A CAP, FINE & REWARD POLICY FRAMEWORK:
Creating energy consciousness and urging residents to save energy?

Colophon

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“What a patronization!” (Respondent 563)

“ Fascinating and necessary” (Respondent 238)

Preface

The research is entitled as; ‘A Cap, Fine & Reward policy framework’ and holds the following question as sub-title; ‘Creating energy consciousness and urging residents to save energy?’.
This report is the outcome of my graduation research for the master Construction Management and Engineering and is conducted within the KENWIB research program.

The research creates insight in the potential of a new stringent policy framework stimulating energy savings and creating energy consciousness in the consumption behaviour of residents.

I take this opportunity to thank a few people for their valuable contribution to my graduation research. First of all, thanks to the members of the graduation committee; Bauke de Vries and Han Qi, the guiding professors from the Technical University Eindhoven, and Joop Ketelaers, advisor sustainable construction at the municipal of Eindhoven, for their guidance and advise. Besides these experts, I would like to thank my fellow graduation mates for the discussions and fun we had during the graduation period.

Finally, I would like the thank my family, friends and of course, my girlfriend for their support during my graduation and study period.

Sam van ‘t Westeinde
27 July 2011

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1. Introduction; Eindhoven energy neutral

All energy related targets and the belonging measures are directly caused by the Kyoto agreements complied with by governments in 1997. It is agreed that Europe should decrease their emissions by an average of 8%. Within this reduction target The Netherlands should decrease their emissions by 6% in the period of 2008-2012. Subsequently, the EU's leaders endorsed an integrated approach to climate and energy policy that aims to combat climate change and increase the EU's energy security while strengthening its competitiveness. The "20-20-20" targets, which is focussed to a reduction of carbon emissions by 20%, commit Europe to transforming itself into a highly energy-efficient, low carbon economy in the year of 2020. Besides this, a percentage of 14% renewable energy should exist in 2020, in 2009 this percentage was only 3.8%. See figure 1; during the last ten years the share of renewable energy in The Netherlands is increased from 1 to almost 4 percent, implicating that the speed of the energy transition should be increased significantly in the upcoming years.

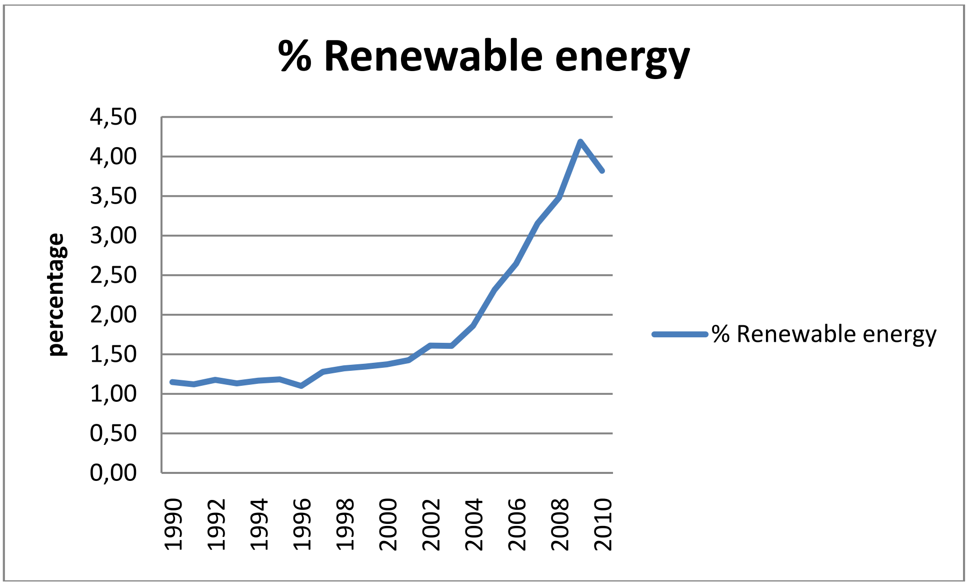


Figure 1, Percentage renewable energy (CBS, www.compendiumvoordeleefomgeving.nl, 2011)

Despite that these targets seem already hard to meet, the municipality of Eindhoven stated in the document 'Uitvoeringsprogramma klimaatbeleid 2009-2012' that they have the intention to be energy neutral in the period of 2035-2045. To realize this goal a roadmap is developed to elaborate the steps to be taken reaching energy neutrality (BuildDesk, 2009). Briefly stated, the municipal goal is to be achieved by a two sided approach; on the one hand the efficiency of the energy used should be increased, realised by energy savings; and, on the other hand by the realization of renewable energy producing projects. The focus of Eindhoven is to the development of an innovative, renewable energy supply. All energy used within the municipal boundaries should be produced renewable and within the municipal boundaries. For making this possible the production of renewable energy should be increased, however using the available energy more efficiently is equally important. Increasing efficiency and saving energy can be done in the residential and the business sector. For this research the focus is to energy saving in the residential sector. Since the reduction of energy demand in the existing housing stock contributes for 25% to Eindhoven's energy-neutral strategy (BuildDesk, 2009) it is essential that action is taken.

Besides the importance, research has shown that the energy use varies dramatically per person, by region and even by neighbourhood (Salon & al., 2010). Although, people often seem to be aware of the environmental and energy problems, they often do not act in line with their concerns, and total household energy use is still rising. This seems to be partly caused by a lack of insight in the relation between behaviour and energy use (Steg, 2008). Furthermore, many people attach only a low priority to saving energy and since energy use is not only driven by concerns about environmental and energy problems, this lowers the energy savings. However, since the government has too few (financial and legal) means to push the energy neutral target forward in the public sphere, the municipality is dependent on the voluntary participation of residents. Despite all efforts being undertaken, the energy-saving rate is still very low (Nieuwenhuijsen, 2010). This is also supported by Abrahamse, who states that household energy use keeps rising and the governmental financial incentives appear to be inadequate (Abrahamse, 2007). When aiming for substantial energy savings it is important to implement soft measures in combination with hard measures (Delft, 2006). This is supported by expert H.Nieman who stated that during the journey to reach the energy goals *"it is a matter of persuading and forcing"* (Alfrink & Westeinde, 2010). The soft measures represent the persuading, and the stringent measures the forcing.

Together with the appearance of the emission reduction targets, resulting from the Kyoto agreement, a new phenomenon is created; the emission trading system / cap and trade system. Carbon trading is the initiated strategy for mitigating these and other emissions through an Emission Trading / Cap-and-Trade system, see figure 2. This system has the potential to help Eindhoven and also The Netherlands reaching their energy ambitions. Despite the potentials of the Cap and Trade system it is currently only in use in several international and national oriented schemes. Just recently the Tokyo Metropolitan Government (TMG) claims to have developed the world's first cap and trade program at the city level targeting energy-related carbon (Lee & Colopinto, 2010). Despite the positive data and the promising potentials there also seems to be down sides of the Emission Trading Systems. Rousse criticizes and reviews the present programs and then proposes an alternative. He concludes with; "Based on theoretical findings, we demonstrate that implementing citizens' participation in emission trading is an economically efficient and a morally preferable option (Rousse, 2008).

Emissions Trading Systems

Emissions trading is a market-based approach for addressing air pollution problems. If designed and implemented well, emissions trading systems can be economically efficient, providing incentives for participants to reduce their emissions of specified pollutants.

Also known as "cap and trade", the basic principle of any emissions trading scheme is to set a limit on the total quantity of pollutants for a given time period (the "cap"). Each participant in the scheme receives an individual cap or allowance. Within the overall cap, individual allowances may be determined in a number of ways, for example from historical baselines, or by auctioning allowances to participants.

Trading can then take place: for the specified time period for which allowances are set, a participant who emits less than their allowance may then sell the unused balance to another participant who has exceeded their allowance. The price for allowance units is determined by the market. Those who are able to reduce emissions cheaply, for instance by investing in more efficient technology, have the incentive to do so, in order to benefit from selling their unused allowances. Likewise, those who find it difficult or expensive to reduce emissions may find it cheaper to purchase allowances from others.

An ETS, when functioning well, results in overall emissions remaining within the cap, while individual participants have the flexibility of a market-based mechanism within which to operate.

Figure 2, Emission trading systems (Lee & Colopinto, 2010).

1.1. Problem definition

Eindhoven has the ambitious goal of becoming energy neutral. Twenty-five percent of this goal should be realized through energy savings by the residents. Despite the effort put, no significant results are achieved. A relatively new high potential phenomenon; Cap & Trade system, which is based on promising basic principles, might have the potential to provide the municipal with a hard policy measure to achieve the goals set. Since there is a lack of insight in this subject this subject research is required.

The previous results in a problem definition which is twofold; in spite of the high awareness among residents to save energy no significant energy, savings have been realised in the energy use of households in practice; there is a new phenomenon with the potential to provide the municipal with a more stringent policy measure, however, there is a lack of insight in the principles, possibilities, of such a measure.

The problem definition for the research, resulting from the context, introduction and most important problems, can be stated as:

> *"There is no clarity in the potential of a city based cap and trade system, urging residents to save energy and creating energy consciousness."*

1.2. Hypothesis

The envisioned hypothesis needs to be substantiated with an extensive literature research which is still to be performed. However, based on the previous we can put that energy savings by residents are despite the effort of the municipal not yet achieved. According to previous research, a combination of soft and hard policy measures could result in achieving the goals set by the Eindhoven municipality. Some forms of Emission Trading Systems might be able to deliver the municipals with this hard/stringent policy measure needed to urge residents into energy savings. Therefore the hypothesis is stated as:

> *"An stringent and for residents acceptable policy measure, based on the principles of 'Cap & Trade', can be designed, urging residents into energy savings"*

1.3. Research target

This research provides municipalities with knowledge and insight in the potential of a new policy measure; a Cap & Trade based policy framework. For enabling this research to meet the targets set a desk study is done to create theoretical knowledge about the energy using behaviour of residents. Besides this, research is done to the Cap & Trade principles and its potential to provide the municipal with a stringent policy measure. Based on this theoretical research and expert interviews a policy design is created. This design is tested quantitatively among the Eindhoven residents in order to create insight in the design with the best potential and acceptability for the Eindhoven residents.

1.4. Main research question

From the problem stated, the research target set a general research question can be formulated:

> *"What is the potential of a city based 'Cap & Trade' system urging residents to energy savings?"*

For answering this question two sub questions have been formulated:

1. *What combination of attributes and levels results in an optimized policy package?*
2. *Is this optimized policy package acceptable for the Eindhoven population?*

For enabling to answer these questions the following topics need research:

- ✓ Governmental energy policy
- ✓ Energy reduction strategy Eindhoven
- ✓ Human behaviour and energy conservation
- ✓ Household energy use
- ✓ Emission trading systems (Personal Carbon Trading)
- ✓ Create insight in current knowledge about Emission trading schemes.

1.5. Research boundaries

The research is executed within a limited time frame of six months, therefore the research boundaries have been set carefully. The main target is to provide the municipal with insight and recommendations about an 'Cap & Trade' based policy measure. This insight will be created by perfoming a literature study, designing a policy measure, and testing this design among Eindhoven residents. This the point where the research boundaries are set, thus this research is not including recommendations about the implementation or realization of the policy measure. Secondly, this research is focussed to energy savings in the residential sector and not to other sectors such as the businesses sector. The third boundary is set to the municipal of Eindhoven. Despite that the policy measure is developed for the municipal of Eindhoven it might turn out that it is also an interesting option for other municipals or even the national government.

1.6. Research design & expected results

The research design and the belonging expected results are described in this paragraph. The research design is elaborated in figure 3, it consists of 5 main parts; the literature research, the design, the field research, the analyses and the conclusions and recommendations.

The research will according to the expectations first result in theoretical insight in residential energy use, energy using behaviour and in theoretical knowledge about of Cap & Trade based policy measures. Also performed in this phase is the desk research to the scientific research method used. Secondly, a Cap & Trade based policy measure will be designed based upon the knowledge gathered from literature and experts. This design will then be tested among Eindhoven residents for its potential and acceptability by performing a conjoint choice based experiment. The gathered data will be analysed and lead to the results. These results are the input for the fifth phase, which is the development of the recommendations to the municipal and the conclusions. In the discussion the outcome and potential of a Cap and Trade based policy measure will be discussed.

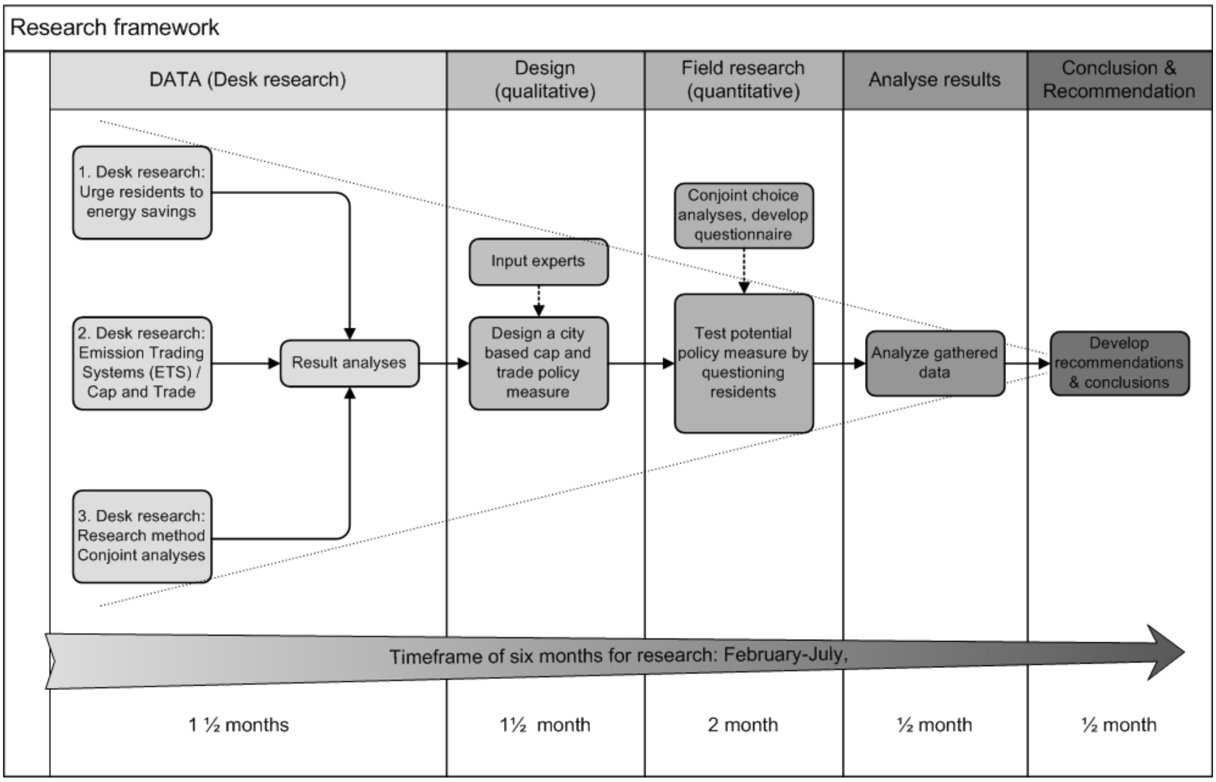


Figure 3, research design.

Part 1; Theoretical orientation

2. Eindhoven energy neutral

In this first chapter the governmental and Eindhoven's energy policy and goals are elaborated briefly, besides this the available policy measures are described. Then the orientation focussed to determining which definition; carbon neutral or energy neutral, to use further on in this research is described. (VROM, 2007)

2.1. Energy reduction strategy Eindhoven

The municipality of Eindhoven wants to become energy-neutral in 2035-2045. As stated before this could be done by realizing renewable energy producing projects and by using energy more efficiently. Eindhoven strives to realize the goals by developing measures based on the philosophy Trias Energetica. This is a simple and logical concept that helps to achieve energy savings, reduce our dependence on fossil fuels, and save the environment.
The three elements of Trias Energetica are (SenterNovem, 2011):

1. Reduce the demand for energy by avoiding waste and implementing energy-saving measures;
2. Use sustainable sources of energy like wind, solar power and water;
3. Use fossil fuel energy as efficiently as possible and only if sustainable sources of energy are unavailable.

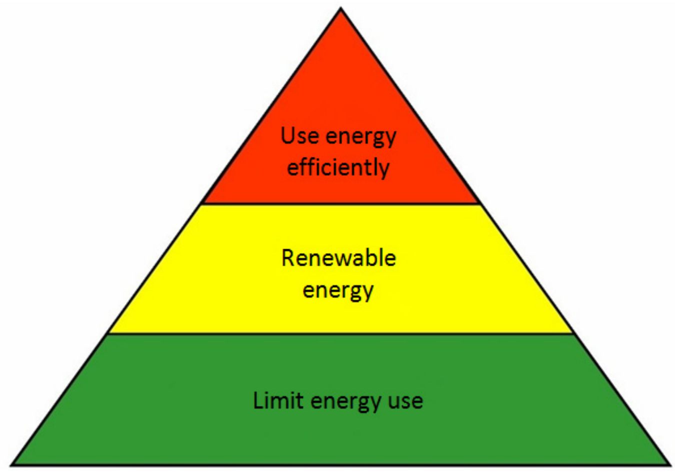


Figure 4, Trias energetic (Nieman, 2011).

The residential sector of Eindhoven is with an energy use of 33% the largest energy consumer in the Eindhoven municipal (BuildDesk, 2009). Therefore the municipal is searching for possibilities to realize great reductions in this sector. One of the ambitions stated in the current climate policy is; realize energy saving behaviour at 20% of the households (Eindhoven G. , 2008). Besides this in the roadmap to realize energy neutrality is state that the reduction of the energy demand in the existing housing stock should contribute for 25% to the energy-neutral strategy (BuildDesk, 2009), see figure 5.

	Sector	Energy saving	Renewable energy	total
1	Municipality	5%	4%	9%
2	Businesses buildings	18%	9%	26%
3	Businesses production processes	10%	0%	10%
4	Existing houses	25%	18%	43%
5	New houses	2%	1%	3%
6	Traffic	8%	0%	8%
	Total	68%	32%	100%

Figure 5, Contribution to energy neutrality per sector (BuildDesk, 2009).

2.2. Policy measures

In this paragraph municipal and national policy measures are briefly described. Only the policy measures which could potentially be used within the research are elaborated more extensively. With this overview insight is created in currently available national and local measures targeting the residential energy use and in particular the energy using behaviour.

2.2.1. National policy measures

The Dutch national climate strategy is based on the document 'Schoon & Zuinig' (VROM, 2007), the section concerning the build environment is described in the document 'Meer met Minder'. However, key for this research is that the first document states that research should be done to the desirability of a Cap & Trade system. Besides this, it states that the energy label for houses should be implemented. This energy label might be an interesting tool for determining the allocation of energy permits under an particular Cap & Trade system. Secondly the regulating energy tax is described.

Energy label.

The Dutch energy label for real estate initiated in 2008, is the result of the European Performance Building Directive (EPBD). This directive is initiated to decline the energy consumption of buildings. The Dutch energy label mandates that, with every residential transaction or utility building older than 10 years, an energy label should be provided to the new estate owner. The energy label is determined on the amount of primary energy needed for heating, the production of hot water, ventilation and lightning of the real estate object. The amount of energy benefits from for example solar cells are extracted from the use. The energy use is being determined on the following housing characteristics; isolation of roof, floor and walls, installations such as the heating apparatus. In the calculation of the label the average climate situation, average amount of inhabitants and average energy use is taken to determine the energy use. The amount of energy used is expressed in an amount of 'Mega Joules' (MJ) and translated to an indication number. The present indication numbers are visualized in table 1.

A++	Lower than 0,5
A+	Lower than 0,7
A	Lower than 1,05
B	Lower than 1,3
C	Lower than 1,6
D	Lower than 2,0
E	Lower than 2,4
F	Lower than 2,9
G	Higher than 2,9

Table 1, Residential energy-label.

Regulating energy tax.

The in 1996 initiated 'Regulerende Energie Belasting' (REB) is a tax initiated with the purpose to stimulate efficient energy using behaviour. The REB is a tax per kWh electricity or M^3 natural gas used; intended for the business sector as well as the residential sector. In spite of its purpose several sources state that the tax is not leading to the intended energy savings.

2.2.2. Municipal taxes and policies

A municipality has limited tools to implement or influence taxes or policies. This limited influence is reflected in the income resulting from the municipal taxes, this represents only 10 % of the municipal income. The municipal taxes are can be separated in two types; the taxes and the charges.

- ✓ The taxes are used for the means of the municipal. The town council decides for itself where to use the gains. The major part of income realized by the municipal itself is resulting from the property taxes (onroerendezaakbelasting/OZB). Besides this, revenues are gained from tourism, parking and dog taxes.

- ✓ The second type are the charges or retributions. The gains from charges are limited since the revenues may not exceed the calculated cost for running the charge. Examples of retributions are sewing charges and waste disposal.

The height of municipal taxes are determined by the city council and differentiates between municipalities. On ground of the 'Gemeentewet' can municipals charge taxes.

In the reasoning for the policy measure to be developed in this research it is important to consider the following;

- ✓ If residents already pay for the treading of waste and the use of sewage, should it not be reasonable to let them also pay for their emissions?

