	0.20	0.20
CHI	TAD	0.20	0.20	0.20	0.20
CHI	TAI	0.30	0.30	0.30	0.30
CHI	TRB	0.15	0.15	0.15	0.15
CHI	TRC	0.20	0.20	0.20	0.20
CHI	TRE	0.10	0.10	0.10	0.10
CHI	TRH	0.20	0.20	0.20	0.20
CHI	TRL	0.25	0.25	0.25	0.25
CHI	TRM	0.20	0.20	0.20	0.20
CHI	TRT	0.25	0.25	0.25	0.25
CHI	TRW	0.10	0.10	0.10	0.10
CHI	TTF	0.10	0.20	0.10	0.20
CHI	TTP	0.10	0.15	0.10	0.15
CHI	TWD	0.10	0.10	0.10	0.10
CHI	TWI	0.20	0.20	0.20	0.20

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
CSA	AGR	0.10	0.10	0.10	0.10
CSA	CC1	0.20	0.20	0.20	0.20
CSA	CCK	0.10	0.10	0.10	0.10
CSA	CH1	0.20	0.20	0.20	0.20
CSA	CHW	0.20	0.20	0.20	0.20
CSA	CLA	0.15	0.15	0.15	0.15
CSA	COE	0.20	0.20	0.20	0.20
CSA	CRF	0.15	0.15	0.15	0.15
CSA	ICH	0.15	0.15	0.15	0.15
CSA	IIS	0.15	0.15	0.15	0.15
CSA	ILP	0.15	0.15	0.15	0.15
CSA	INF	0.15	0.15	0.15	0.15
CSA	INM	0.15	0.15	0.15	0.15
CSA	IOI	0.15	0.15	0.15	0.15
CSA	RC1	0.20	0.20	0.20	0.20
CSA	RCD	0.20	0.10	0.20	0.10
CSA	RCW	0.20	0.20	0.20	0.20
CSA	RDW	0.20	0.20	0.20	0.20
CSA	REA	0.20	0.20	0.20	0.20
CSA	RH1	0.20	0.10	0.20	0.10
CSA	RHW	0.15	0.15	0.15	0.15
CSA	RK1	0.00	0.00	0.00	0.00
CSA	RL1	0.20	0.20	0.20	0.20
CSA	RRF	0.20	0.20	0.20	0.20
CSA	TAD	0.20	0.20	0.20	0.20
CSA	TAI	0.30	0.30	0.30	0.30
CSA	TRB	0.15	0.15	0.15	0.15
CSA	TRC	0.20	0.20	0.20	0.20
CSA	TRE	0.10	0.10	0.10	0.10
CSA	TRH	0.20	0.20	0.20	0.20
CSA	TRL	0.20	0.20	0.20	0.20
CSA	TRM	0.20	0.20	0.20	0.20
CSA	TRT	0.20	0.20	0.20	0.20
CSA	TRW	0.10	0.10	0.10	0.10
CSA	TTF	0.10	0.20	0.10	0.20
CSA	TTP	0.10	0.15	0.10	0.15
CSA	TWD	0.10	0.10	0.10	0.10
CSA	TWI	0.20	0.20	0.20	0.20

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
EEU	AGR	0.10	0.10	0.10	0.10
EEU	CC1	0.20	0.20	0.20	0.20
EEU	CCK	0.10	0.10	0.10	0.10
EEU	CH1	0.20	0.20	0.20	0.20
EEU	CHW	0.20	0.20	0.20	0.20
EEU	CLA	0.15	0.15	0.15	0.15
EEU	COE	0.20	0.20	0.20	0.20
EEU	COT	0.20	0.20	0.20	0.20
EEU	CRF	0.15	0.15	0.15	0.15
EEU	ICH	0.15	0.15	0.15	0.15
EEU	IIS	0.15	0.15	0.15	0.15
EEU	ILP	0.15	0.15	0.15	0.15
EEU	INF	0.15	0.15	0.15	0.15
EEU	INM	0.15	0.15	0.15	0.15
EEU	IOI	0.15	0.15	0.15	0.15
EEU	RC1	0.20	0.20	0.20	0.20
EEU	RCD	0.20	0.10	0.20	0.10
EEU	RCW	0.20	0.20	0.20	0.20
EEU	RDW	0.20	0.20	0.20	0.20
EEU	REA	0.20	0.20	0.20	0.20
EEU	RH1	0.20	0.10	0.20	0.10
EEU	RHW	0.15	0.15	0.15	0.15
EEU	RK1	0.00	0.00	0.00	0.00
EEU	RL1	0.20	0.20	0.20	0.20
EEU	RRF	0.20	0.20	0.20	0.20
EEU	TAD	0.20	0.20	0.20	0.20
EEU	TAI	0.30	0.30	0.30	0.30
EEU	TRB	0.15	0.15	0.15	0.15
EEU	TRC	0.20	0.20	0.20	0.20
EEU	TRE	0.10	0.10	0.10	0.10
EEU	TRH	0.20	0.20	0.20	0.20
EEU	TRL	0.20	0.20	0.20	0.20
EEU	TRM	0.20	0.20	0.20	0.20
EEU	TRT	0.20	0.20	0.20	0.20
EEU	TRW	0.10	0.10	0.10	0.10
EEU	TTF	0.10	0.20	0.10	0.20
EEU	TTP	0.10	0.15	0.10	0.15
EEU	TWD	0.10	0.10	0.10	0.10
EEU	TWI	0.20	0.20	0.20	0.20

Table 16: Maximal Variations of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
FSU	AGR	0.10	0.10	0.10	0.10
FSU	CC1	0.20	0.20	0.20	0.20
FSU	CCK	0.10	0.10	0.10	0.10
FSU	CH1	0.20	0.20	0.20	0.20
FSU	CHW	0.20	0.20	0.20	0.20
FSU	CLA	0.15	0.15	0.15	0.15
FSU	COE	0.20	0.20	0.20	0.20
FSU	COT	0.20	0.20	0.20	0.20
FSU	CRF	0.15	0.15	0.15	0.15
FSU	ICH	0.15	0.15	0.15	0.15
FSU	IIS	0.15	0.15	0.15	0.15
FSU	ILP	0.15	0.15	0.15	0.15
FSU	INF	0.15	0.15	0.15	0.15
FSU	INM	0.15	0.15	0.15	0.15
FSU	IOI	0.15	0.15	0.15	0.15
FSU	RC1	0.20	0.20	0.20	0.20
FSU	RCD	0.20	0.10	0.20	0.10
FSU	RCW	0.20	0.20	0.20	0.20
FSU	RDW	0.20	0.20	0.20	0.20
FSU	REA	0.20	0.20	0.20	0.20
FSU	RH1	0.20	0.10	0.20	0.10
FSU	RHW	0.15	0.15	0.15	0.15
FSU	RK1	0.00	0.00	0.00	0.00
FSU	RL1	0.20	0.20	0.20	0.20
FSU	RRF	0.20	0.20	0.20	0.20
FSU	TAD	0.20	0.20	0.20	0.20
FSU	TAI	0.30	0.30	0.30	0.30
FSU	TRB	0.15	0.15	0.15	0.15
FSU	TRC	0.20	0.20	0.20	0.20
FSU	TRE	0.10	0.10	0.10	0.10
FSU	TRH	0.20	0.20	0.20	0.20
FSU	TRL	0.20	0.20	0.20	0.20
FSU	TRM	0.20	0.20	0.20	0.20
FSU	TRT	0.20	0.20	0.20	0.20
FSU	TRW	0.10	0.10	0.10	0.10
FSU	TTF	0.10	0.20	0.10	0.20
FSU	TTP	0.10	0.15	0.10	0.15
FSU	TWD	0.10	0.10	0.10	0.10
FSU	TWI	0.20	0.20	0.20	0.20

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
IND	AGR	0.10	0.10	0.10	0.10
IND	CC1	0.10	0.10	0.10	0.10
IND	CC2	0.20	0.20	0.20	0.20
IND	CCK	0.10	0.10	0.10	0.10
IND	CH1	0.20	0.20	0.20	0.20
IND	CH2	0.20	0.20	0.20	0.20
IND	CHW	0.20	0.20	0.20	0.20
IND	CLA	0.15	0.15	0.15	0.15
IND	COE	0.20	0.20	0.20	0.20
IND	COT	0.20	0.20	0.20	0.20
IND	CRF	0.15	0.15	0.15	0.15
IND	ICH	0.15	0.15	0.15	0.15
IND	IIS	0.15	0.15	0.15	0.15
IND	ILP	0.15	0.15	0.15	0.15
IND	INF	0.15	0.15	0.15	0.15
IND	INM	0.15	0.15	0.15	0.15
IND	IOI	0.15	0.15	0.15	0.15
IND	RC1	0.10	0.10	0.10	0.10
IND	RC2	0.20	0.20	0.20	0.20
IND	RCD	0.10	0.10	0.10	0.10
IND	RCW	0.10	0.10	0.10	0.10
IND	RDW	0.10	0.10	0.10	0.10
IND	REA	0.20	0.20	0.20	0.20
IND	RH1	0.20	0.10	0.20	0.10
IND	RH2	0.20	0.10	0.20	0.10
IND	RHW	0.20	0.20	0.20	0.20
IND	RK1	0.00	0.00	0.00	0.00
IND	RK2	0.00	0.00	0.00	0.00
IND	RL1	0.10	0.10	0.10	0.10
IND	RL2	0.20	0.20	0.20	0.20
IND	RRF	0.20	0.20	0.20	0.20
IND	TAD	0.20	0.20	0.20	0.20
IND	TAI	0.30	0.30	0.30	0.30
IND	TRB	0.15	0.15	0.15	0.15
IND	TRC	0.20	0.20	0.20	0.20
IND	TRE	0.10	0.10	0.10	0.10
IND	TRH	0.20	0.20	0.20	0.20
IND	TRL	0.25	0.25	0.25	0.25
IND	TRM	0.20	0.20	0.20	0.20
IND	TRT	0.25	0.25	0.25	0.25
IND	TRW	0.10	0.10	0.10	0.10
IND	TTF	0.10	0.20	0.10	0.20
IND	TTP	0.10	0.15	0.10	0.15
IND	TWD	0.10	0.10	0.10	0.10
IND	TWI	0.20	0.20	0.20	0.20

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
JPN	AGR	0.10	0.10	0.10	0.10
JPN	CC1	0.15	0.10	0.15	0.10
JPN	CCK	0.10	0.00	0.10	0.00
JPN	CH1	0.10	0.00	0.10	0.00
JPN	CHW	0.10	0.00	0.10	0.00
JPN	CLA	0.15	0.00	0.15	0.00
JPN	COE	0.15	0.00	0.15	0.00
JPN	COT	0.10	0.10	0.10	0.10
JPN	CRF	0.00	0.00	0.00	0.00
JPN	ICH	0.15	0.15	0.15	0.15
JPN	IIS	0.15	0.15	0.15	0.15
JPN	ILP	0.15	0.15	0.15	0.15
JPN	INF	0.15	0.15	0.15	0.15
JPN	INM	0.15	0.15	0.15	0.15
JPN	IOI	0.15	0.15	0.15	0.15
JPN	RC1	0.15	0.10	0.15	0.10
JPN	RCD	0.05	0.00	0.05	0.00
JPN	RCW	0.05	0.00	0.05	0.00
JPN	RDW	0.05	0.05	0.05	0.05
JPN	REA	0.15	0.10	0.15	0.10
JPN	RH1	0.10	0.00	0.10	0.00
JPN	RHW	0.10	0.00	0.10	0.00
JPN	RK1	0.00	0.00	0.00	0.00
JPN	RL1	0.15	0.00	0.15	0.00
JPN	RRF	0.05	0.05	0.05	0.05
JPN	TAD	0.20	0.20	0.20	0.20
JPN	TAI	0.30	0.30	0.30	0.30
JPN	TRB	0.10	0.10	0.10	0.10
JPN	TRC	0.20	0.20	0.20	0.20
JPN	TRE	0.10	0.10	0.10	0.10
JPN	TRH	0.20	0.20	0.20	0.20
JPN	TRL	0.20	0.10	0.20	0.10
JPN	TRM	0.20	0.20	0.20	0.20
JPN	TRT	0.20	0.10	0.20	0.10
JPN	TRW	0.10	0.10	0.10	0.10
JPN	TTF	0.10	0.20	0.10	0.20
JPN	TTP	0.10	0.15	0.10	0.15
JPN	TWD	0.10	0.10	0.10	0.10
JPN	TWI	0.20	0.20	0.20	0.20

