

Chapter 1

Introduction

1.1 Introduction

In 1987, the World Commission on Environment and Development (WCED), also known as the Brundtland commission, wrote a report warning the world about the implications of the speed of energy consumption (cf. WCED, 1987). The current high level of energy consumption damages the environment and humanity in three ways. Firstly, the current energy consumption level is largely responsible for the high pollution level (with related problems such as the depletion of the ozone layer and climate changes). The environment is incapable of absorbing these high pollution levels. This incapability is also caused by the growing amount of waste. Secondly, due to the winning of exhaustible resources, such as fossil fuels and wood, the quality of the environment diminishes, and it consequently loses regeneration capacity. Finally, future generations are not ensured of exhaustible resources which may result in welfare losses if sufficient or new energy substitutes are not available.

The Brundtland commission emphasized the sustainability concept, which is the durable relationship between human needs and aspiration, and the environment. This relationship contains two major perspectives, an ecological and a social perspective. Energy consumption and waste generation must be restrained in such a way that the environment is enabled to regenerate itself (ecological), and future generations are ensured of exhaustible resources (social).

Since then, researchers – ecologists, economists, and other social scientists – have proposed almost as many definitions for the sustainability concept as there were researchers writing about it, and still the animated debate is going on

(cf. Pearce *et al.*, 1989 ; Pezzey, 1989; Daly and Cobb, 1989; Van den Bergh, 1991; and Opschoor, 1992). Without actually giving a detailed definition of sustainability, we presume in this study that in practice sustainability requires a substantial reduction of current energy and water consumption as well as waste generation.¹

Due to the complexity of environmental problems governments have a duty to take the leading role in the establishment of policies towards – more – sustainable consumption. They have a wide range of policy instruments, such as public awareness campaigns and education, prohibition and regulation by law, (tradeable) quantity rations, and financial incentives, with which they can influence the consumption patterns. However, the success or failure of a policy instrument is determined by the effectiveness, but also by the political feasibility and the public acceptability. In this thesis we restrict ourselves to the analyses of the effectiveness of economic instruments. In particular, we try to answer the question whether or not taxes and subsidies are effective. The political feasibility and public acceptability are beyond the scope of this thesis. Ligteringen (1999) extensively reviews both issues.

The outline of this Chapter is the following. Section 1.2 summarizes the multi-disciplinary project of which this thesis is a part. Then, we discuss the household production theory which is the starting point of economic analyses when analyzing the household demand for energy, water and household waste collection (see section 1.3). Finally section 1.4 summarizes the remainder of this thesis.

1.2 HOMES

Environmental problems relate to various fields in society as well as in research. Therefore, it is best studied in a multi-disciplinary project as is HOMES (HOUsehold Metabolism Effectively Sustainable). HOMES aims to define a consumption pattern so that a sustainable relationship between humanity and environment is guaranteed. In addition, HOMES studies changes in consumer behavior necessary to achieve such a sustainable relationship. On the one hand, the environment should be able to absorb the pollution, and on the other hand, we should make sure that future generations still have the

¹It is not our objective to participate in the debate about the sustainability definition. In particular, we limit ourselves to the general notion that in order to achieve a more sustainable consumption pattern, the current levels of energy consumption, water consumption and waste generation have to be reduced.

availability of exhaustible resources. In particular, HOMES aims to formulate how such changes in consumer behavior can be realized, and which role policy instruments can play in these changes.²

Households are the central entities in HOMES. The household sector is responsible for a substantial part of the energy consumption. In 1990, approximately 45 percent of Dutch energy consumption was directly demanded by households. However, ecologists state that in general total energy consumption can be attributed to households. They distinguish two different energy consumption concepts: direct and indirect energy consumption. Direct energy consumption relates to the consumption of energy directly supplied to households by energy-supplying utilities or bought by households such as car fuel. The indirect energy consumption is the energy quantity necessary to produce all remaining consumption goods and services. Thus 55 percent of the Dutch energy consumption is indirect energy consumption. This distinction emphasizes the importance of research on the household level in dealing with energy and ecological problems.

Another reason for household-level research is the diversity of households. Policy makers usually tend to neglect that households differ in several aspects, such as family size and composition, income, and education. The policy instruments may affect each household differently (see Baker *et al.*, 1989).