When realizing the policy measure also the following can be considered;

- ✓ Can the cost of a trading scheme be charged from the individuals in the municipality?
- ✓ Is it possible to make profits from the implemented policy?
- ✓ Should the revenues be used as subsidies for stimulating renewable energy in order to prevent the municipal from making profits?

2.3. Energy neutral / carbon neutral

In the field of urban development many definitions and terms are used to implicate a energy ambitions. To prevent ambiguity in the research, this paragraph is devoted to the suitable definition to be used.

On urban scale the commonly used terms are energy neutral and carbon neutral. Since there is ambiguity about the suitable definition in a certain situation, a research to this topic is been performed. The research states the following; energy neutral is the term used in situations about the performance of a building, and is about the mega joules in the form of gas, electricity and hot water. The belonging carbon emissions is a derivative from those. The energy demand of a building is determined by the building characteristics and the user behaviour. Carbon neutral is used in the performance of a organisation. The term carbon neutral is wider and covers topics as the energy savings of buildings, the reductions caused by transportation, and the use of renewable energy and carbon compensation (Agentschap_NL, 2010).

During this research the term energy neutral will be used since the matter concerned is about the energy use within a household. Besides this, the energy using behaviour is an essential part in this research. Since residents are familiar with energy use and less or not with carbon emissions a policy measure affecting the energy use will be developed. However, since the literature and the present cap and trade systems concern commonly the carbon emissions the literature research will focus hereto.

3. Residential energy using behaviour

This research is focused to the development of a policy measure improving the energy saving behaviour of residents. This chapter creates insight in the energy use and behaviour of residents. Besides this, insight is created in the possibilities of urging residents into energy savings.

3.1. Human behaviour and energy conservation (context)

This paragraph elaborates the main definitions and contextual knowledge according to the human behaviour in combination energy savings.

3.1.1. Human behavioural change

Human behaviour is essential in reducing the energy use, and reaching energy neutrality. However, the human behaviour is a complex matter, which is hard to influence. The process leading to the changes in the behaviour is described by (Steckler & al, 2002): It begins when the individual becomes aware of a problem or need which gives the individual an initial reason or incentive to pursue a given course of action, in this case energy savings. This awareness is often raised by external forces. Sometimes experiences of peers, or marketing campaigns raise the individuals' awareness of a problem. The individual weighs the advantages and disadvantages of behavioural alternatives and makes a decision. Advantages and disadvantages (costs and benefits) are not only seen in terms of money, but also in terms of comfort, quality, image and perceived uncertainty. Values and norms also influence the assessments of advantages. This weighing of advantages and disadvantages leads to the forming of an attitude. An attitude is, thus, a form of evaluation directed towards a specific action or a situation and is cognitive, affective and normative in character. All the factors, awareness, knowledge, norms and values, and attitude, lead to an intention for making the decision to implement the solution. This intention may suffice to start the change in behaviour, but it will not be carried out unless the individual has the required resources and skills, and no barriers stand in the way. Often such a change in behaviour is followed by an emotional, physical or social reaction towards the behaviour from the context. This feedback directly strengthens the behaviour. Because of this, behaviour can be seen as a product of the individual and its environment (energy-behave, framework).

To illustrate the human and particularly the consumer behaviour and the complexity of managing this behaviour the following statement of Gabriel & Lang is shown:

> *How should we think about the consumer? As a god-like figure, before whom markets and politicians bow? A weak and malleable creature – a mere pawn in corporate games played in invisible boardrooms? A political trendsetter with the power to save the planet? In reality, despite huge efforts to constrain, control and manipulate them, consumers themselves can and do act in ways that are unpredictable, inconsistent and contrary…* (Gabriel & Lang, 1995)

3.1.2. Energy efficiency & conservation (definitions)

Energy reduction could be achieved by conservation and energy efficiency; these are terms with different definitions, it is essential to define the terms clearly. Energy conservation refers to the reduction in energy consumption through lowering the demand for services or products. An example could be lower the heating levels, through turning down the thermostat level, or speed limits for cars. Efficient energy use, or energy efficiency, is the goal of efforts to reduce the amount of energy required to provide the same products and services. For example, to heat a house to a comfortable temperature a certain amount of energy is required. When the house is isolated properly less energy is required for the same task and thus energy efficiency is increased. The previous means that increased energy efficiency and an increased effort in energy conservation could go along with an increment in energy use when the rising demand is larger than the reduction resulting from conservation and increased efficiency. The policy framework which is designed in this study is focussed to energy conservation.

3.2. Household energy use

The total household energy use is determined by energy using behaviour and by the sum of energy using functions. Van Raaij and Verhallen have developed a behavioural model of residential energy use (Raaij & Verhallen, 1983). This model is visualised below and provides a clear overview of the household energy use en the influencing factors. The energy use and the evaluation of energy use are the dependent variables in the proposed model. The influencing behaviour related variables are; *purchase, usage* and *maintenance related behaviour*. Besides this, the *life-style, home characteristics and socio-demographic* (household income) factors are crucial to energy conservation. Furthermore, *energy-related attitudes* such as energy concern and home comfort, and individuals acceptance of *responsibility,* the individuals perceived *effectiveness* and energy related *knowledge* of cost and benefits. The behaviour is also being influenced by the prices of energy and the belonging *cost benefit tradeoff.* The *feedback information* provided about the energy use is also important to the learning aspect of individuals.

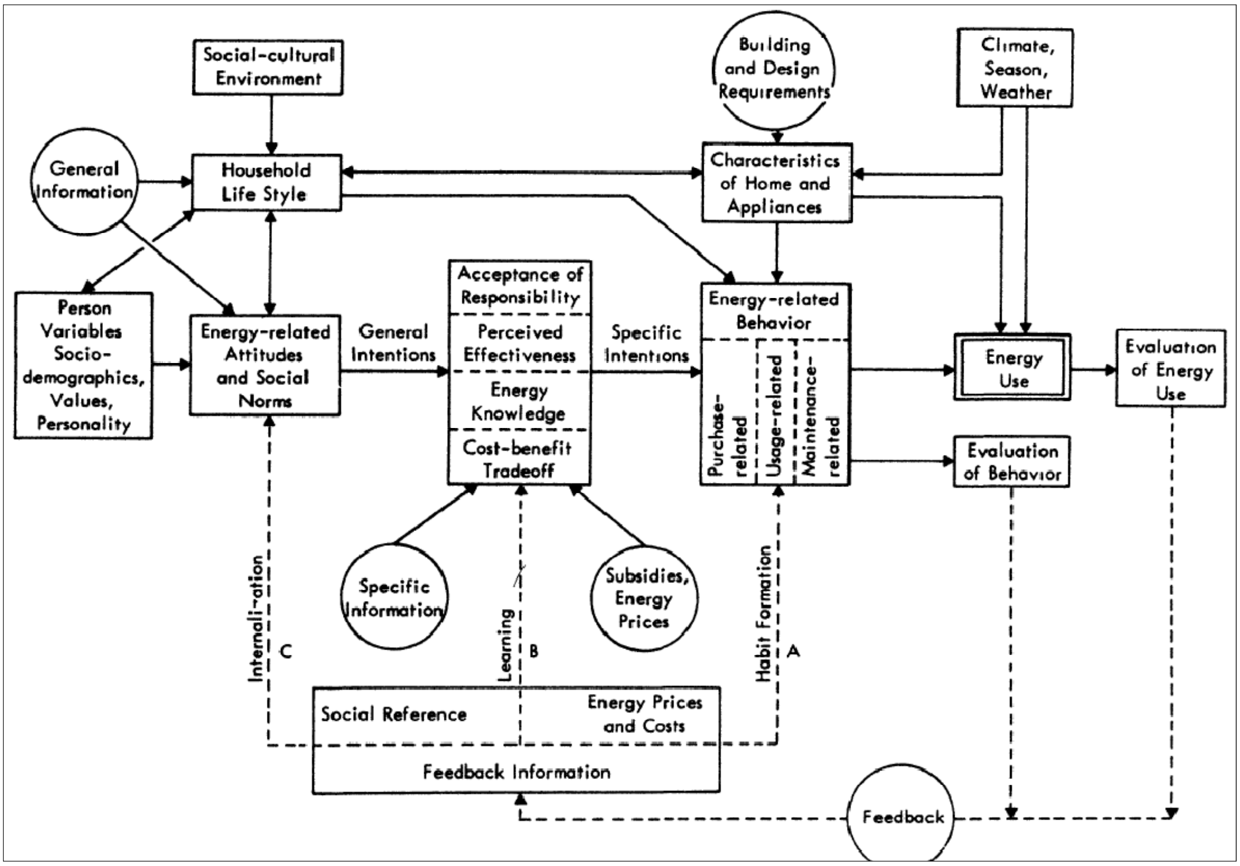
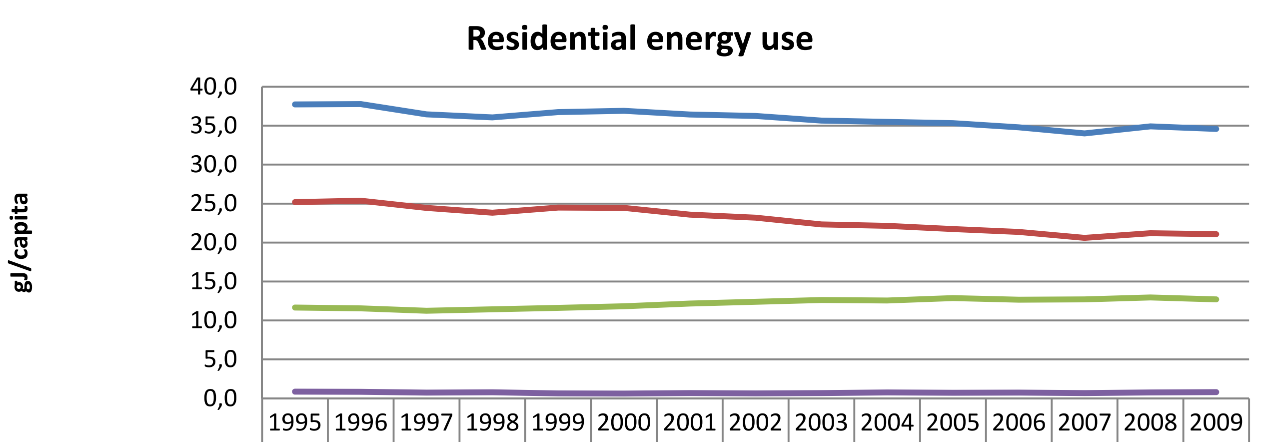


Figure 6, A behavioural model of residential energy use (Raaij & Verhallen, 1983).

3.2.1. Household energy use

The total residential energy use per capita has almost doubled since 1950. However there are significant differences in the developments of the two most important energy carriers.

In the nineteen sixties and seventies the use of natural gas has increased significantly, however, since then the use declined due to the energy saving measures such as improved isolation and boiler efficiencies. The trend of the electricity consumption per capita is only increased since the nineteen fifties and is currently four times the size of then. This difference can be seen in figure 7, which shows the residential energy use per capita over the last fifteen years.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Totaal	37,7	37,8	36,5	36,1	36,7	36,9	36,4	36,2	35,7	35,5	35,3	34,8	34,0	34,9	34,6
Natural gas	25,2	25,4	24,4	23,8	24,5	24,4	23,6	23,2	22,3	22,1	21,7	21,4	20,6	21,2	21,1
Electricity	11,7	11,6	11,3	11,4	11,6	11,8	12,2	12,4	12,6	12,6	12,9	12,7	12,7	13,0	12,7
Other carriers	0,9	0,9	0,7	0,8	0,6	0,6	0,7	0,6	0,7	0,8	0,7	0,7	0,7	0,8	0,8

Figure 7, Residential energy use (CBS, 2011).

From the table above we seem to be able to conclude that the effort put in energy savings do not result in significant results totally.

3.2.2. Behaviour in household energy use

The energy use per household differs much. The main causes of the differences can be found in the dwelling characteristics such as architectural design and quality of isolation on the one hand, and, on the other hand the behaviour of the residents represented in the household characteristics such as number of household members, price concern or level of education. Since this research focuses to the behaviour of energy use, this paragraph will focus to the second.

Research shows that overall building related energy use is decreasing in the Netherlands due to Dutch building regulation, making the role of the occupant, and user related energy use (energy for house hold appliances), more important. Besides this, the main characteristics influencing the residential energy use are elaborated, based on a literature research (Groot & Spiekman, 2008):

- ✓ Amount of occupants;
- ✓ Age of occupants;
- ✓ Amount of time that someone is present in the residence;
- ✓ Income;
- ✓ Shower and bath frequency;
- ✓ Heating behaviour (preferred temperature, amount of heated rooms);
- ✓ Ventilation behaviour (preferred ventilation setting, opening windows);
- ✓ Use of available devices;
- ✓ Motivation to save energy/ life style.

Since user behaviour has a significant impact on the energy performance of dwellings and it is composed of many parameters the phenomenon ‘user behaviour’ is a complex thing. For example, indoor temperature, lighting levels, use of appliances and shower behaviour all relate to energy consumption. Composition of household and occupancy makes this effect even more complex. In current development of building concepts, this variety in user behaviour is rarely and not structurally incorporated. The need for addressing this user behaviour issue however, becomes more significant in case of development of ambitious, energy efficient building concepts and policy measures. User behaviour will have relatively a larger impact on total energy consumption and varieties in energy consumption will increase (Paauw & Roossien, 2009). This implies the need for an effective policy addressing the user behaviour.

3.2.3. Energy using functions & household profiles

As stated before there are many parameters influencing the energy use of residents. De Groot & Spiekman, 2008 developed user profiles based on the potential drivers for energy consumption such as saving money, saving the environment, or personal convenience. This resulted in the following four profiles:
1. *Profile Ease*: Persons in this profile act to create comfort and have no sense or interest in energy use, costs or environment;
2. *Profile Conscious*: These households choose for comfort, but take into account costs and environment;
3. *Profile Costs*: Persons are aware of costs and save energy to reduce costs;
4. *Profile Environment*: These households act mainly from the point of view of environment. (Groot & Spiekman, 2008)

Latter research shows that different household types have different drivers for energy saving behaviour, see table 2. Despite the differences in the household types, the costs is important for all households.

Household type	Convenience	Conscious	Costs	Climate
Single	●○○○○	●●●○○	●●●●●	●○○○○
Two adults below the age of 60	●●●○○	●●●○○	●●○○○	●●○○○
Single parent family	●○○○○	●●●●○	●●●●○	●○○○○
Family (two parents)	●○○○○	●●●○○	●●●●○	●●○○○
Seniors above the age of 60	●●●○○	●○○○○	●●●●○	●●○○○

Table 2, Drivers per household combination from the Building Future study (Paauw & Roossien, 2009)

As stated before, (Delft, 2006), the energy consumption is not only determined by the characteristics of the devices and homes of the residents; it is also depending on the household type, and, the energy consumption profile which is determined by the energy consuming behaviour. The table below elaborates the estimated average household energy use per profile (Paauw & Roossien, 2009).

	Energy use (GJ/yr)	Energy use (GJ/yr) per profile			
	Average	Convenience	Conscious	Costs	Climate
Heating	45,4	91,4	38,4	26,8	35,9
Cooling	2,1	2,8	2,1	0,8	2,0
Hot water	15,1	30,4	13,4	9,9	9,9
Ventilation	0,0	0,0	0,0	0,0	0,0
Lighting	1,9	2,8	1,4	0,9	0,9
Cooking	3,0	8,0	2,7	2,0	2,1
Washing/drying	2,7	3,0	0,8	0,8	0,8
Misc. electric	3,0	7,9	3,1	1,8	2,2
Total	73,1	146,3	61,8	43,1	53,8
% of average	100%	200%	85%	59%	74%

Table 3, Energy use per household in GJ/year (Paauw & Roossien, 2009).

Table 3 reveals large consuming differences in particular in the heating and hot water use. Since the largest differences are related to the energy use behaviour, this implicates that there are significant potentials for a (hard) policy measure. While stating this it is important to bear in mind that the relation between profile and factors such as household type, income and level of education are not incorporated in this table.

3.3. Energy conservation strategy

To determine the focus of this research a separation needs to be made in the several energy conservation strategies possible. In this focus several aspects need to be addressed.

The research of (Poortinga, Steg, Vlek, & Wiersma, 2003) elaborates a very clear overview of characterising household energy-saving measures. Energy saving measures could be characterised by domain represented by housing or transportation energy saving measures (1), strategy which is represented by behavioural or technical energy saving measures (2) or by amount (3).

The books entitled; 'Energiebesparingsgedrag' (Delft, 2006) and 'Een graadje slimmer' (Energieraad, 2006) state that there are three sorts of energy saving behaviour. The energy saving potential is being affected by the choices for the needs, the investment behaviour and the using behaviour.

The research of Vringer & Blok (Vringer & Blok, 1995) separates the energy use in direct and indirect energy use. Direct energy use is caused by the use of gas, electricity and petrol, and indirect use is embodied in consumer goods such as food, furniture and services.
An overview is created by combining the above in the figure below.

1. **Domain**: Home and transport energy saving measures (direct & indirect).

   Two domains of household activities can be distinguished: indoors and outdoors. In these domains choices affecting the required needs of the residents are made. These needs are:
   - ✓ Commuting distance
   - ✓ House size

2. **Strategy**: Technical and behavioural energy-saving measures (direct)

   The following energy-saving strategies can be distinguished:
   a. Improving the energy-efficiency of products. This strategy focuses to ***technical*** measures. Which are generally seen as an expensive way to reduce ***direct*** energy use.
   - ✓ A-label refrigerator

   b. Different use of products. These are the ***behavioural*** measures, and are often associated with additional effort or decreased comfort. This strategy focuses to the ***direct*** energy use.
   - ✓ Shower time
   - ✓ Level of house heating

   c. Shifts in consumption. This strategy focuses to the ***indirect*** energy use and ***behavioural*** change. This strategy enhances more than half of the total households energy use (Vringer & Blok, 1995), however, this shift is beyond the scope of this research.
   - ✓ Give a CD instead of flowers as a present because this requires less energy for the production and transportation.

3. **Amount**: effectiveness of energy-saving measures.
   Not all energy saving measures are equally effective. For example buying a more energy efficient heating system saves more energy that applying radiator insulation.

Figure 8, energy saving strategies and measures.

Eindhoven aims to create more consciousness in the energy use of residents and urge them to conserve energy. For addressing this appropriately the focus of this research is to improving the behaviour of residents and thus their direct energy use (2.b.). However, the policy to be developed might also influence the investing behaviour of residents which is affecting the technical saving measures (2.a.).
From the past years we can conclude that devices use energy more efficiently, thus, need less energy for the same task to perform. However, despite many (governmental) attempts to urge residents to save energy, there is still much improvement to be achieved in the consuming field. Achieving energy conservation by a change in behaviour is still an uncultivated field and therefore an interesting research field.

3.4. Residential resistance against energy savings

The human behaviour, energy savings and the energy using activities are elaborated in the previous paragraphs. This paragraph will focus to the resistance against energy savings.

Generally, we can state that energy consumption is determined by unconscious habitual imitation behaviour or conscious choices (Energieraad, 2006). The latest provides clear focus points for the policy development; simply stated the policy should create insight in the total cost and benefits and improve the balance between the two; lower the cost and improve the benefits. Currently however, the unaware group of residents still seems to have the overhand since there are no or less energy savings resulting from behavioural savings.

Since the Kyoto protocol is into force, climate change is receives much attention. International, national and regional governments are initiating many policies and regulations to save energy and promote renewable energy. However, limited attention is being paid to change the individuals behaviour. The attention which is paid to stimulate residents into energy saving is mainly put forward by local governments through soft policy measures. Providing residents with information, education or incentives are examples of such measures. However it appears not to be sufficient that people know about climate change in order to be engaged; they also need to care about it, be motivated and able to take action (Lorenzoni & al., 2007).

Individual barriers:

- ✓ Lack of knowledge about where to find information.
- ✓ Lack of desire to seek information.
- ✓ Perceived information over-load.
- ✓ Confusion about conflicting information or partial evidence.
- ✓ Perceived lack of locally-relevant information, for example about impacts or solutions.
- ✓ Format of information is not accessible to non-experts.
- ✓ Source of information is not credible or trustworthy, particularly the mass media.
- ✓ Confusion about links between environmental issues and their respective solutions.
- ✓ Information conflicts with values or experience and is therefore ignored.

Various other barriers can be found between the actual saving of energy and the point in time when individuals become aware of the climate problems. These various barriers limit behavioural elements of engagement can therefore be interpreted either as principally individual or social (Lorenzoni & al., 2007).

Other examples of these denial mechanisms are:

- ✓ Denying personal contribution to climate change.
- ✓ Personal responsibility, blaming others ('the USA isn't doing anything so why should I?').
- ✓ Pointing to government inaction.
- ✓ Claiming ignorance.
- ✓ Arguing that climate change will happen anyway.
- ✓ Having faith in technological solutions.
- ✓ Being too busy to change one's behaviour ('life is too short to worry about this').
- ✓ Finding that other issues are of greater importance.
- ✓ Claiming there are no alternatives to current behaviours.

Another significant barrier perceived to taking action on climate change concerns the prospect of having to change one's lifestyle. This was because many participants considered that this would only be achievable with great discomfort and sacrifice of standards of living and social image. Residents tended to be reluctant to consider changing many of their routines and habits, and to consider alternative options, even when these may be overall more individually and environmentally beneficial (Jackson, 2005).

