UNITED NATIONS
DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS

SUSTAINABLE CONSUMPTION AND PRODUCTION

Promoting Climate-Friendly Household Consumption Patterns

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30 April 2007

Contents

1. Introduction

1. Sustainable consumption and production (SCP) has been on the international agenda since Agenda 21 (1992) identified unsustainable patterns of production and consumption as the major cause of the continued deterioration of the global environment. The 2002 Johannesburg Summit called for a ten-year framework of programmes in support of national and regional initiatives to accelerate the shift towards sustainable consumption and production.

2. To develop the framework called for in Johannesburg, the “Marrakech Process” was launched at an international expert meeting held in Marrakech, Morocco, in 2003, organized by UN-DESA's Division for Sustainable Development and the UN Environment Programme (UNEP). The “Marrakech Process” includes regular global and regional meetings, informal expert task forces, and other activities to promote and coordinate efforts toward more sustainable consumption and production. A second international expert meeting was held in Costa Rica in 2005, and a third meeting will take place in Stockholm in June 2007. The 10-year framework is to be considered by the Commission on Sustainable Development at its sessions in 2010 and 2011.

3. The meetings of the Marrakech Process have requested the UN Secretariat to prepare policy-focused papers on themes under consideration at the sessions of the Commission on Sustainable Development, addressing them from the perspective of sustainable consumption and production (SCP), which the Commission has identified as a cross-cutting issue to be addressed at all sessions. The background paper on SCP for the 14th session of the Commission focused on industrial energy use, its impacts on air pollution and climate change, and policies and other measures to reduce those impacts.[1] The present paper focuses on the patterns and trends in energy consumption by households, the climate change impact of those patterns and trends, and policies and measures by which consumption patterns can be changed to promote sustainable development.

2. The role of households in energy consumption

4. Total world energy consumption and CO_2 emissions continue to increase steadily. From 1990 to 2004, world energy consumption increased by about 30% and CO_2 emissions by 26%, while world GDP has increased by over 50%.[2] There have thus been modest improvements in overall energy efficiency (GDP per unit of energy consumed) and carbon intensity (CO_2 emissions per unit energy or GDP), but these improvements in efficiency have been overwhelmed by increasing production and consumption. As a result, the driving forces of human-induced climate change are steadily increasing. For the purposes of this paper, CO_2 emissions will be taken as the indicator relevant to climate change, as the impacts of household consumption on other greenhouse gas emissions are smaller, usually indirect, and more difficult to analyze.

5. Households consume energy in various forms, particularly fossil fuels for space heating and hot water, and electricity for lighting and appliances. In the United States, for example, such energy consumed directly in the household amounts to about 12% of total national energy supply. If the primary energy (mostly fossil fuels) used to generate the electricity consumed by households is included, the household share of total energy supply increases to 22%.[3]

6. Standard national energy accounts divide the total primary energy supply (TPES) for each country among four sectors, with the fossil-fuel energy lost in generating and distributing electricity allocated among the sectors according to their electricity consumption. For the United States (2005), this gives 22% for the residential sector, 32% for industry, 28% for transportation, and 18% for the commercial sector (including offices and stores). The generation and distribution of electricity, if taken separately, consumes about 40% of the national energy supply. The question of how to measure consumption of electricity is important as two-thirds of primary energy is lost in the generation and distribution of electricity. In general, in this paper, household electricity consumption will be taken to include the losses in generating electricity from fossil fuels, as that is a better reflection of the contribution of electricity consumption to climate change. It also avoids the implication that switching from fossil fuel to electricity, for space heating or hot water for example, would necessarily reduce energy consumption and CO_2 emissions.

7. Household energy consumption has been increasing steadily, with trends similar to overall energy consumption. In 11 OECD countries, household energy consumption increased about 10% from 1990 to 1998, accounting for a steady 22% of total energy consumption. Energy for household vehicles increased by 15%, somewhat faster than other household energy consumption. In the United States, household energy consumption increased by 28% from 1990 to 2005, with the share increasing from 20% to 22%.[4]

8. As noted above, in conventional energy accounts, fuel for household vehicles is considered part of the transportation sector rather than the residential sector. However, over half of the energy consumed for transportation in developed countries is consumed by households in the form of gasoline or diesel fuel for household vehicles, including cars, sports utility vehicles (SUVs), vans and pick-up trucks. In the United States, of the 28% of total primary energy supply that goes to the transportation sector, about 15% (of TPES) goes to household vehicles, with the remaining 13% going to other passenger and freight transportation, including rail, air and water transportation. Of energy consumed by road vehicles, 68% is consumed by household vehicles.[5] In this paper, fuel for household vehicles will be considered part of household consumption. Direct household energy consumption in the United States, then, including fuel for household vehicles as well as primary energy lost in generating and distributing electricity, amounts to about 37% of the total energy supply.[6]

9. In examining the impact of households on overall energy consumption and climate change, it should be noted that household consumption involves substantially more

energy than the energy consumed as such by households. Energy has also gone into the production and distribution of everything that households consume, from appliances, to food, to newspapers, to cars. This energy "embodied" in consumer goods, called "indirect energy consumption" is generally greater than the energy consumed directly, although it is somewhat difficult to define and determine precisely. Just as most economic activity is devoted ultimately to private consumption, so most of the national energy supply is devoted, directly or indirectly, to private energy consumption. The relatively small share of national energy consumption that is not associated with household consumption includes energy for government activities such as the military, street lighting, heating and air conditioning of public buildings, public vehicles, schools and hospitals.

10. Indirect energy consumption associated with household consumption in the United States has been estimated to be 50% of the total energy supply, giving a total of 85% of the total energy supply attributable, directly and indirectly, to household consumption. It should be noted that, because indirect energy consumption includes energy embodied in imports, total energy consumption, direct and indirect, can be greater than national energy supply if imports are more energy-intensive than exports, as is the case for the United States.[7]

11. An analysis of direct and indirect household energy consumption for the Netherlands found that direct household energy consumption accounted for 33% of total national energy consumption, while indirect household consumption accounted for 37%, for a total of 70% of national energy consumption being accounted for by household consumption.[8] In Australia, CO_2 emissions associated with private consumption, direct and indirect, were six times the energy associated with public consumption.[9]

12. In developing countries with relatively affluent and modern urban consumption patterns, and poorer and more traditional rural consumption patterns, urban households often consume far more fossil fuel and electricity than rural households. In China, for example, urban households are estimated to consume about 20% of national energy consumption, directly and indirectly, including household transport, while the far more numerous rural households consume only about 7%. Urban households consume more energy indirectly than directly, as in developed countries, while rural households consume more energy directly. For personal transport in China, however, rural household energy consumption is higher, both per household and collectively, as motorcycles have replaced bicycles as the most common form of personal transport.[10]

13. In many developing countries, particularly in Sub-Saharan Africa and South Asia, most rural households consume much or all of their energy in the form of traditional biomass, including fuelwood, agricultural residues and animal dung, for cooking and heating. While much of this is renewable, combustion is often very inefficient and generates large amount of smoke and other air pollutants that cause severe damage to health, especially of women and children. Sustainable energy development is these areas requires more efficient biomass stoves, expanded use of liquefied petroleum gas (LPG), renewable energy sources, and connection to the electrical grid.

14. Households are generally aware of their direct energy consumption as they pay for household electricity and gas and fuel for vehicles. However, there are significant exceptions, such as heating energy for renters in apartment buildings, who often have no knowledge of or control over heat supply. Households are generally not aware of their indirect energy consumption. While the cost of energy embodied in goods and services is generally reflected in the price, it cannot easily be separated from other elements.

15. Whether household energy consumption is direct or indirect does not necessarily indicate whether households control the amount of energy consumed. In the case of lighting, the number of lights, the wattage, the efficiency and the amount of time they are on are determined by the household. On the other hand, the electrical energy consumed by a refrigerator is determined primarily by the efficiency built into the appliance, not by how it is used. However, a household purchasing a new refrigerator may be able to consider energy efficiency among other characteristics if appliances have understandable energy efficiency labels. The energy required for space heating will depend largely on the construction of the dwelling, as well as on the temperature at which the space is maintained. In the case of transportation, the amount of fuel consumed will depend on the driving patterns of the household, but those will depend on urban planning, infrastructure and alternative transportation systems. In many cases, households have little alternative to private cars for commuting, shopping, visiting and other errands. For long distance travel, the energy consumption depends primarily on the destination (distance) and secondarily on whether the trip is made by car (direct household consumption) or aircraft (indirect).