To formulate sustainable consumption patterns for energy and water, many aspects are involved, including legal, economic, demographic, environmental, and social-psychological factors. In HOMES, therefore, researchers from several disciplines collaborate which allows for a broader perspective on the relation between households and sustainability. To analyze the energy and water consumption accurately, HOMES is divided into three stages: diagnosis, evaluation and change. First, the diagnostic phase summarizes historical trends of consumption, expenditure and prices in the time span 1950–1990. Note that HOMES focuses on the Dutch society. In the second phase, HOMES evaluates the determinants of households energy and water consumption by making an inventory of the relevant economic, demographic and psychological factors. Finally, in the change phase developments necessary to

²In the household sector, the necessity to reduce energy consumption is strengthened by the expected growth of both population and number of households (cf. Van der Wal and Noorman, 1998). Particularly, even if the aggregate household energy consumption remains constant, the consumption per household must still be reduced due to growth of the number of households caused by declining family size and population growth. In the Netherlands, this growth is likely to continue according to *Statistics Netherlands* forecasts.

achieve a sustainable consumption pattern can be formulated with the results of the evaluation phase. In particular, implementation and justification of policy rules are analyzed by making scenarios and forecasts for the future. Within the change phase two time horizons will be used, 2015 and 2050.³

1.3 Household production theory

From an economic perspective, the demand for energy, water and household waste collection can be best viewed within the context of household production (see Becker, 1965). The demands for energy, water and household waste collection are derived demands, since these goods are not directly consumed.⁴ Energy for instance is primarily used to power consumer durables, while water is used as an input for cleaning and cooking. The demand for household waste collection is derived from the fact that households produce waste with all kinds of activities within a household. In other words, the demands for energy, water and household waste collection are derived from the demands for certain goods and services (so-called ‘commodities’), such as transportation, cooling, cleaning, heating, and cooking. Moreover, consumers do not directly experience utility from the consumption of energy, water and household waste collection. Rather, they experience utility from the consumption of the commodities that are produced using these as inputs. To illustrate this view, we cite Hausman (1979)

‘...energy demand may be viewed usefully as part of a ‘household production process’ in which services of a long-lived consumer durable good are combined with energy inputs to produce household services.’

Hausman stated that there are two important components which determine the energy demand, the production technology and the utilization of the stock of consumer durables.

³The output of HOMES includes five Ph.D. theses as well as two books, one reporting the integral overview of the diagnostic phase (see Noorman and Schoot Uiterkamp, 1998), and the other reporting the integral overview of the change phase. Three Ph.D. theses have already been completed, see Ligteringen (1999), Van Diepen (2000), and Gatersleben (2000). This thesis is the fourth one completed.

⁴An exception, of course, is water used for direct human consumption. However, in the Netherlands this applied to less than 2 percent of household water consumption in 1995 (see Van der Wal and Noorman, 1998).

The theory of household production is based on (but different from) the traditional or neoclassical theory of consumer demand. Similar to the neoclassical theory of consumer demand, the theory of household production assumes that consumer preferences are reflected in a utility function, and that the consumer maximizes utility subjected to the income budget restriction. However, a consumer derives utility from commodities instead of market goods. These commodities are outputs of production processes at home with market goods and time used as inputs. In addition, the consumer considers a time budget constraint.

The household production theory emphasizes topics of consumer behavior and constraints which are ignored in the traditional neoclassical theory of consumer demand (see Pollak and Wachter, 1975). In particular, the theory provides a framework for analyzing the allocation of goods within the household as well as the allocation of time. Finally, the role of technology in the production processes of commodities can be analyzed.

The household production model is a very broad model which is applied to many topics. Standard topics analyzed with the model are fertility, health, home versus market production and labor supply. Other topics are education, environment, value of home production (particularly in studies on less developed countries) and family economics (intra-household distribution of resources), while Rios-Rull (1993) and Rupert *et al.* (1995) have incorporated household production explicitly in their general equilibrium models. Recent surveys of household production models can be found in Gronau (1997) and Kooreman and Wunderink (1997).

Although it is valuable from a theoretical point of view, the household production model has one main disadvantage. The empirical applicability is limited, because there are usually no data on the commodities produced. As a consequence, it is impossible to disentangle the effects of tastes and technology changes on consumer behavior (see Pollak and Wachter, 1975, and Kooreman and Kapteyn, 1987). In the studies where market goods and leisure directly enter the utility function taste and technology effects cannot be distinguished.