Table 16: Maximal Variations of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
MEA	AGR	0.10	0.10	0.10	0.10
MEA	CC1	0.10	0.10	0.10	0.10
MEA	CCK	0.10	0.10	0.10	0.10
MEA	CH1	0.20	0.20	0.20	0.20
MEA	CHW	0.20	0.20	0.20	0.20
MEA	CLA	0.15	0.15	0.15	0.15
MEA	COE	0.20	0.20	0.20	0.20
MEA	COT	0.20	0.20	0.20	0.20
MEA	CRF	0.15	0.15	0.15	0.15
MEA	ICH	0.15	0.15	0.15	0.15
MEA	IIS	0.15	0.15	0.15	0.15
MEA	ILP	0.15	0.15	0.15	0.15
MEA	INF	0.15	0.15	0.15	0.15
MEA	INM	0.15	0.15	0.15	0.15
MEA	IOI	0.15	0.15	0.15	0.15
MEA	RC1	0.10	0.10	0.10	0.10
MEA	RCD	0.10	0.10	0.10	0.10
MEA	RCW	0.10	0.10	0.10	0.10
MEA	RDW	0.10	0.10	0.10	0.10
MEA	REA	0.20	0.20	0.20	0.20
MEA	RH1	0.20	0.10	0.20	0.10
MEA	RHW	0.20	0.20	0.20	0.20
MEA	RK1	0.00	0.00	0.00	0.00
MEA	RL1	0.10	0.10	0.10	0.10
MEA	RRF	0.20	0.20	0.20	0.20
MEA	TAD	0.20	0.20	0.20	0.20
MEA	TAI	0.30	0.30	0.30	0.30
MEA	TRB	0.15	0.15	0.15	0.15
MEA	TRC	0.20	0.20	0.20	0.20
MEA	TRE	0.10	0.10	0.10	0.10
MEA	TRH	0.20	0.20	0.20	0.20
MEA	TRL	0.25	0.25	0.25	0.25
MEA	TRM	0.20	0.20	0.20	0.20
MEA	TRT	0.25	0.25	0.25	0.25
MEA	TRW	0.10	0.10	0.10	0.10
MEA	TTF	0.10	0.20	0.10	0.20
MEA	TTP	0.10	0.15	0.10	0.15
MEA	TWD	0.10	0.10	0.10	0.10
MEA	TWI	0.20	0.20	0.20	0.20

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
MEX	AGR	0.10	0.10	0.10	0.10
MEX	CC1	0.20	0.20	0.20	0.20
MEX	CCK	0.10	0.10	0.10	0.10
MEX	CH1	0.20	0.20	0.20	0.20
MEX	CHW	0.20	0.20	0.20	0.20
MEX	CLA	0.15	0.15	0.15	0.15
MEX	COE	0.20	0.20	0.20	0.20
MEX	CRF	0.15	0.15	0.15	0.15
MEX	ICH	0.15	0.15	0.15	0.15
MEX	IIS	0.15	0.15	0.15	0.15
MEX	ILP	0.15	0.15	0.15	0.15
MEX	INF	0.15	0.15	0.15	0.15
MEX	INM	0.15	0.15	0.15	0.15
MEX	IOI	0.15	0.15	0.15	0.15
MEX	RC1	0.20	0.20	0.20	0.20
MEX	RCD	0.20	0.10	0.20	0.10
MEX	RCW	0.20	0.20	0.20	0.20
MEX	RDW	0.20	0.20	0.20	0.20
MEX	REA	0.20	0.20	0.20	0.20
MEX	RH1	0.20	0.10	0.20	0.10
MEX	RHW	0.15	0.15	0.15	0.15
MEX	RK1	0.00	0.00	0.00	0.00
MEX	RK2	0.00	0.00	0.00	0.00
MEX	RL1	0.20	0.20	0.20	0.20
MEX	RL2	0.20	0.20	0.20	0.20
MEX	RRF	0.20	0.20	0.20	0.20
MEX	TAD	0.20	0.20	0.20	0.20
MEX	TAI	0.30	0.30	0.30	0.30
MEX	TRB	0.15	0.15	0.15	0.15
MEX	TRC	0.20	0.20	0.20	0.20
MEX	TRE	0.10	0.10	0.10	0.10
MEX	TRH	0.20	0.20	0.20	0.20
MEX	TRL	0.20	0.20	0.20	0.20
MEX	TRM	0.20	0.20	0.20	0.20
MEX	TRT	0.20	0.20	0.20	0.20
MEX	TRW	0.10	0.10	0.10	0.10
MEX	TTF	0.10	0.20	0.10	0.20
MEX	TTP	0.10	0.15	0.10	0.15
MEX	TWD	0.10	0.10	0.10	0.10
MEX	TWI	0.20	0.20	0.20	0.20

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
ODA	AGR	0.10	0.10	0.10	0.10
ODA	CC1	0.10	0.10	0.10	0.10
ODA	CCK	0.10	0.10	0.10	0.10
ODA	CH1	0.20	0.20	0.20	0.20
ODA	CHW	0.20	0.20	0.20	0.20
ODA	CLA	0.15	0.15	0.15	0.15
ODA	COE	0.20	0.20	0.20	0.20
ODA	COT	0.20	0.20	0.20	0.20
ODA	CRF	0.15	0.15	0.15	0.15
ODA	ICH	0.15	0.15	0.15	0.15
ODA	IIS	0.15	0.15	0.15	0.15
ODA	ILP	0.15	0.15	0.15	0.15
ODA	INF	0.15	0.15	0.15	0.15
ODA	INM	0.15	0.15	0.15	0.15
ODA	IOI	0.15	0.15	0.15	0.15
ODA	RC1	0.10	0.10	0.10	0.10
ODA	RCD	0.10	0.10	0.10	0.10
ODA	RCW	0.10	0.10	0.10	0.10
ODA	RDW	0.10	0.10	0.10	0.10
ODA	REA	0.20	0.20	0.20	0.20
ODA	RH1	0.20	0.10	0.20	0.10
ODA	RHW	0.20	0.20	0.20	0.20
ODA	RK1	0.00	0.00	0.00	0.00
ODA	RL1	0.10	0.10	0.10	0.10
ODA	ROT	0.20	0.20	0.20	0.20
ODA	RRF	0.20	0.20	0.20	0.20
ODA	TAD	0.20	0.20	0.20	0.20
ODA	TAI	0.30	0.30	0.30	0.30
ODA	TRB	0.15	0.15	0.15	0.15
ODA	TRC	0.20	0.20	0.20	0.20
ODA	TRE	0.10	0.10	0.10	0.10
ODA	TRH	0.20	0.20	0.20	0.20
ODA	TRL	0.25	0.25	0.25	0.25
ODA	TRM	0.20	0.20	0.20	0.20
ODA	TRT	0.25	0.25	0.25	0.25
ODA	TRW	0.10	0.10	0.10	0.10
ODA	TTF	0.10	0.20	0.10	0.20
ODA	TTP	0.10	0.15	0.10	0.15
ODA	TWD	0.10	0.10	0.10	0.10
ODA	TWI	0.20	0.20	0.20	0.20

Table 16: Maximal Variations of End-Use Demands (continued)

Region	End-Use Demand	2000 LO	2000 UP	2050 LO	2050 UP
SKO	AGR	0.10	0.10	0.10	0.10
SKO	CC1	0.20	0.20	0.20	0.20
SKO	CCK	0.20	0.20	0.20	0.20
SKO	CH1	0.20	0.20	0.20	0.20
SKO	CHW	0.20	0.20	0.20	0.20
SKO	COE	0.15	0.15	0.15	0.15
SKO	ICH	0.15	0.15	0.15	0.15
SKO	IIS	0.15	0.15	0.15	0.15
SKO	ILP	0.15	0.15	0.15	0.15
SKO	INF	0.15	0.15	0.15	0.15
SKO	INM	0.15	0.15	0.15	0.15
SKO	IOI	0.15	0.15	0.15	0.15
SKO	RC1	0.20	0.20	0.20	0.20
SKO	RCD	0.20	0.10	0.20	0.10
SKO	RCW	0.20	0.20	0.20	0.20
SKO	RDW	0.20	0.20	0.20	0.20
SKO	REA	0.20	0.20	0.20	0.20
SKO	RH1	0.20	0.10	0.20	0.10
SKO	RHW	0.15	0.15	0.15	0.15
SKO	RK1	0.00	0.00	0.00	0.00
SKO	RL1	0.20	0.20	0.20	0.20
SKO	RRF	0.20	0.20	0.20	0.20
SKO	TAD	0.20	0.20	0.20	0.20
SKO	TAI	0.30	0.30	0.30	0.30
SKO	TRB	0.15	0.15	0.15	0.15
SKO	TRC	0.20	0.20	0.20	0.20
SKO	TRE	0.10	0.10	0.10	0.10
SKO	TRH	0.20	0.20	0.20	0.20
SKO	TRL	0.20	0.20	0.20	0.20
SKO	TRM	0.20	0.20	0.20	0.20
SKO	TRT	0.20	0.20	0.20	0.20
SKO	TRW	0.10	0.10	0.10	0.10
SKO	TTF	0.10	0.20	0.10	0.20
SKO	TTP	0.10	0.15	0.10	0.15
SKO	TWD	0.10	0.10	0.10	0.10
SKO	TWI	0.20	0.20	0.20	0.20
USA	AGR	0.10	0.10	0.10	0.10
USA	CC1	0.15	0.10	0.15	0.10
USA	CC2	0.15	0.10	0.15	0.10
USA	CC3	0.15	0.10	0.15	0.10
USA	CC4	0.15	0.10	0.15	0.10
USA	CCK	0.10	0.00	0.10	0.00
USA	CH1	0.10	0.00	0.10	0.00
USA	CH2	0.10	0.00	0.10	0.00
USA	CH3	0.10	0.00	0.10	0.00
USA	CH4	0.10	0.00	0.10	0.00
USA	CHW	0.10	0.00	0.10	0.00
USA	CLA	0.15	0.00	0.15	0.00
USA	COE	0.15	0.00	0.15	0.00
USA	COT	0.10	0.10	0.10	0.10
USA	CRF	0.00	0.00	0.00	0.00
USA	ICH	0.15	0.15	0.15	0.15
USA	IIS	0.15	0.15	0.15	0.15
USA	ILP	0.15	0.15	0.15	0.15
USA	INF	0.15	0.15	0.15	0.15
USA	INM	0.15	0.15	0.15	0.15
USA	IOI	0.15	0.15	0.15	0.15
USA	RC1	0.15	0.10	0.15	0.10
USA	RC2	0.15	0.10	0.15	0.10
USA	RC3	0.15	0.10	0.15	0.10
USA	RC4	0.15	0.10	0.15	0.10
USA	RCD	0.05	0.00	0.05	0.00
USA	RCW	0.05	0.00	0.05	0.00
USA	RDW	0.05	0.05	0.05	0.05
USA	REA	0.15	0.10	0.15	0.10
USA	RH1	0.10	0.00	0.10	0.00
USA	RH2	0.10	0.00	0.10	0.00
USA	RH3	0.10	0.00	0.10	0.00
USA	RH4	0.10	0.00	0.10	0.00
USA	RHW	0.10	0.00	0.10	0.00
USA	RK1	0.00	0.00	0.00	0.00
USA	RL1	0.15	0.00	0.15	0.00
USA	ROT	0.10	0.10	0.10	0.10
USA	RRF	0.05	0.05	0.05	0.05
USA	TAD	0.20	0.20	0.20	0.20
USA	TAI	0.30	0.30	0.30	0.30
USA	TRB	0.10	0.10	0.10	0.10
USA	TRC	0.20	0.20	0.20	0.20
USA	TRE	0.10	0.10	0.10	0.10
USA	TRH	0.20	0.20	0.20	0.20
USA	TRL	0.20	0.10	0.20	0.10
USA	TRM	0.20	0.20	0.20	0.20
USA	TRT	0.20	0.10	0.20	0.10
USA	TRW	0.10	0.10	0.10	0.10
USA	TTF	0.10	0.20	0.10	0.20
USA	TTP	0.10	0.15	0.10	0.15
USA	TWD	0.10	0.10	0.10	0.10
USA	TWI	0.20	0.20	0.20	0.20
WEU	AGR	0.10	0.10	0.10	0.10
WEU	CC1	0.15	0.10	0.15	0.10
WEU	CCK	0.10	0.00	0.10	0.00
WEU	CH1	0.10	0.00	0.10	0.00
WEU	CHW	0.10	0.00	0.10	0.00
WEU	CLA	0.15	0.00	0.15	0.00
WEU	COE	0.15	0.00	0.15	0.00
WEU	COT	0.10	0.10	0.10	0.10
WEU	CRF	0.00	0.00	0.00	0.00
WEU	ICH	0.15	0.15	0.15	0.15
WEU	IIS	0.15	0.15	0.15	0.15
WEU	ILP	0.15	0.15	0.15	0.15
WEU	INF	0.15	0.15	0.15	0.15
WEU	INM	0.15	0.15	0.15	0.15
WEU	IOI	0.15	0.15	0.15	0.15
WEU	RC1	0.15	0.10	0.15	0.10
WEU	RCD	0.05	0.00	0.05	0.00
WEU	RCW	0.05	0.00	0.05	0.00
WEU	RDW	0.05	0.05	0.05	0.05
WEU	REA	0.15	0.10	0.15	0.10
WEU	RH1	0.10	0.00	0.10	0.00
WEU	RHW	0.10	0.00	0.10	0.00
WEU	RK1	0.00	0.00	0.00	0.00
WEU	RL1	0.15	0.00	0.15	0.00
WEU	RRF	0.05	0.05	0.05	0.05
WEU	TAD	0.20	0.20	0.20	0.20
WEU	TAI	0.30	0.30	0.30	0.30
WEU	TRB	0.10	0.10	0.10	0.10
WEU	TRC	0.20	0.20	0.20	0.20
WEU	TRE	0.10	0.10	0.10	0.10
WEU	TRH	0.20	0.20	0.20	0.20
WEU	TRL	0.20	0.10	0.20	0.10
WEU	TRM	0.20	0.20	0.20	0.20
WEU	TRT	0.20	0.10	0.20	0.10
WEU	TRW	0.10	0.10	0.10	0.10
WEU	TTF	0.10	0.20	0.10	0.20
WEU	TTP	0.10	0.15	0.10	0.15
WEU	TWD	0.10	0.10	0.10	0.10
WEU	TWI	0.20	0.20	0.20	0.20