From the barriers mentioned above many can be seen as a form of denial to cope with an discrepancy between the demands to engage with climate change and actual personal engagement (Stoll-Kleeman, O'Riordan, & Jaeger, 2001). Simple clarified; the cost in comfort of showering shorter or lowering the heating temperature are too high and thus neglected, this in spite of their awareness to save energy.

3.5. Policy measures for behavioural change

The aim of this research is to develop a policy measure which urges residents into energy savings. Therefore it is essential to make a distinction between the two possible policy instruments; hard and soft policy measures.

- ✓ Soft policies are mainly psychological strategies with the aim to influence particular behaviour by providing information such as feedback, education, examples and arguments. A tool in the soft policy could be for example a smart meter.
- ✓ Hard policy measures are strategies with the aim to force people to particular and structural behaviour, by implementing requirements in the form of regulations or technical standards, or price instruments in the form of taxes, subsidies or trading units.

As stated before only limited governmental effort is put into urging residents to structural behavioural changes, the hard policy measures; up till now the focus was to developing and realizing soft policies. Past behavioural issues for example concerning smoking, provided us with the knowledge that significant improvements are only gained when combining hard and soft policy measures. In the case of smoking only significant results where gained when marketing campaigns, which are soft measures, were combined with price increments and smoking prohibitions at work and public spaces, the hard measures (Delft, 2006). We can conclude that a soft and hard policy measures both have their advantages. An effective energy conservation policy should therefore combine the two; use a soft policy measure to increase the public awareness, use hard policy measures to gain significant results (Energieraad, 2006). An example of such a measure could be the implementation of a cap for the use of fossil fuels.

3.6. Conclusion

Research states that large differences are found in the residential energy use, this implicates that energy conservations can be achieved by affecting the using behaviour. Human behaviour and in particular creating a change in consuming behaviour is essential in reducing the energy use. However, changing behaviour seems to be a complex matter (energy-behave, framework); behavioural factors such as awareness, knowledge, norms and values, and attitude, lead to an intention for making the decision to implement the solution. This intention may suffice to start the change in behaviour, but it will not be carried out unless the individual has the required resources and skills, and no barriers stand in the way. Van Raaij & Verhallen developed a comprehensive model of residential energy use creating insight in this complexity, see figure 6.

When designing a policy which affecting the human behaviour the books of (Delft, 2006) and (Energieraad, 2006) state that a mix of soft and hard policy measures achieve the best results. Since the research of (Nieuwenhuijsen, 2010) focussed to soft policy measures, this research is focussed to developing a hard policy measure. The policy focuses to achieving energy conservation by behavioural change of residents. This direct reduction should result from behavioural changes such as decreasing the shower time, lowering the heating temperature and other direct behavioural energy savings (see figure 8, 2.b.). In the longer term the policy might also influence the awareness of the energy use of technical appliances (see figure 8, 2.a.).

The above is supported by (Tambach, Hasselaar, & Itard, 2010) who conclude that the current Dutch energy transition policy instruments for the existing housing stock, which are largely focused on communication, need to be complemented by more traditional and long-term energy policy instruments. Since the regulating energy tax is not achieving the intended results an alternative should be developed. A Cap & Trade based measure seems to have the potential to become a structural measure to create energy consciousness among residents and urge them to save energy. Furthermore it provides a framework for carbon reductions. The measure allows people to reduce their emissions in the way that suits them best, whether through technical efficiency improvements and using more renewable energy or through demanding fewer energy services, or any combination of these strategies (Tambach, Hasselaar, & Itard, 2010). However, without this policy measure there is no stringent policy framework urging the residents to save energy.

Since there is a lack of insight in the potential and acceptability of such a measure, and it has never been realized on a small scale research is needed.

4. Cap & Trade

Cap & Trade mechanisms, also known as Emission Trading Systems appear in many forms in literature and practice. This chapter creates insight in this phenomenon by describing the system itself, the key principles and the barriers and resistance towards the system.

4.1. What is an Emission Trading System?

Emission trading is a market based approach resulting from the Kyoto agreement. The phenomenon emission trading is created to address the Greenhouse gas emission problems and is also known as the 'Cap & Trade' mechanism. The basic principle is to set a limit on the amount of emissions emitted. Each individual, company or household under the scheme receives an allowance to emit a certain amount. When the cap is exceeded extra permits need to be bought to compensate for the extra emissions; when remaining below target energy permits can be sold. The mechanism enables participants to compensate for the emissions where it is cheapest.

4.1.1. Scale and focus

Emission trading could be implemented on several scales; initiatives and existing emission trading schemes differentiate from global, to national and sub national scale. Besides the scale the focus of the systems could vary from the product producing level, which is the upstream enforcement focus such as the electricity companies, to the end users which is represented by the downstream enforcement focus group.

Currently, the European Union Emissions Trading Scheme (EU ETS) is the largest multi-national emissions trading scheme in the world. It was launched in 2005 and is one of the major pillars of the European Union climate policy. The EU ETS currently covers more than 10,000 installations with a net heat excess of 20 MW in the energy and industrial sectors which are collectively responsible for close to half of the EU's emissions of CO2 and 40% of its total greenhouse gas emissions (Wikipedia, 2011). Besides this scheme there are several schemes proposed and implemented in different nations and scales.

Since this research is focussed to improving the energy using behaviour of residents the focus of this chapter will be to a downstream Cap & Trade system to which much research is done in the UK; Personal Carbon Trading (PCT). PCT is a radical policy proposal which would entail all adults receiving an equal, tradable carbon allowance to cover emissions from household energy and/or personal travel. The allowance would reduce over time, in line with national emissions reduction goals (Fawcett, 2010).

One of the major benefits is that a PCT scheme, provides a framework for carbon reductions. When setting a cap individuals can reduce their emissions in the way that suits them best, whether through technical efficiency improvements and using more renewable energy or through demanding fewer energy services, or any combination of these strategies. Without carbon rationing there would be no framework for ensuring that they did so (Fawcett, 2004). This is supported by other research which states that if PCT were to be introduced to cover personal energy use emissions, it would not be a stand-alone policy. It would simply form the umbrella mechanism where under a wide range of other policies would operate (Hillman & Fawcett, 2004).

4.2. Key principles of PCT

Some countries have committed reducing emissions to the levels needed to keep global average temperature rises below 2 degrees Celsius. It is likely that new policies are required in order to help governments achieve their very challenging reduction targets. PTC is a forward-looking policy idea which arguably could provide the national and international framework for delivering emissions reductions over the med-to-long term (Fawcett, 2010). As stated before, there are several different PCT schemes proposed, despite the differences they all contain the following features:

- ✓ Ratios for all individuals.
- ✓ Tradable ratios.
- ✓ Year-on-year reduction of the annual ration.
- ✓ Personal transport and / or household energy use included.
- ✓ A mandatory arrangement.

Under the current carbon trading schemes a combination of rewarding and fining is used. People with low emissions are rewarded since they have the ability to sell emission rights. On the other hand people who exceed their emission budget are fined because they need to buy emission reduction rights. This combination of rewarding and fining is enabled by the trading mechanism. The differences between the various PCT schemes are elaborated in the next following sub paragraphs.

4.2.1. PCT proposals

There are several proposals which fit under the container concept of Personal Carbon Trading (PCT). As stated above the different concepts emphasize the same key elements, however, the differences between the systems and their attributes seem to be critical to the potential and the success factor of these systems. Therefore, this subparagraph is devoted to the differences in systems and their attributes.

Personal Carbon Allowances (PCA), is an proposal developed by Hillman and Fawcett entails each adult having a tradable carbon allowance which covers the carbon emitted from their household energy use and personal transport. Each adult receives an identical amount of allowance for their own use, and children receive a partial allowance managed by their parents. PCA covers in the United Kingdom 40 % of the carbon emitted totally in the UK, and would work besides other policies (Hillman & Fawcett, 2004).

Tradable Energy quotas is initiated first by Fleming, and is more comprehensive than PCA. It covers carbon emissions from the whole economy. All organisations and individuals participate in the scheme, therefore it replaces existing trading schemes such as the EU ETS (Fleming, 2007).

Cap & Share is developed by Feasta, and covers all the carbon emissions in an economy. Each individual receives an share of national emissions, organisations which supply these individuals need to buy these certificates via a post office or bank. Ten the suppliers surrender certificates equal to emissions from the use of the fossil fuels that are needed for their activities (Feasta, 2008).

The PCT mechanisms above might be hard to implement because of their size; all are covering at least 40 % of the emissions. Niemeier & al. (2008) developed a proposal with a scope covering only household energy, the system would concern for about 25 % of the energy use within Eindhoven. *Household carbon trading* is defined as follows;

> A yearly carbon emissions cap is set for residential energy use based on emissions reduction targets. Allowances are allocated to each household on an equal per household allocation basis via utility service providers who place the allowances in each user's account. These are deducted periodically by the utility according to energy use, and additional allowances must be purchased if the account is in deficit. The carbon allowances are fully tradable. At the end of a compliance period, the state collects the permits from the utilities and determines compliance with the cap. Household carbon trading was proposed in California and examined against its emission targets.

The schemes mentioned above all have their strengths and weaknesses in certain situations. Still the common objective remains the same; limiting the overall carbon emissions from society effectively, efficiently and equitably, by engaging individuals in managing their carbon emissions. At the moment none of the versions of PCT is a fully worked-out policy proposal and all require further development (Fawcett, 2010).

4.2.2. PCT attributes

Recently, a research is published by A.L. Bristow et al., the research elaborates several attributes and levels which influence the public acceptability of PCT. The several attributes together could form a PCT policy package with the best potential to be accepted by the residents. With a stated preference method the preferred policy package of a sample group from the UK is determined. The respondents acceptability to PCT differentiated between the several policy attribute packages from 0.23 to 0.80 in that research. This considerable amount of variation in the individuals acceptability to the different policy designs implicates that an appropriately determined policy package suitable for the situation is highly important to the public acceptability. Since public acceptability is essential to a policy measure for being potentially successful, it is essential to define the appropriate combination of attributes.

The attributes included in the research of (Bristow & al., 2010)are:

1. Permit allocation

This is the manner of determining the allowed permit per individual or household. For the acceptability it is important that the amount of permits for everyone complied to the policy is distributed fairly. When allocating per capita large households will have surplus permits and thus have financial benefits. However, when allocating per household certain housing types (apartments) might be winners, and detached houses might be losers. Beside the choice of allocating personally or per household, a decision has to be made whether to allocate equally, in line with the complaint's need, or in an otherwise.

2. Excess permits

After a period a individual may have remaining permits. What can be done with these permits might be of influence to the acceptability. People might want to bank, sell or even destroy their remaining permits. Destroying the permits could be done for environmental reasons en preventing anyone else to use their permits.

3. Permit life

The permit life represents the length in time when the permits are valid for use. Individuals might want to bank permits for the future. However, other respondents might think this undermines the policy idea.

4. Purchase limits

A base level of permits is set, with the purchase of limits this level can be increased. However, it might be preferable by respondents that a certain limit is set to the ability to purchase extra limits.

5. Scope of the scheme

The scheme can cover energy use in the home, personal transport, and public transport. The scope of the policy could influence the acceptability significantly.

6. Transactions

A PCT scheme would involve the exchange of both money and carbon however how this is done could affect the acceptability of the scheme.

7. Regulator

The authority managing, tracking is the operator; this could be a public or private organisation or a combination of both.

8. Market operation

The prices of permits could be determined by the government, or on a free market basis.

The attributes mentioned above influence the acceptability of the PCT policy package. Some attributes might be of higher influence than others. Especially the initial allocation of permits is critical to the acceptability. According to (Bristow & al., 2010) the respondents prefer an allocation that not only represents fairness but also one that reflects the need. In paragraph 5.2. the attributes are described more extensively.

4.3. Barriers and resistance towards PCT

PCT is stated to be a radical (Fawcett, 2004), innovative, potentially uncomfortable (Bristow & al., 2010) and a forward-looking policy idea which arguably could provide the national and international framework for delivering emissions reductions over the med-to-long term (Fawcett & Parag, 2010). Barriers and resistance towards implementing a PCT scheme could be expected from two sides. From the one hand the government implementing the policy should be convinced of the benefits from the policy, on the second hand the majority of individuals under the PCT scheme should be convinced of the benefits.

4.3.1. Political barriers

Radical innovative policies tend to be perceived as risky by politicians and policy designers and are therefore less likely to be implemented. One such radical policy is PCT, PCT is a policy measure with no experience or evidence base therefore it is surrounded by debate, uncertainty and doubt (Parag & Eyre, 2010). Yet history is full of examples of policies that were once considered novel, radical or unacceptable, and which today seem mainstream and unquestionable (Vries, 2006). The research of Yael Parag and Nick Eyre concludes that if PCT is to be seen as a serious policy option the population needs to support the policy.

4.3.2. Individual resistance

As stated before, the PCT is a downstream policy measure, thus influencing the individuals living environment. Furthermore, the general structure of the different systems is quite the same. However, since the precise structure of a scheme could vary considerably given the potential range of additional design features including management of individual carbon accounts, market operation, regulation, permit allocation, scope of coverage and transaction costs. Therefore, policy makers would be interested in which scheme designs have the greatest acceptability amongst the general public (Bristow & al., 2010)

4.3.3. Equity issues

The equity of a particular PCT scheme is affected by justice and distributional impacts. Social and geographical factors need to be taken into account when developing a fair PCT policy. A policy addressing the following questions is highly important (Defra, 2006):

- ✓ Who will win and who will lose financially? Think of characteristics such as household income, rural vs urban, housing condition.
- ✓ Beyond financial impacts, what other issues are there in terms of access to opportunities to reduce emissions (information and advice, products, services, capital etc)?
- ✓ Are there 'crunch points' where, after some emission reductions, the cost of cutting carbon emissions increases dramatically for certain types of people which may alter the distributional impacts? For example with particularly housing types or growing families.
- ✓ What are the implications of extreme weather conditions on overall demand for carbon?
- ✓ Are there mechanisms for avoiding or correcting these inequities within or outside the system?
- ✓ How do these impacts compare with those caused by other ways of curbing carbon emissions?

The study of Defra focused to identifying the factors that have a significant relationship with household CO2 emissions and investigated their characteristics. The study focused on seven variables found to have the most significant impact on household CO2 emissions and to be the most useful for characterizing the population from a social and political perspective. These were: number of adults in the home, number of children, income, urban/ rural, number of rooms, tenure (rented/owned), dwelling category (detached, semi, etc.). However, another research focused to the energy use of residents identified besides these more common factors other factors such as race, age of inhabitant and building period of the residents (Rijneveld, 2010). The many influencing factors implicate that it is complex to design a PCT policy scheme which is perceived fair and equal for everyone. Since there is a lack of insight in particular to allocating the permits equally and the effects in practice, it is important to address this as a point of attention in the policy design. This is also concluded by Hyams who states than an unequal distribution of emissions rights may be a more just allocation despite the loss in simplicity this would bring (Hyams, 2009).

4.4. Conclusion

This research is focussed to develop a city based Cap & Trade system urging residents to save energy, and to do research to its potential and to the acceptability among residents. A Cap & Trade based measure seems to have the potential to become a structural measure to create energy consciousness among residents and urge them to save energy. Furthermore it provides a framework for carbon reductions (Tambach, Hasselaar, & Itard, 2010). In principle the mechanism enables participants to compensate for their emissions where it is cheap and simple. Besides this, the inclusion of a trading function results in a rewarding and fining mechanism in the scheme.

Personal Carbon Trading is a downstream emission trading scheme addressing the end users of energy. There are various schemes proposed with similar key principles, each of them however incorporates its own strengths and weaknesses. It is clear that PCT as it is described in this chapter would be a relatively expensive policy to introduce and maintain, however there is also evidence for suspecting that PCT could deliver a wide range of non-economic benefits (Fawcett, 2010). In spite of the benefits, the previous implicates that simplicity and effectiveness are key when aiming to design an applicable policy measure for the municipality of Eindhoven.

The different PCT schemes face quite similar issues when considering the practical implementation. The major issues are political and individual acceptability and the equity issues. Research states (Parag & Eyre, 2010) that the political acceptability is highly depending on the individual acceptability. The individual acceptability is on its turn is heavily leaning on the fairness and effectiveness (Fawcett, 2010) and the initial allocation of permits (Bristow & al., 2010). When addressing in particular these last three aspects properly, a significant part of the political and individual issues seem to be addressed.

This paragraph describes the key principles of PCT, besides this it shows that there is potential and need for a Cap & Trade based policy framework. However, no research is done to the potential and acceptability of such a mechanism on a city scale within The Netherlands. In the next chapter a Cap & Trade based policy framework is designed suitable for a city in The Netherlands. In the experiment part of this report the elaborations of the conjoint choice based experiment in Eindhoven are elaborated.

Part 2; Policy design

5. Policy design

The policy design elaborated in this chapter is based on the several Personal Carbon Trading (PCT) mechanisms. Since PCT is never realised in practice and the research done to this subject is all done outside of The Netherlands, this research aims to design and test a policy design, based on the literature research and expert interviews, which is applicable in The Netherlands. Because the design elaborated in this paragraph is different from al PCT variants it is named a 'Cap, Fine & Reward' policy framework.

In this chapter first the policy goal and the overall policy outline are described, secondly the design attributes for the experiment are described and elaborated.

5.1. Goal policy measure

This policy has the aim to provide the municipality with a stringent, long term policy measure urging residents to save energy and enhancing energy consciousness. The policy measure should urge residents to safe energy by changes in first instance in the energy using behaviour, and in the longer term by changes in the purchase behaviour for appliances. Examples of such behavioural changes are savings caused by a lowered heating temperature or the purchase of an A label refrigerator. Critical is that investments in housing characteristics, such as isolation or double glazing are beyond the scope of the policy. Other policies however could stimulate these improvements. Besides this policy measure other regulations could stimulate investments in the real estate.

Briefly stated the policy focuses to save energy by:

- ✓ Different use of products, for example, turn off the standby modus
- ✓ Shifts in consumption, for example shorten the showering time
- ✓ Improving the energy-efficiency of devices, e.g. A label refrigerator

5.1.1. Cap, Fine & Reward

The structure of the Cap, Fine & Reward mechanism differentiates from the other PCT schemes. Therefore the basic outlines are described below.

The cap is the strive target for the residential energy use of a particular household over one year time. When a household is exceeding the strive target it will get fined, when it remains below the target it gets rewarded. Despite the strive target every household has the ability to use as much energy as preferred; however, the financial rewarding structure will stimulate to lower the energy use.

> By setting a strive target to the households utility energy use, and combining this with a financial incentive this Cap, Fine & Reward policy measure aims to save energy by changing the residential energy using behaviour.

In the original PCT mechanism the trading aspect is one of the basic principles. However, as the name Cap, Fine & Reward implicates, the trading aspect is eliminated from the scheme and replaced by a reward and fine structure. The trading aspect enables households to purchase extra permits and sell them when the permit prices are higher. However, this form of speculation is thought to be undermining the main goal of the policy and is therefore prohibited. The positive aspect of a trading mechanism is that it incorporates a reward and fine structure. This aspect is still incorporated because a household can sell the remaining permits to the regulating organisation to get for example a discount on his energy bill, or buy extra permits when exceeding the strive target, for example by paying an extra grant.

Besides the previous, the trading aspect is a complex thing to realize in practice, requiring from the regulator to supervise a policy with a significantly higher complexity because all households can buy and sell permits from each other. This would probably result in constantly changing carbon accounts, requiring much effort to update and thus in a costly policy measure.

5.1.2. Policy scope

The scope of the PCT policy measures differentiate, causing different impact too society and energy reductions, therefore the scope is specified before outlining the Cap, Fine & Reward variables.

With this policy measure an *energy* cap for a household will be created. By using an energy cap instead of a carbon emission cap, no calculation has to be made for translating the used energy (natural gas, electricity, heat) to the emitted carbon dioxide. Besides this, it is the most straight forward manner, understandable for residents; therefore it is thought to be the best way to create conscious energy using behaviour among residents.

The policy is focussed to the direct, residential energy use in Eindhoven. This includes the energy using behaviour, and the investment in household appliances such as televisions, refrigerators; and not to investments in the home characteristics such as isolation and PV panels. Therefore the policy is supposed to run besides other measures such as subsidies stimulating the isolation of houses or the production of renewable energy. The focus is thus only to the utilities; natural gas, electricity and heat. When implementing the policy scheme nationally, transportation might also be included under the scheme; this however is beyond the scope of this research.

Other forms of PCT schemes might also incorporate transportation or even upstream carbon trading, however this is thought to be unrealistic when aiming for a city based cap and trade scheme. The grounds are practically; when including transportation under the scheme, individuals will simple gas their cars outside the city borders and when incorporating upstream carbon trading the scope of the policy should at least cover the entire nation. Besides these practical reasons, the scheme would be become more costly and might also be considered as too radical by the residents and governmental organisations.

When the initiated policy measure covers a large geographical area significant differences might arise resulting from differences in climate or weather. For example it could be expected that residents in Sweden use more energy for heating than residents in the Netherlands. However, this aspect is excluded from this study since the focus is to a city based policy scheme and the differences caused by climate are too small to be taken into account. Even when applying the scheme on the scale of The Netherlands the geographical differences can be neglected since there are only minor differences.