1.4 The structure of this book

This thesis focuses on the effectiveness and efficiency of economic incentives with respect to the household demand for energy, water and the collection of household waste. In particular, we are primarily interested in the price and income responses of households with respect to the energy and water consumption as well as the household waste production. We determine the effects of prices and income as well as other factors on the consumption of energy, water, and household waste collection. Since our scope includes the long run, we analyze the consumer durables stock. In particular, we focus on the purchase prices and the energy and water use of domestic appliances. Below, we summarize the topics discussed in the following chapters.

Chapter 2 reviews the historical trends of the natural gas, electricity and water consumption and their determinants – in particular prices – in the Netherlands. The historical perspective covers the period 1950 – 1990. The development of prices has several aspects such as nominal versus real prices, pricing schedules and the price per unit of consumer durable services.⁵ In addition, we present the penetration rates of household appliances. Furthermore, we review the development in household waste collection and taxes paid by households for the collection of household waste. Finally, we make a small side step and evaluate car ownership and usage.⁶

Chapter 3 analyzes two issues with respect to consumer durables: first, we analyze the effect of energy and water use on the purchase price of domestic appliances empirically, and secondly, we analyze the effect of subsidies on high-efficiency versions on the consumer decision and consequently on the penetration rate theoretically. As to the first issue, we estimate hedonic regressions equations for purchase prices, energy use and water use with data on four domestic appliances.

As to the second issue, the purchase of an appliance has implications for future consumption. Therefore, the purchase decision is analyzed with an intertemporal choice model including the time preferences of consumers measured by subjective discount rates. We build a general framework in which a consumer can choose between a low-efficiency version and a high-efficiency version. The latter version requires less energy, produces similar services, and

⁵With the outcomes of the hedonic regressions of Chapter 3 we calculate quality-corrected energy and water uses.

⁶Although included in the HOMES project, these subjects do not have our primary interest.

has a higher purchase price; see Kooreman and Steerneman (1998). The model describes the consumer decision and in addition it generates a penetration rate. The government is assumed to maximize the penetration rate by providing a subsidy which affects the consumer decision and consequently the penetration rate. Two subsidy regimes – a continuous subsidy and an instantaneous subsidy – are analyzed and compared on the basis of the penetration rate. We also consider the introduction of an energy tax to finance the subsidy.

Chapter 4 analyses the price and income effects of the household demand for energy and water conditional on the durable stock. We estimate reduced-form demand equations with a pooled sample of the Netherlands Consumer Expenditure Surveys (DBO) 1978 – 1994. This approach is similar to Baker *et al.* (1989) and Booij *et al.* (1992). In the case of the demand for electricity we explicitly include the consumer choice between a single electricity rate and a two-part electricity rate. As a result, the demand for electricity is described by a switching regression model which is estimated with the Heckman's two-step estimation procedure. We calculate price and income elasticities for different types of households. Since we have a sample of pooled cross-sections, we can only analyze short-run effects assuming that the consumer durable stock is fixed.

Chapter 5 analyzes the effectiveness of a particular pricing regime: weight-based pricing in the collection of household waste. With a panel data set of households in the Dutch municipality Oostzaan we estimate reduced-form demand equations for household waste collection following the work of Fullerton and Kinnaman (1996). We extend their work in three ways. First, we distinguish two types of waste which are collected at the curb, compostable waste and non-recyclable waste. Secondly, since we use panel data, the specifications include household-specific fixed effects absorbing unobserved heterogenous effects. Finally, since we observe households up to 42 points in time, we include a lagged dependent variable in the specification to determine, in addition to short-run price elasticities, long-run price elasticities. We also discuss possible undesired behavioral side effects and implementations costs.

Chapter 6 deals with the question how helpful economic instruments are in order to steer consumer behavior towards sustainability. The challenge of environmental policy is to find an optimal mix of policy instruments. We discuss some theories with elements from economics, psychology and sociology which we think are relevant in understanding consumer behavior regarding sustainability. Next, we review policy instruments such as public awareness campaigns and

education, prohibition and regulation by law, (tradeable) quantity rations, and financial incentives.

With regard to financial incentives we discuss some issues related to their practical implementation. We conclude that applying financial incentives is the most important instrument a government has available for affecting behavior. Financial incentives are effective provided that they are sufficiently large and properly implemented.