Table 17: Existing transportation technologies

Code	Description	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
Efficiency (billion veh-km / PJ)																
TRBDST000	BUS: .00.CFV.DST.EXISTING.STD.	0.09	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.10	0.08	0.09	0.09	0.08	0.10	0.10
TRBELC000	BUS: .00.AFV.ELC.EXISTING.STD.	0.12	0.14	0.14	0.14	0.13	0.13	0.14	0.12	0.14	0.11	0.13	0.12	0.11	0.14	0.14
TRBETH000	BUS: .00.AFV.ETH.EXISTING.STD.	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.06	0.08	0.07	0.06	0.08	0.08
TRBGAS000	BUS: .00.CFV.GAS.EXISTING.STD.	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.09	0.07	0.09	0.08	0.07	0.09	0.09
TRBLPG000	BUS: .00.AFV.LPG.EXISTING.STD.	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.06	0.08	0.07	0.06	0.08	0.08
TRBMET000	BUS: .00.AFV.MET.EXISTING.STD.	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.06	0.08	0.07	0.06	0.08	0.08
TRBNGA000	BUS: .00.AFV.NGA.EXISTING.STD.	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.06	0.08	0.07	0.06	0.08	0.08
TRCDST000	COMMERCIAL TRUCK: .00.CFV.DST.EXISTING.STD.	0.12	0.12	0.14	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
TRCETH000	COMMERCIAL TRUCK: .00.AFV.ETH.EXISTING.STD.	0.11	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
TRCGAS000	COMMERCIAL TRUCK: .00.CFV.GAS.EXISTING.STD.	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.11	0.12	0.12	0.11	0.12	0.12
TRCLPG000	COMMERCIAL TRUCK: .00.AFV.LPG.EXISTING.STD.	0.11	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
TRCMET000	COMMERCIAL TRUCK: .00.AFV.MET.EXISTING.STD.	0.11	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
TRCNGA000	COMMERCIAL TRUCK: .00.AFV.NGA.EXISTING.STD.	0.11	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
TREDST000	THREE WHEELS: .00.CFV.DST.	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
TREGSL000	THREE WHEELS: .00.CFV.GAS.	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
TRHDST000	HEAVY TRUCK: .00.CFV.DST.EXISTING.STD.	0.05	0.06	0.06	0.05	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.05	0.06	0.06	0.06
TRHETH000	HEAVY TRUCK: .00.AFV.ETH.EXISTING.STD.	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TRHGAS000	HEAVY TRUCK: .00.CFV.GAS.EXISTING.STD.	0.05	0.06	0.06	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05	0.06	0.06	0.06
TRHLPG000	HEAVY TRUCK: .00.AFV.LPG.EXISTING.STD.	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TRHMET000	HEAVY TRUCK: .00.AFV.MET.EXISTING.STD.	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TRHNGA000	HEAVY TRUCK: .00.AFV.NGA.EXISTING.STD.	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TRLDST000	LIGHT TRUCK: .00.CFV.DST.EXISTING.STD.	0.18	0.22	0.21	0.21	0.18	0.18	0.18	0.17	0.22	0.22	0.18	0.20	0.18	0.20	0.21
TRLELC000	LIGHT TRUCK: .00.AFV.ELC.EXISTING.STD.	0.42	0.50	0.48	0.48	0.42	0.42	0.42	0.40	0.50	0.50	0.42	0.46	0.42	0.46	0.48
TRLETH000	LIGHT TRUCK: .00.AFV.ETH.EXISTING.STD.	0.15	0.18	0.17	0.17	0.15	0.15	0.15	0.14	0.18	0.18	0.15	0.16	0.15	0.16	0.17
TRLGAS000	LIGHT TRUCK: .00.CFV.GAS.EXISTING.STD.	0.19	0.23	0.22	0.21	0.19	0.19	0.19	0.18	0.23	0.23	0.19	0.21	0.19	0.21	0.22
TRLLPG000	LIGHT TRUCK: .00.AFV.LPG.EXISTING.STD.	0.15	0.18	0.17	0.17	0.15	0.15	0.15	0.14	0.18	0.18	0.15	0.16	0.15	0.16	0.17
TRLMET000	LIGHT TRUCK: .00.AFV.MET.EXISTING.STD.	0.15	0.18	0.17	0.17	0.15	0.15	0.15	0.14	0.18	0.18	0.15	0.16	0.15	0.16	0.17
TRLNGA000	LIGHT TRUCK: .00.AFV.NGA.EXISTING.STD.	0.15	0.18	0.17	0.17	0.15	0.15	0.15	0.14	0.18	0.18	0.15	0.16	0.15	0.16	0.17
TRMDST000	MEDIUM TRUCK: .00.CFV.DST.EXISTING.STD.	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08
TRMETH000	MEDIUM TRUCK: .00.AFV.ETH.EXISTING.STD.	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Table 17: Existing transportation technologies (continued)

Code	Description	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
TRMGAS000	MEDIUM TRUCK: .00.CFV.GAS.EXISTING.STD.	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
TRMLPG000	MEDIUM TRUCK: .00.AFV.LPG.EXISTING.STD.	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
TRMMET000	MEDIUM TRUCK: .00.AFV.MET.EXISTING.STD.	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
TRMNGA000	MEDIUM TRUCK: .00.AFV.NGA.EXISTING.STD.	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
TRTDST000	CAR: .00.CFV.DST.EXISTING.STD.	0.26	0.31	0.31	0.29	0.26	0.26	0.26	0.25	0.31	0.31	0.26	0.28	0.26	0.28	0.30
TRTELC000	CAR: .00.AFV.ELC.EXISTING.STD.	0.42	0.50	0.50	0.48	0.42	0.42	0.42	0.40	0.50	0.50	0.42	0.46	0.42	0.46	0.48
TRTETH000	CAR: .00.AFV.ETH.EXISTING.STD.	0.33	0.40	0.40	0.37	0.33	0.33	0.33	0.32	0.40	0.40	0.33	0.36	0.33	0.36	0.38
TRTGAS000	CAR: .00.CFV.GAS.EXISTING.STD.	0.23	0.27	0.27	0.25	0.23	0.23	0.23	0.22	0.27	0.27	0.23	0.25	0.23	0.24	0.26
TRTLPG000	CAR: .00.AFV.LPG.EXISTING.STD.	0.25	0.29	0.29	0.28	0.25	0.25	0.25	0.24	0.29	0.29	0.25	0.27	0.25	0.27	0.28
TRTMET000	CAR: .00.AFV.MET.EXISTING.STD.	0.33	0.40	0.40	0.37	0.33	0.33	0.33	0.32	0.40	0.40	0.33	0.36	0.33	0.36	0.38
TRTNGA000	CAR: .00.AFV.NGA.EXISTING.STD.	0.25	0.29	0.29	0.28	0.25	0.25	0.25	0.24	0.29	0.29	0.25	0.27	0.25	0.27	0.28
TRWMCG000	MOTOR CYCLE: .00.CFV.GAS.MCG.	0.49	0.63	0.63	0.63	0.63	0.63	0.63	0.49	0.63	0.63	0.49	0.49	0.63	0.49	0.63
TRWMPG000	MOTOR PED: .00.CFV.GAS.MPG.	0.70	0.90	0.90	0.90	0.90	0.90	0.90	0.70	0.90	0.90	0.70	0.70	0.90	0.70	0.90
2000 Residual capacity (billion veh-km)																
TRBDST000	BUS: .00.CFV.DST.EXISTING.STD.	9.74	1.97	0.35	10.15	49.25	6.09	10.56	14.91	3.98	13.88	10.40	35.78	6.00	18.76	23.45
TRBELC000	BUS: .00.AFV.ELC.EXISTING.STD.	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRBETH000	BUS: .00.AFV.ETH.EXISTING.STD.	0.00	0.00	0.00	0.00	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRBGAS000	BUS: .00.CFV.GAS.EXISTING.STD.	1.82	0.14	0.04	1.58	8.39	0.58	0.85	0.24	0.00	5.41	4.35	9.28	0.11	0.45	0.25
TRBLPG000	BUS: .00.AFV.LPG.EXISTING.STD.	0.15	0.03	0.00	0.01	0.76	0.00	0.00	0.00	0.00	0.58	4.90	0.15	0.00	0.01	0.00
TRBMET000	BUS: .00.AFV.MET.EXISTING.STD.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRBNGA000	BUS: .00.AFV.NGA.EXISTING.STD.	0.00	0.18	0.08	0.02	2.49	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.02	0.32
TRCDST000	COMMERCIAL TRUCK: .00.CFV.DST.EXISTING.STD.	20.31	1.22	2.44	6.27	10.75	7.97	6.52	21.08	54.98	32.17	2.27	12.44	9.22	28.99	86.99
TRCETH000	COMMERCIAL TRUCK: .00.AFV.ETH.EXISTING.STD.	0.00	0.00	0.00	0.00	3.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRCGAS000	COMMERCIAL TRUCK: .00.CFV.GAS.EXISTING.STD.	10.49	1.04	4.18	2.03	23.68	7.07	9.81	1.23	0.00	34.61	12.29	23.38	0.38	79.33	21.69
TRCLPG000	COMMERCIAL TRUCK: .00.AFV.LPG.EXISTING.STD.	0.00	0.35	0.87	0.00	0.00	1.11	0.51	0.00	0.00	0.00	0.00	0.10	1.60	0.29	3.45
TRCMET000	COMMERCIAL TRUCK: .00.AFV.MET.EXISTING.STD.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRCNGA000	COMMERCIAL TRUCK: .00.AFV.NGA.EXISTING.STD.	0.00	0.03	0.00	0.01	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
TREDST000	THREE WHEELS: .00.CFV.DST.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TREGSL000	THREE WHEELS: .00.CFV.GAS.	1.59	1.29	2.34	3.02	2.67	0.95	5.96	0.47	3.62	5.02	1.39	2.37	0.65	5.52	9.23
TRHDST000	HEAVY TRUCK: .00.CFV.DST.EXISTING.STD.	5.75	8.74	17.84	11.66	38.80	11.99	14.70	17.91	2.75	10.54	8.19	52.85	8.87	221.65	152.44
TRHETH000	HEAVY TRUCK: .00.AFV.ETH.EXISTING.STD.	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 17: Existing transportation technologies (continued)