The allocation of allowances can be done personally or per household. This matter affects demographic characteristics as household size, income, race, age, location and many other aspects, each of them affecting the household or personal energy use differently. Despite this complexity, the matter can be simplified because of practical reasons; the energy use needs to be measured. Since this is currently already been done for the utility functions at a household scale the allocation will be on a household scale. Besides this, Niemeier states that the household cap and trade systems appears more equitable by most measures (Niemeier & al, 2008). Since equity is essential to the public and political acceptance, the policy measure will be on household basis.

Briefly described a household energy Cap, Fine & Reward structure is proposed, using existing household utility accounts. Niemeier stated that limiting the scope of the program does limit possible efficiency gains, but reduces the complexity, risk, and political opposition. This in particular is also the reasoning for the inclusion of the compromises in this concept. Although the scope is limited, the practical applicability is increased enabling the concept to realize efficient and effective energy savings.

5.2. Policy attributes (independent variables)

In the previous paragraph the basic principles of the Cap, Fine & Reward mechanisms are elaborated. However, to see what the Eindhoven residents might think about this mechanism more insight needs to be created in the policy attributes. The scheme below elaborates the attributes influencing the design and impact of the policy scheme. For enabling this research to achieve the goals set, not all of the attributes elaborated can be incorporated in the experiment since this would become too complex for the respondents. In the following sub-paragraphs the attributes are described more extensively and is reasoned why incorporated are excluded from the actual experiment.

Design factors

Various design aspects or in the experiment named as variables, can be appointed in the design of this policy measure. However, to remain the experiment and in particular the questionnaire suitable for the respondents, deliberate choices have to be made about which variables to include.

The design factors for the conjoint experiment are marked in table 3 with a tick. An extensive description of the aspects is elaborated in the following sub-paragraphs. In the experiment conjoint choice is used to model residents' choices in hypothetical policy packages. In total there are five attributes (design factors), each of them containing three levels. The attributes and levels are used to develop choice sets which are used in the questionnaire. The data gathered from respondents enables the research to reveal the main effects influencing the potential and the acceptability of the policy packages.

The amount of levels is set to be three since this enables the levels to cover the whole attribute range and still enabling the conjoint choice experiment to reveal the main effects. Besides this the amount of profiles included in the choice sets of the survey must remain limited to warrant reliant experimental results. Furthermore, research of Virelli and Wittink et al. conclude that the relative average weight of attributes with more levels are higher when defined with more levels (Virelli, 2001) (Wittink, Mc Lauchlan, & Seetharaman, 1997).

Attribute (LABEL)	Levels	description
Scope	- Transportation - Households - Transportation & households	See paragraph 5.1.2.
✓ **Allocation (ALL)**	- Equal - Need - Current	Every household gets the same target. Amount of permits determined on house label and number of household members. Amount of permits determined on current energy use.
✓ **Remaining permits (REM)**	- Sell - Bank - Choose	Excess permits must be sold to the regulator at the end of the year. Excess permits are banked for the next year. When the permit life expires the permits are sold. Households can choose to bank or sell excess permits.
Permit life	- 1 year - 2 year - 5 years	Permits expire after one year Permits expire after two years Permits expire after 5 years
✓ **Purchase limits (PUR)**	- Half limit - Limited - Unlimited	You may buy extra limits up to half of the allocated amount. You may buy extra limits up to the same amount of your allocation. You may buy extra permits unlimited.
✓ **Permit price (PRI)**	- Stress is to rewarding - Fine & reward equal - Stress is to correction/fine.	The reward for staying below the cap is higher than a fine would cost. The rewards are equal to the fines. The fine for exceeding the cap is higher than a reward would cost.
✓ **Regulator (REG)**	- Public - Public – Private organisation - Private	A public, governmental organisation manages the carbon accounts. The government determines the allocation and the permit price. The private party keeps the energy accounts updated. Non profit organisation manages the carbon accounts; allocation, buying and selling permits
Transactions	- Auto	Not incorporated, because it has no significant influence to public acceptability (Bristow & al., 2010).
Market operation	- Free market - Free market with price ceiling - Government sets price annually	Not incorporated; the height of the rewards and fines are set by the government.
Feedback (FEE)	- Daily - Monthly - Yearly	One a month an overview is provided of the energy used, and remaining permits Every house receives an smart meter so individuals have the ability to see what effect particular activities have to their household energy consumption Combination of the two

Table 4, Attributes & levels.

5.2.1. Allocation

As stated in the literature research, the perceived fairness of the permit or energy allocation is essential to the acceptability of the policy design. The attribute allocation represents the manner of setting the energy cap for a household.

When reasoning from the perspective 'we are all the same'. Someone might favour an equal amount of energy for every person since this is in line with the perception that every individual has an equal right to use energy and emit carbon dioxide. Since the scope of this scheme is an allocation per household the allocation per person should be multiplied with the number of residents of a house.

The allocation based on the need is intended to be an allocation perceived as being fair in the sense that everyone receives an cap based on the need, taking in account the circumstances of the household. For being able to determine the energy need of a household a calculation method is developed. This method determines the need, taking into account the household circumstances and sets based on this information the energy cap. The factors determining the household energy use can be separated in two groups; the household characteristics, and the dwelling characteristics. For evaluating the dwelling characteristics an energy label is developed. Since this label does not incorporate the household characteristics it does not reflect the need of the household. Therefore the level of joules set by the energy label is corrected for the number of residents living in the dwelling.

Housing Energy label (Joules) * Nr. household inhabitants (index number) = need

In practice this can only be implemented when a robust and high quality housing energy label (in Dutch; energielabel woningen) is mandatory for all dwellings. The output of the energy label has to be corrected for the number of inhabitants; the required data is available at the municipal (GBA). When the average need for every household is determined, the municipal can decide to set the cap lower by multiplying the cap with a reduction factor.

The third level is based on the current levels of consumption and is incorporated to do investigate if this is perceived as a fair allocation.

5.2.2. Remaining permits

When a period with a length of one year has passed, a household is short in energy permits or has a surplus of permits. This attribute assesses the respondents' perception about what to do with excess permits.

When the first level is incorporated the surplus energy permits must be sold to the regulating organization, this results in financial gains for the energy saver for example through a discount on the energy bill.

The second level allows households to save the surplus energy permits for the years after. In the latter years extra consumption freedom could be gained by using the saved permits. The remained permits can only be turned in financial benefits when the permit life expires. In this situation it is important to set an appropriate permit life. The last level enables households to choose whether they want to sell or bank the permits.

5.2.3. Permit life

Households might have a preference for one of the levels mentioned in the excess permits attribute. For example the levels allowing the banking of permits require a longer permit life than the level which enforces households to sell the remaining permits. Since this attribute is being affected by other attributes this is not incorporated in the scheme; independency of the attributes is essential for performing the conjoint choice experiment.

5.2.4. Purchase limits

When a period with a length of one year has passed, and a household is short in energy permits extra limits need to be bought on top of the free allocated permits. Some might favour limiting permit purchases in order to avoid excess personal use of carbon or energy (Bird, Jones, & Lockwood, 2009). Others might find this patronizing or restrictive and prefer the option to buy extra permits unlimited. The level in between enables households to buy extra permits; however there are still limitations.

Theoretically the levels above enable the situation that a household exceed his cap and also on top of that exceeds the purchasing limit. Since excluding a households from the utilities would be not possible in practice. Therefore, an extra fine which is significantly higher than the purchasing cost, could be set when exceeding the purchase limit.

Theoretically it is possible that the this Cap, fine & reward policy creates profit, however these gains have to be used for stimulating energy savings since the main goal of this policy is save energy. Besides this, the interest of the regulating organisation to make profits is prevented.

5.2.5. Permit price

The rewarding and fining is regulated per unit energy and is being managed by the regulating organisation; all transaction will proceed via this organisation. The manners elaborated below are differentiate in the height of the fines and rewards.

- The rewards is higher than the fine; this results in higher cost for running the policy measure.
- The height of the fine and reward are equal. This implicates that the potential benefit is equal to the potential correction.
- The fine is higher than the reward; the potential correction is higher than the potential reward.

This attribute is added to see whether respondents prefer rewarding good behaviour, or prefer that the emitter pays extra.

5.2.6. Regulator

This attribute is about the regulator managing the allocation and energy permits accounts. Between the levels differentiation is made in a public regulator, a private regulator and a combination of both. A governmental organisation might be in favour because of the private data incorporated in the allocation, besides this they might find social aspects more important than private companies. A non profit private company might be more specialized to the task and therefore more efficiently. A third level is an option which is a combination of both. For example, the allocation and determination of the prices could be done by the government, and the verification and the managing of the accounts could be done by the network operator.

5.2.7. Transactions

A policy measure such as this one requires transactions to be made. The household energy permit accounts needs to be updated, and households have the ability to sell or buy permits via the regulating organisation. However, since this attribute is not found to be important for the public acceptability (Bristow & al., 2010), the attribute is eliminated from the experiment.

5.2.8. Market operation

The research of Bristow et al concludes that the respondents in the United Kingdom prefer the permit prices to be set by the government on an annual basis. Since no significant difference is expected between the two situations it is assumed that also the Eindhoven respondents prefer a market operation regulated by the municipal. Second reason is that only limited attributes can be incorporated in the experimental design.

5.2.9. Feedback

This policy measure focuses to energy savings by changes in the energy using behaviour. Essential when attempting for energy conscious behaviour is the feedback provided about the current energy use. Since it is important to find a suitable manner of providing feedback to the households this attribute it is added to the experiment. However the attribute is not incorporated within the policy packages because it is not found of key importance to the potential and acceptability. A separate question is included concerning the feedback aspect. The levels differentiate in the frequency of provided feedback. For example daily feedback could be provided by an online accessible account or smart meters; monthly feedback by letters or emails send to households; yearly feedback could be provided together with the final yearly bill.

5.3. Conclusion

In this chapter a Personal Carbon Trading based policy framework is proposed named Cap, Fine & Reward.

The policy strives to achieve energy savings by setting a energy target for the utilities of households, besides this it aims to create energy consciousness among residents. These energy savings should be realised by different use of products, shifts in consumption and improving the energy efficiency of devices. Where other measures focus to improve the housing characteristics this policy framework is focussed to the energy using behaviour of residents.
The key variables of the policy framework are elaborated in table 4 and marked with a tic. These variables are used in the experiment to investigate their influence to the policy framework's acceptability and potential.

Part 3; Field research

6. Experimental design

This chapter elaborates the problem focus of the research and the goal of the experiment. Furthermore it elaborates the experimental dependent and independent variables, the questionnaire, experimental design, underlying analyses theories and the sample group.

6.1. Problem focus

The Dutch government has put much effort in saving energy, in spite of this effort; individual energy use is still rising. For changing the energy using behaviour to conscious behaviour factors as awareness, attitude and knowledge seem to be important. These factors can be influenced by soft policy measures, however, research states that greater results can be expected from a combination between a hard and soft policy measure. Insight in the soft side of policy measures is recently created by former master student Ingrid Nieuwenhuijsen.

This research is focussed to provide municipalities with insight in the development of a hard, stringent, long term policy measure. A downstream cap and trade policy scheme seems to have the potential to urge residents to safe energy and to make residents conscious about their energy using behaviour. However, the policy is never been implemented or realized yet. Therefore the problem can be stated as:

> *"Despite the promising potential of a city based downstream cap and trade scheme, there is a lack of insight in the potential of such a scheme in practice"*

6.2. Experimental goal

Radical new policy instruments such as a Cap & Trade system face individual and political resistance. The performed literature study however, shows that if individuals accept the policy measure, the policy measure has a chance to be realised in practice. Besides this, the desk research elaborated significant variance in the acceptability of different Cap & Trade policy designs. By using conjoint analyses an optimized policy package with the highest acceptability will be determined. The following main question is described:

> *What is the potential of a city based Cap, Fine & Reward policy framework system?*

Within this main question it is important to determine which policy variables are most influential for the optimization and the acceptability of the policy measure. Therefore the following two sub-questions are formed:

> 1. *What combination of attributes and levels results in an optimized policy package?*
> 2. *Is this optimized policy package acceptable for the Eindhoven population?*

Individuals acceptability towards a policy framework is very much determined on factors as the perceived fairness and effectiveness of the system (Bristow & al., 2010) this seems to be implicating that an optimized policy package would result in a high acceptability. The experiment aims to create insight in an acceptable and optimized policy package based on the PCT principles.

6.3. Experimental variables

In this paragraph the variables incorporated in the experiment design are elaborated. A distinction is made between the independent socio demographic variables and the dependent policy design variables. The two can be separated as follows; those variables available at the start of a process and those being created by it, where the latter (dependent variables) are dependent on the former (independent variables) (wikipedia, 2011).

6.3.1. Socio demographic variables (independent)

In first instance the social demographic variables are included in the research to determine the characteristics of the respondents. Secondly, these variables might affect the perception of respondents and can therefore potentially be used to recognize characteristics of latter defined latent classes. Below the variables which cannot be affected by the policy packages are summed up:

- ✓ Age
- ✓ Education
- ✓ Household composition
- ✓ Time occupant present in home

Besides these variables the housing characteristics can be summed up:

- ✓ Ownership; including social rent, private rent and privately owned houses
- ✓ Type; such as apartment, townhouses, detached houses,
- ✓ Energy label;
- ✓ Building period

The variables mentioned above are uncontrollable by the design policy framework, however they might have significant influence to the acceptability of the proposed policy. Therefore, these variables will be taken into account in the survey. The analyses of those factors might lead to appointing certain covariate factors.

6.3.2. Policy design variables (dependent)

The policy design variables are shown in table 5 below. For an extensive description see paragraph 5.2.

Attribute (LABEL)	Levels	description
✓ **Allocation (ALL)**	- Equal - Need - Current	Every household gets the same target. Amount of permits determined on house label and number of household members. Amount of permits determined on current energy use.
✓ **Remaining permits (REM)**	- Sell - Bank - Choose	Excess permits must be sold to the regulator at the end of the year. Excess permits are banked for the next year. When the permit life expires the permits are sold. Households can choose to bank or sell excess permits.
✓ **Purchase limits (PUR)**	- Half limit - Limited - Unlimited	You may buy extra limits up to half of the allocated amount. You may buy extra limits up to the same amount of your allocation. You may buy extra permits unlimited.
✓ **Permit price (PRI)**	- Stress is to rewarding - Fine & reward equal - Stress is to correction/fine.	The reward for staying below the cap is higher than a fine would cost. The rewards are equal to the fines. The fine for exceeding the cap is higher than a reward would cost.
✓ **Regulator (REG)**	- Public - Public – Private organisation - Private	A public, governmental organisation manages the carbon accounts. The government determines the allocation and the permit price. The private party keeps the energy accounts updated. Non profit organisation manages the carbon accounts; allocation, buying and selling permits

Table 5, dependent policy variables.

6.4. Questionnaire

Past research has shown that conducting a survey is a very valuable tool for assessing opinions; in this case the respondents' opinion about a new policy framework is tested. The questionnaire contains two sections with different purposes; the first section enables the validating and the grouping of the sample, the latter section contains the conjoint choice experiment, see the next paragraph.

To validate whether the sample group is reflects the Eindhoven population several questions are asked concerning the respondents socio-demographic characteristics. These are characteristics such as; gender, age, level of education and the ownership type of the dwelling; furthermore, several questions are asked about the characteristics of the dwelling and the household behaviour to enable the respondents group to be divided. These are questions concerning the type of dwelling, the residential energy label, the amount of isolation and in which energy using profile they recognize their household in, see figure 9. The questionnaire ends with eighteen conjoint choice based questions. How these questions are provided to the respondents is described in paragraph 6.6.

Before sending out the questionnaire it is tested to its ambiguity, clarity, and complexity among 20 test respondents. Their feedback has resulted in the reformulation of questions and introduction texts. However, the key adjustment is excluding the ‘no choice’ option in the conjoint choice experiment. It appeared that this option was picked too often and therefore could affect the research outcome negatively. In paragraph 6.6. the changes and causes are described more extensively.

Using a suitable survey program to produce the questionnaires is critical to the research success because the program enables the researchers to perform the tasks to achieve the targets set, furthermore the program can influence the quality of the research. Therefore, the survey program is chosen carefully; Netq is an internet based survey program that enables providing the choice sets randomly to the respondents. It also enables downloading the data in spreadsheets with numeric values, which is required for importing the data in the analyses programs SPSS and LIMDEP.

Which of the profiles described represents your household best?

- ○ *Profile Ease*: Persons in this profile act to create comfort and have no sense or interest in energy use, costs or environment;
- ○ *Profile Conscious*: These households choose for comfort, but take into account costs and environment;
- ○ *Profile Costs*: Persons are aware of costs and save energy to reduce costs;
- ○ *Profile Environment*: These households act mainly from the point of view of environment.

Figure 9, Question concerning the energy using profiles.

6.5. Stated conjoint choice experiment

In conjoint analysis respondents are asked to indicate their preference for a certain product. For that purpose, products are defined on a limited number of key attributes, each with a limited number of levels, see paragraph 6.3.2.. Based on these attributes and levels a set of (often hypothetical) products (called profiles) are constructed (Haaijer, 1999). There are various conjoint analysis methods available for data collection, see figure 10 (Kemperman, 2000).

The various conjoint analysis methods can generally be split up in two approaches; the revealed methods are based on past behaviour, and the stated methods consider hypothetical situations.

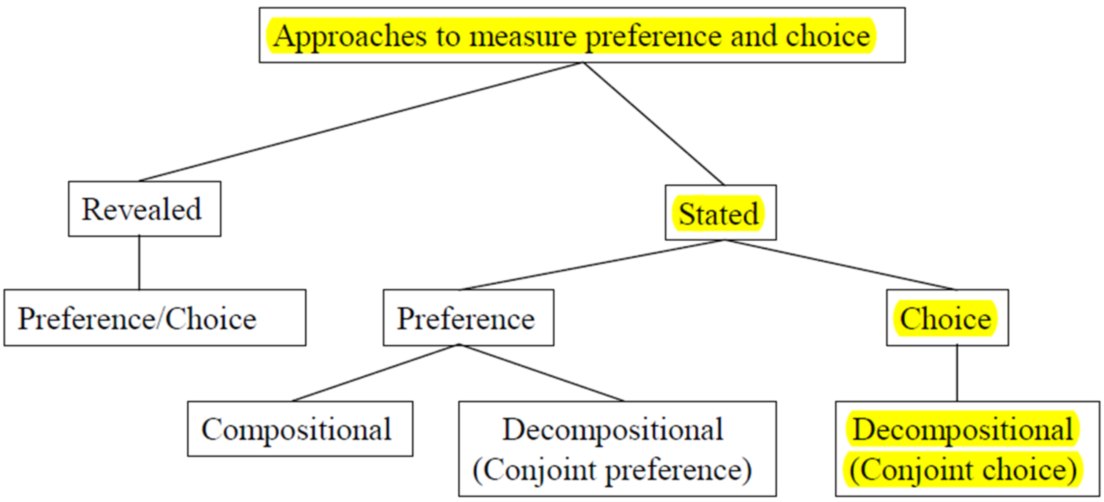


Figure 10, an overview of preference and choice measurement approaches (Kemperman, 2000).

For this research only the stated modelling is considered because the research is about a hypothetical situation of a policy measure which is not brought into practice yet.

Conjoint stated choice experimentation involves the design of product profiles on the basis of product attributes specified at certain levels, and requires respondents to repeatedly choose one alternative from different sets of profiles offered to them (Haaijer, 1999). In the traditional preference method the choice alternatives are ranked, however past experience shows that this is a rather difficult task for the respondents since it is different from their normal behaviour when buying (choosing for) a product. Conjoint stated choice is reflecting the real life choosing situation better and is therefore preferable in this situation. Furthermore, Timmerman & Oppewal conclude that stated conjoint choice experiments combine the most important advantages; experimental abilities, amount of observations per respondent and observations for new products (Oppewal & Timmermans, 1993).

6.6. Experimental design

The study uses conjoint stated choice to do research too the most important attributes in an energy policy urging households to save energy and behave themselves more energy conscious. This specific conjoint analyses method is determined since it enables the respondents to make the best tradeoffs between the choice packages.

The experiment holds five attributes, each holding three variable levels. All packages constructed hold one of the three levels of each attribute. The total number of packages resulting from all possible combinations of levels is named a full factorial design. For this research a full factorial design holds 3^5 = 243 alternatives. Incorporating all the alternatives requires too many choice sets to be incorporated in the experiment. Therefore a fractional factorial design is created (Montgomery, 2005). A fractional factorial design is an experimental design presenting a small fraction of the full factorial design still enabling the researcher to discover the main effects for each factor level in the experiment.

The orthogonal generator function of SPSS 19 is used to design the fractional factorial design, holding 18 alternatives. These alternatives have randomly put in choice sets, each holding two alternatives. In the experiment the respondents are first asked to give their preferred package from the set presented, totally nine choice sets are presented to them, for an example see figure 11. Secondly, they are asked to reveal whether they find the packages acceptable to be realised in practice. For the conjoint design it is assumed that the alternatives are independent from each other.