16. The CO_2 emissions associated with household energy consumption depend not only on the amount of energy consumed, but also on the source of energy. In particular, if electricity is derived from renewable sources or from nuclear energy, there may be no CO_2 emissions resulting directly from electricity consumption (although there may be some indirect fossil fuel consumption in the energy infrastructure). The climate impact of household electricity consumption will therefore by quite different in Norway, which generates over 98% of its electricity from hydropower, and in the Netherlands, which generates almost 90% of its electricity from fossil fuels. Among fossil fuels, natural gas emits less CO_2 per unit of energy than oil, which emits less than coal. While some renewable energy is generated by households, most non-fossil fuel power, particularly nuclear and hydropower, is generated by utilities. The relationship between CO_2 emissions and household energy consumption is therefore complex and to a substantial extent, but not entirely, is outside the control of the household. For that reason, this paper focuses primarily on energy consumption, with associated CO_2 emissions discussed explicitly only where available studies permit; otherwise, climate change impacts are left implicit depending on the national or local energy supply situation.

17. As most energy consumption and CO_2 emissions are related, directly or indirectly, to household consumption, changes in household consumption patterns and the production patterns that serve them will be required in order to address climate change.

Those changes will need to include changes in consumer behaviour, housing construction and maintenance, appliance design, volume and type of goods and services consumed, vehicle design and use, public transportation infrastructure and systems, urban planning, waste management and recycling, electricity generation, and other factors. Some of these changes could, in principle, be undertaken fairly quickly (e.g. lighting), while others will take decades to be effective (housing design, urban planning, transportation infrastructure, and electricity generating systems). The policy question will be not so much which of these to choose, but how much energy conservation and emission reduction can be achieved from each in ways that are technologically, economically and politically feasible.[11]

18. The analysis of household energy consumption patterns in this paper should not be taken to suggest that the conventional sectoral analysis, emphasizing the importance of the transportation, industrial and power sectors, is incorrect or misleading. Rather it indicates that a household consumption perspective is also essential, as most of the goods and services of the transportation, industrial and power sectors are produced to serve household demand. In market economies, changing consumer demand will be an essential element to achieving major changes in energy consumption and CO_2 emissions, in addition to changing production processes. Policies will need to address all aspects of, and approaches to, improving energy efficiency, reducing energy consumption and curtailing carbon emissions from energy use.

3. Elements of household energy consumption

(a) Overview

19. Energy consumed by households is used for space heating, hot water, appliances, lighting, air conditioning, and household transportation. In the United States, for example, 18% of direct household energy consumption is for space heating, 8% is for hot water, 27% is for appliances and lighting, 6% for air conditioning, and 41% is for household vehicles.[12]

20. In Europe, households' share of total energy consumption has increased in the past ten years in almost all EU-15 countries and in some new Member States. In terms of climate change impact, an increasing share of energy has come from renewable sources, offsetting the increase in energy use, so that CO_2 emissions from household consumption have been stable between 1990 and 2002.[13]

21. Household energy consumption increases steadily with income, with indirect energy embodied in goods and services forming a greater share as income rises, particularly in developing countries. Most of the energy consumption in poor households takes the form of fuel combustion in the household, whereas for affluent people most energy consumption is related to the purchase of goods and services. Total household energy consumption generally increases somewhat more slowly than income; the increase in household energy consumption associated with a doubling of income varies

between 67% for India and 90% for Denmark, with most other countries falling between those values.[14]

22. Demographically, larger households require less energy per person, due to increased sharing of resources. In the Netherlands, for example, two-person households consume somewhat more total energy than single-person households, but there is little increase with the number of residents above two (excluding transportation). The trend in many countries toward more numerous but smaller households therefore increases energy consumption per capita and total household energy consumption.

23. As noted above, in some developing countries, particularly in Africa and Asia, urban households consume more energy, particularly fossil fuels and electricity, than rural households, which consume mostly biomass and often do not have access to the electricity grid. As biomass fuel is often, although not always, harvested as a renewable resource, the climate impact of energy consumption in rural Africa and Asia is generally small. As those areas develop and modernize, their household energy consumption patterns and CO_2 emissions are expected to gradually evolve towards those in urban areas and in developed countries. In developed countries, rural and suburban households consume somewhat more energy than urban households, particularly for space heating and transportation, as urban residents are more likely to live in smaller apartments with smaller appliances and to travel by foot or public transportation.

24. Biogas, derived from animal wastes and other biomass, offers a cost-effective and climate-friendly renewable energy source in rural areas, particularly for cooking and lighting. Initial efforts to promote biogas in China, India, Sri Lanka and other countries suffered from poor systems design and lack of maintenance. More recent designs are more reliable and convenient to maintain and better integrated into farming and household systems.[15] Vietnam has a national programme for converting animal waste to biogas for household use in rural areas.[16]

25. A recent study of the costs and benefits of various measures for reducing greenhouse gas emissions concluded that the most cost-effective measures — measures which would pay for themselves quickly under present conditions — were household and building energy conservation measures, including building insulation, improving vehicle fuel efficiency, more efficient lighting and air conditioning, sugarcane biofuel and reducing stand-by power consumption. These measures are good financial investments now, without considering the benefits of climate change mitigation or other environmental costs.[17]

(b) Space heating and hot water

26. Space heating is a major component of household energy consumption, typically consuming about half of the energy consumed directly within the household, and 15-20% of total household energy consumption.[18] In Europe, energy consumption for household space heating continues to grow due to the increase in the number of

households (and decline in average household size) and the size of the average dwelling.

27. Improved designs and standards for housing, particularly for construction, can substantially reduce energy consumption for space heating and air conditioning. Various design elements affect energy efficiency, particularly insulation, but also sealing joints between building components, and the orientation and shape of the building, which influence the heat gain from daylight.

28. Following the oil price shocks of the 1970s, most OECD countries introduced mandatory energy efficiency building codes, focusing mainly on improved insulation to reduce heating and air conditioning costs. In addition, countries have offered tax incentives, subsidies and low-interest loans for builders who go beyond the regulatory standards, as well as information and technical assistance to encourage builders and buyers to adopt more energy-efficient building technologies. Regulations and incentives directed at builders have been more effective than measures aimed at consumers, as home buyers generally focus much more on the purchase price than the operating cost, for which they usually have little information.

29. OECD countries generally began by introducing energy-efficiency codes for each building element, including windows, walls, roofs, and systems for space heating, water heating, ventilation and air conditioning. Some countries have since introduced overall building performance standards, taking into account the components and other factors, such as passive solar heating from building orientation and design. Regular review and updating of building codes on the basis of current technologies and best practices can ensure a steady and cost-effective strengthening of regulations, as exemplified by California state regulations in the United States.

30. In the United Kingdom, electricity and gas suppliers are required to assist customers in improving energy efficiency through low-cost methods, with a particular focus on low-income households. In Denmark, the United States and other countries, building owners have been able to request free energy audits with recommendations for cost-effective energy efficiency measures. Surveys indicate that the majority of households participating in such programmes have undertaken at least some of the energy conservation measures recommended.

31. In the United States, some states and communities have passed Residential Energy Conservation Ordinances (RECOs) requiring some basic low-cost energy-efficiency measures such as insulation, weather stripping and caulking to be undertaken when existing buildings are sold or renovated. Germany, in 2002, began to require energy efficiency measures in all existing buildings, including replacement of old boilers, insulation of attics, and insulation of pipes in unheated rooms.

32. Some countries have introduced incentives to promote energy efficiency in buildings beyond regulatory standards. In Canada, for example, the Commercial Buildings Incentive Program offers subsidies for investments in energy efficiency based

on projected annual energy savings. In other countries, tax credits have been used for the same purpose. Analysis of such approaches suggests that subsidies at the design and construction stage have substantially greater impact on building performance than incentives based on operating costs, such as energy taxes. Some countries, such as the United Kingdom and Denmark, have introduced mandatory labelling of the energy efficiency of buildings.