Code	Description	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
TRHGAS000	HEAVY TRUCK: .00.CFV.GAS.EXISTING.STD.	1.15	0.04	0.00	0.33	1.32	0.36	0.51	0.08	0.00	6.57	0.69	2.92	0.02	2.35	0.65
TRHLPG000	HEAVY TRUCK: .00.AFV.LPG.EXISTING.STD.	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.01	0.00
TRHMET000	HEAVY TRUCK: .00.AFV.MET.EXISTING.STD.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRHNGA000	HEAVY TRUCK: .00.AFV.NGA.EXISTING.STD.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
TRLDST000	LIGHT TRUCK: .00.CFV.DST.EXISTING.STD.	14.29	6.86	0.94	3.61	11.84	1.56	1.42	32.90	52.46	17.41	2.50	13.89	4.73	15.67	34.69
TRLELC000	LIGHT TRUCK: .00.AFV.ELC.EXISTING.STD.	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00
TRLETH000	LIGHT TRUCK: .00.AFV.ETH.EXISTING.STD.	0.00	0.00	0.00	0.00	14.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.25
TRLGAS000	LIGHT TRUCK: .00.CFV.GAS.EXISTING.STD.	67.48	23.26	108.88	147.48	89.98	34.20	149.30	20.66	88.65	126.32	50.47	112.24	26.84	1478.9	397.55
TRLLPG000	LIGHT TRUCK: .00.AFV.LPG.EXISTING.STD.	0.46	5.08	5.83	0.02	0.09	1.33	0.62	0.00	4.05	2.43	0.55	0.38	7.21	1.23	8.59
TRLMET000	LIGHT TRUCK: .00.AFV.MET.EXISTING.STD.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRLNGA000	LIGHT TRUCK: .00.AFV.NGA.EXISTING.STD.	0.00	0.07	0.03	0.03	0.80	0.00	0.31	0.00	0.00	0.00	0.00	0.01	0.00	57.72	0.11
TRMDST000	MEDIUM TRUCK: .00.CFV.DST.EXISTING.STD.	12.71	1.53	3.97	7.85	33.62	6.65	8.16	35.18	9.99	20.71	7.10	38.93	5.94	39.91	90.73
TRMETH000	MEDIUM TRUCK: .00.AFV.ETH.EXISTING.STD.	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRMGAS000	MEDIUM TRUCK: .00.CFV.GAS.EXISTING.STD.	6.56	0.27	0.66	0.77	35.57	4.42	6.14	1.10	0.00	19.50	18.46	14.63	0.16	19.62	5.40
TRMLPG000	MEDIUM TRUCK: .00.AFV.LPG.EXISTING.STD.	0.19	0.23	0.23	0.00	0.00	0.70	0.32	0.00	3.47	0.83	0.00	0.00	1.03	0.09	0.93
TRMMET000	MEDIUM TRUCK: .00.AFV.MET.EXISTING.STD.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRMNGA000	MEDIUM TRUCK: .00.AFV.NGA.EXISTING.STD.	0.00	0.01	0.00	0.00	0.73	0.00	0.30	0.00	0.00	0.00	0.01	0.00	0.00	0.30	0.00
TRTDST000	CAR: .00.CFV.DST.EXISTING.STD.	5.09	6.61	0.86	2.77	7.22	2.50	2.28	46.82	63.59	6.19	1.53	10.64	4.49	13.05	197.49
TRTELC000	CAR: .00.AFV.ELC.EXISTING.STD.	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00
TRTETH000	CAR: .00.AFV.ETH.EXISTING.STD.	0.00	0.00	0.00	0.00	49.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.71
TRTGAS000	CAR: .00.CFV.GAS.EXISTING.STD.	123.03	167.37	221.71	249.08	230.50	80.45	200.03	32.65	442.36	226.48	116.06	189.56	50.23	2240.7	861.58
TRTLPG000	CAR: .00.AFV.LPG.EXISTING.STD.	1.78	31.90	17.14	0.06	0.29	4.52	2.10	0.00	13.73	9.47	1.87	1.27	18.05	1.01	24.01
TRTMET000	CAR: .00.AFV.MET.EXISTING.STD.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRTNGA000	CAR: .00.AFV.NGA.EXISTING.STD.	0.00	0.11	0.55	0.21	2.01	0.00	2.04	0.00	0.00	0.00	0.00	0.04	0.00	96.34	2.15
TRWMCG000	MOTOR CYCLE: .00.CFV.GAS.MCG.	0.45	2.09	3.79	5.43	12.99	3.09	8.89	0.40	5.86	3.62	4.95	6.63	2.11	6.96	14.95
TRWMPG000	MOTOR PED: .00.CFV.GAS.MPG.	2.55	0.33	0.60	31.04	2.06	0.49	1.41	2.26	0.93	7.75	1.25	14.21	2.01	1.10	2.37

Table 18: New transportation technologies

Code	Description	EFF (billion veh-km / PJ)	FIXOM MUS$$_{2000}$/billion veh-km	INVCOST MUS$$_{2000}$/billion veh-km
TRBDSA005	BUS: .05.CFV.DST.10%MPG.	0.10	160.8	5592.3
TRBDSB005	BUS: .05.CFV.DST.20%MPG.	0.12	292.3	8699.2
TRBDST005	BUS: .05.CFV.DST.STD.	0.09	160.8	4971.0
TRBELC005	BUS: .05.AFV.ELC.	0.15	250.5	8699.2
TRBETH005	BUS: .05.AFV.ETH.	0.09	215.4	7249.3
TRBFUE010	BUS: .05.FUC.	0.13	357.9	12427.4
TRBGAA005	BUS: .05.CFV.GAS.10%MPG.	0.10	38.8	1491.3
TRBGAB005	BUS: .05.CFV.GAS.20%MPG.	0.12	38.8	1967.7
TRBGAS005	BUS: .05.CFV.GAS.STD.	0.09	38.8	1346.3
TRBHYB005	BUS:.05.AFV.HYB.	0.13	292.3	8699.2
TRBLPG005	BUS: .05.AFV.LPG.	0.09	190.6	5695.9
TRBMET005	BUS: .05.AFV.MET.	0.09	215.4	7249.3
TRBNGA005	BUS: .05.AFV.NGA.	0.09	190.6	6420.8
TRCDST005	COMMERCIAL TRUCK: .05.CFV.DST.STD.	0.17	50.0	1350.0
TRCETH005	COMMERCIAL TRUCK: .05.AFV.ETH.	0.15	50.0	1400.0
TRCGAS005	COMMERCIAL TRUCK: .05.CFV.GAS.STD.	0.16	50.0	1250.0
TRCLPG005	COMMERCIAL TRUCK: .05.AFV.LPG.	0.15	50.0	1400.0
TRCMET005	COMMERCIAL TRUCK: .05.AFV.MET.	0.15	50.0	1400.0
TRCNGA005	COMMERCIAL TRUCK: .05.AFV.NGA.	0.15	50.0	1400.0
TREDST005	THREE WHEELS: .05.CFV.DST.	0.40	60.0	1200.0
TREGSL005	THREE WHEELS: .05.CFV.GAS.	0.50	40.0	1200.0
TRHDSA005	HEAVY TRUCK: .05.CFV.DST.10%MPG.	0.10	71.9	1065.7
TRHDSA010	HEAVY TRUCK: .10.CFV.DST.10%MPG.	0.10	79.1	1172.2
TRHDSA020	HEAVY TRUCK: .20.CFV.DST.10%MPG.	0.10	80.6	1193.5
TRHDSB005	HEAVY TRUCK: .05.CFV.DST.15%MPG.	0.10	82.7	1225.5
TRHDSB010	HEAVY TRUCK: .10.CFV.DST.15%MPG.	0.10	86.3	1278.8
TRHDSB020	HEAVY TRUCK: .20.CFV.DST.15%MPG.	0.10	89.9	1332.1
TRHDST005	HEAVY TRUCK: .00.CFV.DST.STD.	0.08	65.2	966.6
TRHDST010	HEAVY TRUCK: .10.CFV.DST.STD.	0.08	68.5	1014.9
TRHDST020	HEAVY TRUCK: .20.CFV.DST.STD.	0.09	71.9	1065.7
TRHETH005	HEAVY TRUCK: .05.AFV.ETH.	0.08	89.1	1319.4
TRHETH010	HEAVY TRUCK: .10.AFV.ETH.	0.08	90.8	1345.8
TRHETH015	HEAVY TRUCK: .15.AFV.ETH.	0.09	92.7	1372.7
TRHETH020	HEAVY TRUCK: .20.AFV.ETH.	0.09	94.5	1400.1
TRHGAS005	HEAVY TRUCK: .05.CFV.GAS.STD.	0.06	65.1	964.2
TRHLPG005	HEAVY TRUCK: .05.AFV.LPG.	0.05	71.8	1063.2
TRHLPG010	HEAVY TRUCK: .10.AFV.LPG.	0.05	73.2	1084.5
TRHLPG015	HEAVY TRUCK: .15.AFV.LPG.	0.05	74.7	1106.2
TRHLPG020	HEAVY TRUCK: .20.AFV.LPG.	0.05	76.2	1128.3
TRHMET005	HEAVY TRUCK: .05.AFV.MET.	0.08	89.1	1319.4
TRHMET010	HEAVY TRUCK: .10.AFV.MET.	0.08	90.8	1345.8
TRHMET015	HEAVY TRUCK: .15.AFV.MET.	0.09	92.7	1372.7
TRHMET020	HEAVY TRUCK: .20.AFV.MET.	0.09	94.5	1400.1
TRHNGA005	HEAVY TRUCK: .05.AFV.NGA.	0.07	88.1	1304.9
TRHNGA010	HEAVY TRUCK: .10.AFV.NGA.	0.07	89.8	1331.0
TRHNGA015	HEAVY TRUCK: .15.AFV.NGA.	0.07	91.6	1357.6
TRHNGA020	HEAVY TRUCK: .20.AFV.NGA.	0.07	93.5	1384.7
TRLDCA005	Light Truck: .05.CFV.DST.CAFE.STD.	0.38	66.3	1237.6
TRLDCA010	Light Truck: .10.CFV.DST.CAFE.STD.	0.38	69.7	1301.4
TRLDCA015	Light Truck: .15.CFV.DST.CAFE.STD.	0.38	74.8	1397.0
TRLDCB005	Light Truck: .05.CFV.DST.CAFE.2.0MPG.	0.42	66.0	1388.3
TRLDCB010	Light Truck: .10.CFV.DST.CAFE.2.0MPG.	0.42	71.1	1589.5

Table 18: New transportation technologies (continued)