Example choiceset

Characteristics:	Package X.	Package Y.
1. Price energy rights.	Households receive energy rights based on their past use.	All households receive the same target.
2. Regulator.	Sell or bank	Sell or bank
3. Shortage energy rights:	At most the target can be doubled by purchasing.	Energy rights can be purchased unlimited.
4. Price energy rights.	Focus is to the correction.	Equal; the reward is as high as the correction.
5. Regulator.	Public-private regulator	Private organisation

1. Which choice package do you prefer?

- Choice package X.
- Choice package Y.

2. Would you accept the choice packages in reality?

	acceptable	not acceptable
Choice package X	◉	○
Choice package Y	◉	○

Figure 11, Choice set example.

During the design process of the experiment including a 'no choice' option enabling to test the acceptability is considered. However after a test run, it appeared that this option holds the potential to be preferred too much and thus resulting in high information loss. Although the extra insights, including this option could deliver about bringing the policy in practice, the 'no choice' option is not incorporated in the choice sets. Instead of this, a second question is incorporated which asks whether the respondent finds the presented policy packages acceptable to be realised.

Effect coding

For enabling the processing and analyzing of the survey data the variables are coded. Effect coding is used to code the categorical variables; the variable levels take the values; -1, 0 and 1. The sum of the effects is equal to zero for all attributes, therefore it enables to determine the estimates for all three levels. The intercept is equal to the grand mean of the dependent variable, and the parameter estimates are equal to the deviation of the mean of the attribute level assigned 1's in the corresponding vector from the grand mean (Kemperman, 2000).

Variable	Level	Effect 1	Effect 2
X	a	1	0
	b	0	1
	c	-1	-1

The entire coding scheme for the experiment is elaborated in appendix 1.

6.7. The data analyses

The conducted conjoint choice experiment has resulted in data from which the choice behaviour for certain policy packages can be estimated. Besides this, the acceptability to a certain package realized in practice can be estimated based on the second question asked in the choice sets. The following models are used to analyse the output of the conjoint choice experiment.

Random utility theory

The Random utility theory is based on the following assumption; if an individual must choose between two sets of alternatives, the set with the highest random value will be chosen (Oppewal & Timmermans, 1993). In discrete choice models this value is determined by a structural and a random error component. The utility (U_r) for a profile consists of a systematic utility (V_r) and a random error component (ε_r). The utility for a certain alternative is expressed as follows:

$$U_r = V_r + \varepsilon_r$$

Then the systematic utility V_r of alternative r is described as a linear function. This is implicating that the utility V_r can be determined by the summation of all attribute utilities.

$$V_r = \sum \beta_i + X_{ir}$$

The attribute values X_{ir} for all attributes. The parameter values β_i of the attributes indicate the relative influence of the various attributes on the utility of alternative r (Oppewal & Timmermans, 1993).

Binary logistic regression

Logistic regression is useful for situations when predicting the outcome based on values of a set of predictor variables. It is similar to a linear regression model but is suited to models where the dependent variable is dichotomous (SPSS regression). The probability that an alternative will be chosen for a binary logistic regression is determined with the following formula:

$$P(Y) = \frac{1}{1 + e^{--(\beta_0 + \beta_1 X_{ri} + \beta_2 X_{ri} + \ldots + \beta_n X_{ni})}}$$

When the part worth of all attribute levels have been determined, the relative importance of the attributes against each other are determined. This is done by adding the absolute values of the part worth of the highest and lowest attribute levels. Then the contribution of each attribute to this total is calculated and expressed as a rate.

Ordinal regression analyses
First the respondents have given their preference for a particular package in a choice set. However, since the 'no choice' option is not included this is not revealing anything about the acceptability of the policy package and the included variables. Therefore a second question is included; in this question respondents reveal whether they find a choice package acceptable or not acceptable. Ordinal regression enables analyzing data in which causality might be involved (Vosters, 2008); in this case it is used to determine the influence of particular variable levels (cause) to the acceptability of the policy package. The method estimates a threshold representing in this research the turning point between not acceptable to acceptable. When the sum of all variable levels exceeds this threshold the package would be accepted according to the estimation; when the sum is lower than the value of the threshold the package is unacceptable. For performing the ordinal regression SPSS is used.

Binary Latent class analyses
Lazarsfeld and Henry (1968) introduced the LCA model as a way to identify a latent categorical attitude variable that was measured by dichotomous survey items. LCA models identify a categorical latent class variable measured by a number of observed response variables. The objective is to categorize people into classes using the observed items and identify items that best distinguish between classes (Nylund, 2007). By performing this analyses insight is created in the influence of particular respondents socio demographic characteristics to the acceptability of the proposed Cap, Fine & Reward policy frameworks. For performing this analyses the LIMDEP 9.0 is used.

Goodness of fit
The likelihood ratio, Rho square, is a measurement to calculate the goodness of hit of choice models. It is an indication of how good the predictability is resulting from the analyses made. Generally, a model with a Rho square above 0,2 indicates a good fit and thus a well predictability.

6.8. Sample

This paragraph describes the sample group approached for this experiment.

The respondents have been approached via a research institute of the municipal of Eindhoven named Digi panel. This panel of civilians can be used for asking their point of view about a wide range of matters via a web based questionnaire. Although the panel members are not selected, there is something to notice; it could be questioned whether the sample group is reflecting the Eindhoven population entirely since people have to subscribe to become a panel member. However, since the number of responses is very critical and the research has to be conducted in a tight time schedule this is taken for granted. Furthermore, the experiment performs only an exploratory research to the potential and acceptability of a Cap, Fine & Reward policy framework.

General statistics		
Approached:	# 2083	100 %
Started questionnaire:	# 909	44 %
Finished questionnaire:	# 703	77 % from started, 34 % from totally approached.
Average time:	00:14:08	

Table 6, The general response statistics.

The general statistics about the responses is elaborated in the scheme above. As can be seen the number of responses is 703 this is an response rate of 34 percent. Somehow several questionnaires are not filled in completely, despite making the questions obligated to be answered by respondents. These questionnaires have been removed from the database.

6.4. Conclusion

Despite the need for a policy measure effectively targeting energy savings and the potential of a PCT based policy framework, such a system is never been realized. Therefore the research question of this study is; what is the potential of a city based Cap, Fine & Reward policy framework system?

To test the acceptability and potential of the PCT based policy framework a conjoint choice based experiment is designed. To gather sufficient data for the experiment a questionnaire is send to 2083 people. In this questionnaire the respondents are asked to answer several questions concerning socio demographic topics. Furthermore, they are asked to complete 9 choice sets containing a question asking the respondents preference and a question concerning the acceptability of the packages. The resulting 703 completely filled in responses are analysed using binary logistic regression, ordinal regression and binary latent class analyses. The results are elaborated in the next chapter.

7. Results

The results of the data analysis of the conjoint choice experiment are presented in this chapter. First the socio-demographic data is described. Secondly the results from the main effect analyses are elaborated. Third the ordinal regression analyses describing the acceptability and optimal policy packages is elaborated and, fourth paragraph elaborates the results of the latent class analyses; this analyses divides the sample group in segments.

7.1. Socio-demographic data

In the first part of the survey the respondents are asked to fill in several questions concerning their socio-demographic characteristics. The more general characteristics are visualised in the scheme below to validate the sample group.

Table 7 elaborates the gender, age, education level, of the respondent, furthermore the ownership situation of the dwelling and the household composition is shown. As can be seen the male are overrepresented when comparing the data to the statistical data of entire Eindhoven. Furthermore there seem to be many middle aged people, higher educated people and owners of private property in the sample. When comparing the household compositions a large amount of single households is found, and relatively less households with children and couples are found in the sample. Unfortunately no data is found concerning the education level or the type of ownership of the dwelling. Since this is an exploratory study to the potential and acceptability of a Cap, Fine & Reward policy framework it is still possible to withdraw valuable results and conclusions.

	Sample		Eindhoven		
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Source**
Gender					(Eindhoven, 2011)
Male	# 449	63.9 %	# 110.001	50.9 %	
Female	# 254	36.1 %	# 106.067	49.1 %	
Total (missing)	# 703 (0)	100 % (0 %)	# 216.068	100 %	
Age					(Eindhoven, 2011)
20-35	# 88	12.5 %	# 38120	39.7 %	
36-50	# 202	28.7 %	# 44813	26.15 %	
51-65	# 283	40.3 %	# 33763	19.7 %	
55+	# 122	17.4 %	# 24685	14.4 %	
Total (missing)	# 695 (8)	98.9 % (1.1 %)	# 171381	100 %	
Education level					
None	# 1	0.1 %	-	-	
Primary school	# 3	0.4 %	-	-	
Lower secondary education	# 82	11.6 %	-	-	
Higher secondary education	# 81	11.5 %	-	-	
Primary vocational education	# 15	2.1 %	-	-	
Secondary vocational education	# 105	14.9 %	-	-	
Degree	# 415	59.1 %	-	-	
Total (missing)	# 702 (1)	99.9 % (0.1 %)	-	-	

Ownership					
Social rent	# 149	21.2 %	-	-	
Rental	# 39	5.5 %	-	-	
Private property	# 512	72.7 %	-	-	
Total (missing)	# 700 (3)	99.9 % (0.1 %)			
Household composition					(CBS, 2009)
One person	# 139	19.7 %	# 47 123	45.0 %	
Household with children	# 233	33.1 %	# 28 422	27.1 %	
Household without children	# 311	44.2 %	# 29 250	27.9 %	
Different	# 20	2.8 %	-	-	
Average household size	# 2,67	-	# 1,98	-	
Total (missing)	# 703 (0)	100 % (0 %)	# 104795	100 %	

Table 7, Socio- demographic data of the sample.

Based on the researches of (Groot & Spiekman, 2008) and (Paauw & Roossien, 2009) a question is incorporated concerning the household energy using profile. In this question respondents are asked to mark the profile which is most representative for their household. Remarkable is that profile conscious is by far the biggest group. This, instead of profile cost which might be expected. Profile conscious holds the households choosing for comfort, but take costs and environment into account. The cause of the large 'conscious group' might be in the big percentage of higher educated respondents in the sample.

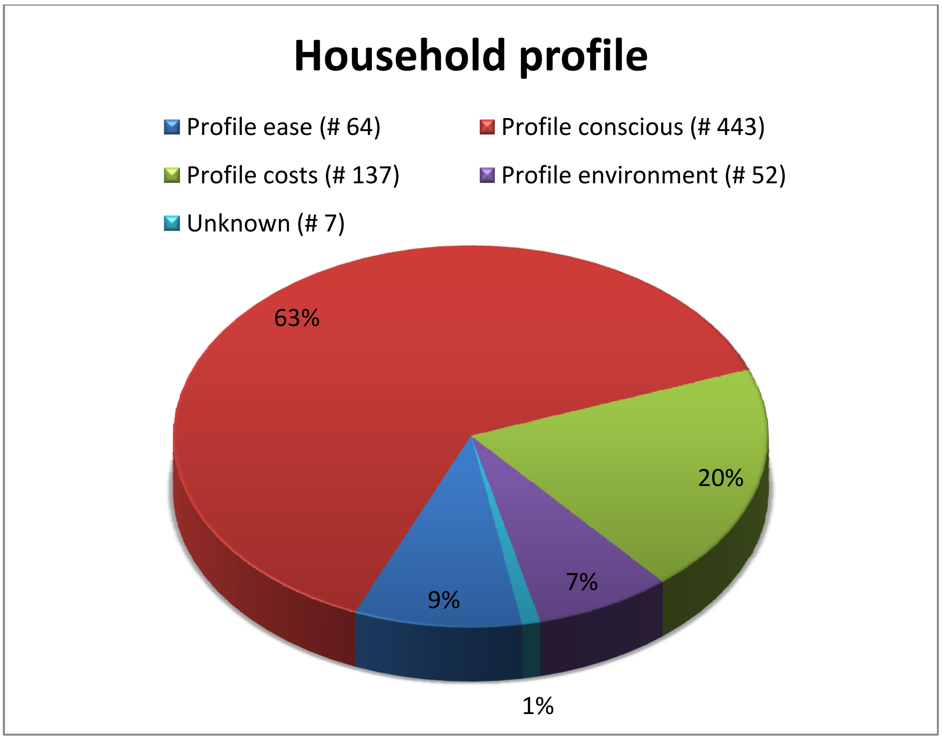


Figure 12, Household profiles of the sample group.

7.2. Main effects

This paragraph elaborates the results of the main effect analyses. First the log likelihood is described, secondly the relative importance between the variables is elaborated and third the influence of particular variable levels is presented. The output of SPSS is added in appendix 2.

In the first choice set question respondents have to choose between two policy packages; a binary logistic regression analyses is used to analyse the main effects. The goodness of fit is indicated by the pseudo Rho square which reveals the predicting ability of the analyses. SPSS uses the methods from Cox and Snell and the method Nagelkerke to determine the pseudo R square; the value for the first is 0,149; the value for the latter is 0,199. Both of these values are below 0,2, indicating that the predictors are not optimally suitable which is thought to be remarkable since the sample is quite large.

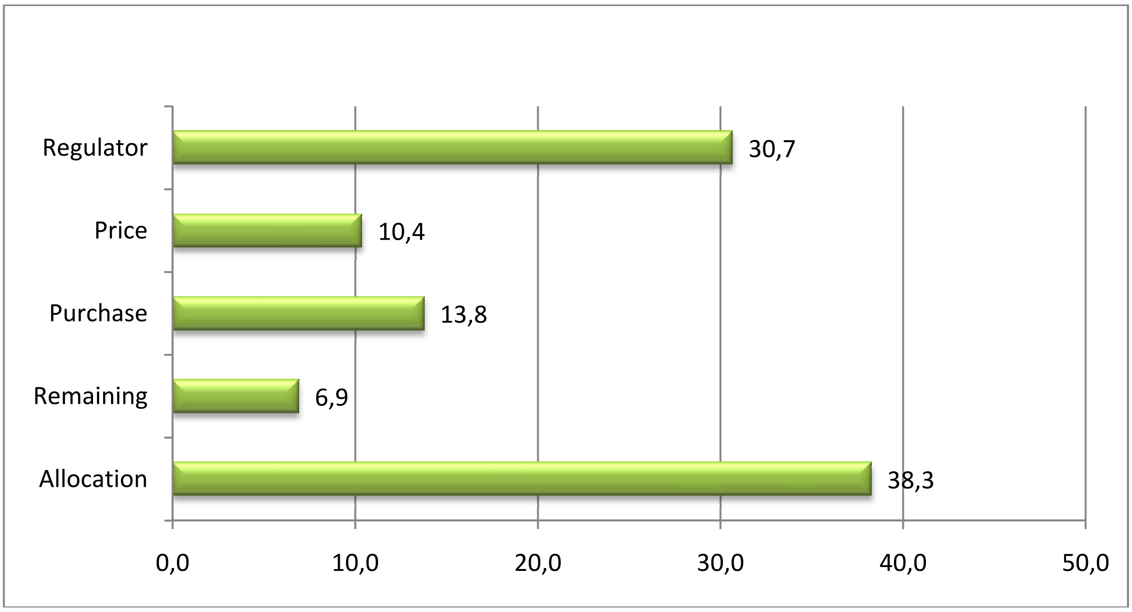


Figure 13, relative importance per variable.

From all data gathered from the respondents and by using the binary logistic regression the relative importance per variable can be determined, this is pictured in figure 13. Key variables seem to be the variables concerning the allocation and the regulator; these are significantly more important than the others. With 38.3 percent the allocation is the most important; implicating that the respondents seem to find it key that the policy framework is fair. Second important is the regulating organisation with a relative importance of 30.7, this seems to be implicating that privacy concern still is an important issue for the civilians. The last three variables concerning what can be done under the policy measure; when being short in permits (purchase); what the fine & reward structure is (price), and what can be done with the remaining permits (remaining) is far less important.

The figures below elaborate the part worth of the variable levels. When a bar is positively the respondents find the level attractive which results in an increased positive attitude towards a particular choice package. This is reverse when the bar shows a negative outcome. The numbers allocated in the bars reflect the relative importance and are used to determine the relative importance of the variable.

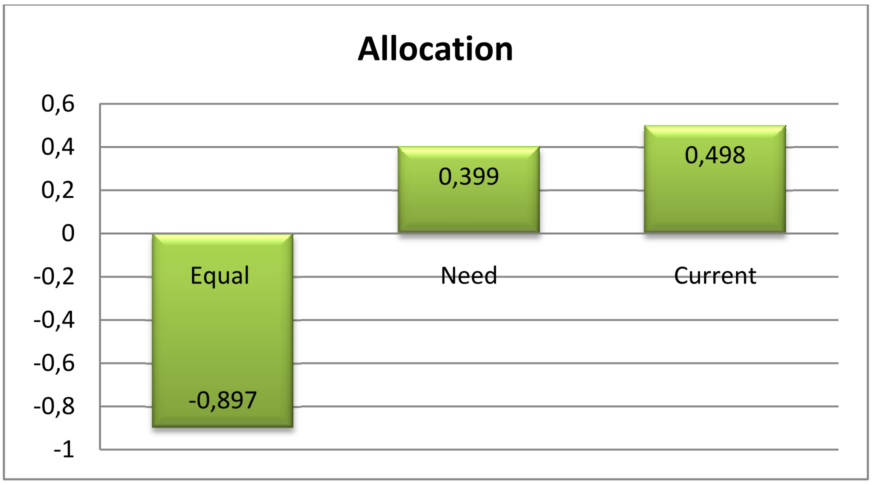


Figure 14, Part worth value 'allocation'.

The part worth values concerning the allocation can be seen in figure 14 above. The figure shows that an allocation based on the current use is the most positive. Almost as positive is the allocation determined on the need, which is based on the household characteristics and number of household members. Although the level 'need' represents the fairest allocation it has not the most positive influence. An equal distribution of energy permits would have a very negative influence.

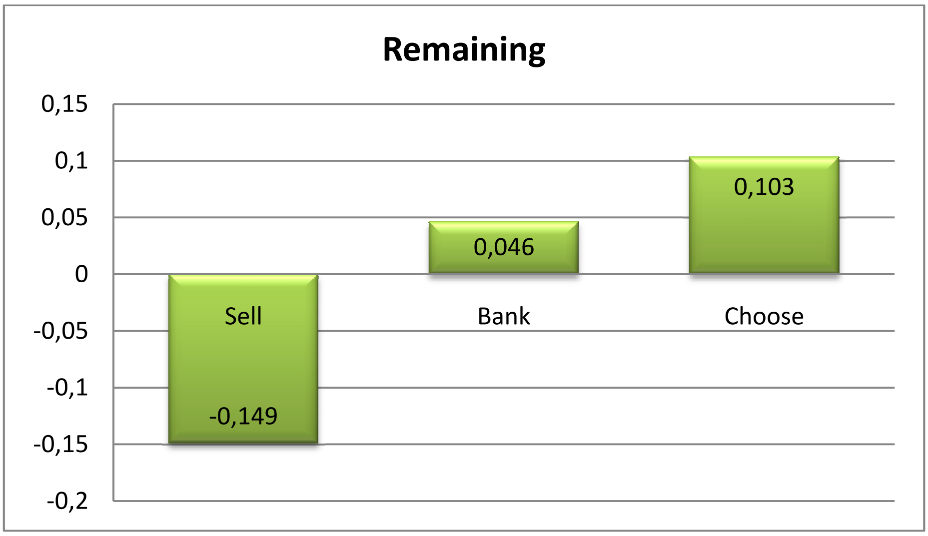


Figure 15, Part worth value 'remaining'.

Figure 15, is about the part worth values concerning what can be done with the remaining permits. An obligation to sell the remaining permits has a negative impact to the respondent's attitude. Banking the permits has a slightly positive impact, however this influence can be neglected because of the low value. Besides this, the significance of this level is not zero implicating that this level is affecting the outcome less and thus is less important, see appendix 2. Choosing whether to bank or sell the saved permits has a positive influence.

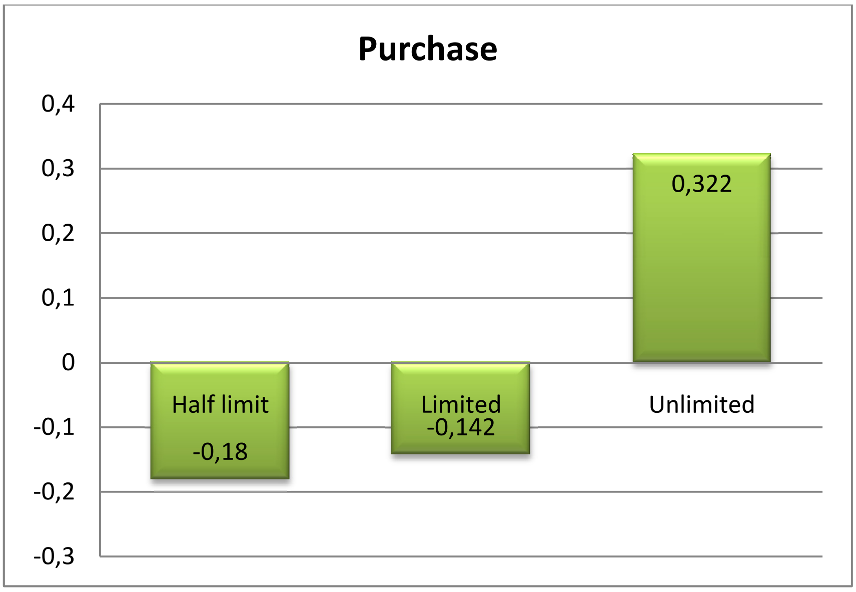


Figure 16, part worth value 'purchase'.