33. Solar heating offers a cost-effective means of reducing CO_2 emissions due to household heating. Globally, solar heating, mostly for water and space heating, is estimated to provide 25 times more power than solar-electric (photovoltaic) systems and has been growing rapidly. China is the leading country in using solar heating, with other major users including India, the United States, Japan, the European Union, Turkey, Israel and Australia. The importance of household solar heating has often been neglected as it is not adequately included in national energy statistics due to its decentralized nature and the consequent lack of national data.[19]

34. In Sweden, many residences are heated by district heating systems fueled with biomass, rather than by conventional fossil fuel or electric heating systems in each building. About 75% of apartment buildings and many individual residences obtain heat from district heating systems, providing about 50% of total national space heating energy. About half of the energy for the district heating systems comes from biomass, including fuelwood, peat, wood by-products, and combustible waste. Biomass district heating has increased in recent years due to a tax on fossil fuel oil, and is expected to increase further as a result of a ban on landfill disposal of combustible waste. In some areas, wood chips are also used directly in modern biomass home heating systems. Biomass fueled district heating systems are also used in Finland and Austria.[20]

(c) Appliances and lighting

35. Electricity consumption for appliances and lighting is a large and rapidly growing component of household energy consumption. In the United States, appliances consume about 30% of the energy consumed in the household (including the primary energy lost in electricity generation and distribution).[21] Many appliances, notably refrigerators and air conditioners, as well as lighting and other energy-consuming consumer products, consume much more energy in use over their lifetimes than in their production. For that reason, their life-time operating costs are much greater than their purchase price.

36. While energy-efficient appliances are somewhat more expensive than less efficient units, the lower operating cost of the efficient units often repays the higher price in a short time. In the United States, for example, an Energy Star qualified refrigerator costs about $180 more than a comparable non-Energy Star model, but saves about $180 in energy costs each year.[22] However, most consumers, when purchasing appliances, pay more attention to purchase price than to operating cost.

37. Households can help reduce national energy consumption, not only by reducing energy consumption in the household, but also by recycling materials, particularly metals. Recycling aluminum can save up to 95% of the energy required to mine, transport and refine bauxite ore into aluminum. Recycling iron, steel, copper and other metals can also save most of the energy required for virgin metals. Recycling plastic and paper can also result in some, although more modest, energy savings.

Energy efficient standards

38. Mandatory energy-efficiency standards applied to manufacturers have been effective in improving the efficiency of appliances by eliminating the least efficient models from the market. Many countries, including Canada, China, Mexico, the United States, the Republic of Korea, Australia, Viet Nam, Indonesia, Colombia and Thailand, have established mandatory standards for a variety of appliances, most commonly refrigerators and air conditioners. [23] Other countries have voluntary standards. Developing countries and smaller developed countries have often drawn on the established standards of other countries in developing their national standards. In OECD countries, as a result of such measures, the least efficient refrigerator on the market today consumes about half of the energy of the least efficient product ten years ago.

39. In Mexico, in accordance with the 1992 Federal Metrology and Standardization Law, energy efficiency standards have been developed for washing machines, refrigerators, water heaters, lights, water pumps, boilers, thermal insulation materials and other household systems. As a result, the energy consumed in Mexico by washing machines and refrigerators fell by 30% and 53% respectively between 1992 and 2002.[24]

40. Australia, in February 2007, announced plans to establish energy efficiency standards for light bulbs that would ban incandescent bulbs by 2010, with both regulatory and persuasive measures used to induce a shift to compact fluorescent bulbs (CFLs). It is estimated that household lighting costs will be reduced by up to 66% and that CO_2 emissions will be reduced by 800,000 tonnes per year for the 2008-2012 period.[25] Similar measures have been proposed in the United States, Canada and Europe. Cuba and Venezuela also have national programmes to replace incandescent bulbs with compact fluorescents. Some countries require electric utilities to actively promote energy efficiency, for example by giving away CFL bulbs in order to introduce them to consumers.

41. In Thailand, the national utility's demand side management (DSM) programme, supported by the Global Environment Facility, has reduced peak demand by 383 MW and achieving annual energy savings of 1,868 GWh. The utility created a dedicated DSM office, now with a staff of 375 people working on energy efficiency programmes for refrigerators, air conditioners, compact fluorescent lamps and green buildings, as well as public awareness campaigns, development of energy service companies (ESCOs), and industrial energy efficiency programmes. The utility works with manufacturers to promote development of new high-efficiency equipment and sales of efficient

refrigerators and air conditioners, including through workshops with distributors and retailers.[26]

Energy labeling

42. Energy labels complement energy efficiency standards: standards eliminate the least efficient models, while labels promote the most efficient models and the development of more efficient models. Energy labels are of two types: "information labels" identifying the energy consumption of all products within a particular category; or "endorsement labels" identifying the most energy-efficient products. Studies indicate that information labels tend to be more effective as they allow consumers to compare all products and consider energy efficiency along with other characteristics. Information labels often provide information not only on energy consumption, but also on the approximate operating costs of different models, allowing consumers to identify cost savings and compare them with price differentials.

43. Information labeling programmes may be mandatory or voluntary. Studies have shown that mandatory programmes have a greater impact, as they allow all products to be compared. However, countries often begin with a voluntary programme, then make labelling mandatory as standards improve and producers and consumers become familiar with the system. Public information campaigns, as a complement to product labeling, can encourage consumers to look for the labels and help them to interpret the information and recognize the financial savings that can be achieved through energy efficiency.

44. Energy labels tend to have the greatest impact on purchases of large, high-cost appliances, for which consumers are more likely to make detailed comparisons of different brands and models. However, energy efficiency is generally not a primary decision criterion for most consumers when they choose appliances, so energy efficiency must be integrated with other information. The impact of labels is also limited by the fact that many consumers are unable or unwilling to make the effort to translate the information on labels into decision-making criteria, for instance to compare purchase price with operating costs.

45. Energy-efficiency labels for appliances and equipment are used in many OECD countries, and the range of appliances to which they are being applied is expanding. The EU Energy Labeling Framework Directive makes labeling compulsory for refrigerators and freezers, dishwashers, light bulbs, washing machines and dryers. Energy labels are in preparation for a number of other appliances, including boilers and hot water heaters. In the United States, the Energy Star label is a voluntary "endorsement label" introduced in 1992 for computer systems and subsequently expanded to over 50 products for the home and office, and to houses themselves. Its effectiveness has been strengthened by government procurement policies requiring that products purchased by the government meet Energy Star standards, thus providing a strong incentive for manufacturers to provide qualifying products. It is estimated that Energy Star labeled products resulted in $14 billion in savings in 2006.[27]

46. The refrigerator market in China has been transformed by an energy efficiency standards project implemented by China's Environmental Protection Agency, with support from the Global Environment Facility (GEF), UNDP, the UN Department of Economic and Social Affairs, the Collaborative Labeling and Appliance Standards Programme (CLASP), the UN Foundation, and the Energy Foundation. Manufacturers are required to reduce the energy consumption of refrigerators by 20% by 2008. In addition, a national consumer education programme, linked with an incentive programme requiring manufacturers to use at least 10% of their advertising budgets to promote energy efficiency, has succeeded in shifting consumer preferences toward higher energy efficiency. An energy information label was developed for refrigerators, and retailers were trained in marketing the benefits of energy efficiency to increase the impact of the labels at the point of sale.[28]

47. The Efficient Lighting Initiative (ELI), supported by the International Finance Corporation (World Bank Group) and the Global Environment Facility (GEF), has developed a testing method and certification/labeling system to promote high quality, energy efficient fluorescent lights. In 2005, the China Standard Certification Center was designated to develop and expand the ELI certification and branding system globally.[29]

Public procurement

48. Public procurement can be used to promote energy efficiency, as exemplified by Energy Star computers in the United States. After the Energy Star label was introduced in the United States in 1992 as a voluntary label for computers meeting energy-efficiency criteria, all federal government agencies, beginning in 1993, were required to procure personal computers, monitors, and printers meeting the Energy Star criteria. The United States Government spends nearly $4.6 billion annually to buy about 1 million computers, about 3 per cent of the total market. As a result of the Energy Star procurement requirement, the number of manufacturers in the United States and elsewhere making Energy Star labeled computers and peripherals rose from 10 in 1992 to 600 by 1998, and sales of such computers account for a majority of the total market for personal computers. The standard for public procurement thus became a general standard for the entire market.[30]

49. In Canada, in 1996, the federal government announced plans for green power purchases, including electricity generated from new or expanded renewable energy sources with the EcoLogo certification, including wind, water, biomass and solar power. In 1997, the Natural Resources Canada and Environment Canada ministries made commitments to purchase 15% to 20% of their electricity in the form of green power by 2010, and began purchasing green power from the electric utility in Alberta to run their facilities in the province, with a commitment to 10 years of such purchases. In addition to providing renewable energy for government operations, the programme is also intended to promote the development of green power markets for private consumers.[31]