Code	Description	EFF (billion veh-km / PJ)	FIXOM MUS$2000/billion veh-km	INVCOST MUS$2000/billion veh-km
TRLDCB015	Light Truck: .15.CFV.DST.CAFE.2.0MPG.	0.42	87.1	1450.0
TRLDCC005	Light Truck: .05.CFV.DST.CAFE.4.0MPG.	0.46	73.8	1536.9
TRLDCC010	Light Truck: .10.CFV.DST.CAFE.4.0MPG.	0.46	83.9	1876.3
TRLDCC015	Light Truck: .15.CFV.DST.CAFE.4.0MPG.	0.46	90.1	2014.3
TRLDEG005	LIGHT TRUCK: .05.AFV.DEG.ETH/GAS.	0.36	93.1	1369.2
TRLDMG005	LIGHT TRUCK: .05.AFV.DMG.MET/GAS.	0.34	94.0	1383.0
TRLELC005	LIGHT TRUCK: .05.AFV.ELC.	0.70	132.5	1742.5
TRLELC010	LIGHT TRUCK: .10.AFV.ELC.	0.61	100.0	1930.0
TRLELC015	LIGHT TRUCK: .15.AFV.ELC.	0.62	100.0	1940.0
TRLELC020	LIGHT TRUCK: .20.AFV.ELC.	0.63	100.0	1960.0
TRLETH010	LIGHT TRUCK: .10.AFV.ETH.	0.22	60.0	1550.0
TRLETH015	LIGHT TRUCK: .15.AFV.ETH.	0.23	60.0	1560.0
TRLETH020	LIGHT TRUCK: .20.AFV.ETH.	0.24	60.0	1570.0
TRLFUC010	Light Truck: .10.AFV.FUC.	0.35	121.7	1810.9
TRLFUC020	Light Truck: .20.AFV.FUC.	0.39	104.8	1684.8
TRLGCA005	Light Truck: .05.CFV.GAS.CAFE.STD.	0.31	60.3	1004.5
TRLGCA010	Light Truck: .10.CFV.GAS.CAFE.STD.	0.32	63.4	1056.3
TRLGCA015	Light Truck: .15.CFV.GAS.CAFE.STD.	0.32	68.0	1134.0
TRLGCB005	Light Truck: .05.CFV.GAS.CAFE.2.0MPG.	0.35	68.2	1136.7
TRLGCB010	Light Truck: .10.CFV.GAS.CAFE.2.0MPG.	0.35	71.7	1193.7
TRLGCB015	Light Truck: .15.CFV.GAS.CAFE.2.0MPG.	0.35	77.0	1281.4
TRLGCC005	Light Truck: .05.CFV.GAS.CAFE.4.0MPG.	0.38	81.2	1301.9
TRLGCC010	Light Truck: .10.CFV.GAS.CAFE.4.0MPG.	0.39	79.3	1319.3
TRLGCC015	Light Truck: .15.CFV.GAS.CAFE.4.0MPG.	0.39	85.1	1416.3
TRLHHA005	LIGHT TRUCK: .05.AFV.HH2.Combustion.Liq sto.	0.25	75.0	2000.0
TRLHHA010	LIGHT TRUCK: .10.AFV.HH2.Combustion.Liq sto.	0.26	75.0	1750.0
TRLHHA015	LIGHT TRUCK: .15.AFV.HH2.Combustion.Liq sto.	0.27	75.0	1600.0
TRLHHA020	LIGHT TRUCK: .20.AFV.HH2.Combustion.Liq sto.	0.28	75.0	1528.3
TRLHHB020	LIGHT TRUCK: .20.AFV.HH2.Combustion.Carbon sto.	0.03	75.0	1928.6
TRLHHC005	LIGHT TRUCK: .05.AFV.HH2.Hybrid.Liq sto.	0.33	75.0	2500.0
TRLHHC010	LIGHT TRUCK: .10.AFV.HH2.Hybrid.Liq sto.	0.33	75.0	2000.0
TRLHHC015	LIGHT TRUCK: .15.AFV.HH2.Hybrid.Liq sto.	0.34	75.0	1750.0
TRLHHC020	LIGHT TRUCK: .20.AFV.HH2.Hybrid.Liq sto.	0.35	75.0	1673.9
TRLHHD020	LIGHT TRUCK: .20.AFV.HH2.Hybrid.Carbon sto.	0.40	75.0	2074.2
TRLHHE005	LIGHT TRUCK: .05.AFV.HH2.FUC.Liq sto.	0.46	75.0	5000.0
TRLHHE010	LIGHT TRUCK: .10.AFV.HH2.FUC.Liq sto.	0.46	75.0	2500.0
TRLHHE015	LIGHT TRUCK: .15.AFV.HH2.FUC.Liq sto.	0.47	75.0	2200.0
TRLHHE020	LIGHT TRUCK: .20.AFV.HH2.FUC.Liq sto.	0.48	75.0	1892.2
TRLHHF020	LIGHT TRUCK: .20.AFV.HH2.FUC.Carbon sto.	0.52	75.0	2292.5
TRLHHG005	LIGHT TRUCK: .05.AFV.HH2.FUC.Gas sto.	0.49	75.0	2500.0
TRLHHG010	LIGHT TRUCK: .10.AFV.HH2.FUC.Gas sto.	0.49	75.0	2000.0
TRLHHG015	LIGHT TRUCK: .15.AFV.HH2.FUC.Gas sto.	0.51	75.0	1800.0
TRLHHG020	LIGHT TRUCK: .20.AFV.HH2.FUC.Gas sto.	0.52	75.0	1608.4
TRLHYB005	LIGHT TRUCK: .05.AFV.HYB.	0.47	101.3	1205.5
TRLHYB015	LIGHT TRUCK: .15.AFV.HYB.	0.36	65.0	1560.0
TRLHYB020	LIGHT TRUCK: .20.AFV.HYB.	0.37	65.0	1570.0
TRLLPG005	LIGHT TRUCK: .05.AFV.LPG.	0.21	60.0	1550.0
TRLLPG010	LIGHT TRUCK: .10.AFV.LPG.	0.22	60.0	1550.0
TRLLPG015	LIGHT TRUCK: .15.AFV.LPG.	0.23	60.0	1560.0
TRLLPG020	LIGHT TRUCK: .20.AFV.LPG.	0.24	60.0	1570.0
TRLMET010	LIGHT TRUCK: .10.AFV.MET.	0.22	60.0	1550.0
TRLMET015	LIGHT TRUCK: .15.AFV.MET.	0.23	60.0	1560.0
TRLMET020	LIGHT TRUCK: .20.AFV.MET.	0.24	60.0	1570.0

Table 18: New transportation technologies (continued)

Code	Description	EFF (billion veh-km / PJ)	FIXOM MUS$2000/billion veh-km	INVCOST MUS$2000/billion veh-km
TRLNGA005	LIGHT TRUCK: .05.AFV.NGA.	0.21	60.0	1540.0
TRLNGA010	LIGHT TRUCK: .10.AFV.NGA.	0.22	60.0	1550.0
TRLNGA015	LIGHT TRUCK: .15.AFV.NGA.	0.23	60.0	1560.0
TRLNGA020	LIGHT TRUCK: .20.AFV.NGA.	0.24	60.0	1570.0
TRMDST005	MEDIUM TRUCK: .05.CFV.DST.STD.	0.11	50.0	1350.0
TRMETH005	MEDIUM TRUCK: .05.AFV.ETH.	0.09	50.0	1400.0
TRMGAS005	MEDIUM TRUCK: .05.CFV.GAS.STD.	0.10	50.0	1250.0
TRMLPG005	MEDIUM TRUCK: .05.AFV.LPG.	0.09	50.0	1400.0
TRMMET005	MEDIUM TRUCK: .05.AFV.MET.	0.09	50.0	1400.0
TRMNGA005	MEDIUM TRUCK: .05.AFV.NGA.	0.09	50.0	1400.0
TRTDCA005	CAR: .05.CFV.DST.CAFE.STD.	0.38	61.8	1176.5
TRTDCA010	CAR: .10.CFV.DST.CAFE.STD.	0.38	62.4	1188.2
TRTDCA015	CAR: .15.CFV.DST.CAFE.STD.	0.38	63.0	1200.1
TRTDCA020	CAR: .20.CFV.DST.CAFE.STD.	0.39	63.6	1212.0
TRTDCB005	CAR: .05.CFV.DST.CAFE.3.5MPG.	0.43	69.3	1154.8
TRTDCB010	CAR: .10.CFV.DST.CAFE.3.5MPG.	0.43	70.0	1166.4
TRTDCB015	CAR: .15.CFV.DST.CAFE.3.5MPG.	0.43	70.7	1178.0
TRTDCB020	CAR: .20.CFV.DST.CAFE.3.5MPG.	0.43	71.4	1189.7
TRTDCC005	CAR: .05.CFV.DST.CAFE.7.0MPG.	0.48	76.7	1278.4
TRTDCC010	CAR: .10.CFV.DST.CAFE.7.0MPG.	0.48	77.5	1291.1
TRTDCC015	CAR: .15.CFV.DST.CAFE.7.0MPG.	0.48	78.2	1304.1
TRTDCC020	CAR: .20.CFV.DST.CAFE.7.0MPG.	0.49	79.0	1317.0
TRTDEG005	CAR: .05.AFV.DEG.ETH/GAS.	0.36	88.6	1304.0
TRTDEG010	CAR: .10.AFV.DEG.ETH/GAS.	0.36	88.6	1304.0
TRTDEG015	CAR: .15.AFV.DEG.ETH/GAS.	0.35	89.5	1317.2
TRTDEG020	CAR: .20.AFV.DEG.ETH/GAS.	0.35	89.5	1317.2
TRTDMG005	CAR: .05.AFV.DMG.MET/GAS.	0.34	89.5	1317.2
TRTDMG010	CAR: .10.AFV.DMG.MET/GAS.	0.35	89.5	1317.2
TRTDMG015	CAR: .15.AFV.DMG.MET/GAS.	0.35	89.5	1317.2
TRTDMG020	CAR: .20.AFV.DMG.MET/GAS.	0.35	89.5	1152.5
TRTELC005	CAR: .05.AFV.ELC.	0.70	132.5	1742.5
TRTELC010	CAR: .10.AFV.ELC.	0.71	131.2	1725.0
TRTELC015	CAR: .15.AFV.ELC.	0.73	129.9	1707.8
TRTELC020	CAR: .20.AFV.ELC.	0.74	128.6	1690.7
TRTETH005	CAR: .05.AFV.ETH.	0.31	86.9	1146.6
TRTETH010	CAR: .10.AFV.ETH.	0.31	86.1	1135.1
TRTETH015	CAR: .15.AFV.ETH.	0.32	85.2	1123.8
TRTETH020	CAR: .20.AFV.ETH.	0.32	84.3	1112.5
TRTFUC010	CAR: .10.AFV.FUC.	0.69	120.0	1797.5
TRTFUC015	CAR: .15.AFV.FUC.	0.73	108.0	1617.8
TRTFUC020	CAR: .20.AFV.FUC.	0.76	97.2	1456.0
TRTGCA005	CAR: .05.CFV.GAS.CAFE.STD.	0.35	62.3	1097.7
TRTGCA010	CAR: .10.CFV.GAS.CAFE.STD.	0.35	62.9	1108.6
TRTGCA015	CAR: .15.CFV.GAS.CAFE.STD.	0.35	63.6	1119.7
TRTGCA020	CAR: .20.CFV.GAS.CAFE.STD.	0.35	64.2	1130.9
TRTGCB005	CAR: .05.CFV.GAS.CAFE.3.5MPG.	0.39	57.2	1152.5
TRTGCB010	CAR: .10.CFV.GAS.CAFE.3.5MPG.	0.40	57.8	1164.1
TRTGCB015	CAR: .15.CFV.GAS.CAFE.3.5MPG.	0.40	58.4	1175.7
TRTGCB020	CAR: .20.CFV.GAS.CAFE.3.5MPG.	0.39	65.4	1245.7
TRTGCC005	CAR: .05.CFV.GAS.CAFE.7.0MPG.	0.44	65.4	1317.2
TRTGCC010	CAR: .10.CFV.GAS.CAFE.7.0MPG.	0.44	66.1	1330.4
TRTGCC015	CAR: .15.CFV.GAS.CAFE.7.0MPG.	0.44	66.7	1343.7
TRTGCC020	CAR: .20.CFV.GAS.CAFE.7.0MPG.	0.44	71.5	1361.1

Table 18: New transportation technologies (continued)

Code	Description	EFF (billion veh-km / PJ)	FIXOM MUS$$_{2000}$/billion veh-km	INVCOST MUS$$_{2000}$/billion veh-km
TRTHHA005	CAR: .05.AFV.HH2.Combustion.Liq sto.	0.37	80.0	2000.0
TRTHHA010	CAR: .10.AFV.HH2.Combustion.Liq sto.	0.39	80.0	1750.0
TRTHHA015	CAR: .15.AFV.HH2.Combustion.Liq sto.	0.40	80.0	1600.0
TRTHHA020	CAR: .20.AFV.HH2.Combustion.Liq sto.	0.41	80.0	1528.3
TRTHHB020	CAR: .20.AFV.HH2.Combustion.Carbon sto.	0.45	80.0	1928.6
TRTHHC005	CAR: .05.AFV.HH2.Hybrid.Liq sto.	0.50	80.0	2500.0
TRTHHC010	CAR: .10.AFV.HH2.Hybrid.Liq sto.	0.50	80.0	2000.0
TRTHHC015	CAR: .15.AFV.HH2.Hybrid.Liq sto.	0.51	80.0	1750.0
TRTHHC020	CAR: .20.AFV.HH2.Hybrid.Liq sto.	0.52	80.0	1673.9
TRTHHD020	CAR: .20.AFV.HH2.Hybrid.Carbon sto.	0.59	80.0	2074.2
TRTHHE005	CAR: .05.AFV.HH2.FUC.Liq sto.	0.69	80.0	5000.0
TRTHHE010	CAR: .10.AFV.HH2.FUC.Liq sto.	0.69	80.0	2500.0
TRTHHE015	CAR: .15.AFV.HH2.FUC.Liq sto.	0.71	80.0	2200.0
TRTHHE020	CAR: .20.AFV.HH2.FUC.Liq sto.	0.73	80.0	1892.2
TRTHHF020	CAR: .20.AFV.HH2.FUC.Carbon sto.	0.78	80.0	2292.5
TRTHHG005	CAR: .05.AFV.HH2.FUC.Gas sto.	0.74	80.0	2500.0
TRTHHG010	CAR: .10.AFV.HH2.FUC.Gas sto.	0.74	80.0	2000.0
TRTHHG015	CAR: .15.AFV.HH2.FUC.Gas sto.	0.76	80.0	1800.0
TRTHHG020	CAR: .20.AFV.HH2.FUC.Gas sto.	0.78	80.0	1608.4
TRTHYB005	CAR: .05.AFV.HYB.	0.58	90.0	1349.3
TRTHYB010	CAR: .10.AFV.HYB.	0.59	88.2	1322.3
TRTHYB015	CAR: .15.AFV.HYB.	0.60	86.4	1295.8
TRTHYB020	CAR: .20.AFV.HYB.	0.62	84.7	1269.9
TRTLPG005	CAR:.05.AFV.LPG.	0.31	86.9	1324.1
TRTLPG010	CAR: .10.AFV.LPG.	0.31	86.1	1310.9
TRTLPG015	CAR: .15.AFV.LPG.	0.32	85.2	1297.8
TRTLPG020	CAR: .20.AFV.LPG.	0.32	84.3	1284.8
TRTMET005	CAR: .10.AFV.MET.	0.31	86.9	1146.6
TRTMET010	CAR: .10.AFV.MET.	0.31	86.1	1135.1
TRTMET015	CAR: .15.AFV.MET.	0.32	85.2	1123.8
TRTMET020	CAR: .20.AFV.MET.	0.32	84.3	1112.5
TRTNGA005	CAR:.05.AFV.NGA.	0.26	86.9	1383.3
TRTNGA010	CAR: .10.AFV.NGA.	0.26	86.1	1369.5
TRTNGA015	CAR: .15.AFV.NGA.	0.26	85.2	1355.8
TRTNGA020	CAR: .20.AFV.NGA.	0.26	84.3	1342.2
TRWMCG005	MOTOR CYCLE: .05.CFV.GAS.MCG.	0.70	30.0	800.0
TRWMPG005	MOTOR PED: .05.CFV.GAS.MPG.	1.00	20.0	600.0