The part worth value of the variable levels belonging to the purchase variable are elaborated in figure 16. As can be seen the unlimited level is in favour among the respondents, this finding meets the expectations since people tend to prefer freedom of choice. The remarkable though is that the two levels limiting the purchasing are not very negative, and differ not that much from each other.

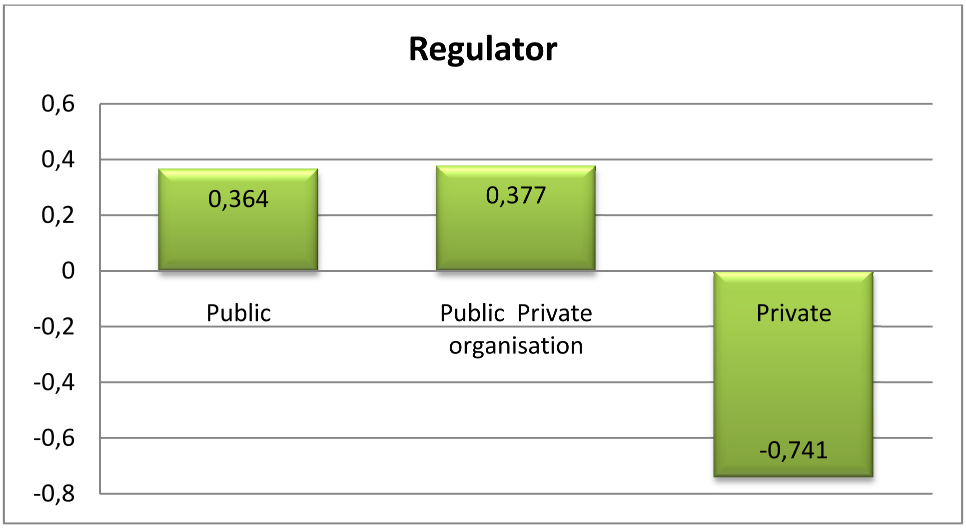


Figure 17, part worth value 'regulator'.

Figure 17, elaborates the numbers of the regulator variable. The relatively high numbers indicate that the regulator variable is found important by respondents and have a relative high influence to the choices made. The key difference between the levels affect turns out to be the involvement of a public organisation in the regulating organisation; when this is the situation it affects the respondents choice positively. A private regulator has a strong negative impact to the respondents choice.

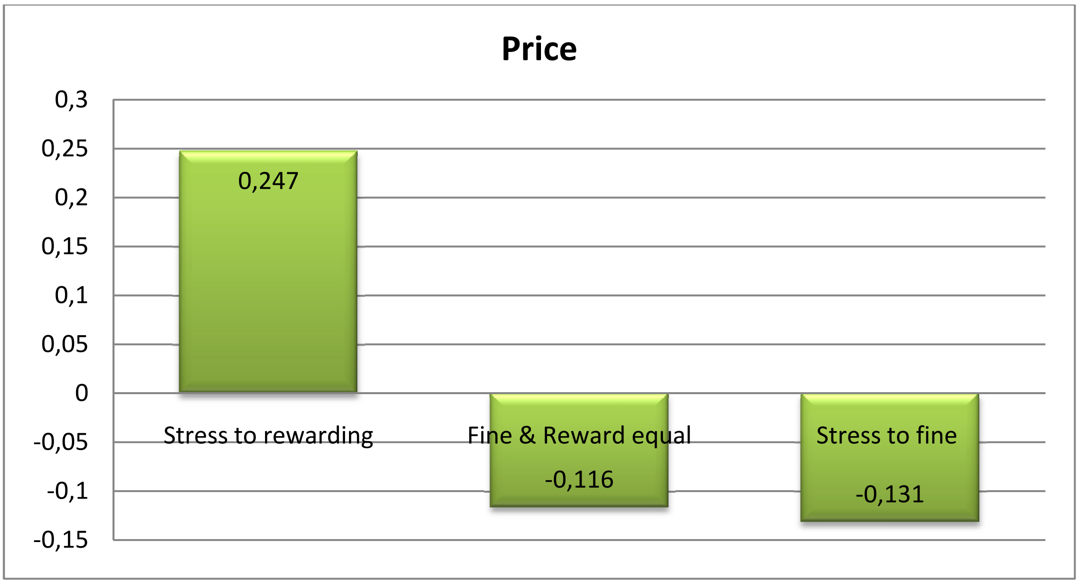


Figure 18, part worth value 'price'

Figure 18, concerns the price of buying and selling permits. The revenues from selling energy permits creates the reward, and the cost from buying permits forms the fine. In the level with the 'stress is to the reward' the revenue per unit sold is higher than buying extra permits would cost. As can be expected this has an positive effect to the choice of respondents. When the stress is to the fine, this affects the choice negatively; this is also the case when the fine and reward are equal distributed.

7.2.1. Feedback

The literature research shows that providing feedback is essential for increasing the energy consciousness and the energy savings of residents. Factors such as awareness and knowledge affect the actual energy use of residents. By providing feedback regularly residents are confronted regularly with their energy use, and are able to see how their behaviour affects the energy used. This might lead to the intention of saving energy.

The majority of the respondents, 65 %, prefers receiving feedback on a monthly basis. Currently the last payment at end of the year is the only feedback residents receive. This mechanism seems to be outdated since residents want to receive feedback more often to improve insight in their energy use. Besides this, governmental authorities are willing to increase the energy consciousness and energy savings among residents. By providing feedback more often better residential insight can be created, leading to an increased probability of energy savings. When combining this with a stringent policy measure such as Cap, Fine & Reward this seems to have the potential result in energy savings caused by behavioural changes.

7.3. *Ordinal regression analyses*

In an ordinal regression analyses the part worth values of the variable levels are determined in the same manner as in the previous paragraph. However, the input data is gathered from the question whether respondents find the policy package acceptable or not acceptable for being realised. This difference results in the ability to make a prediction about the acceptability of the Eindhoven population towards particular policy packages. Various policy packages have been designed and tested for their acceptability. Before picturing the acceptability of the various policy packages the goodness of fit is indicated, the thresholds are elaborated and the policy packages are described. The output from SPSS in elaborated in appendix 3.

The outputs from goodness of fit indicators show that the values for the pseudo Rho-square is rather low; implicating a low predicting value. The pseudo Rho square value for the Cox and Snell method is 0.070; the value for the Nagelkerke method is 0.093; the value for the Mc Fadden indicator is 0.052. Clarification for this can be that there is a large variance between respondents; some reject all policy packages, where others accept all policy packages. Despite the low goodness of fit the results of the analyses are shown below and conclusions have been made.

The output of an ordinal regression provides threshold values. Since this research only includes the answer possibilities acceptable and not acceptable only one threshold is determined. The threshold is an indication for the respondents' reaction to a particular policy package (combination of variable levels). The threshold in this analyses is 0,391, indicating that the sum of the part worth values of the variable levels should be above 0,391 to be acceptable for the respondents.

Since the part worth values are known, policy packages can be combined predicting the acceptability for the Eindhoven population. The policy measure is developed to provide the municipal with a tool to urge residents to energy savings. Therefore the packages are created from the viewpoint of the municipal. Generally this means that the packages are defined to achieve energy savings fairly and as cost effective as possible. Besides the insight this creates in the acceptability it generates insight in the potential of a Cap, Fine & Reward policy framework.

1. *Acceptability;* the first policy package elaborates the combination of variable levels resulting in the highest prediction for the acceptability of the respondents.
2. *Optimal;* the second package elaborates the combination which is found optimal for the municipality of Eindhoven. This package is characterized by creating as much energy savings as possible, obtained in a fair manner, and with the lowest cost for the municipal. The allocation is determined by the need of the household; the need is determined by the number of household members and the dwelling characteristics. The remaining permits must be sold to the regulator; households generate revenues and the energy target for the following years remains equally. When a household is short in energy permits it must buy extra permits from the regulator; this generates revenues for the municipal and secures the freedom of choice for households. The price variable is with the stress to the fine; implicating that savings are still rewarded however when exceeding the energy target the price

per unit is higher for buying extra permits. Fifth variable considers the regulator, a public-private partnership organisation is considered to be preferable for the municipal since cost are minimized while maintaining the controlling function.

3. *Fine & reward;* in this policy package the focus is to achieving high energy savings in a fair manner, besides the variable level 'fine & reward' the package is entirely the same as the optimal package. Financial concessions have been made by adjusting the price variable to the 'fine and reward' level. This price structure is equal for energy savers and surplus energy users; the height of the revenues is per unit equal to the cost.
   From the viewpoint of the municipal this is not preferable since this would be more costly compared to the previous package.
4. *Reward;* This package focuses also to fairness and energy savings, however the focus in this package is to rewarding the energy savings. From the municipals perspective this package is more expensive than the previous however, it is also more acceptable among the respondents.
5. *Choose;* this package is the same as the 'optimal' package accept for the variable 'remaining'. Under this package the households are free to choose for selling or keeping the remaining permits. When households choose for saving the remaining permits they create themselves a margin for the next year. From the viewpoint of the municipal this is not preferable since the savings could be used during the next year. The other variables are the same as in package 'optimal'.

Policy package	Variable	Levels	Part worth values
1. Acceptability	Allocation;	need	0.959
	Remaining;	choose	0.239
	Purchase;	unlimited	0.081
	Price;	stress to reward	0.283
	Regulator;	public	0.776
2. Optimal	Allocation;	need	0.959
	Remaining;	sell	-0.405
	Purchase;	unlimited	0.081
	Price;	stress to fine	-0.232
	Regulator;	public private organisation	-0.061
3. Fine & reward	Allocation;	need	0.959
	Remaining;	sell	-0.405
	Purchase;	unlimited	0.081
	Price;	fine & reward equal	-0.051
	Regulator;	public private organisation	-0.061
4. Reward	Allocation;	need	0.959
	Remaining;	sell	-0.405
	Purchase;	unlimited	0.081
	Price;	stress to reward	0.283
	Regulator;	public private organisation	-0.061
5. Choose	Allocation;	need	0.959
	Remaining;	choose	0.239
	Purchase;	unlimited	0.081
	Price;	stress to fine	-0. 232
	Regulator;	public private organisation	-0.061

Table 8, Policy packages; acceptability of respondents.

The outcome of the acceptability to the previously described policy combinations are pictured below in figure 19. The red line resulting from the ordinal regression is indicating the threshold; 0.391. When the total value of the policy package reaches above the threshold it implicates that the policy package is predicted to be found acceptable by the respondents.

The first bar represents the policy package most preferred by the respondents; it is added to create an indication of the maximized acceptability. However, this package will probably be too expensive to be realised, it also could be doubted whether it realizes sufficient energy savings. The optimal combination from the viewpoint of the municipal is represented by the second bar, for the people this policy package would probably be not acceptable.

However when adjusting the price variable this changes; changing only the price variable from the level with the stress to the fine to the level in which the height of the potential fine per unit is equal to the reward it policy package becomes acceptable for the residents. In the situation of changing it even towards the level with the stress to the reward the acceptability number is more than doubled.

When instead of the previous, the manner of handling the remaining permits is changed to allowing the residents to choose whether to sell or bank the permits the acceptability rises even more. The cause of this is not in the very high positive part value of this level; it is in the very negative impact of forcing the residents to sell their energy rights, see table 9.

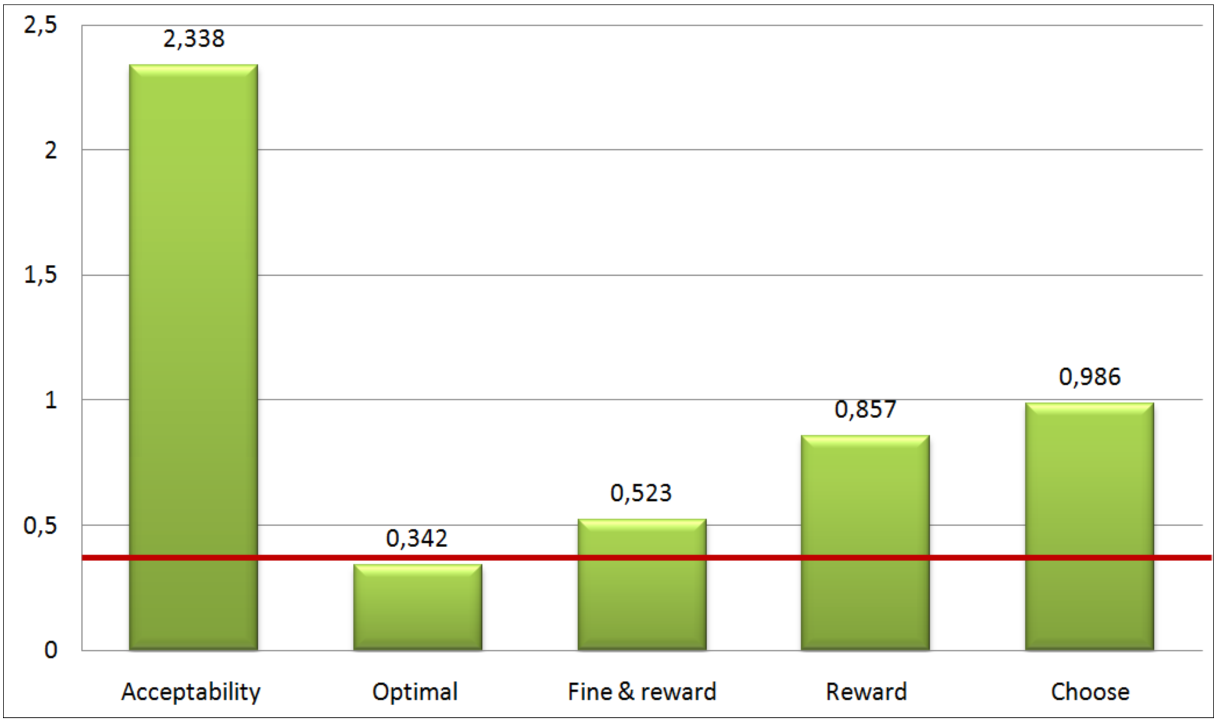


Figure 19, Predicted acceptability to a Cap, Fine & Reward policy framework.

7.4. Latent Class Analyses

As described in paragraph 6.7., Latent Class Analyses (LCA) is a method able to find respondent segments in a sample group based on preference variables. After performing the LCA and determining the number of latent classes these classes are analysed generally; the relative importance for the attributes is determined to see whether significant differences are found between the two classes. Furthermore, SPSS is used to see whether homogeneity is found in the socio demographic characteristics of the respondents in the classes.

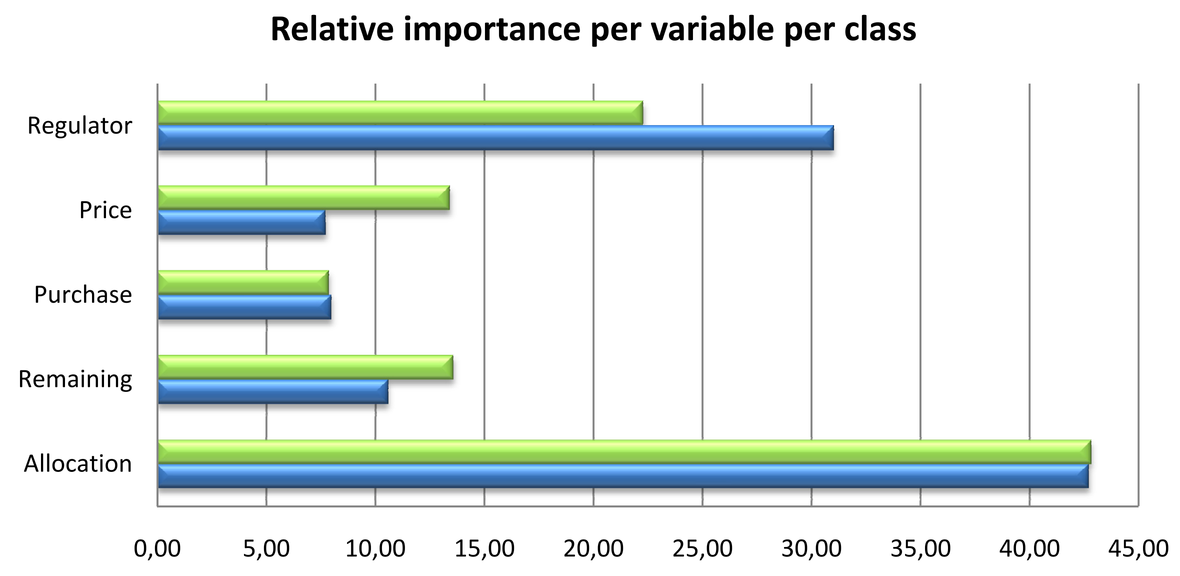
To find the number of latent classes which can be defined several LCA runs are performed. Important determinants for the number of classes found are the variables Mc Fadden R^2, the AIC and the BIC. Normally a higher pseudo R^2 indicates a better predictability of the model, besides this the AIC value should decrease, and the lowest BIC value indicates the fitting number of classes. Considering only this 6 latent classes can be found. However, when analysing the model parameters for the latent classes thoroughly it becomes clear that these parameters show numbers that do not fit. Therefore the result of the latent class analyses recognizes two segments.

The output of the two segment binary latent class analyses is elaborated in appendix 4.

# Latent classes	Mc Fadden R^2	AIC	BIC	Model parameters
# 2	0.163	1.103	1.117	Fit
# 3	0.198	1.059	1.079	No fit
# 4	0.219	1.034	1.061	No fit
# 5	0.239	1.009	1.044	No fit
# 6	0.251	0.995	1.036	No fit
# 7	0.255	0.992	1.041	No fit
# 8	0.257	0.991	1.047	No fit

Table 9, LCA, # segments found.

The first segment covers 58 percent (blue) and the second segment covers 42 percent (red) of the total respondents. Respondents belonging to different classes make different choices. The general differences can be elaborated in classes resulting in different importance values for the attributes. In the figure below the relative importance of the different attributes is shown. As can be seen the variables ‘allocation’ and ‘purchase’ do not differ very much. However the ‘price and remaining’ variables are found more important by class two. Class one finds the variable ‘regulator’ far more important than class two. Overall can be stated both classes value the ‘allocation’ variable as most important, furthermore the ‘regulator’ variable is found second important.



	Allocation	Remaining	Purchase	Price	Regulator
Class 2	42,82	13,58	7,88	13,43	22,29
Class 1	42,71	10,58	7,99	7,72	31,01

Figure 20, Relative importance per variable per class

SPSS is used to investigate whether different socio demographic characteristics can be found in the two segments by determining the frequencies and percentages. In the search to find these differences research is done to the variables gender, age class, education, type and sort of ownership of the dwelling, household size, and the hours a person is home. Besides these rather common characteristics it is investigated whether different household energy using profiles (Groot & Spiekman, 2008) affect the chance that a resident belongs to a particular segment.

Based on the performed analyses no distinctive characteristics have been found in the two respondent segments.

7.5. Conclusion

First the gathered socio demographic data is analysed by determining the frequencies and percentages of the particular variables and the belonging levels. Furthermore this information is compared with the socio demographic information available for the municipality of Eindhoven. Based on this analyses it can be concluded that the sample group is not reflecting the Eindhoven population entirely.

Secondly, a binary logistic analyses is conducted to investigate the main effects. The determined part worth values are used to determine the relative importance of the variables allocation, remaining, purchase, price and regulator. The results indicate that the allocation and regulator variables are key.

Third, an ordinal logistic regression analyses is performed to determine the acceptability and potential of several Cap, Fine & Reward policy packages created from the municipals point of view. It can be concluded that several policy packages are found acceptable by the respondents.

Although the Latent Class Analyses is not required for answering the stated research questions this analyses is conducted. This resulted in the ability to appoint two response segments. The mc Fadden pseudo R^2 indicates a better predictability when comparing to the previous analyses, however with a value of 0,163 is still below 0,2. When visualizing the relative importance of the variables per class it becomes clear that in both segments the main variables are the allocation and regulator, however there are significant differences between the variable importance values. In spite that two respondent segments have been found no clear distinctive differences in the segment characteristics is found. Still the Latent Class Analyses supports the outcomes of the other analyses.

Part 4; Conclusions

8. Conclusions

During the exploratory research for this study a main research question is stated; '*What is the potential of a city based 'Cap & Trade' system urging residents to energy savings?'* This main question is split up in the following sub-questions:

1. *What combination of attributes and levels resulting in an optimized policy package?*
2. *Is this optimized policy package acceptable for the Eindhoven population?*

To answer these questions a literature research is performed, a design for a policy framework is developed, and a conjoint choice experiment is conducted.

8.1. Conclusions theoretical orientation

The conclusions resulting from the contextual research described briefly: The municipality of Eindhoven wants to become energy-neutral in 2035-2045. Therefore the energy use needs to be reduced, in spite of several initiatives only small improvements have been achieved. Research states that for changing the energy using behaviour the current policy instruments needs to be complemented with a stringent and long term energy policy instrument (Tambach, Hasselaar, & Itard, 2010; Delft, 2006; Energieraad, 2006). A Cap & Trade based measure seems to have the potential to become a structural measure to create energy consciousness among residents and urge them to save energy. Furthermore it provides a framework for carbon or energy reductions.