Reducing stand-by power

50. Many electric appliances now consume energy not only when they are in use, but also when they are in "stand-by" mode, most often to operate a clock or remote control system. A microwave oven that is only used occasionally, for example, may use more energy in stand-by mode than for heating food. It has been estimated that, in the United States, about 5-10% of residential energy consumption is for stand-by power, costing more than $3 billion per year and consuming the output of 18 power stations.[32] Studies in Europe have estimated that stand-by power accounts for as much as 7 to 13% of residential electricity consumption.[33] The United States study concluded that use of the most efficient and cost-effective stand-by technologies could provide the stand-by functions while reducing stand-by power consumption by 72%. In 2001, the United States adopted standards for government purchases. In 2002, Australia adopted a national voluntary standard for stand-by power consumption, and in 2006 the state of California in the United States introduced the first mandatory standards for stand-by power consumption by various appliances. In addition, public information campaigns have encouraged consumers to turn off appliances completely when the stand-by functions are not needed.[34]

Renewable energy sources

51. The generation and use of electric power from household renewable energy systems, particularly wind generators and solar photovoltaic systems, is small but growing. Residences, which consume about 20% of total energy, account for over 75% of renewable energy generation, other than by electric power utilities.

52. A number of countries, including Australia, Austria, Denmark, Germany, Italy, the Netherlands, Poland, Japan and the United States (at the state level), have introduced requirements for utilities to include a specified share of renewable energy in their supplies. In California, for example, a "Renewables Portfolio Standard" (RPS) that took effect in 2003 requires investor-owned utilities to obtain 20% of their power from renewable sources by 2017, with a phase-in requirement of 1% per year.[35] About 18 other states in the United States have RPS requirements.

53. Stand-alone renewable energy systems, such as household solar photovoltaic (PV) systems or wind generators not connected to the electrical grid, require batteries to store power for use when the resource is not available — at night for solar equipment or on windless days for wind generators — increasing the cost of the system and reducing the environmental benefits. Investment in renewable energy systems in areas served by a grid is therefore more economic and sustainable if the generator/consumer can sell surplus renewable energy to the grid and buy energy from the grid when required, thus eliminating the need for batteries, as well as making full use of available wind, sunlight or other renewable energy sources.

54. Utilities have often refused to buy power from private sources in such situations, sometimes citing technical difficulties in accepting power that does not conform to their

operating specifications. Germany, in 1991, in order to promote private investment in renewable energy systems, adopted a “feed-in law” requiring utilities to purchase all renewable energy offered to them at a minimum of 90% of the retail price. For wind energy, Germany guaranteed a minimum purchase price of 8.5 euro cents ($0.11) per kWh for the first five years (12 years for offshore installations) and 5.4 euro cents ($0.07) for the rest of a 20-year period. These policies have made Germany the global leader in wind energy capacity. For household solar photovoltaic installations, Germany began in 1999, as part of a “100,000 Roofs Campaign” to offer interest-free 10-year loans as well as the guaranteed “feed-in” price of 8.5 euro cents per kWh. With the Renewable Energy Law in 2000, the guaranteed purchase price jumped to about 50 euro cents per kWh for 20 years, much above the price of conventional power, creating a strong incentive for private investments in solar power. Solar thermal water heaters are also subsidized. Denmark and Spain also have feed-in provisions.[36]

55. Many countries, including Belgium, the Czech Republic, Denmark, Germany, Greece, Italy, Japan, the Netherlands, Republic of Korea, Spain, Switzerland, Thailand and the United States, have introduced “net metering” arrangements for buildings or facilities that generate electricity, using electricity meters that run backwards when the facility is generating more power than it is consuming and delivering power to the grid. The consumer thus pays only for the net power consumption over time.[37]

56. In some countries, including Sweden, the United Kingdom and the United States, which have introduced competition into the retail electricity business, consumers can select a power company offering green power. Alternatively, consumers can pay utilities a small premium to ensure that the utility generates or purchases enough power from renewable sources to meet the demand of such customers.

57. In Brazil, Ireland, the United States and other countries, utilities add a surcharge to electricity bills to fund renewable energy or energy conservation programmes, including assistance to consumers in the form of grants, low-interest loans, audits or technical assistance for improving energy efficiency or installing renewable energy systems. In Japan, a rebate programme for household solar photovoltaic systems, combined with net-metering provisions, low-interest loans and education programmes, has led to the installation of over 144,000 residential renewable energy systems.[38]

58. In remote rural areas, independent renewable energy generating systems may be more cost-effective that extending the national electrical grid. In some developing countries, including Argentina, Morocco and South Africa, rural power concessions have been offered to companies other than the national electric power utility, using a variety of energy sources including diesel generators, mini-hydro, photovoltaic, wind and biomass to provide electrical power to customres. Kenya has undertaken a number of measures to promote photovoltaic power, including exemptions of solar panels from import duty and VAT. In some rural areas of the United States where new customers for electricity can be required to pay part of the cost of grid extension, utilities are now required to inform them of the costs of an on-site renewable energy system as an alternative.

59. Microcredit programmes such as Grameen Shakti in Bangladesh, the Viet Nam Women's Union, and Sarvodaya in Sri Lanka, have helped low-income rural households to purchase solar home systems or other renewable energy systems for both household consumption and income-generating activities.[39]

(d) Transportation

60. Energy consumption for transportation, and the associated carbon emissions, are steadily increasing despite some improvement in the fuel-efficiency of vehicles. Almost all vehicles use fossil fuels, so CO_2 emissions are directly related to fuel consumption. Private cars and air transportation are the most energy intensive and fastest growing forms of transportation.

61. On a global level, the transport sector produces 24% of CO_2 emissions from fossil fuels, up from 22% in 1990, and projected to increase to 30% by 2020. Two-thirds of the transport emissions are from OECD countries, but the share of other countries is increasing. In the United States, CO_2 emissions from the transport sector increased by 22% from 1990 to 2003, representing a 5% increase in per capita emissions, from 5.7 tonnes per person to 6.2. Economy-wide in the United States, from 1990 to 2003, total CO_2 emissions from fossil fuels increased by 18%, while transport sector emissions increased by 26%, and road transport emissions by 34%. US road transport accounts for 83% of total transport emissions, with air transport second at 10%.[40]

62. In almost all countries, people are traveling more than ever before, and increasingly by private car. In the United States, private cars are used for 97% of land passenger travel, and private car travel has increased from 20,700 km per person in 1990 to 24,300 km in 2004. In Western Europe, private cars provide 84% of land travel, with car travel increasing from 7,000 km per person in 1990 to 8,500 km in 2005. In Japan, private cars provide over 60% of passenger transport, with car travel increasing from 4,700 km per person in 1990 to 5,800 km in 2000.[41]

63. Energy consumed by personal travel, and the resulting CO_2 emissions, depend on the vehicle, the distance traveled, and the number of passengers traveling together (see Fig.1).[42] As indicated, mass transit and trains (when heavily used) are very energy efficient, and walking and biking consume no fuel. Fuel consumption for car travel depends strongly on the type of vehicle and the number of passengers traveling together. A small car with three or four passengers is a very fuel-efficient means of transportation, while a large vehicle with one passenger is the least fuel efficient means (per passenger-km). For long-distance travel, such as a family vacation, the family car is more fuel efficient than flying, as is a fuel-efficient car with one passenger.