Table 19: Exogenous constraints in transportation sector

Code	Description	Bound	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
S_TRAALC	Alcool as a share of total TRA fuels	Low	10%	10%	10%	10%	15%	10%	10%	10%	10%	10%	15%	10%	10%	10%	10%
S_TRAALC2	Alcool as a share UP of total TRA fuels	Up	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
S_TRAELC	Electricity as a share of total TRA fuels	Low	3%	8%	8%	5%	3%	5%	5%	3%	8%	3%	3%	3%	3%	8%	8%
S_TRAGAS	Natural gas as a share of total TRA fuels	Low	10%	15%	15%	10%	10%	15%	15%	10%	15%	10%	10%	10%	15%	15%	15%
S_TRAHH2	Hydrogen as a share of total TRA fuels	Low	10%	15%	15%	10%	10%	15%	15%	10%	15%	10%	10%	10%	15%	15%	15%

Appendix F – Inputs resources

Table 20: Oil resources

(in EJ)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
Non-OPEC															
Conventional oil (ground) - Located reserves	84	18	29	149	118	13	354	29	0	75	179	44	0	133	102
Conventional oil (ground) - Reserves growth	123	11	48	122	200	8	835	17	0	22	141	47	0	465	92
Conventional oil (ground) - New discovery	271	16	171	91	385	4	720	18	0	23	270	56	0	508	131
Oil sands (in situ - ultra hvy) - Located reserves	42	56	903	118	64	5	406	0	0	10	88	56	0	633	109
Oil sands (in-situ - ultra hvy) - Enhanced recovery	33	52	650	63	50	5	367	0	0	6	70	47	0	350	106
Shale oil (ground)	349	150	147	93	2896	0	391	0	0	0	0	28	0	5746	136
Oil sands (mined - synth) - Located reserves	0	0	208	15	0	2	1213	0	0	0	0	0	0	65	1
Oil sands (mined - synth) - Enhanced recovery	0	0	176	13	0	2	813	0	0	0	0	0	0	62	0
Oil sands (mined - synth) - New discovery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OPEC															
Conventional oil (ground) - Located reserves	374	-	-	-	495	-	-	-	-	4162	-	30	-	-	-
Conventional oil (ground) - Reserves growth	308	-	-	-	365	-	-	-	-	1439	-	28	-	-	-
Conventional oil (ground) - New discovery	452	-	-	-	291	-	-	-	-	1196	-	24	-	-	-
Oil sands (in situ - ultra hvy) - Located reserves	14	-	-	-	2097	-	-	-	-	2085	-	3	-	-	-
Oil sands (in-situ - ultra hvy) - Enhanced recovery	14	-	-	-	1432	-	-	-	-	1620	-	3	-	-	-
Shale oil (ground)	0	-	-	-	0	-	-	-	-	0	-	0	-	-	-
Oil sands (mined - synth) - Located reserves	62	-	-	-	14	-	-	-	-	0	-	1	-	-	-
Oil sands (mined - synth) - Enhanced recovery	48	-	-	-	9	-	-	-	-	0	-	0	-	-	-
Oil sands (mined - synth) - New discovery	0	-	-	-	0	-	-	-	-	0	-	0	-	-	-

Sources: SAGE model developed in collaboration with the International Energy Administration (Summer 2003).

Table 21: Gas resources

(in EJ)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
Non-OPEC															
Natural gas (ground) - Located reserves	73	53	66	59	116	25	2111	28	2	67	33	192	0	181	165
Natural gas (ground) - Reserves growth	67	34	43	38	149	16	1258	18	1	18	22	228	0	385	107
Natural gas (ground) - New discovery	348	81	138	58	324	24	1721	51	5	20	29	274	0	571	299
Natural gas (ground) - Not connected	24	53	46	59	116	25	2111	28	2	67	100	192	0	181	0
Natural gas (ground) - Unconventional	0	53	279	59	116	25	2111	28	2	67	100	192	0	181	0
OPEC															
Natural gas (ground) - Located reserves	326	-	-	-	169	-	-	-	-	1727	-	73	-	-	-
Natural gas (ground) - Reserves growth	308	-	-	-	190	-	-	-	-	1121	-	70	-	-	-
Natural gas (ground) - New discovery	443	-	-	-	170	-	-	-	-	1242	-	143	-	-	-
Natural gas (ground) - Not connected	126	-	-	-	0	-	-	-	-	601	-	80	-	-	-
Natural gas (ground) - Unconventional	0	-	-	-	0	-	-	-	-	601	-	80	-	-	-

Sources: SAGE model developed in collaboration with the International Energy Administration (Summer 2003).

Table 22: Fossil fuel resources

(in EJ)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU	World	World IPCC*
Oil conventional	1612	44	248	361	1855	24	1909	64	1	6918	590	229	0	1107	325	15286	13562
Oil unconventional	561	258	2085	302	6562	14	3190	0	0	3721	158	137	0	6857	351	24195	22014
Total oil	*2173*	*302*	*2333*	*664*	*8416*	*37*	*5099*	*64*	*1*	*10638*	*748*	*367*	*0*	*7963*	*676*	*39480*	*35576*
Gas conventional	1565	168	247	156	1176	66	5090	97	8	4256	84	928	0	1137	571	15547	17179
Gas not Connected / unconventional	150	106	326	119	232	51	4222	55	3	1336	200	544	0	363	0	7707	18841
Total gas	*1715*	*274*	*572*	*274*	*1408*	*117*	*9312*	*152*	*11*	*5592*	*284*	*1472*	*0*	*1500*	*571*	*23254*	*36020*
Total coal	*8917*	*11679*	*1900*	*13665*	*2702*	*3959*	*26589*	*9488*	*108*	*90*	*144*	*15545*	*5*	*67974*	*5534*	*168298*	*212193*

* For comparison purpose with MARKAL’s data

Sources: For MARKAL’s regions: SAGE model developed in collaboration with the International Energy Administration (Summer 2003). For World IPCC: Moomaw and Moreira (2001) - Table 3.28a, p.236.

Table 23: Primary biomass* potential

(in EJ)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU	World	World IPCC**
Primary biomass potential (2050)	81	20	17	23	46	4	43	11	2	10	6	32	1	27	12	337	441

* Biomass includes: solid biomass, landfill gas, liquids from biomass, energy crops, industrial and municipal wastes (modeled separately but agregated for reporting purpose)

** For comparison purpose with MARKAL's data

Sources: For MARKAL's regions: Trudel (2004). For World IPCC: Moomaw and Moreira (2001) – Table 3.31, p.244.

Table 24: Potential of renewable power plants in 2050

(in GW)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU	World
Wind	1404	634	1500	1037	1368	1037	1431	276	214	1028	268	1163	17	1551	866	13796
Hydro	359	15	181	555	365	29	416	126	26	20	12	314	5	101	164	2687
Geothermal	36	48	0	7	68	0	7	0	125	0	162	649	0	125	113	1342

Sources:

- Hydroelectricity potential reflects the technically exploitable capability as provided by the World Energy Council (2001).
- Wind potential reflects the potential as provided by Moomaw and Moreira (2001).
- Geothermal potential reflects the potential for deep, very deep and shallow geothermal as provided by Dolf Gielen, International Energy Agency (private communication).

Appendix G – Inputs: Power plants and hydrogen generation

Table 25: Existing power plants

Code	Description	AF (1)	FIXOM (MUS$$_{2000}$/GW) (2)	EFF	LIFE
EBIOPLT100	EPLT: .G1.00.CON.BIO.Existing.	0.04-0.20	60	33%	60
ECOACON100	EPLT: .G1.00.CON.COA.Pulvarized Coal.Existing.	0.03-0.75	38	36%	60
ECOAFLB100	EPLT: .G1.00.CON.COA.Fluidized Bed Coal.Existing.	0.28-0.75	36	36%	60
ECOAIGC100	EPLT: .G1.00.ADV.COA.IGCC.Existing.	0.64-0.75	40	35%	60
EGASCCE100	EPLT: .G1.00.CON.NGA.Gas Comb Cycle.Existing.	0.09-0.75	5	40%	60
EGASCTE100	EPLT: .G1.00.CON.NGA.Gas Turbine.Existing.	0.09-0.75	5	36%	60
EGASSTE100	EPLT: .G1.00.CON.NGA.Gas Steam.Existing.	0.09-0.75	15	38%	60
EGEOPLT100	EPLT: .G1.00.CON.GEO.Existing.	0.07-0.73	35	16%	60
EHYDDAM100	EPLT: .G1.00.CON.HYD.With dam.Existing.	0.39-0.63	15	33%	60
EHYDRUN100	EPLT: .G1.00.CON.HYD.Run of river.Existing.	0.39-0.55	25	33%	60
ENUCPLT100	EPLT: .G1.00.CON.NUC.Existing.	0.68-0.93	85	32%	60
EOILCCE100	EPLT: .G1.00.CON.OIL.Oil Comb Cycle.Existing.	0.42-0.65	5	52%	60
EOILICE100	EPLT: .G1.00.CON.OIL.Oil Internal Combustion.Exist	0.42-0.65	5	38%	60
EOILSTE100	EPLT: .G1.00.CON.OIL.Oil Steam.Existing.	0.42-0.65	15	40%	60
ESOLPLT100	EPLT: .G1.00.CON.SOL.Existing.	0.00-0.43	18	33%	60
ETIDPLT100	EPLT: .G1.00.CON.TID.Existing.	0.28 (WEU only)	0	33%	60
EWINPLT100	EPLT: .G1.00.CON.WIN.Existing.	0.02-0.81	19	33%	60

(1) Depends on regions. These data are the direct results of the energy statistics and balances provided by the International Energy Agency (2001a, 2001b). Investment in existing technologies is not allowed, so that existing technologies are progressively replaced by new technologies.

(2) Costs in USA. In other regions, cost multiplier is applied (Table 12)

Table 26: Technical and economic description of new power plants

Code	Description	START	INVCOST (MUS$$_{2000}$/ GW)	FIXOM (MUS$$_{2000}$/ GW)	VAROM (US$$_{2000}$/ GJ)	LIFE	EFF	AF
	Biomass							
EBIOCRDC05	EPLT: .G1.05.CON.BIO.Crop Direct Combustion.	2005	1700	60	1.00	30	38%	0.85
EBIOCRPG05	EPLT: .G1.05.CON.BIO.Crop Gasification.	2005	2000	75	1.20	30	40%	0.85
EBIOGASW05	EPLT: .G1.05.CON.BIO.Biogas from Waste.	2005	1900	40	1.00	30	33%	0.85
EBIOMSWC05	EPLT: .G1.05.CON.BIO.MSW Direct Combustion.	2005	3500	50	2.00	30	33%	0.80
EBIOSLDC05	EPLT: .G1.05.CON.BIO.Sld Biomass Direct Combustion	2005	1700	60	1.00	30	33%	0.85
EBIOSLGA05	EPLT: .G1.05.CON.BIO.Sld Biomass Gasification.	2005	2000	75	1.20	30	33%	0.85
	Coal							
ECOAAFLB05	EPLT: G1.05.ADV.COA.Atmospheric Fl Bed.	2005	1200	10	0.30	30	36%	0.90
ECOAIGCA05	EPLT: .G1.05.ADV.COA.Air Blown IGCC.	2005	1650	10	0.30	30	43%	0.85
ECOAIGCA10	EPLT: .G1.10.ADV.COA.Air Blown IGCC.	2010	1650	10	0.30	30	48%	0.85

Table 26: Technical and economic description of new power plants (continued)