The term Personal Carbon Trading (PCT) represents various Cap & Trade based mechanisms and is a downstream emission trading scheme addressing the end users of energy. PTC is a forward-looking policy idea which arguably could provide the national and international framework for delivering emissions reductions over the med-to-long term (Fawcett, 2010). The basic principle of any Cap & Trade system is to set a limit to the emissions; when an individual under the scheme has remaining permits at the end of the period it can sell those permits, when an individual is short extra permits can be purchased. This results in an fine and reward structure and thus stimulates savings. In spite of the benefits, it is expected that the policy is relatively expensive. However the major issues are political and individual acceptability. A study of Parag & Eyre states that the political acceptability is highly depending on the individual acceptability. The individual acceptability is on its turn is heavily leaning on the fairness and effectiveness and the initial allocation of permits (Bristow & al., 2010). The previous indicates that simplicity, fairness and effectiveness are key when aiming to design an applicable policy measure for the municipality of Eindhoven. However, no research is done to the potential and acceptability of an applicable Cap & Trade based policy framework for The Netherlands.

8.2. Conclusions Design Cap, Fine & Reward policy framework

The designed policy framework named 'Cap, Fine & Reward', is focussed to the energy using behaviour of household members, the aim of this design is to provide the municipality with a stringent, long term policy measure urging residents to save energy and enhancing energy consciousness. These energy savings should be realised by different use of products, shifts in consumption and improving the energy efficiency of devices. Where other measures focus to improve the housing characteristics this policy framework is focussed to the energy using behaviour of residents.

By setting a strive target to the energy utilities, electricity, natural gas and heat of all households, and combining this with a financial incentive the policy measure stimulates energy savings. Normally Cap & Trade, or PCT policies are focussed to carbon emissions and involve a trading aspect. However, to keep the policy understandable for households and as simple (cheap) as possible this design sets a target to the energy use instead of the carbon emissions because households are already familiar with energy bills. Furthermore trading between households is prohibited; permits can only be bought from and sold to the regulating authority, this to prevent speculation and keep the policy simple, straight forward and as cost effective as possible.

The key principles and aim of the policy design are described. Also the aim of the research is clear; test the potential and acceptability of the policy design among Eindhoven residents. To enable the experiment to reveal the influence of the several policy variables to the respondent acceptability the major variables affecting the acceptability and potential are appointed. Research of Bristow et al. provided insight in the five key variables to be incorporated in the experiment. First is the ‘allocation’, this variable concerns the way of determining the energy cap for an household. Second is the variable ‘remaining’; this variable concerns the way of handling the remaining energy rights at the end of a period. When a household is short in energy rights extra rights need to be bought, the third variable concerns the abilities of the ‘purchase’ limits. The fourth variable concerns the fine and reward structure, the fifth variable concerns the regulating authority of the policy framework. For an extensive description of the variables see paragraph 5.2.

8.3. Conclusions field research

In the experiment a binary conjoint choice experiment is conducted. The required data for the experiment is gathered from the 703 completely filled in questionnaires. Since there are some differences between the sample group and the population of Eindhoven the result should be handled carefully. In spite of this the results can be analysed and do create insight in the potential and acceptability of a Cap, Fine & Reward policy framework.

8.3.1. Main effects

The influence of the variable levels is analysed by using the binary logistic regression analyses. This analyses created insight in the variable levels affecting the policy package positively and negatively. Furthermore the overall importance of the variables is found. The main effect analyses is useful to distinct rather general conclusions.

Based on the main effect analyses it can be concluded that the importance of the energy right ‘allocation’ and the regulating authority is significantly more important than the variables ‘remaining, purchase and price’, see figure 13. When analysing the result more specifically per variable several conclusions can be found which are also supported by the literature research:

- ✓ Residents prefer to have an allocation of energy permits based on the current use or the energy need of a household.
- ✓ Residents prefer to choose what to do with remaining energy permits.
- ✓ It is strongly preferred to be able to buy energy rights unlimited.

- ✓ Residents prefer that an public authority is involved in regulating the policy measure. No clear difference is found between the public and private-public regulating authority.
- ✓ Residents have a strong preference for a reward focussed price variable. That this will result in an more expensive policy measure seems to be neglected or not noticed.

Briefly stated respondents tend to find a fair policy measure regulated by a governmental involved regulator preserving freedom of choice preferable.

8.3.2. Acceptability towards Cap, Fine & Reward

For determining the acceptability of the designed policy framework the second choice set question is asked. By using ordinal regression analyses the acceptability is and potential of the Cap, Fine and Reward policy framework is tested and analysed.

Apart from the policy package 'acceptability', four policy packages have been combined representing the optimal combinations from the perspective of a municipality, see paragraph 7.3. The policy package named 'optimal' can be characterized as the package that fairly and cost effectively optimally saves as much energy as possible. As can be seen in figure 19, this package is slightly below the red line; indicating that the package is not acceptable for the residents. However, when only adjusting the variable concerning price variable or the variable concerning the remaining permits the policy package is found acceptable by the residents. Important factor to notice is that not only the positive impact a certain variable level is important. It can be even more important to prevent the negative impact from affecting the acceptability towards a policy package. Finding the optimum in preventing the negative part worth from occurring and realizing positive part worth is essential because this creates not only the highest acceptability, but also minimizes the potential resistance towards the proposed policy framework.

The optimized Cap, Fine & Reward policy framework considered from the municipals perspective and with regarding the responses of the residents is concluded to be the package elaborated in table 10. Not only because the acceptability value is the highest from the developed alternatives. Additional motivation is that the largest negative part worth is prevented from being incorporated, this results in an declined chance for experiencing resistance from residents when being realized. Another motivation is that from a financial perspective changing the remaining attribute is more preferable than changing the price attribute.

Attributes	Levels	Part worth
Allocation;	need	0.959
Remaining;	choose	0,239
Purchase;	unlimited	0,081
Price;	stress to fine	-0, 232
Regulator;	public private organisation	-0,061
Total acceptability		0,986
Acceptability threshold		0,391

Table 10, Optimized Cap, Fine & Reward policy framework

Table 10, elaborates a policy package which is characterised by creating energy savings, obtained in a fair manner, providing freedom of choice to the residents and with the lowest cost for the municipal. With the elaboration of this package the hypothesis stated is supported:

"An stringent and for residents acceptable policy measure, based on the principles of 'Cap & Trade', can be designed, urging residents into energy savings"

8.3.3. Latent Class analyses

This analyses is performed to create additional insight in the respondents. Based on the latent class analyses two segments can be distinguished in the sample group. The first segment covers 58 percent of the total sample group; the remaining 42 percent is covered by the second segment.

When the relative importance of the variables is determined per class differences are found, however both of the classes value the variables concerning the allocation of energy permits and the regulating authority as most important. This supports the outcome of the binary latent class analyses and the ordinal regression analyses.

In spite that two respondent segments have been found no clear distinctive differences in the segment characteristics are found. However, since this was not the main objective of this study this is not critical to the research outcome. Furthermore the proposed policy measure is targeting all residents equally therefore designing the policy framework and determining the acceptability and potential is not dependent on the distinction of classes.

8.4. Discussion

The Cap Fine & Reward policy framework has the potential to be realized and being acceptable for residents; however, a well considered combination of variables is required. Key in this combination are the variables concerning the allocation of energy permits and the regulating authority executing the policy.

Several policy packages have been created from the viewpoint of the municipal, the optimal acceptable combination is found and elaborated in table 10 and figure 19 ('choose'). This optimal policy package can be characterised as a package urging residents to save energy, obtained in a fair manner, providing freedom of choice to the residents and with the lowest cost for the municipal.

This research adds insight in the potential of a downstream Cap, Fine & Reward policy framework focussed to the energy utilities of households. By designing a relatively simple policy framework with a small scope the chances for creating an acceptable policy framework are maximized, which is reflected in the research outcome.

When generating the outcomes of the analyses it appeared that the predicting values are rather low. This might be the result of respondents filling in the questionnaires inconsistently. Cause of this might be in the complexity of the choice sets.

It seems to be interesting for future research to investigate the potential for this policy framework to be implemented on national scale. Besides this, more research can be done to the applicability and implementation of this policy framework.

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Appendixes

1. Experiment design

# Respondent	Choice	Acceptability	Choiceset	Package	Allocation		Remaining		Purchase		Price		Regulator	
					A1	A2	R1	R2	P1	P2	PR1	PR2	RE1	RE2
1	1	1	1	14	-1	-1	-1	-1	-1	-1	0	1	1	0
	0	1	1	5	1	0	-1	-1	1	0	0	1	-1	-1
	0	1	2	3	0	1	0	1	-1	-1	0	1	0	1
	1	1	2	17	1	0	0	1	0	1	0	1	1	0
	0	1	3	10	0	1	0	1	1	0	1	0	-1	-1
	1	1	3	2	0	1	-1	-1	1	0	-1	-1	0	1
	0	1	4	16	0	1	-1	-1	0	1	1	0	1	0
	1	1	4	8	-1	-1	1	0	1	0	0	1	0	1
	0	1	5	12	1	0	1	0	1	0	1	0	1	0
	1	1	5	9	-1	-1	1	0	-1	-1	1	0	-1	-1
	0	1	6	1	1	0	0	1	-1	-1	-1	-1	-1	-1
	1	1	6	4	-1	-1	0	1	0	1	1	0	0	1
	0	1	7	18	0	1	1	0	0	1	0	1	-1	-1
	1	1	7	6	1	0	-1	-1	-1	-1	1	0	0	1
	1	1	8	11	-1	-1	0	1	1	0	-1	-1	1	0
	0	1	8	13	1	0	1	0	0	1	1	1	0	1
	1	1	9	15	0	1	1	0	-1	-1	-1	-1	1	0
	0	1	9	7	-1	-1	-1	-1	0	1	-1	-1	-1	-1

2. *SPSS output binary logistic regression*

Logistic Regression

Notes

Output Created		16-jun-2011 17:15:43
Comments		
Input	Data	C:\Users\Sam van t Westeinde\Documents\tue\afstuderen\hoofdstukken\5. design policy framework\data\definitef\def\Definitief.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	12655
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing
Syntax		LOGISTIC REGRESSION VARIABLES Choice /METHOD=ENTER Allocation1 Allocation2 Remaining1 Remaining2 Purchase1 Purchase2 Price1 Price2 Regulator1 Regulator2 /CRITERIA=PIN(.05) POUT(.10) ITERATE(20) CUT(.5).
Resources	Processor Time	00 00:00:00,280
	Elapsed Time	00 00:00:00,344

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	12654	100,0
	Missing Cases	1	,0
	Total	12655	100,0
Unselected Cases		0	,0
Total		12655	100,0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
not picked	0
picked	1

Block 0: Beginning Block

Classification Table[a],b

Observed			Predicted: Choice: not picked	Predicted: Choice: picked	Predicted: Percentage Correct
Step 0	Choice	not picked	6331	0	100,0
		picked	6323	0	,0
	Overall Percentage				50,0

a. Constant is included in the model. b. The cut value is ,500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-,001	,018	,005	1	,943	,999

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	Allocation1	812,462	1	,000
		Allocation2	4,370	1	,037
		Remaining1	39,329	1	,000
		Remaining2	3,426	1	,064
		Purchase1	99,028	1	,000
		Purchase2	110,616	1	,000
		Price1	55,136	1	,000
		Price2	,346	1	,557
		Regulator1	496,221	1	,000
		Regulator2	521,765	1	,000
	Overall Statistics		1938,193	10	,000

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	2048,381	10	,000
	Block	2048,381	10	,000
	Model	2048,381	10	,000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	15493,782[a]	,149	,199

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than ,001.

Classification Table[a]

Observed			Predicted: Choice not picked	Predicted: Choice picked	Percentage Correct
Step 1	Choice	not picked	3922	2409	61,9
		picked	1702	4621	73,1
	Overall Percentage				67,5

a. The cut value is ,500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Allocation1	-,897	,028	1001,972	1	,000	,408
	Allocation2	,399	,027	214,266	1	,000	1,491
	Remaining1	-,149	,027	30,202	1	,000	,862
	Remaining2	,046	,028	2,781	1	,095	1,047
	Purchase1	-,180	,027	42,932	1	,000	,835
	Purchase2	-,142	,028	26,414	1	,000	,868
	Price1	,247	,027	83,221	1	,000	1,280
	Price2	-,116	,028	16,956	1	,000	,890
	Regulator1	,364	,027	176,116	1	,000	1,439
	Regulator2	,377	,027	190,817	1	,000	1,458
	Constant	-,021	,019	1,188	1	,276	,979

a. Variable(s) entered on step 1: Allocation1, Allocation2, Remaining1, Remaining2, Purchase1, Purchase2, Price1, Price2, Regulator1, Regulator2.

3. SPSS output ordinal regression

PLUM - Ordinal Regression

Notes

Output Created		16-jun-2011 17:18:04
Comments		
Input	Data	C:\Users\Sam van t Westeinde\Documents\tue\afstuderen\hoofdstukken\5. design policy framework\data\definitef\def\Definitief.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	12655
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		PLUM Acceptable BY Allocation1 Remaining1 Purchase1 Price1 Regulator1 /CRITERIA=CIN(95) DELTA(0) LCONVERGE(0) MXITER(100) MXSTEP(5) PCONVERGE(1.0E-6) SINGULAR(1.0E-8) /LINK=LOGIT /PRINT=FIT PARAMETER SUMMARY.
Resources	Processor Time	00 00:00:00,250
	Elapsed Time	00 00:00:00,265

Case Processing Summary

		N	Marginal Percentage
Acceptable?	not acceptable	6308	49,8%
	acceptable	6346	50,2%
Allocation1	Current	4218	33,3%
	Need	4218	33,3%
	Equal	4218	33,3%
Remaining1	Choose	4218	33,3%
	Bank	4218	33,3%
	Sell	4218	33,3%
Purchase1	Unlimited	4218	33,3%
	Limited	4218	33,3%
	Halflimit	4218	33,3%
Price1	Fine	4218	33,3%
	Fine&Reward	4218	33,3%
	Reward	4218	33,3%
Regulator1	Private	4218	33,3%
	Public_Private	4218	33,3%
	Public	4218	33,3%
Valid		12654	100,0%
Missing		1	
Total		12655	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1059,373			
Final	139,629	919,745	10	,000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	14,924	7	,037
Deviance	14,892	7	,037

Link function: Logit.

Pseudo R-Square

Cox and Snell	,070
Nagelkerke	,093
McFadden	,052

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Acceptable = 0]	,391	,060	41,835	1	,000	,273	,510
Location	[Allocation1=-1]	,858	,045	357,271	1	,000	,769	,948
	[Allocation1=0]	,959	,046	442,391	1	,000	,869	1,048
	[Allocation1=1]	0[a]	.	.	0	.	.	.
	[Remaining1=-1]	,239	,045	27,955	1	,000	,150	,327
	[Remaining1=0]	,166	,045	13,636	1	,000	,078	,255
	[Remaining1=1]	0[a]	.	.	0	.	.	.
	[Purchase1=-1]	,081	,045	3,171	1	,075	-,008	,170
	[Purchase1=0]	-,064	,045	2,035	1	,154	-,152	,024
	[Purchase1=1]	0[a]	.	.	0	.	.	.
	[Price1=-1]	-,232	,045	26,472	1	,000	-,321	-,144
	[Price1=0]	-,051	,045	1,288	1	,256	-,139	,037
	[Price1=1]	0[a]	.	.	0	.	.	.
	[Regulator1=-1]	-,715	,045	248,572	1	,000	-,804	-,626
	[Regulator1=0]	-,061	,045	1,827	1	,176	-,149	,027
	[Regulator1=1]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

4. Limdep LCA output; 2 segments

```
--> LOGIT;
    Lhs=ACCEPTAB;
    Rhs=ONE,ALLOCA1,ALLOCA2,REM1,REM2,PURCH1,PURCH2,PRICE1
    ,PRICE2,REGU1,REGU2;
    ;Pds=18
    ;LCModel
    ;Pts=2
    ;par
    ;maxit =200$
```

```
+---------------------------------------------+
| Logit    Regression Start Values for ACCEPT |
| Maximum Likelihood Estimates                |
| Model estimated: Jul 05, 2011 at 09:56:56AM.|
| Dependent variable              ACCEPTAB    |
| Weighting variable                  None    |
| Number of observations             12654    |
| Iterations completed                  10    |
| Log likelihood function        -8310.275    |
| Number of parameters                  11    |
| Info. Criterion: AIC =           1.31520    |
|   Finite Sample: AIC =           1.31520    |
| Info. Criterion: BIC =           1.32167    |
| Info. Criterion:HQIC =           1.31737    |
+---------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Constant	.00113811	.01846688	.062	.9509	
ALLOCA1	-.60713761	.02641186	-22.987	.0000	.000000
ALLOCA2	.34868270	.02603739	13.392	.0000	.000000
REM1	-.13418348	.02592432	-5.176	.0000	.000000
REM2	.03098601	.02621306	1.182	.2372	.000000
PURCH1	-.00485784	.02603316	-.187	.8520	.000000
PURCH2	-.06897909	.02607696	-2.645	.0082	.000000
PRICE1	.09324184	.02591853	3.597	.0003	.000000
PRICE2	.04197295	.02620557	1.602	.1092	.000000
REGU1	.26037226	.02609709	9.977	.0000	.000000
REGU2	.19738132	.02608055	7.568	.0000	.000000