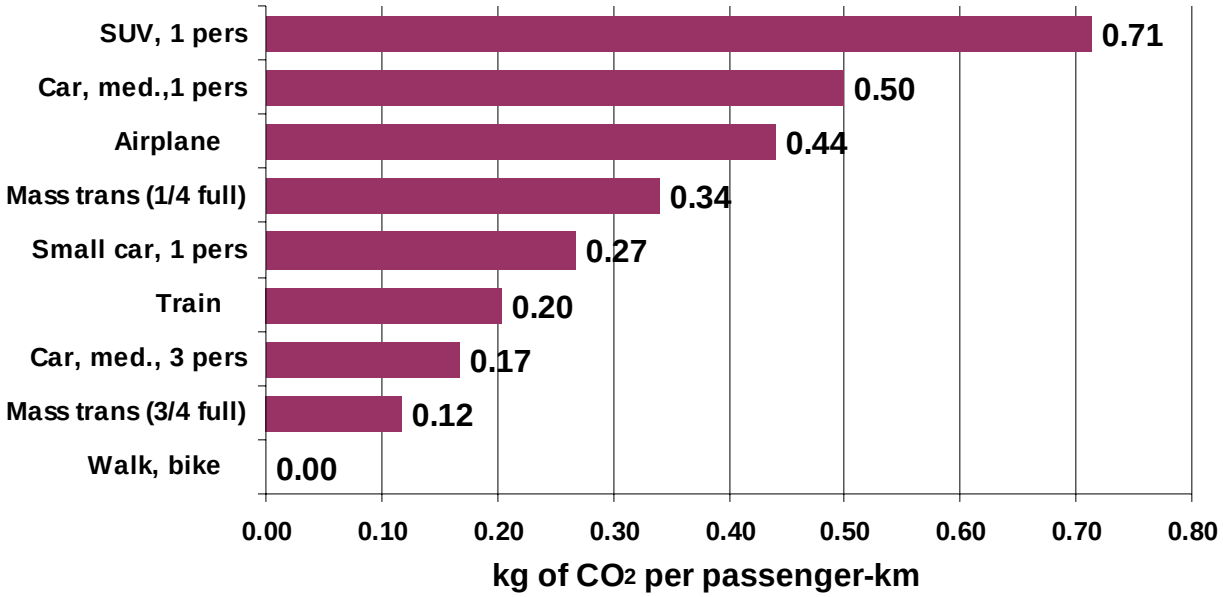

Fig. 1. CO_2 Emissions for Passenger Transport

64. Air transport, which is mostly of passengers but also of freight, generates 3% of global CO_2 emissions from fossil fuels, compared with 21% for ground transportation, but it is growing rapidly. Furthermore, the IPCC has estimated that the climate change impact of air transport is 2.7 times the impact of its CO_2 emissions alone, due to the contributions of high-altitude emissions of water vapour and NO_X. Growth in air transport, which is mostly for leisure travel, is particularly rapid in the EU-15, where CO_2 emissions from air transport grew 62% from 1990 to 2003.[43] A recent movement to mitigate the climate impact of air travel has been the sale of CO_2 offsets, by which travelers can pay a fee or surcharge based on the distance traveled to fund measures such as afforestation to absorb the CO_2 generated by their travel, or renewable energy generation to replace fossil fuel energy.

65. The transport of goods — most of which are ultimately destined for household consumption — has continued to grow more rapidly than population, along with international trade, which continues to grow faster than the global economy. Domestic freight is gradually shifting more toward road transport and away from the more energy efficient rail and water transport.

66. In Western Europe, domestic and regional road freight has increased by more than 50% (in tonne-km) from 1990 to 2005, increasing its share of land freight transport from 76% to 79%, while rail and inland water freight, which are more energy efficient, remained about constant in volume and declined in share. Growth in road transport, both in tonne-km and in share, has been even greater in Central and Eastern Europe, with road transport increasing from 30% of the total in 1990 to 62% in 2005, at the expense of the previously dominant rail transport. In the United States, on the other hand, most domestic land freight (58%) continues to go by rail, with bulk shipments of coal, chemicals, grain, minerals and wood products accounting for most of the traffic. In

Japan, freight transport is divided between road (50%) and water (45%), with the share of road freight increasing.[44]

67. Fuel for shipping, the large majority of which is for international freight, accounts for about 2% of global energy consumption and CO_2 emissions, a share that has been roughly steady since 1990. International shipping, like international aviation, is not covered by the Kyoto Protocol.

68. It has been argued that information and communication technologies can reduce energy use for transportation by allowing telecommuting and teleconferencing. However, there appears to be little evidence to date of such an effect. While some travel has undoubtedly been avoided through such technologies, it also seems that the increased long-range interactions facilitated by new electronic technologies encourage more travel. Globalization generally implies both more electronic interactions and more physical exchanges of both people and goods.

Fuel efficiency standards

69. Fuel-efficiency standards were first introduced in 1975 in the United States, complementing air pollution emission standards. The United States Corporate Average Fuel Efficiency (CAFE) standards were strengthened between 1975 and 1985, increasing fuel efficiency from an average of 20 miles per gallon for all cars and light trucks to 26 miles per gallon in 1986, saving 55 billion gallons of fuel annually and reducing CO_2 emissions by about 10%. The standards have not been strengthened since 1985, however, and increased use by households of sports utility vehicles (SUVs) and light trucks, which have lower fuel efficiency requirements under the CAFE standards, has reduced average fuel efficiency from 26 miles per gallon in 1986 to 25 miles per gallon in 2005. In 2005, China introduced mandatory fuel efficiency standards stricter than those in the United States, with even stricter standards to take effect in 2008. In Europe, which has higher average fuel efficiency than the United States due to voluntary actions by producers and consumers, the European Commission is negotiating voluntary standards with the auto industry.

70. Following the lead of California's 2002 Vehicle Global Warming Law, nine states in the United States now require that future cars sold in those states reduce their emissions of greenhouse gases by about 22% by 2012 and 30% by 2016. It is estimated that the higher costs of the vehicles – $300-$1000 – will be paid for by reduced fuel costs in 1.5–3.5 years. In Canada, the government has negotiated an agreement with car-makers to reduce vehicular greenhouse gas emissions by 17% by 2010.[45]

Alternative vehicle technologies

71. There has been a steady growth in numbers and models of fuel-efficient vehicles with hybrid gasoline-electric engines since Toyota introduced the Prius in 1997. Subsequently, Honda, Ford and General Motors have also introduced cars, SUVs and

pick-up trucks with hybrid engines. Hybrid sales in the United States grew to 255,000 in 2006, an increase of 28% over 2005 sales, stimulated in part by high fuel costs and tax incentives, although there are indications that sales are slowing. The most fuel-efficient hybrids consume fuel at about half the rate of comparable cars with conventional internal combustion engines and are particularly fuel-efficient in slow, stop-and-go city traffic. While hybrid cars are somewhat more expensive than conventional cars, the savings on fuel over the lifetime of the car can cover the extra cost.[46] The United States offers a deduction of up to $2000 from taxable income for the purchase of a hybrid or other "clean fuel" vehicle, including vehicles powered by natural gas, 85% ethanol (E85) or electric vehicles.[47] In some cases, however, car-makers are using hybrid engines to increase power relative to comparable conventional models, rather than to improve fuel efficiency.

72. In Brazil, and to some extent in the United States, drivers have a choice of fuel between gasoline and ethanol, the combustion of which reduces both net CO_2 emissions and air pollution, as well as reducing dependence on imported oil. In Brazil, most vehicles are now produced with "flex-fuel" engines, introduced in 2003 at no extra cost and capable of using gasoline, ethanol or any mixture of the two. Many service stations offer both gasoline and ethanol, allowing consumers to choose their fuel based on availability, price and environmental considerations. The flex-fuel approach has overcome consumer resistance to ethanol-only engines, which lost popularity in the late 1980s when ethanol availability decreased with increasing sugar prices and gasoline became cheaper with declining world oil prices. Brazilian producers estimate that ethanol from sugar cane is cheaper than gasoline when oil is above $30 a barrel. In addition, costs of ethanol production are expected to decline further with improvements in production technology and with the co-generation and sale of electricity generated by burning sugar-cane residue (bagasse).[48]

73. Currently, ethanol production in developed countries with temperate climates is based on corn or grain, which have higher production costs and provide less net fossil fuel savings and CO_2 emission reductions than sugar cane. However, new technologies under development allow ethanol production using plant cellulose from agricultural or forestry wastes or fast-growing grass or trees grown specifically for the purpose. This would also offer new economic opportunities in rural areas and reduce pressure to clear forest land or switch agricultural land to ethanol production, as cellulose for ethanol production can be grown on otherwise unproductive land. The first cellulose-ethanol pilot production facility, using agricultural residues, is now operating in Canada, selling ethanol to the Canadian government for its fleet. Flex-fuel cars and trucks that can use ethanol fuel are sold in the United States by Daimler-Chrysler, Ford, General Motors, Peugeot and Volkswagen.[49]

74. An alternative fuel being developed in Europe, and to a lesser extent in North America, to replace petroleum-based diesel fuel is biodiesel, produced from vegetable oil, most commonly rapeseed (canola) oil, but also from soybean oil and palm oil. In India, efforts are being made to promote jatropha, a hardy oil crop that can grow on dry degraded land. Biodiesel, if grown sustainably, can reduce net CO_2 emissions

compared with fossil fuel diesel, but it may compete with other uses of agricultural land. Used vegetable oil from food processing is also being used as diesel fuel and is more economical than new biodiesel, but the supply is too limited to have a substantial impact on fossil fuel consumption. Recently, concerns have been raised that increasing production of biodiesel through expansion of cultivated land could increase the release of CO_2 and N_2O (another greenhouse gas) from deforestation and peat bog degradation.[50] Such concerns could be addressed by certification schemes ensuring that biodiesel was produced sustainably.