Code	Description	START	INVCOST (MUS$ $_{2000}$/ GW)	FIXOM (MUS$ $_{2000}$/ GW)	VAROM (US$ $_{2000}$/ GJ)	LIFE	EFF	AF
ECOAIGCA30	EPLT: .G1.30.ADV.COA.Air Blown IGCC.	2030	1650	10	0.30	30	50%	0.85
ECOAIGCO05	EPLT: .G1.05.ADV.COA.Oxygen Blown IGCC.	2005	1650	10	0.30	30	42%	0.85
ECOAIGCO10	EPLT: .G1.10.ADV.COA.Oxygen Blown IGCC.	2010	1650	10	0.30	30	46%	0.85
ECOAIGCO30	EPLT: .G1.30.ADV.COA.Oxygen Blown IGCC.	2030	1650	10	0.30	30	48%	0.85
ECOAPFLB05	EPLT: G1.05.ADV.COA.Pressurized Fl Bed.	2005	1250	10	0.30	30	38%	0.90
ECOAPULV05	EPLT: .G1.05.CON.COA.Pulverized Coal.	2005	1300	10	0.30	30	36%	0.85
ECOAPULV10	EPLT: .G1.10.CON.COA.Pulverized Coal.	2010	1300	10	0.30	30	40%	0.85
ECOAPULV30	EPLT: .G1.30.CON.COA.Pulverized Coal.	2030	1300	10	0.30	30	45%	0.85
ECOASOFC05	EPLT: .G1.05.ADV.COA.SOFC.Fuel Cells.	2005	1750	75	2.00	20	59%	0.85
			Oil					
EOILDCN105	EPLT: .G1.05.CON.OIL.DCN.Generic Dist Gen.Base.	2005	599	4	4.04	30	37%	0.90
EOILDCN205	EPLT: .G1.05.CON.OIL.DCN.Generic Dist Gen.Peak.	2005	538	12	6.17	20	32%	0.90
EOILSTEA05	EPLT: .G1.05.CON.OIL.Oil Steam.	2005	1000	15	1.00	30	36%	0.85
			Gas					
EGASCCGT05	EPLT: .G1.05.ADV.NGA.CEN.CCGT.	2005	500	10	0.10	30	53%	0.90
EGASCCGT10	EPLT: .G1.10.ADV.NGA.CEN.CCGT.	2010	500	10	0.10	30	55%	0.90
EGASFCEL05	EPLT: .G1.05.ADV.NGA.DCN.Fuel Cells.	2005	1500	10	0.56	20	64%	0.90
EGASSOFC05	EPLT: .G1.05.ADV.NGA.SOFC.Fuel Cells.	2005	1000	50	1.50	20	70%	0.85
			Gas / Oil					
EGOICCYA05	EPLT: .G1.05.ADV.GOI.Gas/Oil Comb Cycle.	2005	600	12	0.14	30	54%	0.90
EGOICCYC05	EPLT: .G1.05.CON.GOI.Gas/Oil Comb Cycle.	2005	900	12	0.14	30	45%	0.90
			Geothermal					
EGEODEEP05	EPLT: .G1.05.CON.GEO.CEN.Deep.	2005	5000	70	0.00	40	10%	0.90
EGEOSHAL05	EPLT: .G1.05.CON.GEO.CEN.Shallow.	2005	1750	70	0.00	40	10%	0.90
EGEOVDEE05	EPLT: .G1.05.CON.GEO.CEN.Very deep.	2005	10000	70	0.00	40	10%	0.90
			Hydro					
EHYDDAM105	EPLT: .G1.05.CON.HYD.Generic Impoundment Hydro.	2005	1800	15	0.00	60	33%	0.39
EHYDRUN105	EPLT: .G1.05.CON.HYD.Generic ROR Hydro.	2005	2200	25	0.00	60	33%	
			Nuclear					
ENUCADVA05	EPLT: .G1.05.ADV.NUC.Advanced Nuclear.	2005	2000	85	0.46	40	32%	0.85
			Solar					
ESOPV105	EPLT: .G1.03.CON.SOL.CEN.PV.	2003	3000	100	0.00	20	100%	(1)
ESOPVD105	EPLT: .G1.05.CON.SOL.DCN.PV.	2005	4000	100	0.00	20	100%	(1)
ESOTH105	EPLT: .G1.04.CON.SOL.DCN.Thermal.	2004	3150	46	0.00	20	100%	(1)
			Wind					
EWIND1000	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.23
EWIND1010	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.23
EWIND1040	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.23
EWIND105	EPLT: .G1.04.CON.WIN.CEN.	2020	2000	26	0.00	20	100%	0.25

Table 26: Technical and economic description of new power plants (continued)

Code	Description	START	INVCOST (MUS$$_{2000}$/ GW)	FIXOM (MUS$$_{2000}$/ GW)	VAROM (US$$_{2000}$/ GJ)	LIFE	EFF	AF
EWIND1100	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.22
EWIND1110	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.22
EWIND1140	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.22
EWIND1200	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.21
EWIND1210	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.21
EWIND1240	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.21
EWIND1300	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.20
EWIND1310	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.20
EWIND1340	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.20
EWIND1400	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.19
EWIND1410	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.19
EWIND1440	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.19
EWIND1500	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.18
EWIND1510	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.18
EWIND1540	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.18
EWIND1600	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.17
EWIND1610	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.17
EWIND1640	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.17
EWIND210	EPLT: .G1.10.CON.WIN.CEN.Offshore.	2010	1500	75	0.00	20	100%	0.40
EWIND240	EPLT: .G1.40.CON.WIN.CEN.Offshore.	2040	1000	50	0.00	20	100%	0.40
EWIND310	EPLT: .G1.10.CON.WIN.CEN.Offshore.	2010	1400	70	0.00	20	100%	0.35
EWIND340	EPLT: .G1.40.CON.WIN.CEN.Offshore.	2040	900	45	0.00	20	100%	0.35
EWIND410	EPLT: .G1.10.CON.WIN.CEN.Offshore.	2010	1300	65	0.00	20	100%	0.30
EWIND440	EPLT: .G1.40.CON.WIN.CEN.Offshore.	2040	850	43	0.00	20	100%	0.30
EWIND510	EPLT: .G1.10.CON.WIN.CEN.Offshore.	2010	1200	60	0.00	20	100%	0.25
EWIND540	EPLT: .G1.40.CON.WIN.CEN.Offshore.	2040	800	40	0.00	20	100%	0.25
EWIND610	EPLT: .G1.10.CON.WIN.CEN.Offshore.	2010	1000	50	0.00	20	100%	0.20
EWIND640	EPLT: .G1.40.CON.WIN.CEN.Offshore.	2040	750	38	0.00	20	100%	0.20
EWIND700	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	877	44	0.00	20	100%	0.35
EWIND710	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	662	33	0.00	20	100%	0.35
EWIND740	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	554	28	0.00	20	100%	0.35
EWIND800	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.30
EWIND810	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.30
EWIND840	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.30
EWIND900	EPLT: .G1.00.CON.WIN.DCN.Onshore.	2000	815	41	0.00	20	100%	0.25
EWIND910	EPLT: .G1.10.CON.WIN.DCN.Onshore.	2010	615	31	0.00	20	100%	0.25
EWIND940	EPLT: .G1.40.CON.WIN.DCN.Onshore.	2040	508	25	0.00	20	100%	0.25

Sources: Review of literature and expert knowledge.

Table 27: Technical and economic description of power plants with CO_2 capture

Code	Description	START	FIXOM (MUS$_{2000}$/ GW)	INVCOST (MUS$_{2000}$/ GW)	VAROM (US$_{2000}$/ GJ)	LIFE	EFF	Capture efficiency
EZCCGT105	NGCC+CO2 removal from flue gas	2005	50	1120	0.11	30	47%	90%
EZCCGT115	NGCC+CO2 removal from flue gas	2015	40	894	0.79	30	54%	90%
EZIGC1105	IGCC+CO2 removal from input gas	2005	100	1909	1.96	30	36%	88%
EZIGC1120	IGCC+CO2 removal from input gas	2020	75	1459	4.13	30	47%	88%
EZIGC2105	IGCC+CO2 removal from flue gas	2005	100	4855	0.00	30	26%	88%
EZIGC2120	IGCC+CO2 removal from flue gas	2020	75	2000	2.62	30	43%	88%
EZPCOA105	Conventional Pulverized Coal+CO2 removal from flue gas	2005	80	1976	1.36	30	31%	90%
EZPCOA115	Conventional Pulverized Coal+CO2 removal from flue gas	2015	75	1718	1.49	30	36%	90%
EZSOFCOA30	SOFC (COAL) +CO2 removal	2030	50	2000	0.00	15	57%	100%
EZSOFGAS20	SOFC (GAS) +CO2 removal	2020	75	1504	0.00	15	67%	100%

Sources: Dolf Gielen, International Energy Agency (private communication), except for Variable Costs (VAROM). VAROM has been added so that the resulting electricity price is 50% higher than the electricity price generated by power plants without CO2 capture (Moomaw and Moreira, 2001).

Table 28: Hydrogen plants

Code	Description	START	FIXOM (US$_{2000}$/ GJ)	INVCOST (US$_{2000}$/ GJ)	VAROM (US$_{2000}$/ GJ)	LIFE	EFF	AF	Capture efficiency
HHCO105	Hydrogen from Hardcoal	2000	1.50	33.50	0.20	20	0.63	0.95	na
HLYSI05	Electrolysis	2000	0.95	30.00	0.00	30	0.80	0.85	na
HNGA105	Hydrogen from NGA	2000	0.56	10.00	0.00	20	0.81	0.95	na
HZBCO105	Hydrogen from Browncoal + CO2 removal	2020	1.74	36.00	0.22	20	0.63	0.95	100%
HZHCO105	Hydrogen from Hardcoal + CO2 removal	2020	1.74	36.00	0.22	20	0.63	0.95	100%
HZNGA105	Hydrogen from NGA + CO2 removal	2020	0.56	12.50	0.00	20	0.81	0.95	100%

Sources: Dolf Gielen, International Energy Agency (private communication).

Appendix H – Inputs: Sequestration

Table 29: Sequestration potentials

(in Gt CO2 - cumulative 2000-2050)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
Forests - Limited	6	0	2	2	6	0	7	0	2	0	1	4	0	1	1
Underground storage	1550	915	1141	978	1578	411	2061	765	15	1335	425	1707	23	1770	570
Total Sequestration	1561	915	1145	982	1590	412	2074	765	20	1335	427	1715	23	1771	572

Sources: Dolf Gielen, International Energy Agency (private communication). The potential of sequestration by forest has been adjusted by the author to reflect the Bonn (Appendix Z related to the maximum increase in sinks due to forest management) and Marrakech (Russia adjustment) agreements.

Table 30: Comparison of sequestration data with other sources

Sink	Unit	World MARKAL	Kauppi and Sedjo (2001)	Herzog et al. (1997)]
Oil fields (onshore and offshore)	Cumulative GtC	75.6	100	41-191
Gas fields (onshore and offshore)	Cumulative GtC	281.0	400	136-1100
Enhanced Coalbed Methane Recovery	Cumulative GtC	195.7	na	na
Deep saline aquifers	Cumulative GtC	3449.3	> 1000	90-2730
Deep ocean	Cumulative GtC	113.9	> 1000	1400-27300
Enhanced Oil Recovery	Cumulative GtC	41.9	na	na
Forests (limited)	Annual GtC/year	0.2	1.2	na
Forests (no limit)	Annual GtC/year	1.3	1.2	na
Forests (limited)	Cumulative GtC	8.6	85.6-160	na
Total Forests (no limit)	Cumulative GtC	63.6	85.6-160	na

Note: Potential for deep ocean is smaller than literature, but this has no impact of results because deep ocean is not selected as a mitigation option given the high costs of this sequestration option (Table 33).

Table 31: Underground storage potential

(in GtC)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU	World
Enhanced Coalbed Meth recov >1000m	1.02	10.23	6.82	20.45	0.00	4.09	20.45	2.05	0.00	0.00	0.00	10.23	0.00	16.36	6.14	97.84
Enhanced Coalbed Meth recov <1000m	1.02	10.23	6.82	20.45	0.00	4.09	20.45	2.05	0.00	0.00	0.00	10.23	0.00	16.36	6.14	97.84
Depl gas fields (offshore)	2.05	3.27	2.73	0.00	0.00	0.00	0.00	0.00	0.00	20.45	4.09	8.18	0.00	4.09	12.27	57.14
Depl gas fields (onshore)	5.73	0.41	5.45	0.00	12.27	0.00	91.64	0.00	0.00	81.82	4.09	12.27	0.00	4.09	6.14	223.91
Storage in the deep ocean	0.00	20.45	13.64	20.45	0.00	0.00	0.00	0.00	2.05	2.05	2.05	10.23	2.05	20.45	20.45	113.86
Depl oil fields (offshore)	0.82	0.41	0.27	0.08	0.82	0.00	0.00	0.00	0.00	4.09	1.23	0.61	0.00	4.09	1.64	14.06
Depl oil fields (onshore)	1.43	0.00	1.36	0.41	4.09	0.82	12.27	0.00	0.00	30.68	2.05	4.09	0.00	4.09	0.20	61.50
Deep saline aquifers	409.09	204.55	272.73	204.55	409.09	102.27	409.09	204.55	2.05	204.55	102.27	409.09	4.09	409.09	102.27	3449.32
Enhanced Oil Recovery	1.43	0.00	1.36	0.41	4.09	0.82	8.18	0.00	0.00	20.45	0.20	0.61	0.00	4.09	0.20	41.86
Total GtC (cum)	422.59	249.55	311.18	266.81	430.36	112.09	562.09	208.64	4.09	364.09	115.98	465.55	6.14	482.73	155.45	4157.33

Sources: Dolf Gielen, International Energy Agency (private communication)

Table 32: Transportation cost of CO_2 for underground storage

(in $/tCO2)	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	USA	WEU
Sink Pot - Enhanced Coalbed Meth recov <1000 m	10	10	10	10	35	10	10	10	10	10	10	10	30	10	30
Sink Pot - Enhanced Coalbed Meth recov >1000 m	10	10	10	35	35	10	10	10	3	10	10	10	30	10	30
Sink Pot - Depl gas fields (offshore)	35	10	10	3	10	10	10	10	10	10	10	10	10	10	10
Sink Pot - Depl gas fields (onshore)	35	10	10	10	35	10	35	10	10	10	10	10	10	10	10
Sink Pot - Storage in the deep ocean	10	10	10	10	10	35	10	10	10	10	10	10	10	10	10
Sink Pot - Depl oil fields (offshore)	35	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Sink Pot - Depl oil fields (onshore)	35	10	10	10	35	10	10	10	10	10	10	10	10	10	10
Sink Pot - Deep saline aquifers	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Sink Pot - Enhanced Oil Recovery	35	35	10	10	35	10	35	10	10	10	10	10	10	10	10

Sources: Dolf Gielen, International Energy Agency (private communication).

