



UNITED NATIONS
DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS

SUSTAINABLE CONSUMPTION AND PRODUCTION

Promoting Climate-Friendly Household Consumption Patterns

Prepared by the
United Nations Department of Economic and Social Affairs
Division for Sustainable Development
Policy Integration and Analysis Branch

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30 April 2007

Contents

<u>Chapter</u>	<u>Page</u>
1. Introduction	3
2. The role of households in energy consumption	3
3. Elements of household energy consumption	7
(a) Overview	7
(b) Space heating and hot water	8
(c) Appliances and lighting	10
(d) Transportation	16
(e) Food	22
4. Policy considerations	24
(a) Taxes	24
(b) Subsidies	25
(c) The rebound effect	26
(d) Cooperation with the private sector and civil society	26
(e) Innovative approaches	28
References	30

Contents

Chapter Page

1. Introduction	3
2. The role of households in energy consumption	3
3. Elements of household energy consumption	7
(a) Overview	7
(b) Space heating and hot water	8
(c) Appliances and lighting	10
(d) Transportation	16
(e) Food	22
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(b) Subsidies	25
(c) The rebound effect	26
(d) Cooperation with the private sector and civil society	26
(e) Innovative approaches	28
References	30

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 CO₂ emissions continue to increase steadily. From 1990 to 2004, world energy consumption increased by about 30% and CO₂ 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 (CO₂ 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, CO₂ 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.

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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 CO₂ 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

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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, CO₂ 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 in these areas requires more efficient biomass stoves, expanded use of liquefied petroleum gas (LPG), renewable energy sources, and connection to the electrical grid.

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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 CO₂ 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 CO₂ 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 be 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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.

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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 CO₂ 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 CO₂ 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

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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 CO₂ 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

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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

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 CO₂ 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.

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