75. In many countries, government agencies and local authorities have acquired alternative-fuel vehicles for their public fleets of cars, buses and other vehicles. Programmes in New York City, Malmö (Sweden) and other cities have acquired hybrid, biofuel, electric and compressed natural gas vehicles, primarily to reduce air pollution, but also to reduce GHG emissions, and to help develop a larger market for such vehicles and support systems.

Urban public transport, traffic management and non-motorized transport

76. In urban areas, dependence on household cars is a function not only of people's life-styles and consumption choices, but also of land use patterns, infrastructure development and alternative transportation systems. While urbanization has been a long-term global trend, urban growth in developed countries in recent decades has been concentrated in low-density suburbs, where mass transit is not economically feasible — or environmentally beneficial if ridership is low. The separation of residential areas from commercial areas has made walking or cycling less convenient.

77. One extreme of urban transportation patterns is the city of Atlanta in the United States, with a population density of 6 people per hectare, where about 2% of motorized personal travel is by public transport, fuel consumption for private cars is almost 3000 litres per person per year, and non-motorized travel accounts for only 3% of trips. By contrast, in Tokyo, with a similar income per capita, population density is about 90/ha, 56% of personal travel is by public transport, 36% of trips are by foot or bicycle, and fuel consumption for private cars is about 270 litres per person per year.[51] While population density is a critical factor in influencing urban transportation systems and patterns, long-term public investment and urban planning policies are also critical. Making fundamental changes in such patterns requires difficult political choices and large investments over many years.

78. Research indicates that public transit is financially viable only with a population density greater than about 30 people per hectare. Many large cities in Europe, Asia and Latin America have densities of 30 to 100 people per hectare, while many cities in the United States, Canada and Australia have 6 to 20 people per hectare. Cycling and walking are also most feasible at high population densities and with a mix of housing, shops and businesses.

79. A number of policies have been used to discourage the use of cars in urban areas and promote use of mass transit, car-pooling, walking and bicycling. Tokyo and Switzerland require proof of owned or rented parking space before allowing people to buy cars. Many cities have increased charges for parking, restricted the number of parking spaces, developed new car-free residential areas, reserved lanes for buses or high-occupancy vehicles, improved facilities for cycling, and reserved some areas for pedestrians and cyclists.[52] While these policies have commonly had the primary purpose of limiting congestion and air pollution, they have also reduced fuel consumption and CO_2 emissions — although not sufficiently to offset other forces increasing transport emissions.

80. While most public funding for transportation in most countries and cities goes to roads, the share of funding going to public transit has increased in recent years in many places, including funding for environmental measures such as low-emissions buses, fuelling and service facilities for clean-fuel vehicles, and use of biodiesel fuel.[53]

81. While cars offer convenient, flexible and rapid transportation in rural areas and smaller cities, in the growing number of megacities, travel by car is commonly slow, expensive and unhealthy, due to congestion, the costs of car ownership and parking, and air pollution. In many large cities of the developing world, less than 10% of the land is devoted to roads, less than half of the share in most European and North American cities, leading to greater congestion despite the smaller number of cars relative to population. Rush hour speeds in the core areas of cities such as Bangkok, Manila and Jakarta are 6 to 8 km/hr, not much faster than a brisk walk. Because many of these megacities have high population densities – 100 people/ha and more – private cars cannot provide the basis for passenger transportation. The megacities of the developing world thus need efficient mass transit systems and other alternatives to cars even more than cities in the developed world.[54]

82. Some cities in developing countries have developed innovative urban rapid transit systems based on dedicated bus lanes along radial routes from the city centre, as pioneered in Curitiba, Brazil, in the 1970s and 1980s. In Curitiba, about 75% of all commuters (more than 1.3 million passengers per day) take the bus, and per capita fuel consumption rates in Curitiba are 25% lower than in comparable Brazilian cities, even though Curitiba is relatively wealthy and has above average levels of car ownership. Similar bus rapid transit (BRT) systems have subsequently been developed in Bogotà and Jakarta.[55] Such systems can provide efficient rapid transit on main routes for less than 1% of what a subway system would cost.

83. The “finger plan” or radial approach to urban development can help promote public transit and reduce the need for cars, while also promoting energy-efficient housing. High-density housing combined with retail stores are concentrated on axes (fingers) radiating out from the centre of the city, and particularly around stations of rapid transit lines serving the axes, whether subways, light rail or dedicated bus lanes. The land in between the axes can be used for parks or other low-density uses. This approach has proven successful in reducing vehicle traffic, energy consumption and air pollution in

such cities as Curitiba and Copenhagen, and is being applied in Denver (United States) and Vancouver (Canada), among other places.[56]

84. Some cities have used road tolls that depend on the time of day and traffic conditions to improve traffic flow while encouraging use of mass transit systems, an approach pioneered by Singapore in the 1980s. Charges can be automatically deducted at toll points from an electronic card in the vehicle, eliminating the need for toll booths that would slow traffic. Singapore also limits the overall number of cars in the city through auctions for a limited number of license plates. As a result, Singapore achieves average rush hour speeds of 45-65 kph on expressways and 20-30 kph on city roads.[57]

85. London, in 2003, introduced a "congestion charge" of $16, along with improved public transport, to discourage the use of private cars in central London during the day. As a result, many commuters switched to public transit, traffic delays were reduced, average speeds increased, and bus service improved. The zone subject to the charge was expanded in early 2007.[58] Central city congestion charges have also been used successfully in Norway and Sweden.

86. Bicycles can be an effective means of reducing fuel consumption, traffic congestion and air pollution, while improving public health. Four to eight bicycles can use the road space occupied by one car, and 20 bicycles can park in the space occupied by each car. In the Netherlands, with extensive bicycle paths, bikes are used for 25% of short trips (under 7 km) nationally - and about 40% in some cities. This represents 7% of total passenger-km, with the share increasing slightly in recent years, in part due to new pro-cycling policies.[59] In Copenhagen, 36% of residents bike to work. Lima, Peru, is promoting bicycle use, including through a revolving fund supported by the World Bank providing credit vouchers usable in bicycle shops. In Kenya, a luxury tax on bicycles at the rate of 80% until 1986 was gradually reduced, and finally eliminated in 2002, resulting in a large increase in bicycle sales. Most African countries still tax bicycle imports as luxury items, limiting access by poor people to low-cost and environmentally sound transportation.[60]

87. Construction of bicycle paths or separate bicycle lanes can be effective in promoting cycling by making it safer. Many Chinese cities reserve traffic lanes exclusively for bicycles. Allowing and facilitating the transport of bicycles in subways and trains and providing safe and convenient bicycle parking at train stations allows a combination of local cycling and longer distance rail travel for trips that are too long for cycling and inconvenient by rail alone. Some cities, however, as vehicle traffic has increased, have discouraged or even banned bicycles from some streets.

(e) Food

88. Energy consumption and greenhouse gas emissions relating to household food consumption include direct energy consumption for shopping trips and storing and cooking food, and indirect energy consumption from agricultural production, processing

and distribution. Studies indicate that the energy used in producing, processing and distributing food and drinks (indirect household energy consumption) are substantially greater than the energy used directly in shopping and handling food. As the direct household energy consumption for shopping and handling food are included in the consideration of household transportation and appliances above, this section will focus on the indirect energy and greenhouse gas emissions embodied in food purchased by households.

89. Agricultural production, in addition to generating CO_2 from fossil fuel use, is also a major source of methane (CH_4) from animal production and nitrous oxide (N_2O) from fertilizer, both of which are powerful greenhouse gases. In addition, in some areas, expansion of agricultural land through deforestation is an important contributor to CO_2 emissions. Most food related energy use, however, comes not from agricultural production itself, but from processing and distributing food.