Table 33: Sequestration cost of CO_2 for underground storage

(in $/tCO2)	FIXOM	INVCOST	VAROM
Removal by Enhanced Coalbed Meth recov <1000 m	0.25	5	0.5
Removal by Enhanced Coalbed Meth recov >1000 m	0.5	10	0.5
Removal by Depl gas fields (offshore)	0.35	7	1.8
Removal by Depl gas fields (onshore)	0.17	3.33	0.9
Removal by Storage in the deep ocean	0.5	10	0.5
Removal by Depl oil fields (offshore)	0.35	7	1.8
Removal by Depl oil fields (onshore)	0.17	3.33	0.9
Removal by Deep saline aquifers	0.25	5	0.1
Removal by Enhanced Oil Recovery	0.17	3.33	0.9
Removal by Deep saline aquifers	0	0	0.14

Sources: Dolf Gielen, International Energy Agency (private communication).

Table 34: Potentials of sequestration by forests ($GtCO_2$ per year)

Region	Cost level	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Cum 2000-2050
AFR	Level 1	0.000	0.019	0.037	0.019	0.000	0.000	0.000	0.018	0.037	0.037	0.037	1.0
AFR	Level 2	0.000	0.018	0.037	0.024	0.011	0.018	0.026	0.029	0.033	0.046	0.059	1.5
AFR	Level 3	0.000	0.007	0.015	0.057	0.099	0.084	0.070	0.051	0.033	0.017	0.000	2.2
AFR	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.055	0.055	0.055	1.0
AFR	Total	0.000	0.044	0.089	0.099	0.110	0.103	0.095	0.126	0.158	0.154	0.150	5.6
AFR	Total(no limit)	0.000	0.444	0.887	0.994	1.100	1.027	0.953	1.265	1.577	1.540	1.503	56.4
AUS	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
AUS	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
AUS	Level 3	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.0
AUS	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
AUS	Total	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0
AUS	Total(no limit)	0.000	0.037	0.073	0.073	0.073	0.090	0.106	0.150	0.194	0.171	0.147	5.6
CAN	Level 1	0.000	0.009	0.009	0.010	0.012	0.007	0.004	0.002	0.000	0.004	0.007	0.3
CAN	Level 2	0.000	0.005	0.005	0.006	0.009	0.011	0.012	0.010	0.008	0.011	0.013	0.4
CAN	Level 3	0.000	0.030	0.030	0.027	0.023	0.026	0.028	0.015	0.000	0.001	0.001	0.9
CAN	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.036	0.028	0.022	0.5
CAN	Total	0.000	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	2.2
CAN	Total(no limit)	0.000	0.180	0.359	0.321	0.284	0.378	0.473	0.454	0.435	0.501	0.567	19.8

Table 34: Potentials of sequestration by forests ($GtCO_2$ per year) (continued)

Region	Cost level	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Cum 2000-2050
CHI	Level 1	0.000	0.004	0.007	0.004	0.000	0.004	0.007	0.004	0.000	0.000	0.000	0.1
CHI	Level 2	0.000	0.002	0.004	0.002	0.000	0.009	0.018	0.026	0.033	0.017	0.000	0.6
CHI	Level 3	0.000	0.007	0.015	0.013	0.011	0.010	0.009	0.007	0.006	0.012	0.018	0.5
CHI	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.026	0.037	0.048	0.6
CHI	Total	0.000	0.013	0.026	0.018	0.011	0.023	0.035	0.050	0.064	0.065	0.066	1.9
CHI	Total (no limit)	0.000	0.128	0.257	0.183	0.110	0.229	0.348	0.495	0.642	0.651	0.660	18.5
CSA	Level 1	0.000	0.035	0.070	0.035	0.000	0.000	0.000	0.017	0.033	0.017	0.000	1.0
CSA	Level 2	0.000	0.017	0.033	0.025	0.017	0.025	0.033	0.045	0.056	0.075	0.093	2.1
CSA	Level 3	0.000	0.025	0.050	0.070	0.089	0.083	0.076	0.043	0.010	0.005	0.000	2.3
CSA	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.033	0.033	0.033	0.6
CSA	Total	0.000	0.076	0.152	0.129	0.106	0.108	0.109	0.121	0.133	0.129	0.126	5.9
CSA	Total (no limit)	0.000	0.762	1.525	1.293	1.061	1.077	1.094	1.210	1.326	1.293	1.260	59.5
EEU	Level 1	0.000	0.001	0.001	0.002	0.006	0.002	0.000	0.000	0.001	0.001	0.002	0.1
EEU	Level 2	0.000	0.005	0.005	0.005	0.003	0.001	0.000	0.002	0.003	0.003	0.003	0.2
EEU	Level 3	0.000	0.002	0.002	0.002	0.000	0.006	0.008	0.003	0.000	0.000	0.000	0.1
EEU	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.004	0.003	0.1
EEU	Total	0.000	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.4
EEU	Total (no limit)	0.000	0.034	0.069	0.038	0.007	0.012	0.017	0.026	0.036	0.034	0.032	1.5
FSU	Level 1	0.000	0.022	0.022	0.028	0.087	0.026	0.000	0.006	0.009	0.018	0.029	1.2
FSU	Level 2	0.000	0.082	0.082	0.078	0.044	0.013	0.000	0.030	0.043	0.048	0.053	2.4
FSU	Level 3	0.000	0.027	0.027	0.025	0.000	0.091	0.130	0.042	0.000	0.000	0.000	1.7
FSU	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.053	0.078	0.064	0.048	1.2
FSU	Total	0.000	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	6.5
FSU	Total (no limit)	0.000	0.528	1.056	0.583	0.110	0.183	0.257	0.403	0.550	0.523	0.495	23.4
IND	Level 1	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.0
IND	Level 2	0.000	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.0
IND	Level 3	0.000	0.000	0.000	0.002	0.004	0.002	0.001	0.000	0.000	0.001	0.001	0.1
IND	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.003	0.002	0.1
IND	Total	0.000	0.001	0.002	0.003	0.004	0.003	0.001	0.003	0.005	0.005	0.005	0.2
IND	Total (no limit)	0.000	0.009	0.018	0.028	0.037	0.026	0.015	0.034	0.053	0.050	0.046	1.6
JPN	Level 1	0.000	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.6
JPN	Level 2	0.000	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.6
JPN	Level 3	0.000	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.6
JPN	Level 4	0.000	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.6
JPN	Total	0.000	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	2.4
JPN	Total (no limit)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0

Table 34: Potentials of sequestration by forests ($GtCO_2$ per year) (continued)

Region	Cost level	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Cum 2000-2050
MEA	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
MEA	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
MEA	Level 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
MEA	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
MEA	Total	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
MEA	Total(no limit)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
MEX	Level 1	0.000	0.004	0.007	0.004	0.000	0.000	0.000	0.002	0.004	0.002	0.000	0.1
MEX	Level 2	0.000	0.002	0.004	0.003	0.002	0.003	0.004	0.005	0.006	0.008	0.010	0.2
MEX	Level 3	0.000	0.003	0.005	0.007	0.010	0.009	0.008	0.005	0.001	0.001	0.000	0.2
MEX	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.004	0.004	0.1
MEX	Total	0.000	0.008	0.016	0.014	0.011	0.011	0.012	0.013	0.014	0.014	0.013	0.6
MEX	Total(no limit)	0.000	0.081	0.162	0.137	0.113	0.114	0.116	0.128	0.141	0.137	0.134	6.3
ODA	Level 1	0.000	0.015	0.030	0.022	0.014	0.007	0.000	0.000	0.000	0.011	0.022	0.6
ODA	Level 2	0.000	0.006	0.011	0.017	0.022	0.027	0.033	0.044	0.055	0.055	0.055	1.6
ODA	Level 3	0.000	0.011	0.022	0.023	0.024	0.029	0.033	0.017	0.000	0.000	0.000	0.8
ODA	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.079	0.055	0.031	1.0
ODA	Total	0.000	0.032	0.063	0.062	0.060	0.063	0.066	0.100	0.134	0.121	0.108	4.0
ODA	Total(no limit)	0.000	0.317	0.634	0.619	0.605	0.633	0.660	1.001	1.342	1.210	1.078	40.5
SKO	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
SKO	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
SKO	Level 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
SKO	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
SKO	Total	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
SKO	Total(no limit)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
USA	Level 1	0.000	0.003	0.003	0.003	0.004	0.002	0.001	0.001	0.000	0.001	0.002	0.1
USA	Level 2	0.000	0.002	0.002	0.002	0.003	0.004	0.004	0.003	0.003	0.004	0.004	0.1
USA	Level 3	0.000	0.010	0.010	0.009	0.008	0.009	0.009	0.005	0.000	0.000	0.000	0.3
USA	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.012	0.009	0.007	0.2
USA	Total	0.000	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.7
USA	Total(no limit)	0.000	0.169	0.337	0.302	0.266	0.355	0.444	0.426	0.408	0.471	0.533	18.6
WEU	Level 1	0.000	0.007	0.007	0.006	0.005	0.004	0.003	0.002	0.002	0.004	0.007	0.2
WEU	Level 2	0.000	0.013	0.013	0.004	0.000	0.005	0.012	0.008	0.006	0.005	0.005	0.3
WEU	Level 3	0.000	0.003	0.003	0.013	0.017	0.013	0.007	0.003	0.000	0.000	0.000	0.3
WEU	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.015	0.013	0.011	0.2
WEU	Total	0.000	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	1.1
WEU	Total(no limit)	0.000	0.046	0.093	0.147	0.204	0.170	0.137	0.186	0.236	0.256	0.276	8.8

Table 34: Potentials of sequestration by forests ($GtCO_2$ per year) (continued)

Region	Cost level	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Cum 2000-2050
World	Level 1	0.000	0.131	0.208	0.145	0.140	0.064	0.027	0.064	0.097	0.108	0.118	5.5
World	Level 2	0.000	0.162	0.207	0.178	0.121	0.128	0.155	0.214	0.258	0.284	0.308	10.1
World	Level 3	0.000	0.137	0.190	0.259	0.298	0.375	0.393	0.202	0.061	0.048	0.034	10.0
World	Level 4	0.000	0.012	0.012	0.012	0.012	0.012	0.012	0.202	0.359	0.317	0.276	6.1
World	Total	0.000	0.442	0.617	0.594	0.571	0.579	0.587	0.682	0.776	0.756	0.736	31.7
World	Total (no limit)	0.000	2.735	5.470	4.719	3.970	4.294	4.620	5.780	6.939	6.835	6.730	260.5

Sources: Adjustments of data provided by Dolf Gielen, International Energy Agency (private communication). The potential of AUS, CAN, EEU, FSU, JPN, USA, WEU reflects the Bonn (Appendix Z) and Marrakech (Russia) agreements, assuming that they are applied for the whole 2000-2050 horizon, and that the total potential is shared proportionally to the four levels of the total potential. 10% of the annual available potential is used for the other regions. Total (no limit) row reflects data before this adjustment.

Table 35: Cost of sequestration by forests

(in $/tCO2)	Level 1		Level 2		Level 3		Level 4	
Year	2000	2050	2000	2050	2000	2050	2000	2050
Cost	5.45	5.45	13.64	19.09	24.55	27.27	13.64	19.09

Sources: Dolf Gielen, International Energy Agency (private communication)