```
Line search does not improve fn. Exit iterations. Status=3
Check derivatives (with ;OUTPUT=3). This may be a solution
if several iterations have been computed, not if only one.
  Error   806: (The log likelihood is flat at the current estimates.)
```

Latent Class / Panel Logit Model
Maximum Likelihood Estimates
Model estimated: Jul 05, 2011 at 09:57:00AM.

Dependent variable	ACCEPTAB
Weighting variable	None
Number of observations	12654
Iterations completed	28
Log likelihood function	-6959.770
Number of parameters	23
Info. Criterion: AIC =	1.10365
Finite Sample: AIC =	1.10365
Info. Criterion: BIC =	1.11718
Info. Criterion:HQIC =	1.10817
Restricted log likelihood	-8310.275
McFadden Pseudo R-squared	.1625102
Chi squared	2701.009
Degrees of freedom	13
Prob[ChiSqd > value] =	.0000000

Sample is 18 pds and 703 individuals.
LOGIT (Logistic) probability model
Model fit with 2 latent classes.

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Model parameters for latent class 1					
Constant	1.03597586	.04101625	25.258	.0000	
ALLOCA1	-.89111030	.04086718	-21.805	.0000	.000000
ALLOCA2	.52575015	.04687588	11.216	.0000	.000000
REM1	-.21346053	.03934756	-5.425	.0000	.000000
REM2	.07536800	.04132770	1.824	.0682	.000000
PURCH1	-.05300127	.04111783	-1.289	.1974	.000000
PURCH2	-.10628229	.04100725	-2.592	.0095	.000000
PRICE1	.10213814	.04137371	2.469	.0136	.000000
PRICE2	.05155442	.04147842	1.243	.2139	.000000
REGU1	.36791099	.04373284	8.413	.0000	.000000
REGU2	.29301361	.04261150	6.876	.0000	.000000
Model parameters for latent class 2					
Constant	-1.43250733	.05689161	-25.180	.0000	
ALLOCA1	-.69266753	.06369722	-10.874	.0000	.000000
ALLOCA2	.40426979	.05381220	7.513	.0000	.000000
REM1	-.17702421	.05303279	-3.338	.0008	.000000
REM2	.00680039	.05109520	.133	.8941	.000000
PURCH1	.08588623	.05258248	1.633	.1024	.000000
PURCH2	-.11581222	.05446324	-2.126	.0335	.000000
PRICE1	.12225304	.05181149	2.360	.0183	.000000
PRICE2	.10972755	.05148792	2.131	.0331	.000000
REGU1	.34873512	.05249358	6.643	.0000	.000000
REGU2	.23506222	.05120468	4.591	.0000	.000000
Estimated prior probabilities for class membership					
Class1Pr	.57733267	.02153304	26.811	.0000	
Class2Pr	.42266733	.02153304	19.629	.0000	

Article; A CAP, FINE & REWARD POLICY FRAMEWORK; Creating energy consciousness and urging residents to save energy?

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ABSTRACT
Governmental authorities seem to lack the means to urge residents to energy savings and creating energy consciousness among them. However, in this research a new policy framework is designed named Cap, Fine & Reward seeming to have the potential to create energy consciousness and urge residents to save energy. The policy framework can be characterized as a stringent, long term policy framework, aiming to increase the household energy savings by affecting the residential energy using behaviour. A stated conjoint choice experiment is used to test the acceptability of residents towards this policy framework and to do research to the potential of the system.

Keywords: Cap & Trade, Policy framework, stated conjoint choice, residential energy savings.

INTRODUCTION

All over the world there is much attention to decrease the dependency on fossil sources for economic and environmental motives. This can be realised by a two sided approach; the production of renewable energy should be increased, however using the available energy more efficiently is equally important. For this research the focus is to energy savings in the residential sector resulting from behavioural changes and increased energy awareness of residents.

Besides the importance, research has shown that the energy use varies dramatically per person, by region and even by neighbourhood (Salon & al., 2010). Although, people often seem to be aware of the environmental and energy problems, they often do not act in line with their concerns, and total household energy use is still rising. This seems to be partly caused by a lack of insight in the relation between behaviour and energy use (Steg, 2008). Furthermore, many people attach only a low priority to saving energy and since energy use is not only driven by concerns about environmental and energy problems, this lowers the energy savings. Despite all efforts being undertaken by governmental authorities, the energy-saving rate is still very low (Nieuwenhuijsen, 2010). This is also supported by

Abrahamse, who states that household energy use keeps rising and the governmental financial incentives appear to be inadequate (Abrahamse, 2007). When aiming for substantial energy savings it is important to implement soft measures in combination with hard measures (Delft, 2006). This is supported by expert H. Nieman who stated that during the journey to reach the energy goals *"it is a matter of persuading and forcing"*. The soft measures represent the persuading, and the stringent measures the forcing. A relatively new high potential phenomenon; the Cap & Trade system, which is based on promising basic principles, might have the potential to provide the governmental authorities with a hard policy measure to achieve the goals set. However, since there is a lack of insight in the potential and public acceptability of such a system research is required.

RESIDENTIAL ENERGY USING BEHAVIOUR

Research states that large differences are found in the residential energy use, this implicates that energy savings can be achieved by affecting the using behaviour. Human behaviour and in particular creating a change in consuming behaviour is essential in reducing the energy use. However, changing behaviour seems to be a complex matter (energy-behave, framework); behavioural factors such as awareness, knowledge, norms and values, and attitude, lead to an intention for making the decision to implement the solution. This intention may suffice to start the change in behaviour, but it will not be carried out unless the individual has the required resources and skills, and no barriers stand in the way.

When designing a policy affecting the human behaviour it is stated that a mix of soft and hard policy measures achieve the best results (Energieraad, 2006). Since the research of I. Nieuwenhuijsen focussed to soft policy measures, this research is focussed to developing a hard policy measure. The policy focuses to achieving energy conservation by behavioural change of residents. This direct reduction should result from behavioural changes such as decreasing the shower time, lowering the heating temperature and other direct behavioural energy savings. In the longer term the policy might also influence the awareness of the energy use of technical appliances.

The above is supported by (Tambach, Hasselaar, & Itard, 2010)who conclude that the current Dutch energy transition policy instruments for the existing housing stock, which are largely focused on communication, need to be complemented by more traditional and long-term energy policy instruments. Since the regulating energy tax is not achieving the intended results an alternative should be developed. A Cap & Trade based measure seems to have the potential to become a structural measure to create energy consciousness among residents and urge them to save energy.

CAP & TRADE

This research is focussed to develop a city based Cap & Trade system urging residents to save energy, and to do research to its potential and to the acceptability among residents. A Cap & Trade based measure seems to have the potential to become a structural measure to create energy consciousness among residents and urge them to save energy. Furthermore it provides a framework for carbon reductions (Tambach, Hasselaar, & Itard, 2010). In principle the mechanism enables participants to compensate for their emissions where it is cheap and simple. Besides this, the inclusion of the trading function results in a rewarding and fining mechanism in the scheme.

Personal Carbon Trading comprises various downstream emission trading schemes addressing the end users of energy. The common objective are the same; limiting the overall carbon emissions from society effectively, efficiently and equitably, by engaging individuals in managing their carbon emissions. However, at the moment none of the versions of PCT is fully worked-out policy proposal and all require further development (Fawcett, 2010). The various PCT schemes proposed all have their own strengths and weaknesses. Niemeier, (2008) developed a proposal with a scope covering only household energy, the system would concern for about 25 % of the energy use within Eindhoven. It can be described as household carbon trading and is defined as follows;

> A yearly carbon emissions cap is set for residential energy use based on emissions reduction targets. Allowances are allocated to each household on an equal per household allocation basis via utility service providers who place the allowances in each user's account. These are deducted periodically by the utility according to energy use, and additional allowances must be purchased if the account is in deficit. The carbon allowances are fully tradable. At the end of a compliance period, the state collects the permits from the utilities and determines compliance with the cap. Household carbon trading was proposed in California and examined against its emission targets (Niemeier, 2008).

It is clear that any PCT as it is described in this chapter would be a relatively expensive policy to introduce and maintain, however there is also evidence for suspecting that PCT could deliver a wide range of non-economic benefits (Fawcett, 2010). In spite of the benefits, the previous implicates that simplicity and effectiveness are key when aiming to design an applicable policy measure for the municipality of Eindhoven.

The different PCT schemes face quite similar issues when considering the practical implementation. The major issues are political and individual acceptability and equity issues. However, research states (Parag & Eyre, 2010) that the political acceptability is highly depending on the individual acceptability. The individual acceptability is on its turn is heavily leaning on the fairness and effectiveness (Fawcett, 2010) and the initial allocation of permits (Bristow & al., 2010). When addressing in particular these last three aspects properly, a significant part of the political and individual issues seem to be addressed.

This paragraph describes the key principles of PCT, besides this it is shows that there is potential for a Cap & Trade based policy framework. However, no research is done to the potential and acceptability of such a mechanism on a city scale within The Netherlands. In the next chapter a Cap & Trade based policy framework is designed suitable for a city in The Netherlands.

DESIGN; A CAP, FINE & REWARD POLICY FRAMEWORK

Since PCT is never been realised in practice and the research is all done outside of The Netherlands, this research aims to design and test a policy design applicable to The Netherlands based on literature research and expert interviews. The design elaborated in this paragraph is different from al PCT variants, therefore it is named as a 'Cap, Fine & Reward' policy framework.

Goal,
This policy has the goal to provide the municipality with a stringent, long term policy measure urging residents to save energy and enhancing energy consciousness. The policy measure should urge residents to safe energy by changes in first instance in the energy using behaviour, and in the longer term by changes in the purchase behaviour for appliances. Examples of such behavioural changes are savings caused by a lowered heating temperature or the purchase of an A label refrigerator. Critical is that investments in housing characteristics, such as isolation or double glazing are beyond the scope of the policy. Other policies however can stimulate these improvements. Besides this policy measure, other regulations can stimulate investments in the real estate.

Key principles
By setting a strive target to the households utility energy use, and combining this with a financial incentive this policy measure aims to save energy by changing the residential energy using behaviour.

The trading function, normally included in a Cap & Trade based system, is not included in this policy proposal because of multiple reasons, first the trading aspect is complex to realize in practice, requiring from the regulator to supervise a policy with a significantly higher complexity because all households can buy and sell permits from each other. Furthermore it enables speculation with energy permits, this is thought to be undermining the main goal of the policy and is therefore prohibited. The positive aspects of the trading function is still incorporated because a household can sell the remaining permits to the regulating organisation, or buy extra permits when exceeding the strive target. Selling remaining permits results in a reward, and buying extra permits results in a fine.

Scope
The policy framework is focussed to providing an *energy* target for households. By using an energy target instead of a carbon emission target, no calculation has to be made for translating the used energy (natural gas, electricity, heat) to the emitted carbon dioxide. Besides this, it is the most straight forward manner for residents and therefore it is thought to be the best way to create conscious energy using behaviour.

Briefly described a household energy Cap, Fine & Reward structure is proposed, using existing household utility accounts electricity, heat and natural gas. Niemeier stated that limiting the scope of the program does limit possible efficiency gains, but reduces the complexity, risk, and political opposition. Although the scope is limited, the practical applicability is increased enabling the concept to realize efficient and effective energy savings.

Design variables
The previous describes the main elements of the Cap, Fine & Reward framework. However, to investigate the potential of the framework and test the acceptability of the framework to the Eindhoven residents different designs need to be tested. Therefore, various design variables are appointed in the design of this policy measure. However, to remain the experiment and in particular the questionnaire suitable for the respondents, deliberate choices have to be made about which variables to include. The included variables are described below:

1. Permit allocation

As stated in the literature research, the perceived fairness of the permit or energy allocation is essential to the acceptability of the policy design. The attribute allocation represents the manner of setting the energy cap for a household.

When reasoning from the perspective "we are all the same". Someone might favour an *equal* amount of energy for every person since this is in line with the perception that every individual has an equal right to use energy and emit carbon dioxide. Since the scope of this scheme is an allocation per household the allocation per person should be multiplied with the number of residents of a house. The allocation based on the *need* is intended to be an allocation perceived as being fair in the sense that everyone receives an cap based on the need, taking in account the number of household members and the housing characteristics.

The third level is based on the *current* levels of consumption and is incorporated to do investigate whether this is perceived as a fair allocation.

2. Remaining permits

When a period with a length of one year has passed, a household is short in energy permits or has a surplus of permits. This attribute assesses the respondents' perception about what to do with these remaining permits.

When the first level is incorporated the surplus energy permits must be *sold* to the regulating organization, this results in financial gains for the energy saver for example through a discount on the energy bill. The second level allows households to *save* the surplus energy permits for the years after. In the latter years extra consumption freedom could be gained by using the saved permits. The remained permits can only be turned in financial benefits when the permit life expires. In this situation it is important to set an appropriate permit life. The last level enables households to *choose* whether they want to sell or bank the permits.

3. Purchase limits

When a period with a length of one year has passed, and a household is short in energy permits extra limits need to be bought on top of the free allocated permits. Some might favour *limiting* permit purchases in order to avoid excess personal use of carbon or energy (Bird, Jones, & Lockwood, 2009). Others might find this patronizing or restrictive and prefer the option to buy extra permits *unlimited*. The level in between enables households to buy extra permits; however there are still limitations. Theoretically the levels above enable the situation that a household exceed his cap and also on top of that exceeds the purchasing limit. Since excluding a households from the utilities would be not possible in practice. Therefore an extra fine, significantly higher than the purchasing cost, could be set when exceeding the purchase limit.

4. Permit price

The rewarding and fining is regulated per unit energy and is being managed by the regulating organisation; all transaction will proceed via this organisation. The manners elaborated below are differentiate in the height of the fines and rewards.

- ✓ The *rewards is higher than the fine*; this results in higher cost for running the policy measure.
- ✓ The *height of the fine and reward are equal*. This implicates that the potential benefit equal is to the potential correction.

- ✓ The *fine is higher than the reward*; the potential correction is higher than the potential reward.

This attribute is added to see whether respondents prefer that good behaviour is rewarded, or prefer that the emitter pays extra.

5. Regulator

This attribute is about the regulator managing the allocation and energy permits accounts. Between the levels differentiation is made in a *public regulator*, a *private regulator* and a *combination* of both. A governmental organisation might be in favour because of the private data incorporated in the allocation, besides this they might find social aspects more important than private companies. A non profit private company might be more specialized to the task and therefore more efficiently. A third level is an option which is a combination of both. For example, the allocation and determination of the prices could be done by the government, and the verification and the managing of the accounts could be done by the network operator.

METHODOLOGY EXPERIMENT

By using conjoint analyses an optimized policy package with the highest acceptability and potential is determined. The following research questions have been described:

1. *What combination of attributes and levels results in an optimized policy package?*
2. *Is this optimized policy package acceptable for the Eindhoven population?*

Conjoint stated choice experiment

Conjoint stated choice experimentation involves the design of product profiles on the basis of product attributes specified at certain levels, and requires respondents to repeatedly choose one alternative from different sets of profiles offered to them (Haaijer, 1999).
The respondents makes choices between the policy packages based on their preferences, therefore it is possible to test the acceptability and potential of a particular policy package.

Experiment design

Incorporating all the alternatives requires too many choice packages(3^5 = 243) to be incorporated in the experiment. Therefore a fractional factorial design is created, which still enables the discovering of main effects for each variable level (Montgomery, 2005). The orthogonal generator function of SPSS 19 is used to design the fractional factorial design, holding 18 policy packages.

Analyses techniques

Random utility theory is used to analyse the choice behaviour of respondents. The Random utility theory is based on the following assumption; if an individual must choose between two sets of alternatives, the set with the highest random value will be chosen (Oppewal & Timmermans, 1993). Each choice package consists of different attribute levels. Therefore the total utility for an alternative is the summation of the utilities of the attribute levels. Binary logistic regression and ordinal regression enables analyzing data in which causality might be involved. The ordinal regression have in this case been used to determine the influence of particular variable levels (cause) to the acceptability of the policy package. The method estimates a threshold representing in this research the turning point between not acceptable to acceptable. When the sum of all variable levels exceeds this threshold the package would be accepted according to the estimation; when the sum is lower than the value of the threshold the package is unacceptable. For performing the ordinal regression SPSS is used.

Data collection
The respondents have been approached via a research institute of the municipal of Eindhoven named Digi panel. This panel of civilians can be used for asking their point of view about a wide range of matters via a web based questionnaire. Although the panel members are not selected, there is something to notice; it could be questioned whether the sample group is reflecting the Eindhoven population entirely since people have to subscribe to become a panel member. However, since the number of responses is very critical and this is only an exploratory research to the potential and acceptability of a Cap, Fine & Reward policy framework the sample is still found usable. In total 2083 respondents have been approached, 34 percent from the approached have finished the questionnaire. A number of 703 valid responses have been received.

RESULTS

Binary regression analyses
The data gathered from the respondents is used to perform the binary logistic regression and determine the relative importance per variable, this is pictured in figure 1. Key variables seem to be the variables concerning the allocation and the regulator; these are significantly more important than the others. With 38.3 percent the allocation is the most important; implicating that the respondents seem to find it key that the policy framework is fair. Second important is the regulating organisation with a relative importance of 30.7, this seems to be implicating that privacy concern still is an important issue for the civilians. The other variables concerning the regulations about buying permits, selling permits and the fine & reward structure are far less important.

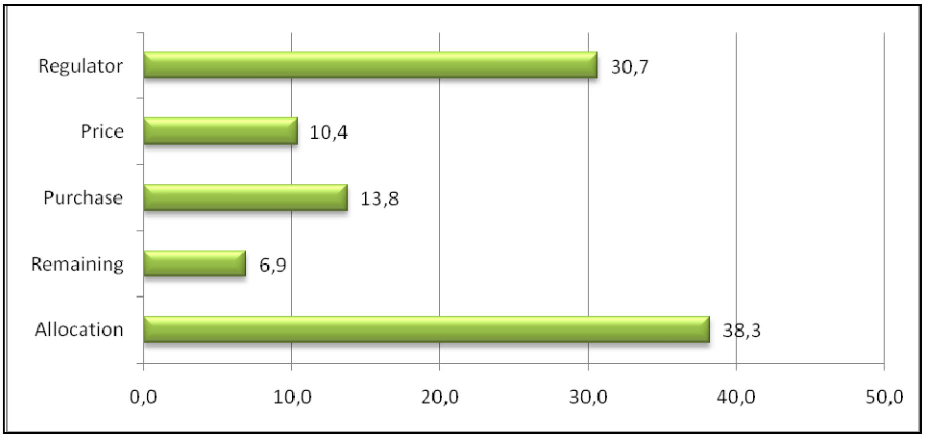

Figure 1, Relative importance per variable.

Ordinal regression
The output of an ordinal regression provides a threshold value, this threshold is an indication for the respondents' reaction (acceptable or unacceptable) towards a particular policy package (combination of variable levels). The threshold (red line in figure 2) in this analyses is 0,391, indicating that the sum of the part worth values from the variable levels of a particular policy package should be above 0,391 to be acceptable for the respondents.

Since the part worth values are known, policy packages can be combined predicting the acceptability for the Eindhoven population. The policy measure is developed to provide the municipal with a tool to urge residents to energy savings. Therefore the packages are created from the viewpoint of the municipal. Generally this means that the packages are defined to achieve energy savings fairly and as cost effective as possible. Besides the insight this creates in the acceptability it generates insight in the potential of a Cap, Fine & Reward policy framework.

1. *Acceptability;* the first policy package elaborates the combination of variable levels resulting in the highest prediction for the acceptability of the respondents.
2. *Optimal;* the second package elaborates the combination which is found optimal for the municipality of Eindhoven. This package is characterized by creating as much energy savings as possible, obtained in a fair manner, and with the lowest cost for the municipal.
3. *Fine & reward;* in this policy package the focus is to achieving high energy savings in a fair manner, besides the variable level 'fine & reward' the package is entirely the same as the optimal package.
4. *Reward;* This package focuses also to fairness and energy savings, however the focus in this package is to rewarding the energy savings.
5. *Choose;* this package is the same as the 'optimal' package accept for the variable 'remaining'. Under this package the households are free to choose for selling or keeping the remaining permits.

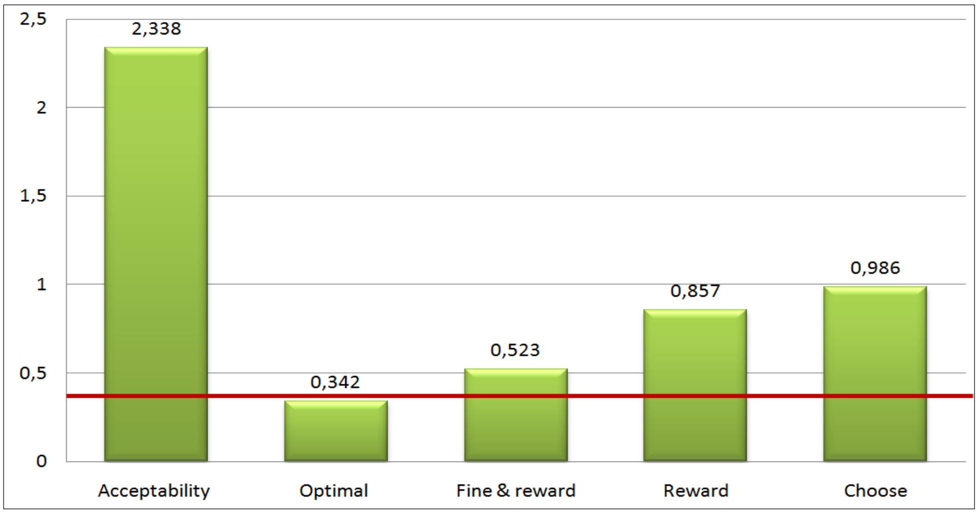

Figure 2, Predicted acceptability to a Cap, Fine & Reward policy framework.

CONCLUSION

In this study first a literature research is performed creating insight in the energy consumption behaviour of residents and in the Cap & Trade mechanism. Based on this research a policy framework is designed with the goal to provide the municipality with a stringent, long term policy framework urging residents to save energy and enhancing energy consciousness. The mechanism sets a strive target to the households utility energy use (natural gas, warmth, electricity), and combining this with a financial incentive this policy measure aims to save energy by changing the residential energy using behaviour. Five main design variables are appointed each containing three variable levels, these variables are used to develop different policy packages. A questionnaire is used to gather data and reveal the respondents preferences for particular variables and variable levels.

Based on the main effect analyses it can be concluded that the importance of the energy right 'allocation' and the regulating authority is significantly more important than the variables 'remaining, purchase and price'. When analysing the results more specifically per variable level several conclusions can be found which are also supported by the literature research:

- ✓ Residents prefer to have an allocation of energy permits based on the current use or the energy need of a household.
- ✓ Residents prefer to choose what to do with remaining energy permits.
- ✓ Residents strongly prefer to be able to buy energy rights unlimited.
- ✓ Residents prefer that an public authority is involved in regulating the policy measure. No clear difference is found between the public and private-public regulating authority.
- ✓ Residents have a strong preference for a reward focussed price variable. That this will result in an more expensive policy measure seems to be neglected or not noticed.

The above is implicating that residents tent to prefer having as much freedom of choice as possible, furthermore people prefer an fair system which is focussed to rewarding.

Based on the ordinal regression the optimized Cap, Fine & Reward policy framework considered from the municipals perspective and with regarding the responses of the residents is determined, the package is elaborated in table 1. The policy package is characterised by creating energy savings, obtained in a fair manner, providing freedom of choice to the residents and with the lowest cost for the municipal. The required value for an acceptable policy package is at least 0.391, with a total acceptability value of 0.986 this package is considered to be acceptable of the Eindhoven population.

Attributes	Levels
Allocation;	need
Remaining;	choose
Purchase;	unlimited
Price;	stress to fine
Regulator;	public private organisation

Table 1, Optimized Cap, Fine & Reward policy framework for Eindhoven

DISCUSSION

This research adds insight in the potential of a downstream Cap, Fine & Reward policy framework focussed to the energy utilities of households. By designing a relatively simple policy framework with a small scope the chances for creating an acceptable policy framework are maximized, which is reflected in the research outcome.

The Cap Fine & Reward policy framework has the potential to be realized and being acceptable for residents; however, a well considered combination of variables is required. Key in this combination are the variables concerning the allocation of energy permits and the regulating authority executing the policy. Several policy packages have been created from the viewpoint of the municipal, the optimal combination is found and elaborated. The optimal policy package can be characterised as a package urging residents to save energy, obtained in a fair manner, providing freedom of choice to the residents and with the lowest cost for the municipal.

When generating the outcomes of the analyses it appeared that the predicting values are rather low; the Rho square is below the required 0,2. This might be the result of respondents filling in the questionnaires inconsistently; implicating that it is found complex by respondents to fill in the choice sets. Because the predicting values are low the research outcome should be handled with care. However for an exploratory research it does create additional insight.

For future research it seems to be interesting to investigate the implementation and realization for this policy framework, possibly even on national scale.

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During the three years of my master education I have learned a lot in the field of construction management, particularly in the project and process management. Besides this, it has been a valuable for my personal and social development.

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