90. In the United Kingdom, food and drinks, which make up the bulk of daily household consumption, are estimated to account for almost half of the indirect greenhouse gas emissions embodied in the goods and services that households consume. About 25% of total national greenhouse gas emissions are estimated to derive from the production and distribution of food and drinks.[61]

91. In the United States, about 10% of the total primary energy supply goes to the food supply system, with only about 20% of that (2% of TPES) going to farm production. Of the energy used in production, fertilizer is estimated to account for 28% and fuel for farm vehicles for 34%, with the remainder going to irrigation, pesticides, crop drying and other farm operations.

92. Food consumption trends in developed countries, and to some extent in developing countries, include increasing food consumption in general, increasing meat and dairy consumption, more frozen and prepared food, year-round consumption of fresh fruits and vegetables, and increasing food imports. These trends result in increasing long-distance refrigerated transport, including air transport, increasing the energy consumption related to food. In the United States and the United Kingdom, where most food is purchased in processed and packaged form, about 80% of the energy used in the food supply system goes for food processing, storage, packaging and distribution to retail stores. Much of that energy goes for transport from farm to processors to wholesalers to retailers; in the United Kingdom, for example, food transport accounts for 31% of total road freight. In developing countries where food is generally purchased by households in less processed form, and often from local sources, energy for production may amount to 50% of total food supply energy.[62]

93. Organic farming generally uses somewhat less energy than conventional farming, as energy-intensive chemical fertilizers and pesticides are not used.[63] However, because yields per hectare tend to be lower for organic farming, more fuel is required for cultivation and harvesting. Furthermore, expanding the cultivated area to compensate for the lower yields can increase greenhouse gas emissions from the land

clearing process. If organic food is imported in place of local conventional food, the lower energy consumption for production may be offset by higher energy consumption for transportation. Currently, demand for organic food is small, but growing.[64]

94. Some have argued that energy consumption for food processing and distribution could be reduced by efforts to promote local food production and consumption, including through the promotion of local farmers markets. The evidence on this is, however, so far inconclusive. A recent DEFRA study in the United Kingdom finds: "Since there is a wide variation in the agricultural impacts of food grown in different parts of the world …, global sourcing could be a better environmental option for particular foods." The study also concluded that most of the climate impacts of farming, including meat, dairy and cultivated crops, were from N_20 (nitrous oxide) and methane emissions, which were largely independent of farming methods, with secondary impacts from CO_2 emissions from fossil fuel use.[65]

95. Meat and other animal products, particularly from animals raised in feedlots, tend to require more energy for production than plant crops, particularly due to the energy used in producing the animal feed, and are associated with greater emissions of CO_2 and other greenhouse gases. Reducing high levels of meat and dairy consumption in favour of grain, vegetable and fruit consumption can therefore contribute to a reduction in energy consumption and greenhouse emissions. However, a study in Sweden concluded that a shift by consumers alone from the present average Swedish diet to a more healthy and sustainable diet would only produce a 5% reduction in CO_2 emissions from the production, processing and distribution of food, as the CO_2 reductions, due primarily to reduced consumption of meat, dairy products and soft drinks, would be largely offset by increased CO_2 emissions due to higher consumption of vegetables, fruit and fish. Larger reductions would require changes in production and distribution processes.[66]

96. Air transport of fresh produce amounts to a small share of food transportation and consumption, but it has a disproportionate climate impact and is increasing rapidly. In the United Kingdom, air freight of food currently accounts for only 1% of food tonne-kilometers, but it accounts for 11% of the greenhouse gas emissions associated with food transportation. Growth in air transport is part of a trend toward increasing international trade in fresh produce. In 2005, supermarkets in the United Kingdom were sourcing two-thirds of salad vegetables, more than a third of other vegetables, and most of their fruit from abroad. A steady increase in food transport is also reported for several other European countries and the United States over the last twenty to thirty years.[67]

4. Policy considerations

(a) Taxes

97. Taxes can be an important means to ensure that energy prices reflect the total costs of energy consumption, including the costs of climate change and other environmental harm. Energy taxes provide direct incentives for both consumers and

producers to reduce energy consumption. Although household energy demand is often relatively inelastic, studies show that price increases can significantly reduce the demand for energy, particularly in the long-term. Several OECD countries introduced or increased taxes on energy during the 1990s as part of a trend towards green tax reform, and carbon taxes have been introduced in Sweden, Finland, the Netherlands, Norway and New Zealand. Further analysis is required to measure the impact of various types and amounts of taxes on household energy consumption, and on ways to avoid hardships for low-income households.

98. In 1999, Germany initiated its Ecological Tax Reform, gradually raising energy taxes without increasing the overall tax burden. The taxes are levied on producers and passed on to consumers. Taxes were raised on fossil fuels and introduced on electricity in 1999, and then raised in subsequent years. Electricity generated from renewable energy sources is exempt from the eco-tax, and electricity used by local public transport enjoys a 50% tax reduction. Some of the revenue is used to provide advice to homeowners on reducing energy consumption and for grants to schools for solar heating, photovoltaic panels and biomass energy systems. The Netherlands, in 2001, through its Environmental Action Plan, increased energy prices for small-scale consumers by more than one-third by means of a tax levied on gas and electricity. Most of the tax revenues are redistributed to taxpayers through reductions in wage and income taxes, but a portion covers the cost of tax incentives for energy conservation measures. With the introduction of this tax, the price of household electricity has gone up by 15%.[68]

99. Tax credits or tax deductions for sustainable energy systems, particularly renewable energy, have also been used in a number of countries. In India, investment tax credits have been used together with financing assistance and accelerated depreciation provisions to promote renewable energy, making India the fifth largest producer of wind power.[69]

(b) Subsidies

100. Energy is heavily subsidized in many economies. In the OECD, subsidies to the energy sector have been estimated to be an order of magnitude higher than subsidies to other sectors, with most support going to nuclear, coal and oil production, often in support of regional employment. These subsidies tend to discourage energy efficiency and the adoption of new fuels. The reform of energy subsidies, particularly for fossil fuels, is an important element of efforts to increase energy efficiency, reduce energy consumption, particularly of fossil fuels, and reduce carbon emissions.

101. In 2002 the Mexican government introduced reforms to reduce residential electricity subsidies. Households consuming between 280 and 500 kilowatt-hours bimonthly face a gradual and differentiated reduction in their electricity rate subsidy, while households that consume more than 500 kWh will have the subsidy eliminated. The subsidy is retained for low-consumption households (less than 280 kWh), representing 75% of the population. The reduction in residential electricity subsidies is

expected to generate revenues of 5 billion pesos. At the same time, a financial support programme will encourage the acquisition of more efficient refrigerators, air conditioners and insulation for consumers who live in hot regions.

(c) The rebound effect

102. Reductions in particular forms of energy consumption will often tend to increase other forms of energy consumption, a phenomenon known as the rebound effect. Where energy conservation result in financial savings for a household, money will be available for other consumption, which will generally involve some additional energy consumption, direct or indirect, offsetting the initial reduction to some extent. A consumer shift to smaller, more fuel-efficient vehicles, for example, would reduce household expenditures on both vehicles and fuels, making money available for, among other things, more or larger appliances, leisure travel, or a larger or second house. Consumers may also respond to greater efficiency by reducing conservation efforts, such as leaving energy-efficient light bulbs on rather than turning them off whenever they are not needed, or using energy efficient air conditioners more often. Much also depends on how far lower energy prices are passed on to consumers, which is in turn a function of market structure and regulation.

103. Studies indicate that the extent of the rebound effect depends on a variety of factors, including the types of energy produced and consumed in the economy concerned, the activities for which energy efficiency is increased, and how producers and consumers react to price changes in energy and other goods and services. Nonetheless, the rebound effect can be considerable, making it difficult to predict accurately the effect of conservation measures on energy consumption or carbon emissions.

(d) Cooperation with the private sector and civil society

104. While public policies, including regulatory measures, economic incentives and information, are essential for reducing household energy consumption, there is also a need for private action by consumers, the businesses that serve them, and organizations of civil society.

105. A new business sector has emerged to support efforts by industry, organizations and households to improve energy efficiency. Energy Service Companies (ESCOs) offer advice and assistance on reducing energy consumption, mostly to industry and organizations, but in some cases in residential buildings. Payment is often made as a share of the financial savings, which commonly derive mostly from lighting, heating and air conditioning. In Nepal, Republic of Korea and South Africa, ESCOs have been involved in improving energy efficiency in multi-family buildings. In Japan, ESCOs have promoted micro combined heat and power (micro-CHP) systems for household use.[70]

106. Public attitudes and preferences are important drivers of corporate behaviour, through both market demand and concerns with corporate image. Corporations are increasingly working with environmental organizations and other elements of civil society to demonstrate environmental concern and social responsibility. Their environmental performance is also under ever closer scrutiny from institutional investors. Voluntary corporate commitments to public and community welfare, going beyond legal requirements, are becoming more common, through codes of conduct and environmental marketing and labeling. One institutional investor-led initiative, called the Carbon Disclosure Project, is designed to encourage large corporations to report regularly on their carbon emissions and on measures taken to reduce them.[71]

107. Young people are important actors in sustainable development due to their role as consumers, their influence on household behaviour, and the long-term habits they develop. Young people have had an important role in household recycling, for example, in part because of school programmes that have promoted recycling within the school, taught children how and what to recycle, and used recycling as a topic for teaching about energy, materials, mass production and consumption, waste management and climate change

108. Universities and other educational institutions in the United States and other countries have begun to assess their energy use and consider options for reducing the climate impact of their operations, often under the leadership of students. The Yale Climate Initiative, for instance, was created by students at the School of Forestry and Environmental Studies, with the initial goal of conducting a study on Yale's greenhouse gas emissions. It now focuses on educating the Yale community about the University's impact on climate and on evaluating options for reducing emissions.[72]

109. Carleton College's wind turbine produces enough electricity to supply 40% of the electricity to its Northfield, Minnesota, campus, as well as providing educational material for the physics department. At least eight universities in the United States report relying entirely on renewable energy sources for power. In various campuses across the United States, new buildings are being designed and older buildings renovated to be energy-efficient.[73] In the United Kingdom, the government has recently pledged that every new secondary school will be carbon neutral.

110. Education and training for sustainable consumption has a key role to play in creating more critical and responsible attitudes towards consumer behaviour in the everyday lives of future adults. The Marrakech Task Force on Sustainable Lifestyles, led by the government of Sweden, is supporting a number of demonstration projects to promote sustainable lifestyles, including UNEP/UNESCO's YouthXchange educational tool on sustainable consumption, targeting urban youth with access to information media.[74] The Marrakech Task Force on Education for Sustainable Consumption, led by the government of Italy, focuses on formal education, and particularly on introducing sustainable consumption issues into educational curricula.[75]

111. Educational institutions can work with interested businesses to promote sustainable development. BP, the energy company, is to launch a major Carbon Challenge education programme for schools in September 2007 covering the themes of carbon footprint and climate change, targeting 14 to 16 year olds in the United Kingdom. The main subjects for the BP Carbon Challenge are science, mathematics and enterprise, with activities linked to UK education curricula and guidelines. Working in partnership with the Science Museum in London and building on the success of BP's Carbon Footprint Toolkit, the programme is designed to reach over 400 schools and 60,000 students annually.

112. The Australian firm Sustain Ability International has developed a series of "Ollie's World" interactive resources for environmental education, including energy and climate change, which have been introduced in Australia, the United Kingdom and the United States with the support of a range of organizations from government, industry and civil society. In Argentina, the Environment and Sustainable Development Agency, in its Programme "Conciencia Activa" (Active Conscience), is distributing the "Faunactiva" (Active Fauna) 2007 calendar to all fifth grade students in order to raise environmental and climate change awareness and provide suggestions on behaviour change.[76]

(e) Innovative approaches

Carbon labels

113. As noted above, households consume more energy indirectly than directly, i.e. as energy embodied in the goods or services they consume. Existing energy labels inform consumers only of the energy that an appliance or vehicle consumes in the household. If consumers are to take into account their indirect energy consumption, they need information on the embodied energy and/or the associated CO_2 emissions.

114. In the United Kingdom, a voluntary labeling scheme was launched in early 2007 to inform consumers of the "carbon footprint" of products. The label, developed by the Carbon Trust in consultation with companies, will show how many grams of CO_2 were emitted during the production and distribution of products, from the extraction of raw materials, through the manufacturing process, to packaging and distribution to stores. Participating companies will undertake a comprehensive carbon audit of their supply chains and commit to reducing products' carbon footprints over a two-year period. The first goods bearing the label were expected to appear on retail shelves in April 2007. During the initial phase, the labels will be tested by a number of familiar brands, including snack foods and cosmetics. Consumer research has been used to ensure that the label is understandable to consumers.[77]

115. Also in the United Kingdom, the Tesco supermarket chain is introducing carbon labeling to help consumers make informed decisions about their food choices, while encouraging food producers, processors and distributors to reduce their carbon

emissions. All products sold in Tesco stores are to receive a carbon rating based on the energy required for the manufacture and transport of the product and its packaging.

116. Such carbon labels would be sensitive to long-distance transport, especially by air, and particularly for perishable products that require refrigerated shipment. Still, the evidence is far from clear on whether imports are associated with high environmental impacts when the full product life-cycle is considered. A recent study of the environmental impacts of different items in a typical United Kingdom "food trolley" finds that "(e)vidence for a lower environmental impact of local preference in food supply and consumption overall is weak".[78] Nonetheless, if such labels effectively discouraged consumption of imported goods, consideration would be needed of how to avoid harmful impacts on developing country exports.

Power consumption monitoring

117. As noted above, electric power for appliances, including stand-by power when appliances are not being used, is the fastest growing form of energy consumed within households. Few consumers are aware of the amounts of power consumed by different appliances, or even that many appliances are consuming power when not in use. If consumers are to manage household electricity use effectively and minimize unnecessary power consumption, they need information on the power consumption of appliances when in use and when "off".

118. Under EU legislation, member states are required to take steps to provide customers with real-time information about their energy consumption. In the United Kingdom, every household will be able to request, at no charge, a small portable device that can be carried around, showing how much electricity is being used in the home at any time. Such "real-time monitors" will show how power consumption changes as appliances are turned on and off or unplugged, and how much power is being consumed when everything is "off". This can help consumers develop household behaviour that reduces power consumption and electricity bills, while maintaining essential energy services.[79]

Carbon offsets and climate credit cards

119. Consumers can reduce their impact on climate change not only by reducing their energy consumption, but also by "offsetting" some or all of the emissions resulting from that consumption. Consumers can invest in planting trees to absorb CO_2 or in renewable energy systems that will generate power equal to their consumption. For consumers who find it difficult to plant trees themselves or to invest directly in renewable energy, there are services that sell "carbon offsets", most prominently for air travel.

120. The business of carbon offsets has been growing rapidly in recent years, with estimates of about $100 million per year on offset sales, and there are concerns about the reliability of some of the offsets, about a possible rebound effect that encourages

people to indulge in energy-intensive activities as long as they are covered by offsets, and about the possibility that easy availability of offsets could undermine support for necessary changes in consumption and production patterns. Currently, there is no regulation of these offsets, although some are based on public voluntary standards or codes of conduct developed in cooperation with environmental organizations. The cost of offsets varies among programmes, with one survey finding the cost of an offset for a tonne of carbon – the emission of a mid-size car driving about 3000 km – ranging from $5 to $25.[80]

121. In September 2006, the Dutch Rabobank introduced a "climate credit card", spending on which would be offset by contributions to environmental projects run by the World Wide Fund for Nature (WWF). The amount of the contribution would reflect the impact of the purchase, with air travel or vehicle fuel being offset by a larger contribution than purchases of less energy-intensive goods or services. A similar initiative was announced in March 2007 in the United States: spending on the Bright Card would involve a contribution for a carbon offset, initially for investment in renewable energy generation. In the United Kingdom, the makers of the ultra-compact Smart Car are offering a credit card, for which 5 trees would be planted by the Woodland Trust, offsetting the one tonne of CO_2 emitted by the car in 10,000 km of driving.[81]

Personal carbon accounts

122. Currently, under the Kyoto Protocol, each Annex 1 State party is committed to holding its greenhouse gas emissions to within a specified limit. To meet those commitments, governments are establishing emission quotas for major emitters, such as power generating stations and energy-intensive industries. To achieve greater reductions in the future, it will probably be necessary to expand the number of entities subject to reduction commitments. In the limit, this may extend to individual emission allowances.

123. The government of the United Kingdom has announced that it is considering personal carbon accounts, with each organization, household or consumer having an annual carbon emission allowance. Whenever a relevant purchase or payment is made, such as vehicle fuel, household electricity or heating fuel, a corresponding deduction would be made from the carbon account by means of an electronic carbon card. If the annual allowance is exceeded, the excess emissions would have to be paid for.[82]

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